

**Optimization of BRTs Operations in Pakistan:
Rawalpindi-Islamabad a Case Study**



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2017-MS-Tn Engg-00000204558

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NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
ISLAMABAD**

SEPTEMBER, 2020

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**A thesis submitted in partial fulfillment of the requirement for the
degree of
M.Sc. Transportation Engineering**

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ISLAMABAD**

SEPTEMBER, 2020

DEDICATION

I dedicate my research thesis to the lovely, kind-hearted, and most civilized personality, the teacher, the honest, the most literate person, and ALLAH's beloved Holy Prophet **MUHAMMAD** (SALLALAHO ALEHEY WA ALAY HE WASALAM) whose teachings made me able to achieve this great milestone.

Also, I dedicate this thesis to my kind Father, lovely mother, and my wife who cleaned my clay and helped me to achieve my target.

THESIS ACCEPTANCE CERTIFICATE

It is certified that final copy of MS Thesis written by **Mr. Muhammad Qasim s/o Muhammad Shoaib** (Registration No. 00000204558), of **National Institute of Transportation (NIT)-NUST** has been vetted by undersigned, found complete in all respects as per NUST Statutes/ Regulations, is free of plagiarism, errors and mistakes and is accepted as partial fulfillment for award of MS/MPhil degree. It is Further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporatd in the said thesis.

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ABSTRACT

PMBS is a BRT system in the Rawalpindi-Islamabad region comprising AADR of 110,000 passengers which is only 4% of total trips of the twin cities with a 41% model share of public transport. Being the Lower-Middle-Income country, with 5.8% of the Current Account Deficit of GDP (US\$ 18.1 Billion), PMBS is important for sustainability and stability for the deplorable transport structure of the twin cities. Moreover, besides an average annual revenue of PKR 148.16 /KM, its expenses are PKR 539.56 /KM i.e. the fare-box recovery ratio is 0.27. About 60% of the total expenses of PMBS are due to the cost of per kilometers of 68 buses for Operations i.e. 70,000 KM/bus/Year as guaranteed KM. Therefore, around 40 Million passengers who traveled during 2018, the demand at every station is studied using VBA of Microsoft Excel and SQL Software. The loss of ridership is observed i.e. 135,005 Passengers/day as per feasibility study to actual 110,000 Passengers/day due to 9 minutes or above Waiting Time of passengers during peak hours at some stations. Other issues are; above 40% Saturation Level of stations during peak hours, increased boarding & alighting time of passengers due to overloading of buses, passengers' discomfort during travel, unavailability of park & ride service, women complaints, and pickpockets issues. The decisions are made based on 1-year data and three routes are suggested to be fully functional so that the demand can be increased to plan. The scheduling model is provided. Using this model, the bus schedule is re-formed and for a single day (Monday) Express & Limited Stop routes are suggested. By using passenger demand at stations at a Load Factor of 0.85, 310,243 minutes/day of passengers-minutes traveled or 2,281 minutes/day of bus trips can be saved. Moreover, around 900 KM/day of bus kilometers can be saved using this schedule which is PKR 100 million savings per annum.

Keywords: BRT System, AADR = Average Annual Daily Ridership, Model Share, Public-Transport, fare-box recovery ratio, ridership, Waiting Time, Saturation Level, Boarding & Alighting Time, Scheduling Model, Park & Ride Service, bus schedule, Load Factor, passengers-minutes, Optimization of cost and comfort level.

ABBREVIATIONS

PMA	=	Punjab Mass Transit Authority
PMBS	=	Pakistan Metrobus System
LFR	=	Lahore Feeder Route
MFR	=	Multan Feeder Route
OLMTS	=	Orange Line Metro Train System
RITS	=	Rawalpindi Integrated Transportation System
VOC	=	Vehicle Operating Cost
LRT	=	Light Rail Transit
LMBS	=	Lahore Metrobus System
HBW	=	Home Based Work Trips
HBS	=	Home Based School Trips
HBO	=	Home Based Other Trips
NHB	=	Non-Home Based Trips
GDP	=	Gross Domestic Product
PPP	=	Purchasing Power Parity
ITDP	=	Institute for Transportation & Development Policies
PPHPD	=	Passengers Per Hour Per Direction
UPS	=	Uninterruptible Power Supply
Gensets	=	Generator Sets for Power supply
TVM	=	Ticket Vending Machines
PDA	=	Personal Digital Assistant

PSD	=	Platform Screen Doors
PIS	=	Passenger Information System
ITS	=	Intelligence Transportation System
C&CC	=	Command & Control Centre
OBU	=	On-board Bus Unit
GPS	=	Global Positioning System
GTFS	=	the General Transit Feed Specification
PPRA	=	Public Procurement Regulatory Authority
RWMC	=	Rawalpindi Waste Management Company
CSV	=	Comma Separated Values
VBA	=	Visual Basics for Applications
SQL	=	Structured Query Language
OD	=	Origin Destination
HVAC	=	Heating, Ventilation & Air Conditioning.

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1. INTRODUCTION

The sustainable transportation system is vital for countries having higher population growth rates. The Bus Rapid Transit (BRT) System is a well-adopted system worldwide, currently operational in around 172 cities. The selecting BRT against other public transport systems for a city depends on many factors. The BRT system provides commuters a comfortable ride along with savings in travel time and other expenditures associated with the private trip. For authorities, it provides social, environmental, and economic benefits.

For a decision-maker, the financial aspect has the foremost selection criteria while selecting the public transport system. Generally, city planners and policymakers prefer the Light Rail Transit (LRT) system (Khan, 2018), integrated with heavy rail systems of the cities. However, due to financial constraints, LRT cannot be afforded by the developing countries. The BRT, in contrast, cost-effective rail like system and proliferating globally as practical transportation due to its ability to exhibit both LRT and conventional buses (Khan, 2018). Ultimately, the selection of the public transport system will shape a city's urban form and the lifestyles of its inhabitants (BRTGuide.itdp, 2018).

In the last 15 to 20 years, BRT systems have been built by many developing countries like India, Pakistan, Bangladesh, Iran, Mexico, Turkey, Columbia, Brazil, Ecuador, etc. The studies around the world have indicated that BRT is an effective alternative for congested cities at a relatively low construction and operation cost (Philemon Kazimil Mzee et al., July, 2010). TransMilenio in Bogota, Columbia, is one of the best examples which was operational in 2000 and drew attention around the world as the state of the art in BRT systems (Oxford, 2004)

1.1 BRT in Pakistan

In Pakistan, BRT was first introduced in the city of Lahore (Capital of Punjab Province) in 2012, under the official name Lahore Metrobus System (LMBS). It went through a lot of opposition due to political reasons. However, it was operated professionally, facilitate a larger number of commuters in the city of Lahore. It also

reduced traffic congestion on some major corridors within the city. After its success, two new BRTs under one administrative authority were introduced in Rawalpindi-Islamabad (Twin Cities) called Pakistan Metrobus System (PMBS) in 2015 and Multan with the name Multan Metrobus System (MMBS) in 2017. The administrative authority to operate these BRT systems is the Punjab Mass transit Authority (PMA) under Punjab Government. The PMA is responsible for Operations & Maintenance of all of its services. The ongoing services & future planned services of the PMA are shown in Figure 1.1.

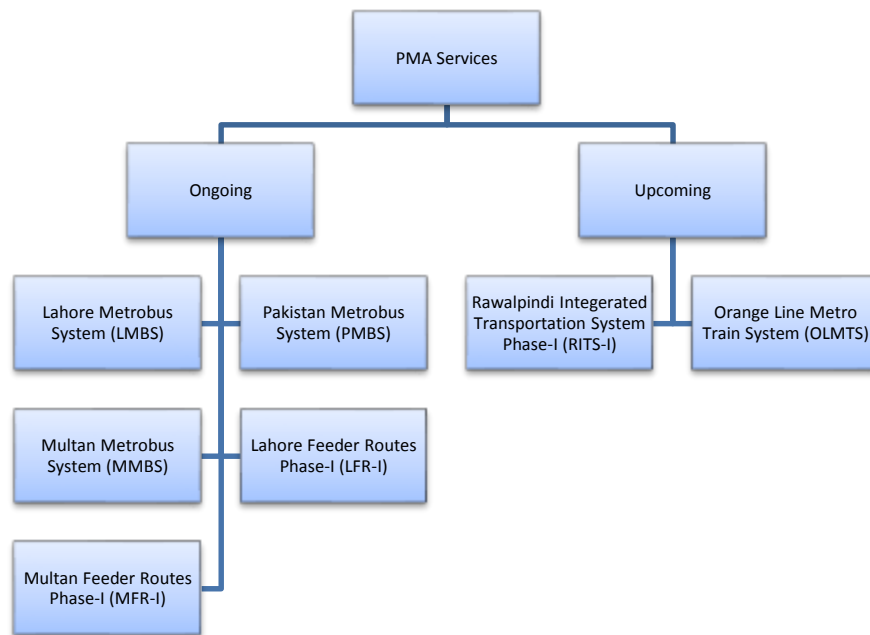


Figure 1.1: The Ongoing & Upcoming Services of PMA

The Lower-Middle-Income country and politically unstable, BRT in Pakistan, is not as successful and well planned as in other countries. The PMBS is “Bronze” ranked by previous research (A.R.Khan, 2017) due to the absence of coordination with other modes of transportation, lack of parking facilities at bus stations for bicycles, motorcycles, and cars, less accessibility, missing feeder routes, political imbalance, and financial issues. In this research, the performance of BRT operational in Islamabad Rawalpindi twin cities is evaluated.

1.2 Study Area & Features of PMBS:

The Pakistan Metrobus System (PMBS) consists of single corridor BRT joining the Twin Cities of Islamabad and Rawalpindi providing access to major commercial, residential, industrial and educational institutional areas. The total length of the

corridor is 22.49 Km and one bus depot facility in the Islamabad region. A total of Twenty four-station are currently operational, having 3 bays in both directions as shown in Figure 1.2.



Figure 1.2: Pakistan Metrobus System (PMBS) Study Area

The details about the PMBS infrastructure and features are provided in Table 1.1. More details and discussion are done related to PMBS operations and other features in CHAPTER II.

Table 1.1: Features of PMBS Infrastructure

Features	Details
Total Length of Corridor	22.49 KM
No of Stations	24
Cities	Twin Cities (8.44 KM Rawalpindi & 14.05 KM Islamabad)
At-Grade or Trench Corridor Length	12.49 KM Length with 13 Stations. All this length lies in Islamabad Region
Elevated Corridor Length	10 KM Length with 11 Stations. 1 st 10 Stations lie in Rawalpindi Region & 1 Station in Islamabad Region
No of Stopping-Bays on Each Station/Direction	3
Station Flooring	Raised Flooring leveled with Bus Floor
Average Length of Station	210 m

Features	Details
Length of Bay	28m (18m for Bus Docking & 10m for Passing) or 22m (18m for Bus Docking & 4m for Passing)
Average Height of Stations	8.5 m
Average Width of Corridor in Station area	18.4 m
Width of Station	6.1 m
Width of Busway with passing lanes	6.1 m
Width of Corridor other than Station Area	9.2 m

1.3 Why PMBS is selected for research?

PMBS is selected for a case study to optimize the BRT structure in Pakistan because of the following factors;

- ✓ PMBS is covering only 110,000 passengers per day against 2.9 million trips per day generated in twin cities as estimated in the feasibility study. (NESPAK, 2015, p. a).
- ✓ PMBS is covering only 4% travel demand of the twin cities.
- ✓ Around 41 % modal share to public transportation of the twin cities which shows people are very dependent on public transportation of these cities. (NESPAK, 2015, p. 40).
- ✓ PMBS is an only comfortable and respectful public transport available in twin cities. It is preferred public transport among daily commuters, especially women because of less travel time, and low cost.
- ✓ The PMBS is considered as the only sustainable public transportation system in Pakistan with high capacity.
- ✓ It can handle the situation (Breakdowns & Emergencies) in real-time. Provides real-time passengers and bus information.

1.4 Problem Statement

The main goal of this research is to define the methodology to optimize the BRT operations in Pakistan. For achieving the goal, PMBS is taken as the case study. The following are some issues and problems in PMBS operations and management, that needed to mitigate for make the operations optimal:

1. A large number of buses running partially empty on part of the route, during some periods. The significant number of travelers observed on the Rawalpindi-Islamabad region & Rawalpindi-Rawalpindi region i.e. around 85% of total ridership. While Islamabad-Islamabad region comprises only 15% of overall ridership besides out of twenty-four Stations, fourteen are in Islamabad. So in most of the hours of a day, almost all links of the Islamabad-Islamabad region go partially empty or fully empty (detailed data is provided in APPENDIX A1).
2. The overcrowding in buses is observed in the Rawalpindi region and on some stations of Islamabad regions. During the year 2018, 478 complaints were received out of which 143 were directly or indirectly related to rush conditions inside the bus. For a load factor of 85% and with a bus capacity of 160 passengers, buses seem overcrowded during some hours of a day.
3. The congestion of commuters was also observed on some stations. It is observed that the passenger demand is within the Rawalpindi region remain the same throughout the day. Figure 1.3 shows the snapshot of passenger congestion in Faizabad Station,



Figure 1.3: Overcrowding in Faizabad Station during 15:33 Hours of a day

4. The waiting time of passengers on average found to be 9 minutes on Faizabad station during peak hours, which is higher as per any international standards for BRT.

5. There are many stations in Islamabad region which have very low utilization factor e.g. Katchery, Ibn-e-Sina, etc. These stations cause unnecessary delays in the BRT operations.
6. The disturbance in the schedule of buses and service irregularities are common during the day operation. While checking the schedule adherences it was found that there are many cases of late arrivals of buses on stations. For example, on December 10, 2018, 303 cases are reported for late arrivals.
7. In other parts of the world, the BRT project is mostly subsidized by the government. For a developing country like Pakistan, subsidizing a BRT project is a big financial burden and also become a popular political issue. Currently, PMBS has a 0.27 farebox recovery ratio and the Government have to provide two billion Pakistani rupees annual subsidy.
8. The average operation cost of PMBS, as per current operations, is 540 Rs. Per Km, whereas the revenue generated is about 148 Rs. Per km. There is a huge difference between operational cost and revenue collected.
9. As per international standards and ranking, PMBS comes under the BRONZE standard. The operational procedures need to be optimized to improve the standing.

The main goal for this research to optimized the operations of BRT and reduce the subsidy as far as possible using the optimum scheduling concept. Moreover, modern techniques and methodologies will be developed to cover all socio-economic factors that are affecting BRT in Pakistan so that its subsidy can be minimized.

1.5 Relevance to National Needs

Pakistan's transport sector is the fourth largest sector contributing 12% to the GDP. Due to negligence in Public Transport, the issues related to Traffic Accidents, Traffic Congestions, Waiting Time, Vehicle Operating Costs and Delays, etc. are arising day by day in Pakistan. BRTs are successfully operational in more than 100 cities of the world while in Pakistan it is introduced in recently. It is obvious that the Mass Transit always brings benefits related to CO₂ Emissions, Energy Consumptions, and contributes significantly in the overall economy of the Country. Keeping in view of such benefits of efficient Mass Transit Projects, it is need of the time to study the

operational capabilities of the BRTs so that these can be operated at their best optimal condition.

1.6 Advantages:

By raising the comfort level of the BRTs Operations and optimization of the system while keeping expenditures at its lowest level, it will bring more awareness to the users of its benefits. Such awareness shall reduce the traffic congestions on our roads, traffic accidents, waiting time of vehicles on roads, energy consumptions, VOC costs, delays, etc. because people will prefer public transport rather than using private vehicles.

1.7 Areas of Application:

This study covers many aspects of engineering, urban policymaking, economy, geopolitics, and management. From an engineering point of view, it covers areas of Traffic Engineering, Environmental Impact Assessment & Transportation Economics by considering Traffic-related problems and solutions in terms of BRTs. In terms of Urban Policymaking, it helps policymakers to provide solutions to the urbanization of the cities and growing population. Without considering the Geo-Political scenario of the country, we cannot find a better solution to the problem. Geopolitical areas cover the economy of the country as well as current political issues which may affect our recommendations therefore keeping those factors in view it is necessary to provide the best optimum and applicable solutions to the problem.

1.8 Thesis Organization

This research is organized as;

- Chapter 1: the introduction of the system, its importance, background, the need/justification of the selection of the topic & its advantages (national and its areas of application).
- Chapter 2: a brief literature review related to the topic.
- Chapter 3: Methods & Materials used related to the topics.
- Chapter 4: Data, discussions, analysis & results of the selected material.
- Chapter 5: Limitations, suggestions & recommendations of thesis work.

2. LITERATURE REVIEW

2.1 World at a glance

According to UNICEF, 70% of people around the globe will live in urban areas by 2050 (UNICEF, 2012) while today, over 4 billion people of the world, more than 50% are living in Cities (WorldBank, 2018). The speed and widening of urbanization bring tremendous challenges. United Nations initiatives for Sustainable Development Goal 11 calls for “Inclusive, Safe, Resilient and Sustainable Cities”. Among others, Green House Gas Emissions that currently representing 23% of Energy-Related emissions from Transport Sectors will lead to 33% by 2050 (World Bank, 2018) is the biggest challenge for policymakers. Moreover, the dense urban population will lead to traffic congestion and traffic congestion related problems like delays, accidents, VOC, etc.

The prevalence of public transport has been increased many folds. It was observed that in the year 2015, 243 billion public transport journeys were made in 39 countries which includes countries in the European Union, North America, Latin America, Eurasia, Asia, and Oceania, representing 2 billion populations and having half of the World’s Urban Population. It was also observed that public transportation ridership increased by 18% as compared to 2000 (UITP, 2017). This increased traffic trend is mainly due to the increased population of the world and the industrial activities made in urban cities.

2.2 Demography of Rawalpindi-Islamabad**2.2.1. Urban Growth & Public Transport in Rawalpindi-Islamabad**

Pakistan has the highest rate of Urbanization in South Asia having a growth rate of 3.06% annually in 2012 (Sawas, Feb 2014). For Punjab, almost half of the population are already urbanized. More than half of the total urban population of the country lived in 2005 in eight urban agglomerations: Karachi, Lahore, Faisalabad, Rawalpindi, Multan, Hyderabad, Gujranwala, and Peshawar (Sawas, Feb 2014, p. 10). While the population was increased annually at the rate of 2.4% from 1998 to 2017 i.e. 132 million to 2018 million, Rawalpindi gained 32.81% growth (2.1 million population in 2017 census from 1.4 million in 1988 and Islamabad 47.86%

(0.529 million to 1.01 million) during these years census (Pakistan Bureau of Statistics, 2019)).

If we ignore the effect of the conurbation, both cities show significant urban expansion. For example, the area of urban expansion of Islamabad Capital Territory has increased from 165 km² in 1972 to 252.31 km² in 2009 while the area of agricultural land/vegetation has decreased from 640.71 km² in 1972 to 561.35 km² in 2009. Thus, there is an increase of 87.31 km² (an increase of 2.36 km² per year) in the area of urban development and a decrease of 79.36 km² (a decrease of 2.14 km² per year) in the area of agricultural land/vegetation over 37 years (1972–2009) in Islamabad (Butt, Waqas, Iqbal, Muhammad & Lodhi, Jan 2011, p. 13). And the deforestation continues to the Rawalpindi area too e.g. deforestation of the Loi Bher Forest Reserves (Sawas, Feb 2014, p. 33) .

The total area of the Rawalpindi Metropolitan Area under the jurisdiction of the Rawalpindi Development Authority is 286 sqkm (70,573 Acre) (Rawalpindi Development Authority, 2019). So the population density is 7347 people/sqkm. The total area of Islamabad Urban Area including parks is 440.30 sqkm (Capital Development Authority, 2019)

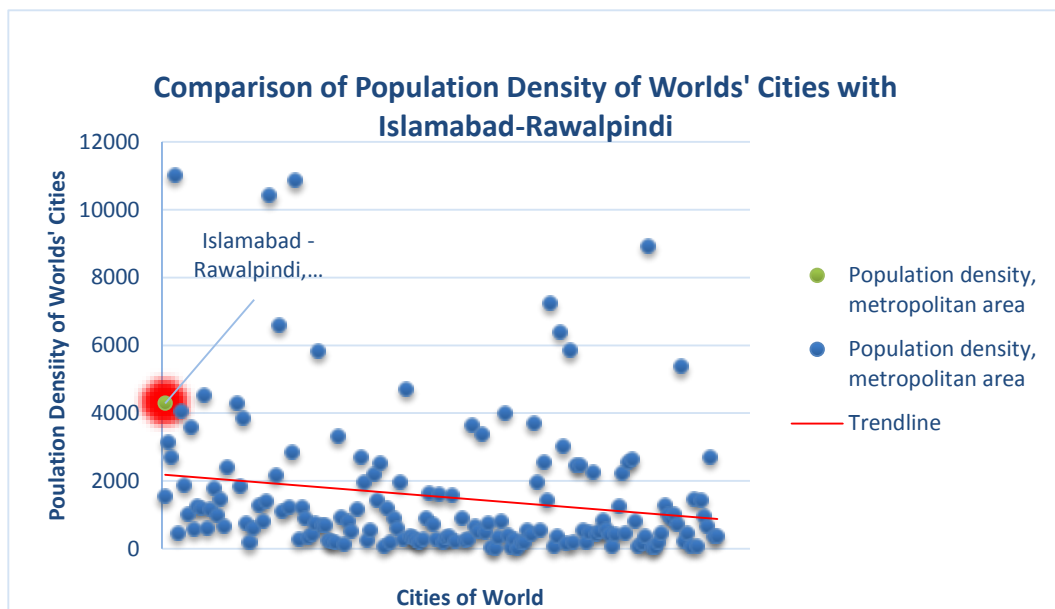


Figure 2.1: Comparison of Population Densities of Worlds' Cities of BRT with Islamabad-Rawalpindi. Source: (Global BRT, 2019)

so its population density is 2305 people/Sqkm. In combination, Islamabad-Rawalpindi population density is 4289 people/Sqkm. A comparison of population

densities of cities having BRT is shown in Figure 2.1. We can see that the population density of Islamabad-Rawalpindi is more than the majority of countries having population densities below or at the trend line.

Due to the high density of the twin-cities and low-income level of the country (The GDP per capita in PPP unit of Pakistan stood at 134th in 2018 recorded at 5714 US dollars (International Monetary Fund, 2019)), the share of public transport for daily trips of commuters are very attractive. It was estimated that 32% Home Based Work trips were shared by Public Transport. While this share is up to 50% for HBS trips in Rawalpindi-Islamabad before the operation of the BRT system in twin cities.

Table 2.1: % age of Trips by Purpose & by Mode of Transport. Source: (NESPAK, 2015, p. 59)

%age of Trips by Purpose & by Mode

Type of Trip	Walk	Motorcycle	Car	Public Transport
HBW	10%	28%	30%	32%
HBS	18%	18%	14%	50%
HBO	43%	16%	23%	18%
NHB	19%	22%	25%	34%

2.3 A Glimpse of PMBS

2.3.1. Infrastructure

The infrastructure of PMBS includes;

Roadway & Station Configurations: PMBS has no walkway of pedestrians along the corridor or bicycle lane.

Busway Configuration: PMBS is median aligned as shown in Figure 2.2 with passing lanes at stations. For busway delineation, a fence is placed at both sides of the corridor to protect the busway from the general public or vehicle crossing (Figure 2.3). These fences are movable at some points so that in case of emergency, BRT may leave the BRT corridor for the safety of passengers. However, curbs to delineation the direction of movement of a vehicle is not present in an elevated corridor of the PMBS so that in case of bus breakdown, other buses may leave the lane to cross the vehicle to avoid being blocked or otherwise, passing lanes have



been placed.

Figure 2.2: Median Aligned of PMBS Corridor



Figure 2.3: Fencing along the corridor of PMBS

Other than end terminals, PMBS consists of 4 rotaries for bus rotations. Since PMBS connects two metropolitan areas, these rotaries help to divide the route path in case of emergency or other situations. For example, security reasons on 10th Mahram of November 21st, 2018, the operation was curtailed from IJP Station to Pak Secretariat, and buses used IJP rotaries for completion of a cycle.

Station & Terminal Configurations: Stations of PMBS are center stations that are called Island Stations i.e. having vehicle doors opposite to the curb (Figure 2.4) and serve two-directional traffic. The raised floor of the stations is at the level of the floor of the buses to ensure level boarding/alighting of passengers. It is recommended in ITDP standards that the Vertical & Horizontal Level Boarding should not be greater than 4 inches (Figure 2.5). The Stations of PMBS are wide enough to accommodate passengers during peak hours. All stations have passing lanes. However, there is no Transfer Stations exist in the PMBS Corridor. To

integrate new BRT of Islamabad which is under-construction, Faiz-Ahmad-Faiz station of PMBS will be converted to Transfer Station in the near future.



Figure 2.4: Doors of Vehicle opposite to Curbs



Figure 2.5: Level Boarding of PMBS.

The Average Length of Stations of PMBS is 210 meters which include 3 docking bays (01 docking bay = 22m or 28m) each having 18 m space for docking vehicle and 4m or 10m space for passing distance (Figure 2.6). Sufficient space for passengers waiting at the platform (Figure 2.9), entry & exit points with automated turnstiles. As per BRT Planning Guide, the minimum length of the station should be 1.7 times the length of the Vehicles i.e. for 18 meters bus this is approximately 30 meters (ITDP, BRT Standards, 2016, p. 838). So PMBS stations are above the BRT



Figure 2.6: 3 Docking Bays of PMBS Stations

standard.

The average distance between stations of PMBS is 930 meters. The inter-station distances are given in Table 2.2. There are 3 docking bays in each direction so total of 6 bays for a station in PMBS Stations. So buses have 3 doors as per international standards.

Table 2.2: The Inter Distances of All Stations of PMBS

Bus Stop Name	Bus Stop Number	Inter Distance (Km)	Cumulative Distance (Km)
Saddar	1	0	0
Marrir Chowk	2	1.0255	1.0255
Liaqat Bagh	3	0.8103	1.8358
Committee Chowk	4	0.9242	2.76
Waris Khan	5	0.7359	3.4959
Chandni Chowk	6	1.1869	4.6828
Rehmanabad	7	0.7849	5.4677
6th Road	8	0.8418	6.3095
Shamsabad	9	0.8243	7.1338
Faizabad	10	1.3078	8.4416
IJP	11	1.1253	9.5669
Potohar	12	0.9151	10.482
Khyaban-e-Johar	13	1.1129	11.5949
Faiz Ahmad Faiz	14	0.8192	12.4141
Kashmir Highway	15	1.2499	13.664
Chaman	16	0.6746	14.3386
Ibn-e-Sina	17	0.7867	15.1253
Katchery	18	1.0328	16.1581
PIMS	19	0.7572	16.9153
Stock Exchange	20	1.1589	18.0742
7th Avenue	21	1.3418	19.416
Shaheed-e-Millat	22	0.7166	20.1326
Parade Ground	23	0.6678	20.8004
Pak Secretariat	24	1.6899	22.4903
Total		22.4903	

Stations have PSD Doors for boarding & alighting of passengers and both PSD doors and level boarding helps to reduce the time of the system and safety.

Saddar & Pak-Secretariat are two station terminals of PMBS. Currently, these are serving as parking of vehicles, drivers' rest areas, cleanliness of vehicles, minor

maintenance or fueling of the vehicles, route selection & instructions to drivers & schedules adjustments, etc.

All stations have passengers access & arrival facilities like stairs, elevators, escalators, pedestrians underpasses & bridges, tunnels, etc.



Elevator



Escalator



Stairs



Underpass



Pedestrian
Bridge

Figure 2.7: Passengers access & arrival facilities in stations of PMBS

Each station of PMBS consists of Ticketing Booth (Two Ticketing booths in case of bigger stations like Faizabad, 7th Avenue Stations). Ticketing booths are spacious enough to accommodate at least 4 ticketing booth operators with all facilities.



Ticketing Booth
with ways to
communicate with
passengers



PDA



Safe, drawers &
trays for cash &
token



TVM

Figure 2.8: Features of Ticketing Booths of PMBS

The components of ticketing booths of PMBS are as following;

- Glass with ways to communicate with passengers, visual, speech, and for transfer of cash & token or cards.
- Safe, drawers, and trays for cash & token.
- Ergonomic i.e. subject to climate e.g. air conditioners, heating, etc.
- Lockers for staff and other storage compartments for staff.
- Staff washrooms.
- Continuous power supply with power back-ups (Gensets & UPS).
- Proper Ventilation.
- Announcement system.
- Automated Passenger Information System at Station.
- PDAs & TVMs for ticketing services. A manual Ticketing system is also available in case the power system completely back off.

Stations of PMBS have the following components;

- Fire Extinguishers.
- Ticket validation equipment i.e. Turnstile at entry & exit points of the station.
- Proper lighting system with power backups.
- Services & Gensets areas.
- Fans & Ventilation of stations through lovers & exhaust fans.
- Emergency Exit Doors.
- Benches for waiting in-front of Ticketing Booths & PSD.
- Electric Water Coolers for the drinking of water with filter.
- Studs for guideways to disabled.
- Raised Flooring leveled with Bus floor level.
- Passenger Information Screens in real-time.
- Escalators and Elevators at all levels of the Station to ensure universal access.
- Proper Sewerage & Water Supply system.



Figure 2.9: Features of Bus Station of PMBS

There is no intersection in the BRT corridor of PMBS.

ITS Components: The ITS Components of the PMBS are as follows;

- Operating & Dispatching System includes around 450 cameras covering all features of all stations & corridor connected with the C&CC, Broadcasting announcements i.e. one announcement at one time in all stations & buses & Information system to passengers in all stations and buses in the form of screens.
- Automated Fare Collection System.
- Sliding Door System in buses and platforms.
- Clock Synchronization.
- Dispatching system.
- Software that handles the Ticketing information. In the case of PMBS, KENTKART is the software that provides real-time information about the users of the system. This software automatically displays ridership summaries, revenue collection & time-distance graphs.
- GPS & OBU system that provides real-time Bus Location System.



Video Surveillance
Wall of C&CC



Real Time Bus &
Passenger Data
Transmission Video
Wall of C&CC
(Kentkart Software)



C&CC of PMBS

Figure 2.10: C&CC of PMBS

Bicycle or Walkway: No walkway of pedestrians along the corridor or bicycle lane.

The Station Operations: PMBS has handed over all the operational services of the stations to the private companies by proper tender proceedings using PPRA rules of Pakistan. The operation of the station and services that have been handed over to private firms for maintenance includes;

- The Security of the station that ensures proper queue both at the ticketing booth and station waiting area for the safety of passengers & the safety of all amenities of the station. Security 2000 is the company that is currently responsible for the safety and security of stations.
- The cleanliness of corridor, platform, pedestrian bridges & underpasses, station fixtures, etc. RWMC is currently providing cleanliness services to PMBS.
- Surveillance System that includes around 450 cameras and features of C&CC like Video Walls, Internet facilities, maintenance of cameras & cables, etc. These services are provided by the Interactive Group of Companies to PMBS.
- The Operation & Maintenance of Buses which includes daily washing of buses, maintenance, and services of parts of buses like tyres, engines, OBU, etc. This is done by Albayrak Company.

- The Operation & Maintenance of Gensets which services are provided by SMJ.
- The Operation & Maintenance of Escalators & Elevators are being carried out by Marin Pvt Company.
- The Operation & Maintenance of PSDs are being carried out by MESSI Pvt Company.

Table 2.3: Summary of Operation & Maintenance of PMBS Stations carried out by Private/Govt. Companies

Sr. No.	Service Name	Company giving Services to PMBS
1	Security & Safety	Security 2000
2	Janitorial & Housekeeping	Rawalpindi Waste Management Company
3	Operations & Maintenance of Buses	Platform Turizm Albayrak Company
4	Surveillance System	Interactive Convergence Pvt. Ltd
5	Automated Fare Collection & Bus Scheduling System	INBOX Simplifying Technology
6	Operation & Maintenance of Gensets	SMJ
7	Operation & Maintenance of Escalators & Elevators	Merin Pvt Ltd
8	Operation & Maintenance of PSDs System	MESSI Pvt Ltd

Depot: PMBS has 14 Acre depot near its station Kashmir Highway Station. It has a capacity of 100 Articulated Buses to park at a time. The other features of PMBS Depot are as follows;

- Rigid pavement for the parking of 100 buses.

- Washing & Fueling areas.
- Water supply, sewerage system, HVAC works, Fire Fighting & Lightening.
- Administration block with Control Center.
- Rest areas for drivers.
- Guard Room.
- Depot Entry & Exit gates.
- Boundary Walls.
- Storage tanks for water (Underground & Overhead) & Fuel (Underground).
- Locker Rooms & Toilets.
- Cafeterias & Mosques.
- Store Room.
- Maintenance workshop of Buses.
- Washing plant for buses.
- Administration Office and Control Center for the staff of depot.
- The Fueling of buses

C&CC: A fully equipped C&CC of PMBS (Figure 2.10) is located at Saddar Terminal. C&CC has the following features;

- Control Room consists of work stations, video walls, fire alarm systems, fire extinguisher systems, smoke detectors, emergency exit doors, Air Conditioners to maintaining temperatures, fall sealing, etc. The Control Room of PMBS can control BRT circumstances in real-time. It has raised floor for better visibility to Video Walls.
- Offices & Meeting room.
- Toilets.
- Parking floors, two specified for general public use like Park & Ride and one for staff parking.
- Entrance & Exit points of the building.
- Kitchen.

2.3.2.Operations

Operations of PMBS has the following features;

Itinerary of every route & average travel time b/w stops: PMBS has only one corridor i.e. Saddar to Pak Secretariat connecting two cities called Twin Cities of Pakistan. This corridor consists of 24 No of stations and has been divided into different route configurations depending upon the physical facility available to the turning of vehicles e.g. the Saddar to Faizabad Route that is using IJP Rotary for turning of vehicles. The detail of each route has been given in Table 2.4.

Table 2.4: Routes of single corridor of PMBS

ROUTES	ROUTE LENGTH IN KM
ROUTE-1: SADDAR TO PAK SECRETARIAT	22.49
ROUTE-2: LIAQAT BAGH TO PAK SECRETARIAT	12.41
ROUTE-3: KASHMIR HIGHWAY TO PAK SECRETARIAT	8.83
ROUTE-4: PIMS TO SADDAR	16.91
ROUTE-5: FAIZABAD TO SADDAR BY USING IJP ROTARY	9.19

Currently, PMBS is using Route-1 with only Local Service i.e. bus starts trip from Saddar station and docks at every station and ends the trip at Pak-Secretariat and vice versa. As shown in. All other routes as mentioned in Table 2.4: Routes of single corridor of PMBS, lie within this main route of the PMBS. So this route is the maximum length route of the corridor.

Other routes mentioned in Table 2.4 are not used regularly except these routes are being used on an emergency or as a deadheading basis.

The route configuration is based on **a)** physical facility available to bus to rotate. PMBS has four (04) turning bays or rotaries at IJP, Potohar, Kashmir Highway, and Parade Ground **b)** Twin Cities are connected by Faizabad Station. For example, the Potohar turning bay or rotary is shown in Figure 2.11.



Figure 2.11: Turning Bay or Rotary of Potohar Station

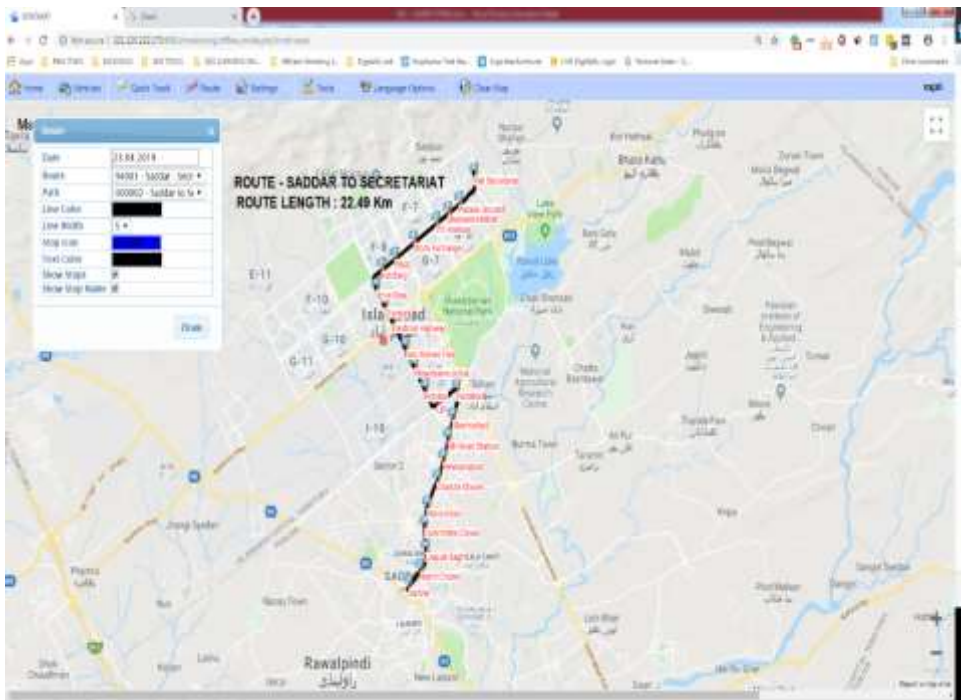


Figure 2.12: Saddar to Pak Secretariat Route of PMBS Corridor

As per demand, 18 buses are being used as deadheading for peak hours of both directions. These trips start from Liaqat Bagh (Early Returns) from 7:16 AM to 9:36 AM (Headway = 8 minutes 15 Sec) to Pak-Secretariat i.e. Route-2 of Table 2.4 to accommodate Morning Peak Hours. These trips are added to the regular (Local Service) of PMBS from Monday to Friday of a week. Similarly, PIMS to Saddar route is used for Evening Peak but in opposite direction, The other routes that are used in PMBS service are the only emergency route. For example, Route 3 & Route 5 of Table 2.4 are used when Rawalpindi is closed and Islamabad is closed respectively.

The current schedule of PMBS is given in Table 2.5. For Sat & Sun same schedule is followed but without Route 2 & Route 4.

Dwell Time of PMBS: The dwell time of the Saddar to Pak Secretariat route (having 24 Station with 2 end to end terminals) is computed as 19 minutes & 39 Seconds. The total travel time, speed & distance (average & total) can be seen in Figure 2.13 & Table 2.6. The detailed calculation of dwell time is given in section 4.1.

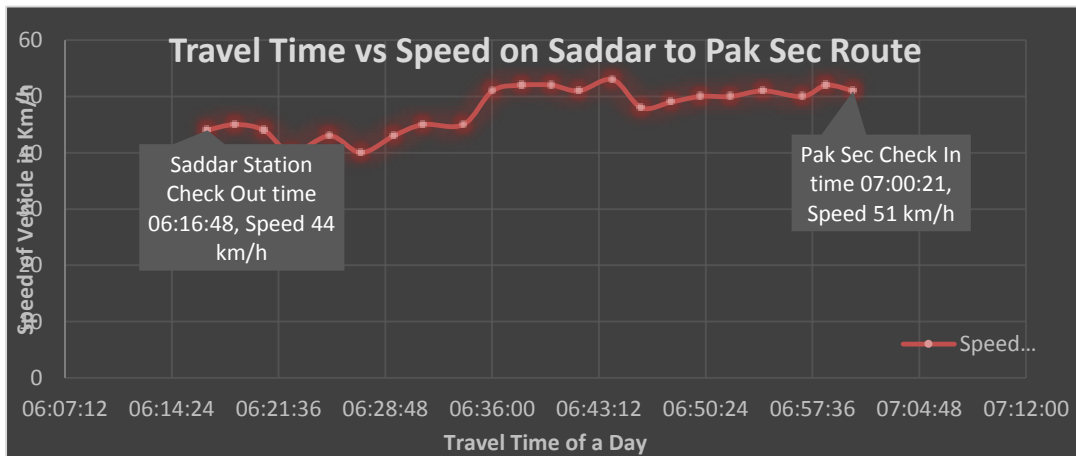


Figure 2.13: Travel Time vs Speed on Saddar to Pak Sec Route of another selected bus

Table 2.5: Current Schedule of Bus of PMBS (From Monday to Friday)

ROUTE 3- KASHMIR HIGHWAY TO PAK SECRETARIAT				ROUTE 5- SADDAR To FAIZABAD			
On Emergency Basis				On Emergency Basis			
ROUTE 1 - SADDAR TO PAK SECRETARIAT							
SADDAR TO PAK SECRETARIAT (FORWARD)				PAK SECRETARIAT TO SADDAR (BACKWARD)			
FROM	TO	HEADWAY	TRIPS	FROM	TO	HEADWAY	TRIPS
6:15:00	7:00:00	0:03:00	16	6:15:00	6:57:00	0:03:30	13
7:02:45	7:57:45	0:02:45	21	7:00:30	8:00:00	0:02:50	22
8:00:30	8:58:15	0:02:45	22	8:02:50	8:59:30	0:02:50	21
9:01:00	9:58:45	0:02:45	22	9:02:20	9:59:00	0:02:50	21
10:01:30	10:58:10	0:02:50	21	10:01:50	10:58:30	0:02:50	21
11:01:00	11:57:40	0:02:50	21	11:01:20	11:59:05	0:02:45	22
12:00:30	13:00:00	0:02:50	22	12:01:50	12:59:35	0:02:45	22
13:02:45	13:57:45	0:02:45	21	13:02:20	13:57:20	0:02:45	21
14:00:30	14:58:15	0:02:45	22	14:00:05	14:57:50	0:02:45	22
15:01:00	15:58:45	0:02:45	22	15:00:35	15:58:20	0:02:45	22
16:01:30	16:59:15	0:02:45	22	16:01:05	16:58:50	0:02:45	22
17:02:00	17:58:00	0:02:40	22	17:01:35	17:59:20	0:02:45	22
18:00:40	18:58:45	0:03:25	18	18:02:05	18:58:55	0:02:35	23
19:02:10	19:58:10	0:04:00	15	19:01:30	19:57:30	0:03:30	17
20:02:10	20:57:10	0:05:00	12	20:01:00	20:59:30	0:04:30	14
21:02:10	21:56:10	0:06:00	10	21:04:00	21:59:00	0:05:30	11
ROUTE 2- LIAQAT BAGH TO PAK SECRETARIAT				ROUTE 4- PIMS TO SADDAR			
FROM	TO	HEADWAY	TRIPS	FROM	TO	HEADWAY	TRIPS
7:16:00	9:36:15	0:08:15	18	15:20:00	17:40:15	0:08:15	18

Table 2.6: The distance, Travel Time (excluding Dwell Time) & Speed of a selected bus

Sr. No.	Station Name	Distance b/w Stations (Kilometers)	Travel Time (mm:ss)	Cumulative Time (mm:ss)	Speed (Km/h)
1	Saddar	0	00:00	00:00	0
2	Marir	1.0255	00:59	00:59	44
3	Liaqat Bagh	0.8103	00:58	01:57	45
4	Committee Chowk	0.9242	01:08	03:05	44
5	Waris Khan	0.7359	00:59	04:04	40
6	Chandni Chowk	1.1869	01:34	05:38	43
7	Rehmanabad	0.7849	01:05	06:43	40
8	6th Road	0.8418	01:59	08:42	43
9	Shamsabad	0.8243	00:59	09:41	45
10	Faizabad	1.3078	01:39	11:20	45
11	IJP	1.1253	01:13	12:33	51
12	Potohar	0.9151	01:01	13:34	52
13	Khyaban-e-Johar	1.1129	01:05	14:39	52
14	Faiz Ahmad Faiz	0.8192	00:56	15:35	51
15	Kashmir Highway	1.2499	01:39	17:14	53
16	Chaman	0.6746	00:57	18:11	48
17	Ibne Sina	0.7867	00:52	19:03	49
18	Katchery	1.0328	01:00	20:03	50
19	PIMS	0.7572	01:00	21:03	50
20	Stock Exchange	1.1589	01:19	22:22	51
21	7th Avenue	1.3418	01:43	24:05	50

Sr. No.	Station Name	Distance b/w Stations (Kilometers)	Travel Time (mm:ss)	Cumulative Time (mm:ss)	Speed (Km/h)
22	Shaheed e Millat	0.7166	00:46	24:51	52
23	Parade Ground	0.6678	00:51	25:42	51
24	Pak Secretariat	1.6899	03:04	28:46	50
	Total Distance	22.4903	28:46		
		Total Docking Time or Dwell Time	19:39	Average Speed	27.6
		Total Travel Time	48:25		

The number of customers boarding & alighting at each stop: PMBS has been operational since the 4th of June 2015. The average annual daily Boarding & Alighting detail of the years 2016 to 2018 is 109,363 passengers per day. The boarding & alighting pattern of the PMBS stations shows that the 1st (Jan-Apr) & 3rd (Sept-Dec) quarters have maximum ridership while the 2nd (May-Aug) quarter shows the least ridership due summer vacations & Ramzan month. Furthermore, during the data analysis of the year 2018, it was revealed that January 2018 is the busiest month among all the months of this year. Weekly data analysis shows that the travel pattern of working-days & weekends is different. Hourly analysis shows three peaks (Morning, Noon & Evening) during working-days (Monday-Friday) and only on peak (Evening) during weekends (Saturday & Sunday).

It is also revealed that there exist different travel patterns for different regional configurations i.e. Rawalpindi-Rawalpindi, Islamabad-Islamabad & Rawalpindi-Islamabad. The %age share of ridership is more for Rawalpindi-Islamabad & Rawalpindi-Rawalpindi regions (i.e. more than 80% of total ridership).

The Saturation Level of PMBS Station: The Congestion Level of the station can be calculated using the Saturation Level. The saturation level of the busiest station of the PMBS (Faizabad Station) during peak hours is 53.18 % against the recommended value of 40 % (ITDP Planning Guide, 2016, p. 169) and beyond this value, significant queues of vehicles at the station may be possible

Trunk & Feeder Services: PMBS is “Trunk-Only” services. A 22.4 km BRT Corridor is operational in two cities of Pakistan without “mixed traffic” parallel to the existing corridor of general traffic. Unlike the main countries where “Trunk & Feeder Services” run successfully, PMBS has planned for Feeder Services to integrate with Trunk Services in the future.

Local, Limited & Express Services: PMBS is a single corridor with few rotaries for turning of vehicles and passing lanes at every stops. Passing lanes at stops allow more services to operate. As with PMBS which operates only, Local Service may allow Limited & Express services too.

The provision of passing lane can also be fulfilled by allowing BRT Vehicles to enter with Mixed Traffic lanes where passing lanes are not present like Select Bus Service of New York. But for PMBS there is no need to enter BRT Vehicles to enter in mixed traffic lane because of passing lanes present in all stations.

In PMBS except for Limited or Express service, Early Return & Deadheading are used. For example, in the morning peak i.e. from 7:15 AM to 9:30 AM 18 buses at 8 minutes’ headway are departed from Waris Khan Station by skipping all 4 stations because of high demand. Similarly, during evening peak i.e. 15:15 hours to 17:45 hours first 5 stations are skipped to dock directly from PIMS station because of high demand from other directions. These types of services are called as Early Return & Deadheading service (detail discussed).

The output of this study shows that the PMBS can operate the Limited & Express route along its corridor.

Load, Critical Link, Maximum Hourly Load on Critical Link (MaxLoad), Passengers per Hour Per Direction (PPHPD) & Load Factor: The corridor capacity of PMBS is 24,480 PPHPD (Punjab Masstransit Authority, 2019). The critical link of PMBS is Faizabad to Saddar link that comprising approximately 2% of 24 x 24 OD matrix of all stations of PMBS. The max load of this critical link is 3,672 PPHPD during peak hours for a load factor of 85%.

It may be noted that the saturation level of Critical Link (Faizabad to Saddar Segment) is 53.18 %. While the MaxLoad is far less than the capacity of the station.

It indicates that a smaller modification is required to reduce the saturation level of the station.

Renovation Factor of the Critical Link: Renovation Factor for the critical link of Faizabad-Saddar 2.17 which means this route 2.17 more profitable than passengers travel from end to end terminal.

Irregularity Index (Irr.): The Irr. The value of PMBS is very low i.e. 0.101708. This is because PMBS has imposed administrative check that bus must dock at the station not less than 15 secs and more than 30 % of the headway which usually comes out to be 30 sec. It is therefore, the calculation of waiting time & cost of waiting time comes out to be very less than expected as due to long queues which may lead to 9 minutes' passenger wait during peak hours in critical link should be more than calculated.

MaxLoadPerCycle: MaxLoadPerCycle of Critical Link is 2576.86 passengers.

Waiting Time & Waiting Time Cost: Waiting Time of passengers in the critical link is 1.212 minutes and the cost of waiting time is 1,720,800 PKR per Year (based on the minimum wage rate in Pakistan).

2.3 Research work carried out by other researchers

M. Imran Majeed, et al. have identified optimum routes to provide multimodal integration for rapid access for commuters with existing BRT of Islamabad-Rawalpindi. They highlighted the major congestion issues in the city, found the existing routes inadequate and inefficient, and do not have sufficient busses. They have designed the Feeder Routes for the BRT to operate at the Optimum level (H Jabbar, 2016).

Adeel et al conducted the study to understand the equilibrium among the transport services providers. The level of Constraints showed by newly constructed BRT and existing paratransit modes like Qinqu, Suzuki, and Wagons were highlighted in the study. They have suggested mitigation measures to reduce constraints by considering a proactive approach by management authorities, integration of modes, improvement of quality of services, facility improvements for women and non-motorized travelers, and condition of vehicles (M Adeel, Towards an Inclusive Public Transport in Pakistan, 2016).

Adeel et al., highlighted the need for Public Transport in GIRA (Greater Islamabad Rawalpindi Area). They mentioned that in December 2013, out of 88 routes available for GIRA only 36 (41%) were active. Moreover, they concluded that most of the fleet was old, the service for women was poor and the Level of Services in Rawalpindi was C, D, or E along the main roads. While giving the idea of the affordability of the people, they strongly recommended the need for BRT for the twin city (M Adeel, International Conference on Town Planning and Urban Management , 2014).

A very comprehensive study that critically overviewed the Public Transport in Pakistan was done by Muhammad Imran from Massey University, New Zealand. He had compared the condition of traffic with India and also discussed the history of Public Transport planning and policies in Pakistan both in pre and post-independence eras. He observed in Indian, due to the presence of Mass Transit Public Transport, people use more Public Transport than Private Vehicles in contrast to Pakistan. He concluded with the complete failure of the capacity of public transport in Pakistan and have suggested the need for BRT in Pakistan (Imran, 2009).

The need for BRT being a Mega Project in the city of Rawalpindi was strongly discouraged by Humera Bibi et al., As an output of their surveys, they concluded that due to Economic and Socio-Economic Crises, mega projects such as BRT are not economically feasible for people of the city. The BRT like projects should not be the preference for the policy makers, based upon economic burden. They suggested that people of Rawalpindi are already using Public Transport and any further enhancement in Public Transport is not the priority of the people (Humera Bibi, 2015).

2.4 Research Gap

This research is about the optimization of the operation of BRT in Pakistan using a case study of PMBS. ITDP has provided detailed guidelines to understand the Operational & Structural parameters of any BRT of the world. Based on these guidelines it provides the Standards of BRT to formulate a system that will help new users to implement world-class BRT. Since its operation in Pakistan, no study is carried out to study its Operational & Structural parameters. However, some researchers like (A.R.Khan, 2017) give the Bronze category to PMBS, and as has

already mentioned some researchers have provided the transport demand and public transport condition of the Rawalpindi-Islamabad cities.

3. RESEARCH METHODOLOGY

The systematic tasks and overall methodology is shown in. The tasks are divided broadly into four main parts; Data Collection, Data Analysis, Operations & Decisions to optimized BRT, and Conclusions & Recommendations. In the end, the overall optimization of the system is summarized.

3.1. Data Collection

The collection of data for research work has two important features;

a. What are the bases upon which data is collected?

To carry out the research work, it was very necessary to understand the overall important features of the system. Institute for Transportation and Development (ITDP) has provided the stepwise guidelines to identify the system features. ITDP's "The BRT Planning Guide" was published in the year 2016 and available on its official web site <https://www.itdp.org/>. This guide consists of eight volumes covering all aspects of BRT (Starting from Volume I: Project Preparation to Volume VII: Integration and Volume VIII: summarized the guiding goal and objectives). To carry out this study, Volume II: Operation & Volume VI: Infrastructure has been studied thoroughly. Figure 3.2 shows the methodology adopted for systems understandings & collection of data.

The BRT Standards is the other source which is used as the base for data collection. PMBS was considered as BRONZE standard BRT Service. The re-evaluation of the standard level of BRT operations was done in this research. It was found that after changes in standard criteria and already implemented some improvements during the last few years, PMBS now lied in the SILVER category. Furthermore, the number of improvements is highlighted in the recommendations section to enhance the level to gold class in the future.

The ITDP guidelines helps to perform data analysis by the collection of data for:

- I. Buses
- II. BRT Corridor

III. Bus Stations

IV. Speed & Distances

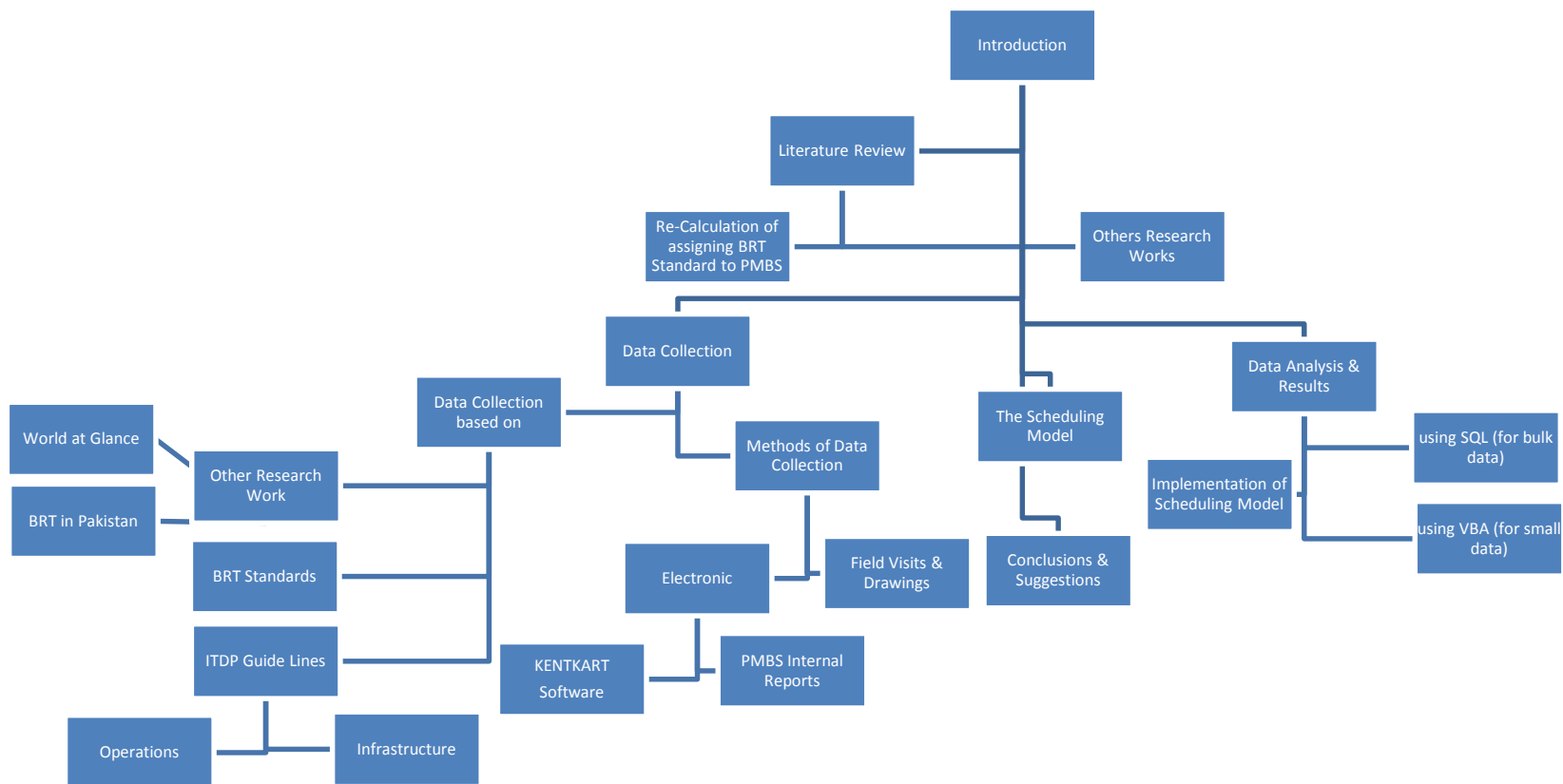


Figure 3.1: Methodology adopted to carry out research work.

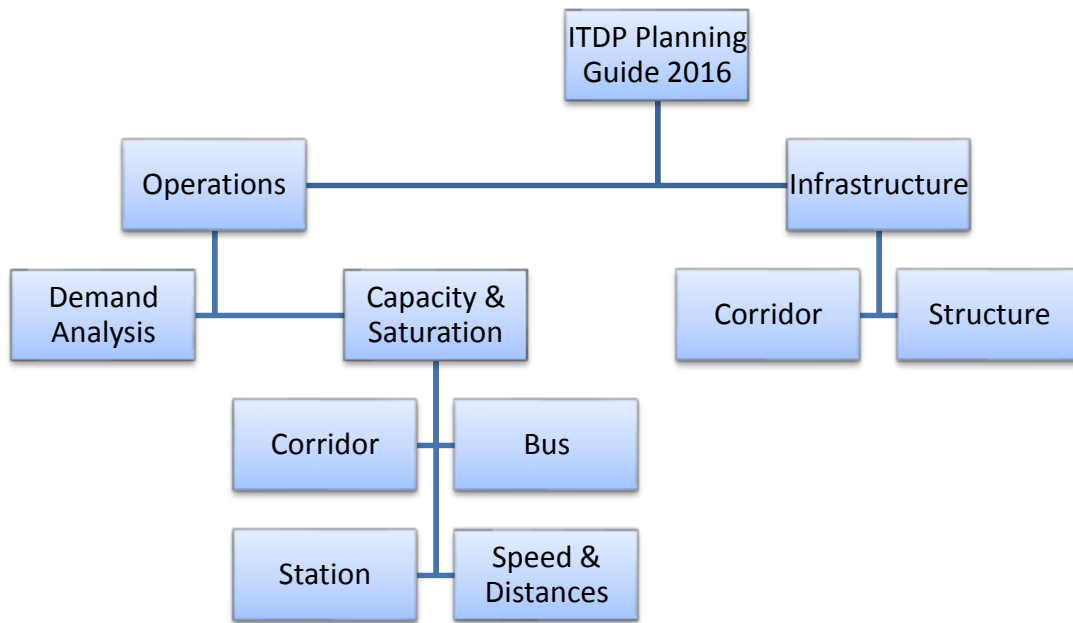


Figure 3.2: Research Methodology (ITDP Planning Guide 2016)

b. Data Collection Methodology

Besides other sources of data, the operational software of PMBS KENTKART is the main source of electronic data. Since the launch, PMBS has accommodated around 160 Million Passengers' and whole data was collected through an automated fare collection system. Detail information about the passenger both having a token or card have stores in the software and can be retrieved easily. The sample output reports that can be generated using the software are provided in APPENDIX A1.

KENTKART is the automated fare collection and vehicle position system software. It provides real-time and offline data. The system automatically generated the passengers (Token & Card) information when he/she enters the entry or exit turnstile as shown in Figure 3.3. While the buses transmit data to software using the Bus OBU device installed in every bus of PMBS

The output of the data of the KENKART system software provides information related to passenger boarding and alighting (see APPENDIX A3). To analyze this data different reports have been generated by the PMBS operational team to run the bus operations such as schedule adherence etc. These reports are used as a secondary source of data for this research work.



Figure 3.3: Entry/Exit turnstiles

Other than this data, the information is gathered through field surveys, BRT drawings, and options/complaints recorded by the general public on helpline. The comparison of the essential features of PMBS with the BRT Standard guide was also made.

3.2. Data Analysis

To understand the passenger's behavior at stations, analysis of the data is required. All the information about the riders are available in the form of electronic data. The data size is huge and need appropriate software or program to handle the analysis. For this Visual Basic for Applications (VBA) of Microsoft Excel is used for short and quick analysis. Whereas for bulk data is dealt with Structured Query Language (SQL).

a. Visual Basic for Application (VBA).

VBA is an application of excel use for quick programming of data to develop the macros of excel. To understand the travel behavior, a program is coded in excel, which provides the Origin and Destination (OD) matrix from the passenger information database. The snapshot of the program shows in Figure 3.4.

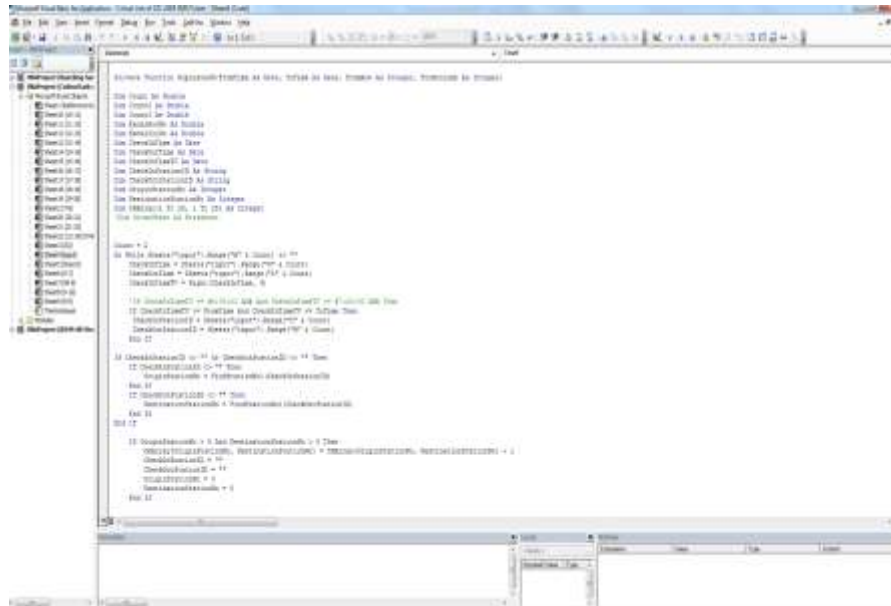


Figure 3.4: A Program in VBA of Excel

The output of this program results in an OD matrix, as shown in Table 3.1. This coded program can be used to develop an OD matrix for any day or an hour, by inserting the values in the User Input box.

b. Structured Query Language (SQL).

The huge database is gathered from the operations of PMBS. As already mentioned, 160 million passenger's data are available up to the year 2018 since its start of operations. VBA is not suited to handle such type of bulk data. Therefore, the SQL language is used for this purpose. The SQL is itself is not a programming language but it helps in framing a procedural measure to form mature programming. The SQL can handle the bulk of data with more efficiency and generates output in seconds. For example, for a program for an example of VBA, SQL generates output for the same results in 2

seconds while VBA took 2 minutes to show results. Figure 3.5 shows a screenshot of the program in SQL software.

3.3. The Scheduling Model

The data collected from KENTKART is analyzed using various software as described in the previous section. It is very necessary to have some model that helps

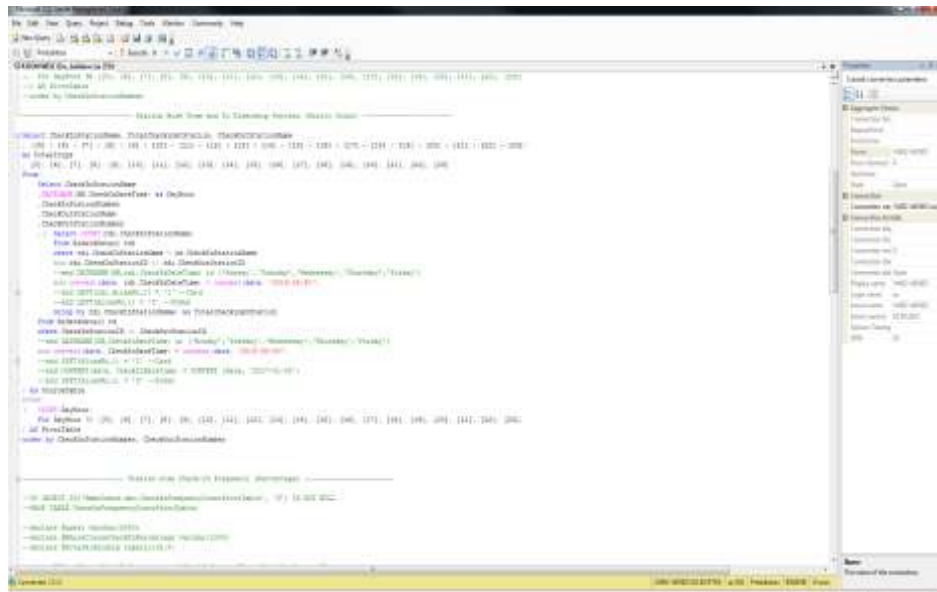


Figure 3.5: Screenshot of Program in SQL for Bulk Data

in scheduling the system bus operations. A model is formulated for easement of procedure of analyzing data that leads to scheduling of operations. The model consists of 8 steps, as shown in Figure 3.6. The step-wise implementation of this model is given in the next chapter.

Table 3.1: An OD formed after running Program in VBA

Station Name	21:00:00 to 22:00:00																								Σ=4102		
	SAD	MAR	LIB	CMC	WKR	CHN	REH	6RD	SHM	FAZ	IJP	POT	KHJ	FAF	KSH	CHH	IBN	KAT	PIM	STE	7AV	SHM	PRG	PKS		1471	
SAD	12	6	15	44	27	47	41	56	56	93	19	25	7	2	10	29	21	10	19	22	12	9	5	9		596	
MAR	1	9	0	9	8	9	13	9	7	22	5	0	0	0	2	1	4	2	5	3	6	0	0	4	0	119	
LIB	22	4	10	3	2	7	18	18	13	34	4	4	0	0	11	4	3	1	2	1	3	2	1	2		169	
CMC	35	9	0	12	4	10	25	45	42	53	6	7	3	0	5	10	8	4	4	12	7	2	1	3		307	
WKR	35	8	10	3	12	1	4	13	19	27	1	1	0	0	0	7	0	1	1	3	2	1	2	0		151	
CHN	43	14	9	15	7	11	0	3	8	22	4	3	4	1	5	7	3	1	0	3	4	2	0	2		171	
REH	63	14	9	26	8	2	11	3	12	25	4	2	4	3	2	20	6	4	2	6	5	7	2	3		243	
6RD	28	13	14	30	10	5	1	5	6	28	4	12	3	5	7	14	5	5	7	12	6	3	0	0		223	
SHM	37	3	4	20	17	8	1	7	9	12	1	3	1	0	0	4	2	5	6	4	1	0	2	5		152	
FAZ	83	30	15	30	17	20	20	28	19	26	4	9	4	0	10	21	10	5	17	14	8	8	4	6		408	
IJP	7	1	2	3	0	2	2	3	4	2	12	1	1	1	4	4	2	2	9	4	4	5	2	3		80	
POT	13	4	4	6	3	4	3	9	5	1	1	11	0	0	1	2	1	2	9	3	3	0	1	0		86	
KHJ	3	3	2	4	1	0	0	2	3	4	2	0	9	0	1	2	0	1	4	1	0	1	0	1		44	
FAF	3	2	1	0	0	1	0	1	5	4	1	0	0	10	0	0	0	0	0	0	1	1	0	0		30	
KSH	3	4	2	5	1	1	7	7	4	15	12	5	0	0	26	0	0	2	5	1	2	1	2	2		107	
CHH	28	8	7	10	6	6	7	10	16	9	10	5	0	1	0	9	0	0	0	2	6	7	0	1		148	
IBN	13	7	1	3	4	1	2	2	8	8	4	0	0	1	0	0	7	0	0	0	1	4	0	3		69	
KAT	7	3	4	7	2	0	1	4	7	2	8	6	3	1	0	2	0	3	0	1	0	1	2	1		65	
PIM	46	19	4	25	5	10	17	29	28	17	14	15	1	0	5	3	0	1	12	0	5	0	7	1		264	
STE	27	9	5	12	8	7	13	21	14	20	25	18	1	2	2	9	2	3	0	8	1	4	2	3		216	
7AV	14	4	7	9	8	5	7	11	9	9	9	14	1	1	0	1	1	1	0	0	35	1	1	2		150	
SHM	17	8	5	7	7	5	11	6	8	4	7	11	0	1	2	2	0	4	1	1	0	4	0	1		112	
PRG	9	7	3	4	8	9	5	3	11	2	13	3	0	0	0	1	2	2	1	2	1	0	4	0		90	
PKS	10	6	4	4	2	4	8	4	9	17	5	5	1	0	2	4	1	1	3	2	3	0	0	7		102	
UNKNOWN																											0
Σ=4102	559	195	137	291	167	175	217	299	322	456	175	160	43	29	95	156	78	60	107	105	116	63	38	59	0	4102	

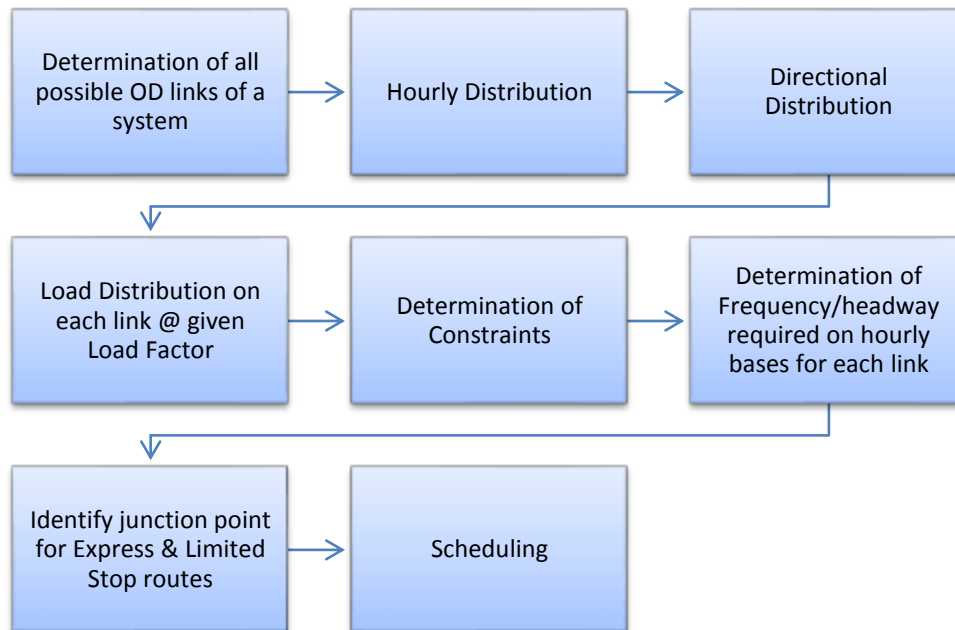


Figure 3.6: 8-Steps Model for Scheduling of Bus Operation

3.4. Decisions

By following the guidelines given in ITDP standards, the operational and infrastructural features are converted into tabular forms. Based on the understandings of the system, some important decisions are made. Data analysis of the following features is given in the next chapter.

- Demand Analysis
- Understanding corridor & structure
- Capacity & Saturation of stations & corridor
 - Renovation factor & Irregularity index
 - Speed & Distances of stations
 - Service need & Headways
 - Loads & Critical Links

Demand Analysis: Demands of each station have been calculated in terms of boarding & alighting in each station using VBA & SQL. The schematic diagram of the Demand Analysis is given in Figure 3.7. After collection of data of years of operations of PMBS, Year 2018 is selected for further analysis based upon the

comprehensiveness of the database and representing the true picture for other years also. The quarterly, monthly, weekly & hourly variations in boarding & alighting are collected for each station during the year 2018 are collected and analyzed.

Understanding Corridor & Structure: The other vital feature needed to be analyzed is the corridor. The understanding of corridor & structure includes determining corridor capacity, the saturation level of the station, determination of Critical Link, Peak Hours for links of a different route, bus & bus capacity, load factor, maximum hourly load of critical link of corridor, number of physical facilities for turning of vehicles, service frequency, irregularity index, renovation factor of station, etc. These different parameters help to understand the corridor & structure together which helps in the decision making of optimization. Figure 3.9 shows how to understand corridor & structure by determining parameters associated with the corridor & structure of a BRT System. For example, by determining the Design Capacity of PMBS, it is obtained that the Corridor Capacity of PMBS is 24,480 Passengers per hour per direction. Similarly, more than 40% saturation level of a station of PMBS during Peak Hour is calculated.

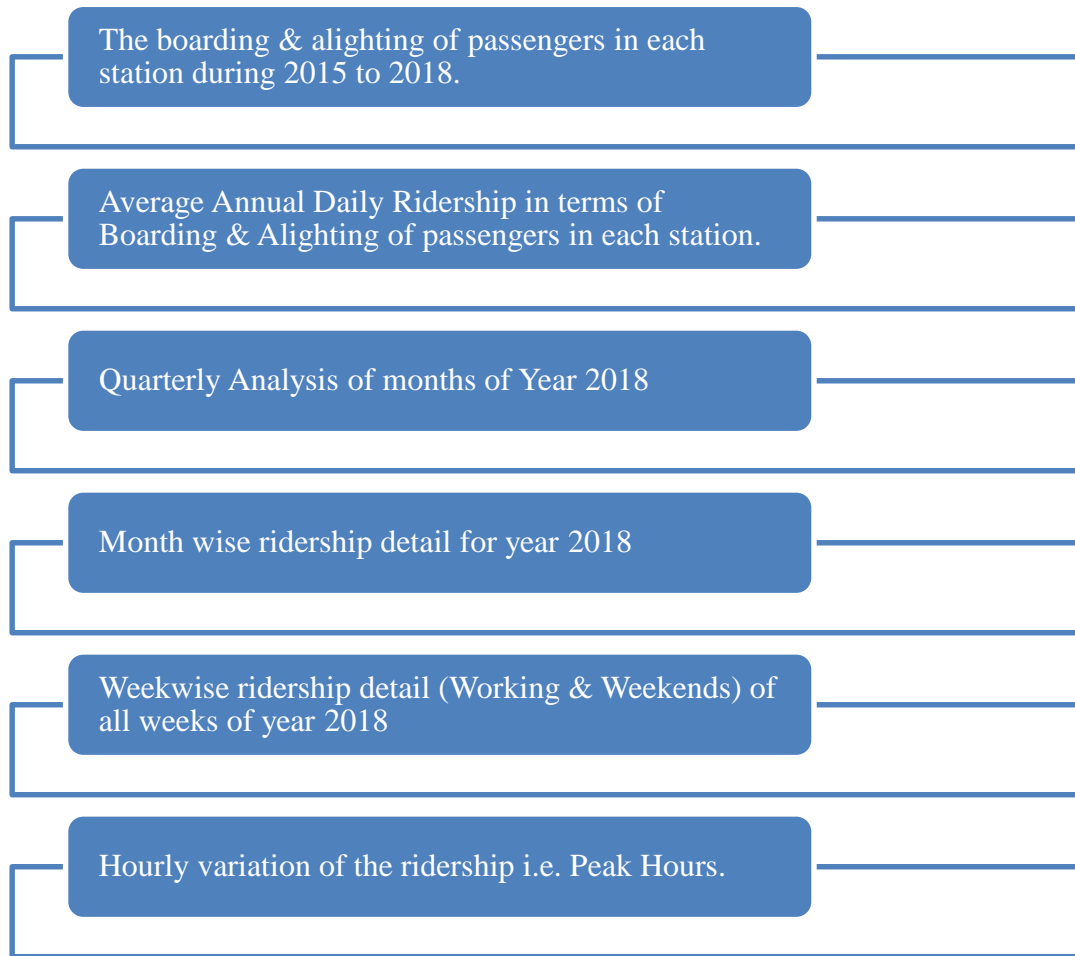


Figure 3.7: Sequence of data collection for data analysis.

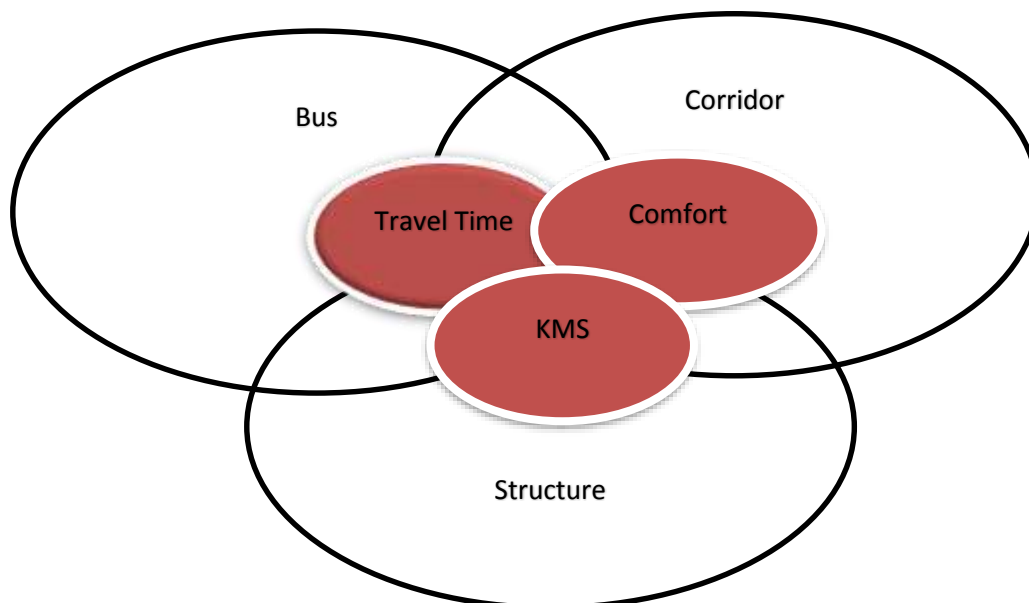


Figure 3.8: Overall Optimization of the BRT System

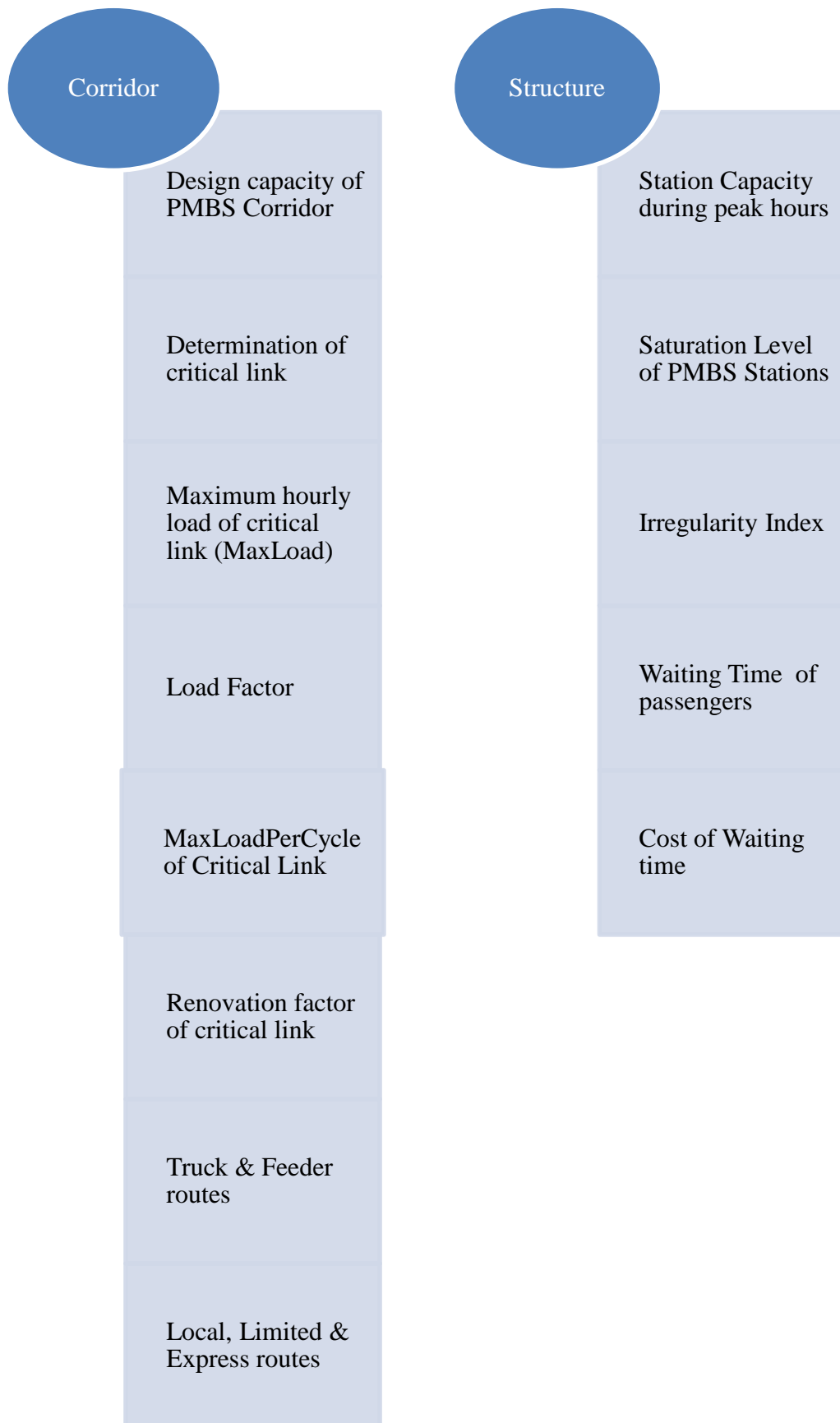


Figure 3.9: Understanding Corridor & Structure

3.5. Overall Optimization Summary

The schematic diagram of the overall optimization is shown in Figure 3.8. To optimize a BRT system its mean we are optimizing three interlinked parameters i.e. Travel Time, Comfort level of passengers, and KMs of bus travel. The comfort level is estimated based upon the load factor. Whereas distances in KMs of Bus is the number of KMs of bus travel for a given demand (may represent in the form of passengers-KMs by multiplying the number of passengers for a trip with route distance). The relationship between the Comfort Level and the number of KMs associated with the number of passengers traveled on a trip is directly proportional. If the comfort level increases, it means a greater number of trips are required to complete the same demand so more number of KMs of bus trips are required. Therefore, comfort level is directly related to cost. More the comfort level more will be the per KM operational cost of the BRT system.

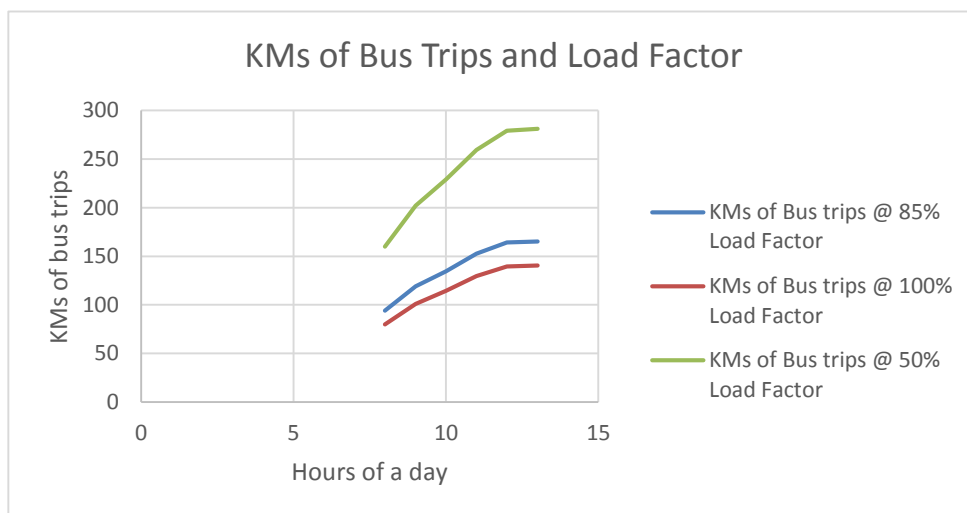


Figure 3.10: Relationship of KMs of Bus Trips and Load Factor

BRT project can benefit the passengers in terms of Travel Time. It is observed that the express and limited stops routes save travel time for a given load factor.

BRT system comprises of Bus, Structure & Corridor. These three elements are interconnected and show many features closely merging each other's. For example, the formula of calculating the saturation level of station (structure) shows it depends on the number of buses running through the corridor (corridor may have some capacity), and the number of passengers boarding & alighting and their time of boarding and alighting.

4. DATA ANALYSIS & RESULTS

4.1. Re-Evaluation of PMBS as BRT Standard

Globally Pakistan Metro Bus System (PMBS) is known as “Bronze” Standard Rawalpindi-Islamabad Metro Bus (ITDP, 2019) while securing 64 points out of 100 total points. Previously, researchers evaluated PMBS as Bronze Standard while following the BRT Standards. However, ITDP has evaluated the score of PMBS based on 2013 data. But PMBS was operational to public use on 4th June 2015, in 2013 PMBS infrastructure was under-construction phase & BRT Standards were revised by ITDP in 2016. Therefore, many progress were ignored so this research work has re-evaluated PMBS and has found progress as per standards enlisted by the Institute for Transportation & Development Policies (ITDP). Such improvements need to familiarize themselves with the world because for Rawalpindi-Islamabad, PMBS will work as a gateway for revolution in public transport for twin cities.

Institute for Transportation & Development Policies (ITDP) forms standards for BRT Systems around the world. These standards function as a planning tool and scoring system for policymakers to achieve the common definition of BRTs (ITDP, BRT Standards, 2016). It helps the operating agencies to work inefficient way to deliver world-class public transport with significant economic benefits keeping in view the safety and positive environmental impacts.

BRT Standards of 2016 put more focus on safety and operations as a key factor in operations of BRTs and have reduced the Passing Lanes at Stations number by 1 to 3 and increased Pedestrian Access and Safety from 3 to 4. While before 2016, Pedestrian Access and Safety was named as Pedestrian Access see Table 4.1. ITDP has scored 53 BRTs around the world in 2014 based on 2013 data. The overall scoring system of BRTs give certification as Gold, Silver or Bronze and Basic BRT to a BRT System

Pakistan Metro Bus System, a BRT system is operating in twin cities of Pakistan. For an estimated population of 4.6 Million in 2014, Total daily trips were estimated as 2.9 Million excluding walk trips (Feasibility Study PMBS, 2013). The Score

Board using all characteristics of BRT for PMBS is given in **Table 4.1**. It can be seen that re-evaluation has categorized PMBS as “**SILVER**” Standard BRT. The pointwise discussion is detailed in the below-given paragraphs.

I. Basic BRT

To be considered as BRT, minimum requirements are;

- Corridor must have a minimum of 3 km dedicated lanes.
- Score 4 or more in dedicated ROW and busway alignment elements.
- Score 20 or more from a total of BRT Basic elements.

PMBS has scored 38 out of 38 in this section of standards as the detail is given in the below paragraphs.

a) Dedicated ROW (8 Points Max)

By definition, a minimum length of 3km has dedicated bus lanes served by the bus route or multiple bus routes for a BRT corridor. Out of a maximum of 8 marks, a system must gain at least 4 to be called BRT. PMBS has 100 % physically separated, dedicated lanes therefore managed to gain 8 out of 8 marks in this element.

b) Busway Alignment (8 Points Max)

Giving different configurations, this section holds a maximum of 8 marks out of which a minimum of 4 must be achieved to be defined as BRT. PMBS has managed to gain 8 in this element because of a 100% two-way median-aligned busway in the central verge of two-way road (Figure 2.2).

c) Off-Board Fare Collection (8 Points Max)

With 100% barrier-controlled i.e. Turnstile, PMBS has managed to get 8 at this section of the score (Figure 2.8).

d) Intersection Treatments (7 Points Max)

Scores at this element are weighted by the percentage of turns prohibited or intersections with signal priority along the corridor. Since PMBS has not any Intersection so all priority is given to the buses of BRT. So PMBS has managed to score 7 in this element.

e) Platform-Level Boarding (7 Points Max)

Platform-Level Boarding covers two types of gaps Vertical Gaps & Horizontal Gaps. Vertical Gaps mean the difference in height between bus floors and station platforms and Horizontal Gaps mean the distance between the bus and the platform. Both of these gaps accommodate maximum safety to the passengers during alighting and boarding.

ITDP recommends 4 centimeter or less vertical gaps and notes measures to reduce the horizontal gaps i.e. less than 10 cm. Buses with an average vertical distance greater than 4 cm or having steps inside will not qualify as BRTs Platform Level. In the scoring system, the percentage of buses operating on the corridor and the percentage of stations on the corridor is multiplied by the Vertical Gaps limits and measures to reduce Horizontal Gaps respectively.

ITDP has given in 2014 scoring board 4 marks to the PMBS. But, with my field surveys, it was observed that not a single station has a greater than 4 cm vertical gap. Similarly, there are several techniques in which PMBS authority is being used to reduce docking gaps like guided busways at stations, alignment markers, and enforcement policies. Therefore, from this point of view, PMBS has maintained 7 scores out of 7.

II. Service Planning

a) Multiple Routes (4 Points Max)

If there are no multiple routes, zero score shall be given to the system. To ensure BRT is operating at its maximum utility but not beyond its saturation level, ITDP gives importance that the BRT corridor should be used for multi-routes. Therefore, 4 marks shall be given to a system with two or more routes that exist on the corridor while serving at least two stations.

PMBS has scored zero marks in this element because there is no other route is operating on the corridor. My objective of this study is to provide route optimization if Islamabad Metrobus is started next year.

b) Express, Limited-Stop, and Local Services (3 Points Max)

To reduce travel time and operating speed, one of the best ways is the provision of express routes and limited-stops. Local services use every station but express routes cover high demand stops by skipping in-between stops.

PMBS has scored zero marks in this element because there is no express route or another route is operating on the corridor. This research work provides express routes based on the history of demand. So if the suggestions of this works will implement to PMBS, it can manage to get 3 points in this element.

c) Control Center (3 Points Max)

Control Center is an important feature of the BRT System. Due to its prevalence in the system, ITDP has given 3 points in standardization of the system. To gain 3 marks, a full-service Control Center should have the following features;

- Automated Dispatch System i.e. based on demand, helps to generated dispatch plans automatically. PMBS doesn't have any such system.
- Active Bus Control System i.e. a fully bus control system should have the system determine the maintenance status of the fleet, record passenger's boarding and alighting's, etc.
- Automatic Vehicle Location (AVL) helps in GPS to respond to incidents in real-time, control of spacing of buses, and tracking and performance monitoring of buses (Figure 2.10).

PMBS has managed to gain 2 out of 3 because of the absence of an Automatic Dispatch System. My area of study will help to form automatic dispatch plans.

Table 4.1: Comparison of BRT Standard Score Board for 2018 PMBS data with ITDP Score based on 2013 BRT Data of PMBS

<u>Scores using 2014 version of BRT Standard Using 2013 BRT Data Published by ITDP</u>				<u>Scores using 2016 BRT Standards</u>			
Descriptions of BRT Points		Country City	Pakistan Islamabad-Pindi	Descriptions of BRT Points		Country City	Pakistan Islamabad-Pindi
BRT Basics - Minimum score of 20 points needed		38	35	BRT Basics - Minimum score of 20 points needed		38	38
Dedicated right-of-way - Minimum 4 points	Score	8	8	Dedicated right-of-way - Minimum 4 points	Score	8	8
Busway alignment - Minimum 4 points	Score	8	8	Busway alignment - Minimum 4 points	Score	8	8
Off-board fare collection	Score	8	8	Off-board fare collection	Score	8	8
Intersection treatments	Score	7	7	Intersection treatments	Score	7	7
Platform-level boarding	Score	7	4	Platform-level boarding	Score	7	7
Service Planning		19	8	Service Planning		19	9
Multiple routes	Score	4	0	Multiple routes	Score	4	0
Express, limited, and local services	Score	3	0	Express, limited, and local services	Score	3	0
Control center	Score	3	2	Control center	Score	3	2
Located In top ten corridors	Score	2	2	Located In top ten corridors	Score	2	2
Demand Profile	Score	3	3	Demand Profile	Score	3	3
Hours of operations	Score	2	1	Hours of operations	Score	2	2
Multi-corridor network	Score	2	0	Multi-corridor network	Score	2	0
Infrastructure		14	10	Infrastructure		13	9
Passing lanes at stations	Score	4	4	Passing lanes at stations	Score	3	3
Minimizing bus emissions	Score	3	1	Minimizing bus emissions	Score	3	1
Stations set back from intersections	Score	3	3	Stations set back from intersections	Score	3	3
Center stations	Score	2	2	Center stations	Score	2	2
Pavement quality	Score	2	0	Pavement quality	Score	2	0
Station Design and Station-bus Interface		10	8	Station Design and Station-bus Interface		10	8
Distances between stations	Score	2	0	Distances between stations	Score	2	0
Safe and comfortable stations	Score	3	3	Safe and comfortable stations	Score	3	3
Number of doors on bus	Score	3	3	Number of doors on bus	Score	3	3
Docking bays and sub-stops	Score	1	1	Docking bays and sub-stops	Score	1	1
Sliding doors in BRT stations	Score	1	1	Sliding doors in BRT stations	Score	1	1
Communications and Marketing		5	4	Communications and Marketing		5	4
Branding	Score	3	2	Branding	Score	3	2
Passenger information	Score	2	2	Passenger information	Score	2	2
Integration and Access		14	2	Integration and Access		15	7
Universal access	Score	3	1	Universal access	Score	3	3
Integration with other public transport	Score	3	0	Integration with other public transport	Score	3	0
Pedestrian access	Score	3	1	Pedestrian access & Safety	Score	4	4
Secure bicycle parking	Score	2	0	Secure bicycle parking	Score	2	0
Bicycle lanes	Score	2	0	Bicycle lanes	Score	2	0
Bicycle-sharing integration	Score	1	0	Bicycle-sharing integration	Score	1	0
TOTAL 100		100	67	TOTAL 100		100	75
BRT BASICS (MINIMUM NEEDED 20)		38	35	BRT BASICS (MINIMUM NEEDED 20)		38	38
Point Deductions		-45	-3	Point Deductions		-45	-3
Commercial Speeds	Score	-10	0	Commercial Speeds	Score	-10	0
Peak passengers per hour per direction (pphd) below 1,000	Score	-5	0	Peak passengers per hour per direction (pphd) below 1,000	Score	-5	0
Lack of enforcement of right-of-way	Score	-5	0	Lack of enforcement of right-of-way	Score	-5	0
Significant gap between bus floor and station platform	Score	-5	0	Significant gap between bus floor and station platform	Score	-5	0
Overcrowding	Score	-5	0	Overcrowding	Score	-5	0
Peak frequency	Score	-3	0	Peak frequency	Score	-3	0
Off-peak frequency	Score	-2	0	Off-peak frequency	Score	-2	0
Poorly-maintained Busway, Buses, Stations and Technology Systems	Score	-10	-3	Poorly-maintained Busway, Buses, Stations and Technology Systems	Score	-10	-3
Total Score:		100	64	Total Score		100	72
Classification:			BRONZE	Classification:			Silver

d) Located in Top Ten Corridors (2 Points Max)

During the planning phase to determine the high demand route, it is necessary to have a corridor on top priority demand corridors. PMBS has managed to get 2 marks in it. NESPAK has conducted a Feasibility Study by giving the Transportation Master plan and recommended the existing route of PMBS as the top priority corridor (Feasibility Study PMBS, 2013).

e) Demand Profile (3 Points Max)

PMBS has managed to score 3 marks in this element because dedicated infrastructure is located within a 2 km distance of either end of the corridor of the highest-demand road segment (Feasibility Study PMBS, 2013).

f) Hours of Operation (2 Points Max)

BRT Standards stated that the operations of buses should cover midnights and weekends. PMBS has 16 hours' operations i.e. from 6 AM to 10P. BRT Standard gives 2 points for both late night and weekend service and gives PMBS 1 out of 2 in this element.

If we observe the required headway after 10 PM in PMBS, more than 15 min headway is observed which is not recommendable. Anyway, PMBS is operational near to midnight and is given 2 marks out of 2.

g) Multi-Corridor Network (2 Points Max)

Ideally, BRT should have multiple corridors for multiple routes that must intersect and form a network. In 2014, when the BRT standard was evaluated for PMBS, there was no future expansion of the corridor for expansion of travel options for passengers. But now, the Islamabad Metrobus corridor is constructed and has been intersected with PMBS at Kashmir Highway Station. Therefore, it should be given 1 mark out of 2 instead 0 that ITDP has given to it at this element.

III. Infrastructure

a) Passing Lane at Stations (3 Points Max)

Passing lanes at the station help to accommodate other routes and express routes. Due to its effectiveness, it has been given 3 points in standard evaluation of a system. Therefore, PMBS has given 3 points in this element.

b) Minimizing Bus Emissions (3 Points Max)

BRT is the replacement of mass transit so that emissions can be controlled. Since the world has entered into the global warming era, engine manufacturers have put a lot of effort to design engines with the lowest emissions of particulate matter (PM) and nitrogen oxides (NO_x). PMBS has given 1 mark in this element out of 3 because of Euro III type bus engines i.e. Yuchai 6MK 340-30 (Punjab Mass Transit Authority, 2018).

c) Station Set Back from Intersections (3 Points Max)

According to the BRT Standard, the station must be at least 40 meters from intersections to avoid delays. Anyways, in PMBS, there is no intersection so it gained 3 marks in it.

d) Center Stations (2 Points Max)

PMBS has 100 % center station therefore it has been given 2 marks in this element.

e) Pavement Quality (3 Points Max)

Good pavement surface reduces the need for maintenance on the busway. Poor quality pavements need to be shut down for repairs more frequently which is not recommendable. In BRT Standards, the thirty-year design life of the pavement is a minimum threshold below which no number is to assign. The quality of the pavement surface is compromised due to poor drainage conditions at elevated portions. Therefore, zero marks are given to this element.

IV. Stations

a) Distance between Stations (2 Points Max)

The distance between stations is optimized at 450 meters. Distance less than 450 meters shall create increased travel time and buses will not be able to achieve optimum speed. Moreover, the distance between stations should not be less than 0.3 km and more than 0.8 km.

In PMBS, however, there are 24 stations at a total corridor length of 22.4 km. So on average, the distance between stations becomes 0.9 km. Surpassing the upper limit of BRT Standard therefore 0 marks shall be given.

b) Safe & Comfortable Stations (3 Points Max)

If a BRT is fulfilling the following four elements regarding safety and comfortability, then it shall be given 3 marks;

- **Wide:** Stations should be wide enough for passengers to move easily. PMBS Stations are around 20 feet wide. Therefore, shall be considered as Wide Station.
- **Weather Protected:** Stations should be protected from snow, heat, wind, rain, and cold. PMBS Stations are weather protected however during summer, heat is trapped inside the stations due to poor ventilation.
- **Safe:** Stations should be well-lit, transparent and security guard should be there. PMBS Stations have such attributes.
- **Attractive:** Aesthetics is another factor that may attract passengers to use service. PMBS stations are aesthetically good.

ITDP evaluates PMBS 3 in this element.

c) No of Doors on Bus (3 Points Max)

If we have more number of doors, then passengers will take less time for boarding and alighting. So BRT Standards tell that for articulated buses there should be at least 3 doors hence PMBS has secured 3 on it.

d) Docking Bays & Sub-stops (1 Points Max)

For the highest demand station, there should be at least 2 bays available. So PMBS has scored 1 on it because all stations of the PMBS have 3 bays (Figure 2.6).

e) Sliding Doors in BRT Stations (1 Points Max)

Since PMBS has all stations and every bay sliding doors mechanism, therefore, it has managed to score 1 on it.

V. Communications and Marketing

a) Branding (3 Points Max)

If all routes, buses, and stations follow a single unifying brand of the entire BRT System, it will manage to secure 3 points in it. PMBS, in this case, has a unifying brand of the entire BRT System, however, ITDP evaluates PMBS System in this category as 2 out of 3.

b) Passenger Information (2 Points Max)

If a BRT is functioning in real-time and up-to-date static passenger information system, it will be given 2 marks. PMBS also has secured 2 on it. Moreover, PMBS authority has planned to provide mobile applications to its users which will come to force in a couple of months.

VI. Access & Integration

a) Universal Access (3 Points Max)

Universally access means to all passengers including physically impaired people.

The PMBS system has given special priority to this element. The following facilities are present in all Stations of PMBS for physically impaired people;

- Elevators & Escalators at each direction and for movement from at grade station to an elevated platform in all Stations of PMBS (see Figure 2.7).
- Studs are installed in stations as guideways for blind people (see Figure 2.9).
- Level boarding at each station.
- Security Personals are present at each level of the station for the guidelines of all types of passengers.
- Seats inside buses are fixed for disabled persons.



Figure 4.1: Preferred seats for the disabled inside the bus.

- Announcements both inside the bus and at the platform for bus arrival and departure times and station names.

In contrast to the Lahore Metro Bus System (LMBS), elevators were installed at each station for old aged and special persons or persons using wheelchairs.

Since ITDP evaluated PMBS before its completion date of the construction period, therefore, these elements were not visible. ITDP evaluation has given PMBS 1 in this element which will be 3 out of 3.

b) Integration with other Public Transport (3 Points Max)

There is no provision in PMBS for other transportation integration like Physical transfer points or fare payment etc. Anyways, it is planned that the newly constructed Islamabad metro shall be integrated with the existing system.

c) Pedestrian Access & Safety (4 Points Max)

Previously this element was named Pedestrian Access however in the BRT Standard guide of 2016, more focus was given in safety and operational efficiency. Also, its number is increased from 3 to 4. By definition, Pedestrian Access & Safety means;

- At grade pedestrian crossing where pedestrians cross a maximum of two lanes of traffic before reaching a pedestrian refuge i.e. sidewalks & medians.
- Safe crossing provided on average every 200 meters in areas where there is continuous activity on both sides of the corridor.
- Signalized crosswalks where pedestrians must cross more than two lanes at once.
- Direct station access, with no time-consuming detours and other delays.
- Posted speed limits for drivers.
- Design that matches posted speed limits to prevent speeding and help with enforcement.

PMBS has a good, safe pedestrian at every station. There are pedestrian crossing bridges or underpasses at every station which enhances the safety of passengers. But ITDP has given 1 to PMBS which is calculated as 4 in this element (see Figure 2.7).

d) Secure Bicycle Parking (2 Points Max)

There is no secure bicycle parking provision in PMBS.

e) Bicycle Lanes (2 Points Max)

There are no bicycle lanes in PMBS.

f) Bicycle Sharing Integration (1 Points Max)

There is no bicycle integration network in PMBS.

VII. Deductions of Points

For a poorly maintained busway, buses, stations, and technology systems, BRT Standard recommends a maximum of 14 numbers deduction from the total. In PMBS, however, only track is not maintained well as per standards due to poor design of subsurface drainage. ITDP has deduced 3 marks as penalty from total PMBS evaluation.

4.2. Data Analysis

Itinerary of every route & average travel time b/w stops: To calculate the average travel time & speed of route 1 given in Table 2.4, a survey of selected bus was

conducted to form a distance-speed & distance-time graph. The results of this survey are given in **Table 4.2**. We see that the total travel time of buses is 49 minutes against the planned time of 48 minutes & 20 seconds. The dwell time comes out to be approximately 48 seconds for each station. It can be seen in the Speed-Distance profile & Speed-Time profile given in Figure 4.2 & Figure 4.3 respectively.

Dwell Time of PMBS: Dwell time is the combination of two times;

$$\text{Dwell Time} = \text{Fixed Dwell Time} + \text{Variable Dwell Time}$$

Fixed Dwell Time is also called as Dead Time. Which depends on three factors;

- a. The deceleration rate of bus when entered in docking or sub-stop area
- b. The time of closing or opening of the bus for boarding and alighting of passengers
- c. The acceleration rate of a bus when start moving for the next station

So Dead Time of a vehicle is the time consuming when vehicle slowing down when entering the station for docking at docking bay, the opening, and closing of doors for alighting and boarding of passengers, and time for accelerating bus to get normal speed to move for the next station.

Usually, this time is fixed for a system and the same vehicle, and for large vehicles 0.17-0.25 seconds per meter of bus time is increased if bus length is increased in meters.

Table 4.2: Travel Time b/w Stops & Speed of a selected Bus

Travel Time b/w all stops & Speed (Bus M-20)														
Sr. No	Date	Station Name	Trip Start Time (Planned)	Diff	Actual Time	Start of Trip	Speed After 10 Sec	Speed After 20 Sec	Speed After 30 Sec	Speed After 40 Sec	Speed After 50 Sec	Speed After 60 Sec	End of Trip	Average Speed
1	22-Jan-18	Saddar – Marrir	06:57			0	1	32	37	39	42	42	0	24.1
2		Marrir - Liaqat Bagh	06:59	00:02:00	00:02:17	0	14	40	41	42	41	41	0	27.4
3		Liaqat Bagh - Committee Chowk	07:00	00:01:50	00:01:48	0	25	41	42	41	41	41	0	28.9
4		Committee Chowk - Waris Khan	07:02	00:01:50	00:02:03	0	3	37	41	42	43	43	0	26.1
5		Waris Khan - Chandni Chowk	07:04	00:01:40	00:01:38	0	22	37	41	41	41	41	0	27.9
6		Chandni Chowk - Rehmanabad	07:06	00:02:30	00:02:38	0	32	39	37	39	41	39	0	28.4
7		Rehmanabad - 6th Road	07:08	00:01:50	00:01:45	0	29	40	41	41	42	40	0	29.1
8		6th Road - Shamsabad	07:10	00:01:50	00:01:52	0	27	40	41	42	40	42	0	29.0
9		Shamsabad - Faizabad	07:12	00:01:50	00:01:50	0	2	35	39	39	40	42	0	24.6
10		Faizabad – IJP	07:15	00:02:50	00:02:54	0	29	40	41	43	44	41	0	29.8
11		IJP – Potohar	07:17	00:02:20	00:02:25	0	22	40	35	38	39	40	0	26.8
12		Potohar – Khyaban-e-Johar	07:19	00:02:00	00:02:02	0	3	38	47	47	46	47	0	28.5
13		Khyaban-e-Johar Faiz Ahmad Faiz	07:21	00:02:20	00:02:22	0	31	43	42	43	42	44	0	30.6
14		Faiz Ahmad Faiz - Kashmir Highway	07:23	00:01:50	00:01:49	0	13	40	44	45	42	43	0	28.4
15		Kashmir Highway - Chaman	07:26	00:02:40	00:02:47	0	3	9	43	34	47	50	0	23.3
16		Chaman - Ibn e Sina	07:27	00:01:30	00:01:30	0	11	42	45	48	47	46	0	29.9
17		Ibn-e-Sina - Katchery	07:29	00:01:50	00:01:45	0	17	39	43	42	42	47	0	28.8
18		Katchery - PIMS	07:31	00:02:00	00:02:18	0	30	39	38	40	45	41	0	29.1
19		PIMS - Stock Exchange	07:33	00:02:00	00:01:41	0	24	38	42	41	39	40	0	28.0
20		Stock Exchange - 7th Avenue	07:36	00:02:30	00:02:35	0	13	34	39	39	38	35	0	24.8
21		7th Avenue - Shaheed e Millat	07:39	00:02:50	00:02:59	0	2	36	43	45	46	46	0	27.3
22		Shaheed e Millat - Parade Ground	07:40	00:01:40	00:01:36	0	16	40	44	46	45	39	0	28.8
23		Parade Ground - Pak Sec	07:42	00:01:40	00:01:29	0	22	39	39	39	32	31	0	25.3
24		Pak Sec	07:45	00:03:00	00:03:05	0								
		Total Travel Time	0:48:20		00:49:07									27.6

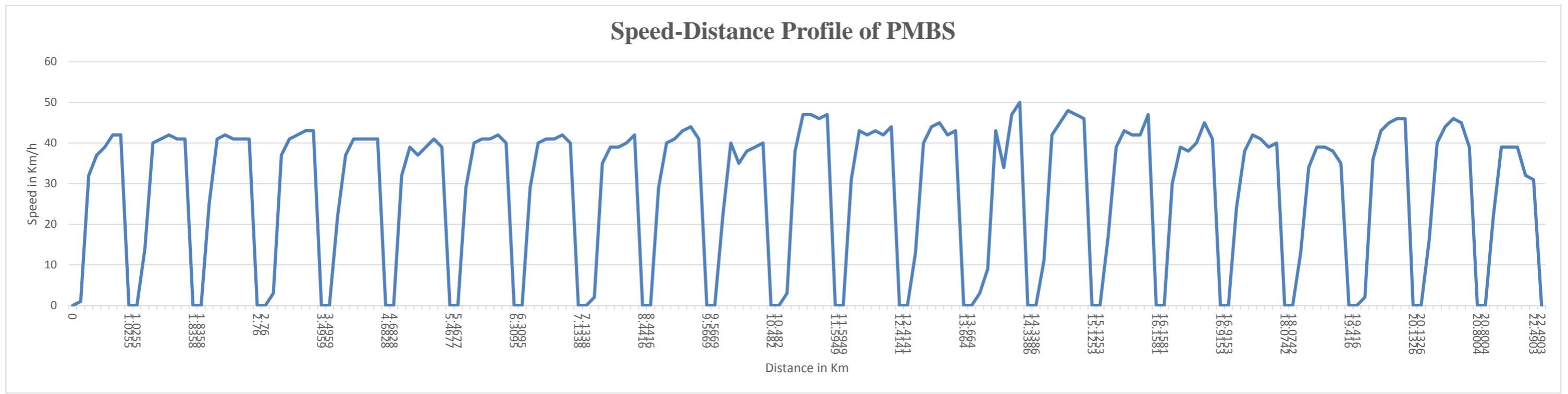


Figure 4.3: Speed-Distance Profile of PMBS Corridor of a Selected Bus

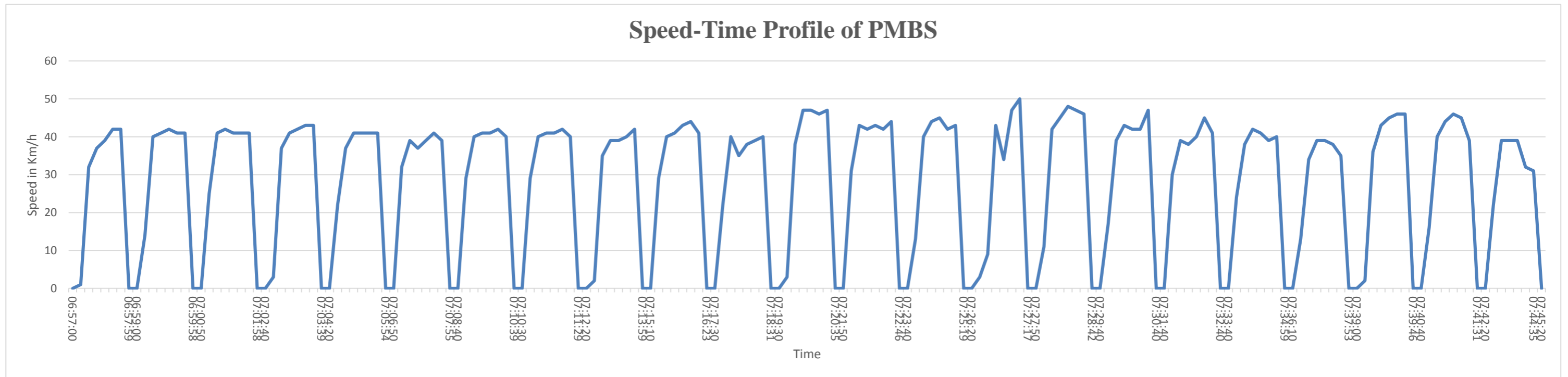


Figure 4.2: Speed-Time Profile of PMBS Corridor of a Selected Bus

ITDP has given a conservative approach to calculate this time by the equation given below, however, for a detailed version of a study, we can calculate the exact dead time of the system. The equation for Average Dead Time is given by the equation;

$$T_o = 13 + L \text{ vehicle} \times 0.25$$

So by putting the values of articulated bus having 18 m bus in length, the average Dead Time comes out to be 17.5 Seconds.

Variable Dwell time is the average Boarding & Alighting Time of the passengers while using BRT Bus and represents as t_b & t_a respectively. During peak hour (i.e. 17-18 hours of Monday, 7th January 2019) 856 Passengers were boarded and 519 Passengers were alight from 27 buses during that hour from Faizabad Station in Faizabad to the Saddar route. Total Boarding Time is 911 Seconds for 856 Passengers for that hour so boarding time per passengers = 1.064 Seconds and Total alighting Time is 531 Seconds for 519 Passengers for that hour so alighting time per passengers = 1.023 Seconds as given in Table 4.3.

Table 4.3: Average Boarding & Alighting Time per Passengers during Peak Hour

Faizabad Station (Faizabad to Saddar Route)					
7th January 2019 (Monday)					
Boarding Duration		Actual Boarding Time	Alighting Duration		Actual Alighting Time
Start Time	End Time		Start Time	End Time	
17:00:02	17:00:27	00:00:25	17:00:02	17:00:12	00:00:10
17:01:39	17:02:13	00:00:34	17:01:39	17:02:10	00:00:31
17:04:41	17:05:15	00:00:34	17:04:41	17:04:54	00:00:13
17:07:03	17:07:44	00:00:41	17:07:03	17:07:31	00:00:28
17:08:24	17:08:58	00:00:34	17:08:24	17:08:36	00:00:12
17:09:30	17:09:59	00:00:29	17:09:30	17:09:45	00:00:15
17:12:46	17:13:19	00:00:33	17:12:46	17:13:04	00:00:18
17:12:46	17:13:19	00:00:33	17:12:46	17:13:04	00:00:18
17:15:38	17:16:28	00:00:50	17:15:38	17:16:00	00:00:22

Faizabad Station (Faizabad to Saddar Route)					
7th January 2019 (Monday)					
Boarding Duration		Actual Boarding Time	Alighting Duration		Actual Alighting Time
Start Time	End Time		Start Time	End Time	
17:16:58	17:17:28	00:00:30	17:16:58	17:17:15	00:00:17
17:18:01	17:18:35	00:00:34	17:18:01	17:18:17	00:00:16
17:20:48	17:21:17	00:00:29	17:20:48	17:21:02	00:00:14
17:23:20	17:23:51	00:00:31	17:23:20	17:23:41	00:00:21
17:25:02	17:25:32	00:00:30	17:25:02	17:25:26	00:00:24
17:26:06	17:26:37	00:00:31	17:26:06	17:26:33	00:00:27
17:28:44	17:29:25	00:00:41	17:28:44	17:29:01	00:00:17
17:31:32	17:32:13	00:00:41	17:31:32	17:31:57	00:00:25
17:33:38	17:34:05	00:00:27	17:33:38	17:34:02	00:00:24
17:37:18	17:37:54	00:00:36	17:37:18	17:37:39	00:00:21
17:40:51	17:41:35	00:00:44	17:40:51	17:41:08	00:00:17
17:42:41	17:43:15	00:00:34	17:42:41	17:42:55	00:00:14
17:45:35	17:46:15	00:00:40	17:45:35	17:45:54	00:00:19
17:48:17	17:48:45	00:00:28	17:48:17	17:48:37	00:00:20
17:50:18	17:50:42	00:00:24	17:50:18	17:50:40	00:00:22
17:51:26	17:51:58	00:00:32	17:51:26	17:51:54	00:00:28
17:52:31	17:53:04	00:00:33	17:52:31	17:52:50	00:00:19
17:52:31	17:53:04	00:00:33	17:52:31	17:52:50	00:00:19
Total Time in Minutes		0:15:11	Total Time in Minutes		0:08:51
Total Time in Seconds		911 Seconds	Total Time in Seconds		531 Seconds
No of Passengers Board		856	No of Passengers Alight		519
Boarding Time Per passengers		1.064252336	Alighting Time Per passengers		1.023121387

The number of customers boarding & alighting at each stop: PMBS has been operational since the 4th of June 2015. The average Boarding & Alighting detail of the years 2016 to 2018 is given in Table 4.4.

The comparison of ridership from 2016 to 2018 shows that there is no significant change in the Boarding & Alighting Pattern of passengers in almost all stops of PMBS. However, station wise comparison shows the busiest and the least busy stops of PMBS. For example, Saddar, Faizabad in Rawalpindi

section, and PIMS in Islamabad Section are the busiest among all stations. (Saddar to Faizabad Stations comes under Rawalpindi Region & IJP to Pak Secretariat comes under Islamabad Region). The comparison of Yearly Boarding & Alighting of passengers in all stations/stops of PMBS is shown in

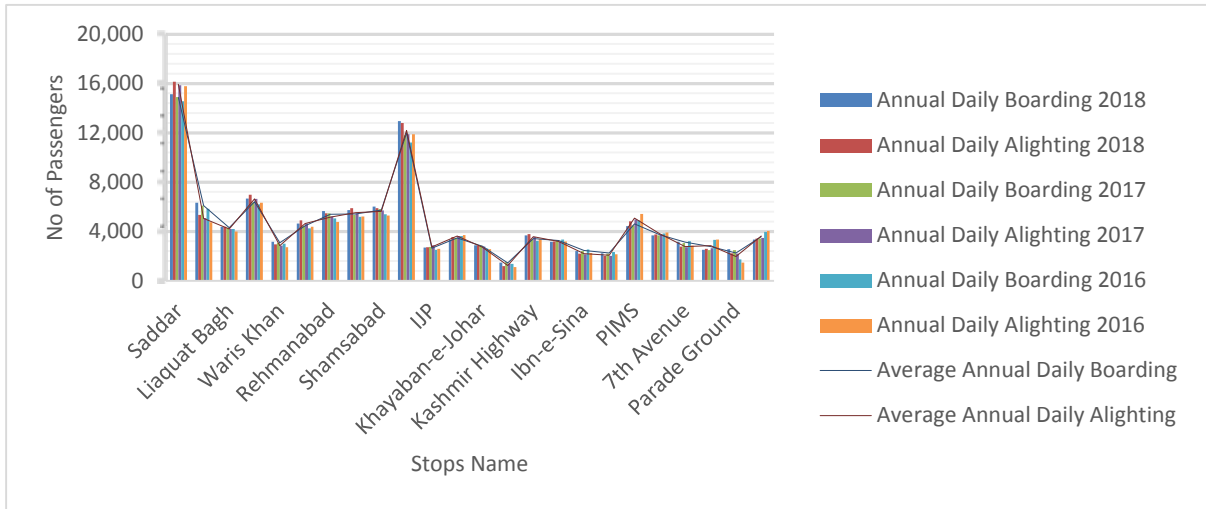


Figure 4.4: Comparison of Yearly Boarding & Alighting of Passengers in all Stops of PMBS

Table 4.4: Average Annual Daily Boarding & Alighting of Passengers in All Stops of PMBS

Start Operation Date: 4 June 2015	Annual Daily Boarding or Alighting Year 2018		Annual Daily Boarding or Alighting Year 2017		Annual Daily Boarding or Alighting Year 2016		Average Annual Daily Boarding & Alighting at Each Stop	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Saddar	15,127	16,147	14,886	15,848	14,561	15,792	14,858	15,929
Marir Chowk	6,318	5,349	6,102	5,076	5,836	4,733	6,086	5,053
Liaqat Bagh	4,375	4,375	4,297	4,198	4,200	3,995	4,291	4,189
Committee Chowk	6,658	6,982	6,353	6,628	6,208	6,336	6,407	6,649
Waris Khan	3,164	2,940	3,078	2,848	2,993	2,721	3,078	2,837
Chandni Chowk	4,642	4,907	4,462	4,638	4,256	4,381	4,453	4,642
Rehmanabad	5,654	5,469	5,471	5,208	5,046	4,774	5,390	5,150
6th Road	5,732	5,874	5,329	5,441	5,185	5,212	5,416	5,509
Shamsabad	6,013	5,894	5,809	5,711	5,391	5,287	5,738	5,631
Faizabad	12,938	12,793	11,796	11,889	11,214	11,896	11,983	12,192
IJP	2,686	2,725	2,746	2,868	2,510	2,593	2,648	2,729
Potohar	3,325	3,547	3,460	3,618	3,632	3,699	3,472	3,621
Khayaban-e-Johar	2,883	2,853	2,851	2,777	2,619	2,552	2,784	2,727
Faiz Ahmed Faiz	1,457	1,187	1,526	1,381	1,366	1,111	1,450	1,226
Kashmir Highway	3,677	3,790	3,337	3,536	3,237	3,377	3,417	3,567
Chaman	3,154	3,194	3,264	3,169	3,352	3,173	3,257	3,179
Ibn-e-Sina	2,411	2,196	2,411	2,149	2,546	2,257	2,456	2,201
Katchery	2,220	2,014	2,200	2,018	2,338	2,154	2,253	2,062
PIMS	4,443	4,832	4,491	4,967	4,907	5,429	4,614	5,076
Stock Exchange	3,683	3,746	3,687	3,760	3,838	3,914	3,736	3,807
7th Avenue	3,145	2,768	3,062	2,720	3,220	2,841	3,142	2,776
Shaheed-e-Millat	2,498	2,594	2,487	2,630	3,321	3,346	2,769	2,857
Parade Ground	2,548	2,222	2,483	2,184	1,734	1,481	2,255	1,962
Pak Secretariat	3,352	3,405	3,410	3,457	3,956	4,035	3,572	3,632
Total	112,101	111,804	108,999	108,718	107,467	107,089	109,522	109,204

It can also be seen that the Rawalpindi Region comprising more ridership than Islamabad Region.

Table 4.5: Quarterly Boarding & Alighting of Passengers during 2018 in all stops of PMBS.

<u>Start Operation Date: 4 June 2015</u>	1st Quarter Boarding or Alighting Year 2018		2nd Quarter Boarding or Alighting Year 2018		3rd Quarter Boarding or Alighting Year 2018	
Station Name	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Saddar	2,022,056	2,151,696	1,665,514	1,782,559	1,818,635	1,927,104
Marrir Chowk	829,248	702,709	705,048	597,113	765,623	641,793
Liaqat Bagh	594,480	588,810	466,800	477,767	531,076	521,506
Committee Chowk	901,862	942,812	699,153	737,605	822,610	853,884
Waris Khan	424,166	396,183	350,006	323,462	377,605	347,738
Chandni Chowk	622,474	658,439	509,261	538,258	557,785	584,412
Rehmanabad	779,481	746,698	568,790	557,425	709,747	681,280
6th Road	772,982	793,246	578,619	593,778	734,863	745,187
Shamsabad	805,029	789,679	630,431	617,788	753,218	732,113
Faizabad	1,656,834	1,679,696	1,494,830	1,431,897	1,557,643	1,532,199
IJP	356,217	362,145	296,095	294,660	325,501	332,415
Potohar	457,516	482,140	357,542	382,526	395,174	422,801
Khyaban-e-Johar	406,632	404,674	270,682	261,947	372,059	369,160
Faiz Ahmed Faiz	202,858	164,188	158,213	131,902	169,110	134,808
Kashmir Highway	477,406	500,194	377,210	388,427	483,915	486,979
Chaman	436,334	436,364	337,490	342,899	374,252	380,109
Ibn-e-Sina	326,797	294,535	256,863	238,092	293,806	264,586
Katchery	303,588	275,353	230,344	207,574	274,221	248,222
PIMS	579,035	622,923	527,033	594,364	511,102	536,757
Stock Exchange	487,602	492,768	403,219	415,444	449,897	451,765
7th Avenue	413,961	367,499	350,115	303,479	380,536	333,980
Shaheed-e-Millat	332,424	346,515	262,332	273,514	314,591	321,644
Parade Ground	335,719	293,933	283,600	247,556	308,007	265,052
Pak Secretariat	461,419	466,409	377,717	386,538	380,938	383,111
Total	14,986,120	14,959,608	12,156,907	12,126,574	13,661,914	13,498,605

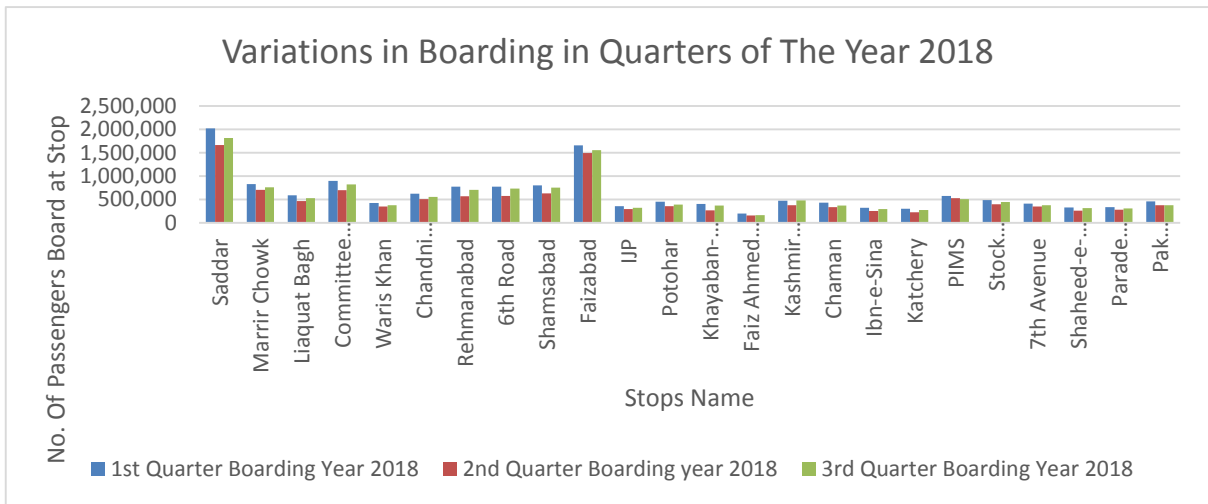


Figure 4.5: Variations in Boarding in Quarters of the Year 2018.

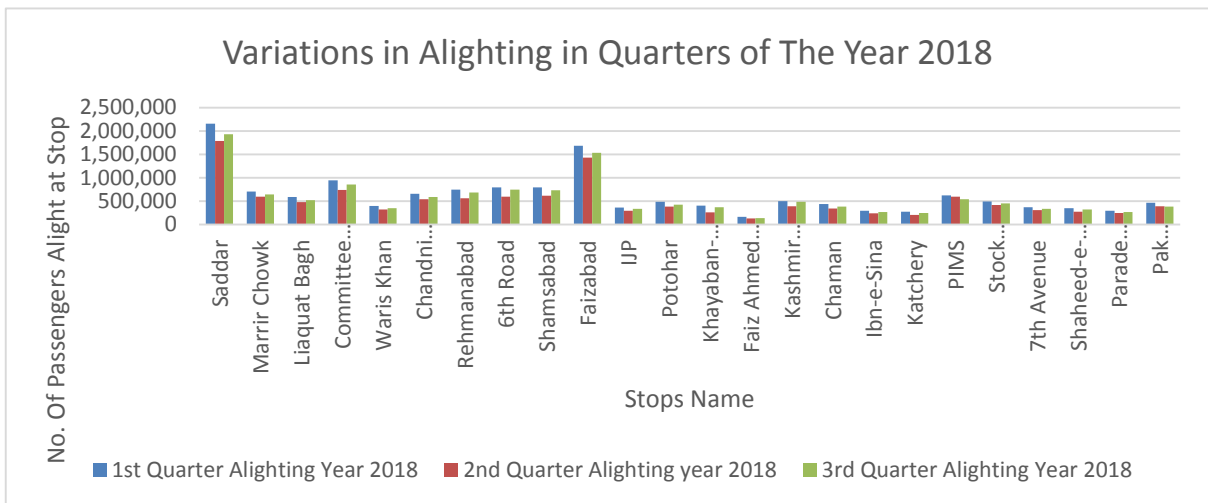


Figure 4.6: Variations in Alighting in Quarters of the Year 2018.

It can be seen that the 1st and Last quarter of the Year 2018 have more boarding and alighting data than the 2nd quarter as shown in Figure 4.5 & Figure 4.6.

The reason behind the 2nd quarter shows least Boarding's & Alighting's because Ramzan Month was started on 17 May to 20 June 2018 including holidays. The ridership for the month of Ramzan as compared to the other months of the year can be compared in the following Table 4.6.

Table 4.6: Comparison of Average Monthly Daily Ridership of all Months with Ramzan Months of the Year 2018

Pakistan Ridership For Year 2018			
Month	Total (Passengers)	Operating Days	Average Ridership (Passengers/Day)
Jan-18	3,861,746	31	124,572
Feb-18	3,696,131	28	132,005
Mar-18	3,829,852	31	123,544
Apr-18	3,598,749	30	119,958
May-18	3,214,939	31	103,708
Jun-18	2,564,202	30	85,473
Jul-18	3,369,725	31	108,701
Aug-18	3,123,437	31	100,756
Sep-18	3,167,722	30	105,591
Oct-18	3,549,010	31	114,484
Nov-18	3,331,208	29	114,869
Dec-18	3,650,548	31	117,760
Total	40,957,269	364	112,520

The drop in ridership can also be seen during the 2015-2018 years. Comparison of monthly ridership since inception i.e. operation date: 4th of June 2015 can be seen in the following table. It is observed that during Ramzan Month, there is a significant reduction in ridership. The Marked cells show the Ramzan Month during the Gregorian months of the years. Graph as shown in Figure 4.7: Comparison of Drop of Passengers' Ridership during Ramzan Months shows the significant reduction in the ridership on months having Islamic Ramzan Month. e.g. from 2015 to 2018, Ramzan was in the middle of May to the end of July including the Holidays of Eid-ul-Fitar therefore, during May, June & July, the Average ridership was 109,984, 91,891 & 105,278 respectively. Which is 4%, 20% & 8.7% less ridership than average of the remaining months.

**Table 4.7: Comparison of Drop of Ridership during Ramzan Season in
Years 2015-2018**

Average Ridership (Passengers/Day)					
Month	Year 2015	Year 2016	Year 2017	Year 2018	Average Ridership (Passengers/Day)
Jan		117,575	128,744	124,572	123,630
Feb		116,982	133,880	132,005	127,622
Mar		107,477	127,796	123,544	119,605
Apr		111,734	122,706	119,958	118,133
May		109,232	117,012	103,708	109,984
Jun	112,073	87,936	82,084	85,473	91,891
Jul	94,861	98,257	119,294	108,701	105,278
Aug	108,747	112,512	112,066	100,756	108,520
Sep	102,296	98,090	101,106	105,591	101,771
Oct	101,800	106,937	124,328	114,484	111,887
Nov	112,698	117,421	101,713	114,869	111,675
Dec	114,888	122,996	104,824	117,760	115,117
Total(per day)	106,659	108,963	115,263	112,520	110,851

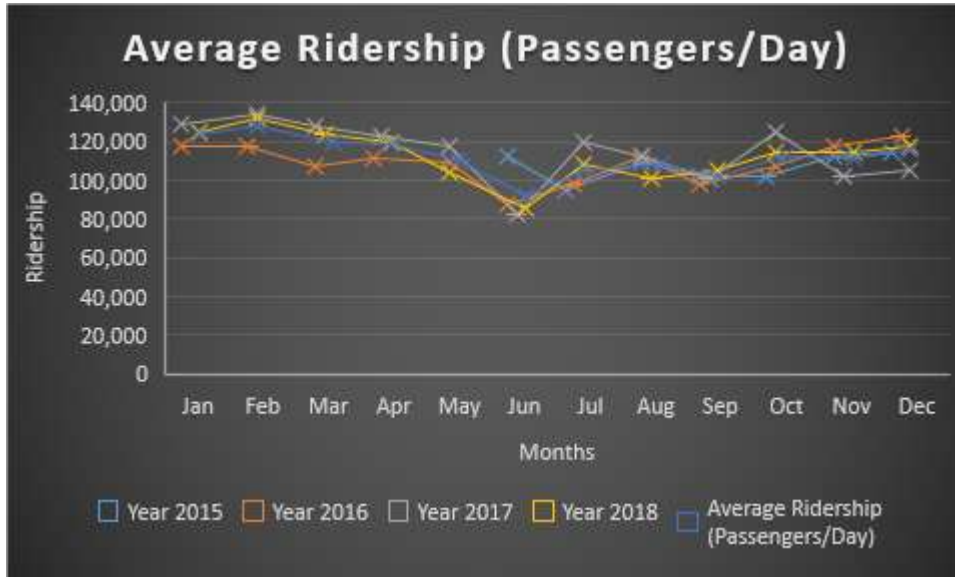


Figure 4.7: Comparison of Drop of Passengers' Ridership during Ramzan Months

There is a significant change in Boarding's in Weekdays (Mon-Fri) &

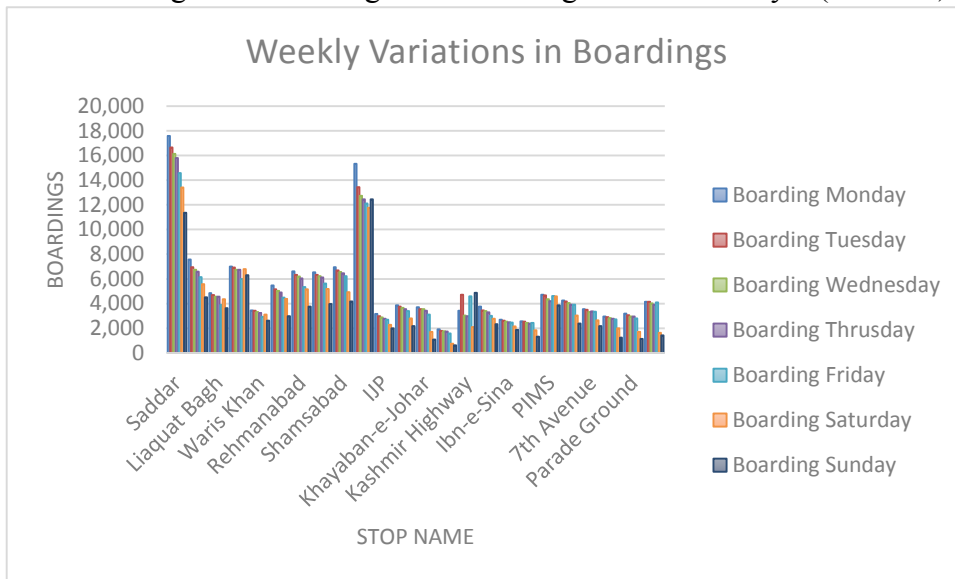


Figure 4.8: Weekly Variations in Boarding's of Passengers

Weekends (Sat-Sun). The average Boarding's during Weekdays is 120,274 while during Weekends is 90,427. Moreover, it can be seen that boarding is high on Monday and decrease gradually until Sunday (Figure 4.8).

There is a significant change in Alighting's in Weekdays (Mon-Fri) & Weekends (Sat-Sun). The average Alighting's during Weekdays is 119,544 while during Weekends is 90,137. Moreover, it can be seen that alighting is High on Monday and decrease gradually until Sunday (Figure 4.9).

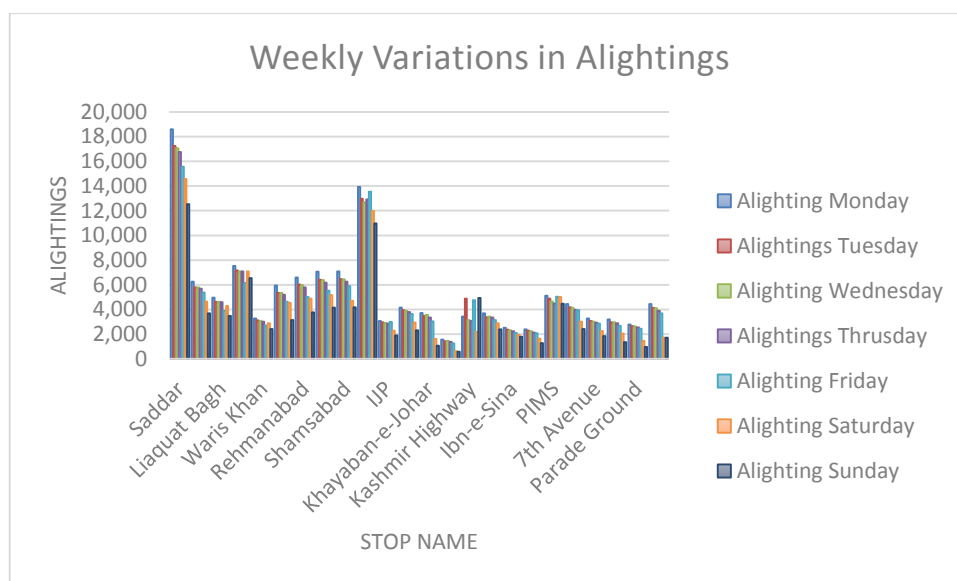


Figure 4.9: Weekly Variations in Alighting's' of Passengers

The Hourly Variations throughout the week can be seen in the table given below, showing the average of all the days of the week for a whole year of 2018

Table 4.8: Hourly Ridership (Day Wise)

HOURLY RIDERSHIP SUMMARY (DAY WISE)								
DAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	AVERAGE RIDERSHIP (PER HOUR)
TIME								
<6	52	42	41	39	38	33	27	39
6-7	2,293	2,080	2,063	2,023	1,900	1,510	1,137	1,858
7-8	7,493	7,166	7,146	6,972	6,446	3,867	1,998	5,870
8-9	9,717	9,247	9,204	8,966	8,269	5,099	2,944	7,635
9-10	8,453	7,738	7,555	7,410	6,746	5,481	3,638	6,717
10-11	8,552	7,836	7,547	7,453	6,810	6,220	4,774	7,028
11-12	8,941	8,403	7,936	8,028	7,545	6,713	5,477	7,578
12-13	9,478	8,958	8,468	8,583	8,764	7,077	6,001	8,190
13-14	9,897	9,473	9,019	8,886	6,775	7,395	6,405	8,264
14-15	9,565	9,153	8,640	8,712	7,679	7,505	6,699	8,279
15-16	9,266	8,924	8,443	8,513	8,566	7,414	7,065	8,313
16-17	9,826	9,493	9,110	9,170	9,177	7,688	7,529	8,856
17-18	10,230	10,043	9,545	9,519	9,511	7,959	7,819	9,232
18-19	8,828	8,900	8,473	8,433	8,533	7,323	7,386	8,268
19-20	6,753	6,765	6,397	6,386	6,400	5,868	5,950	6,360
20-21	5,378	5,449	5,154	5,196	5,118	5,022	5,110	5,204
21-22	4,153	4,110	3,933	3,998	3,773	4,048	3,909	3,989
22-23	381	368	353	378	344	367	390	368
>23	0	0	0	0	0	0	0	0

HOURLY RIDERSHIP SUMMARY (DAY WISE)								
DAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	AVERAGE RIDERSHIP (PER HOUR)
TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	AVERAGE RIDERSHIP (PER HOUR)
Incomplete Trips	88	79	14	52	107	121	18	68
Peak Hour	10,230	10,043	9,545	9,519	9,511	7,959	7,819	9,232

We can see that throughout a day, there is a change in hourly ridership. There exist 3 peaks i.e. Morning Peak from 8-9 Hours, After Noon Peak from 13-14 Hours, and Evening Peak from 17-18 Hours during Weekdays i.e. Mon to Fri. However, there is an abrupt change in Peaks on Friday due to Friday Prayer. Only One Peak is observed during Sat-Sun i.e. 17-18 Hours (Figure 4.10)

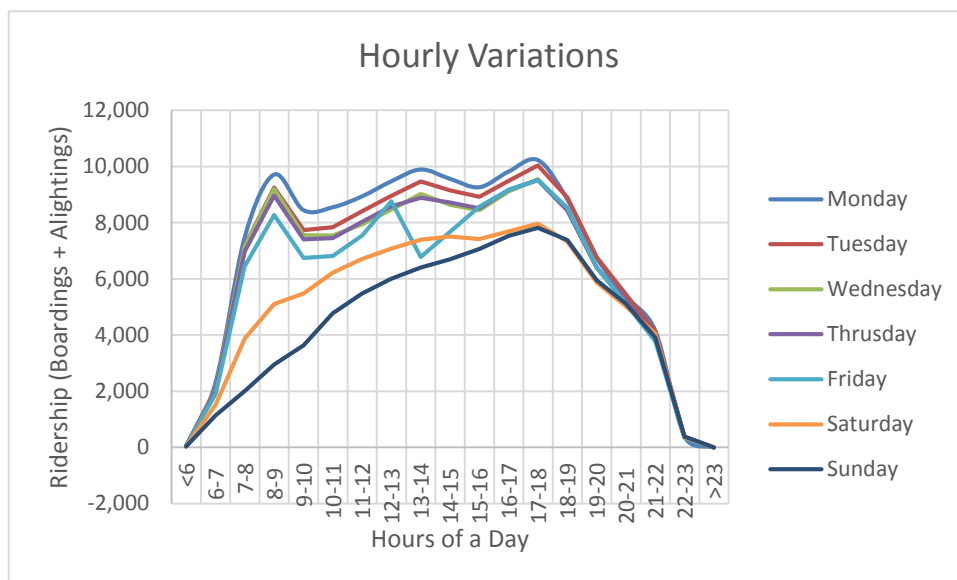


Figure 4.10: Hourly Variations in Ridership

The Saturation Level of PMBS Station: The Congestion Level of the station can be calculated using the Saturation Level. As per the ITDP Planning Guide, the following is the equation to calculate Saturation Level if two things are present in the service;

- If boarding and alighting have occurred through the same door
- External fare collection systems

$$S_{Dock} = \frac{T_o \times N_{Bus} + [(P_b \times t_b) + (P_a \times t_a)]}{\Delta t}$$

Where;

S_{Dock} = Saturation Level of Docking Bay for a given time interval

T_o = Average Dead Time per bus

N_{Bus} = Number of buses that use the docking bay during the interval (If the time interval is an hour it is usually the frequency of services referenced in Vehicles per hour)

P_b = Number of Boarding Customers in docking bay during interval

t_b = Average boarding time per customer

P_a = Number of Alighting Customers in docking bay during interval

t_a = Average alighting time per customer

Δt = Time interval duration in seconds

Refer to the previous picture that is showing the peak hours of PMBS, it is seen that there exist 3 peaks during Mon-Fri while 01 Peak in Sat-Sun as shown in the table given below;

Table 4.9: Peak Hours of different days of a week

<i>Days/Time</i>	<i>Monday</i>	<i>Tuesday</i>	<i>Wednesday</i>	<i>Thursday</i>	<i>Friday</i>	<i>Saturday</i>	<i>Sunday</i>
Morning Peak	8-9 AM	8-9 AM	8-9 AM	8-9 AM	8-9 AM	-	-
Afternoon Peak	01-02 PM	01-02 PM	01-02 PM	01-02 PM	12-01 PM	-	-
Evening Peak	05-06 PM	05-06 PM	05-06 PM	05-06 PM	05-06 PM	05-06 PM	05-06 PM

And the maximum ridership is for 1st quarter of the year 2018 with maximum ridership for Jan 2018. I have selected Last Weekend of the month because Winter Holidays end in mid of 2nd Week of the Month i.e. 22nd Jan 2018 to 28th Jan 2018 as shown in the figure;

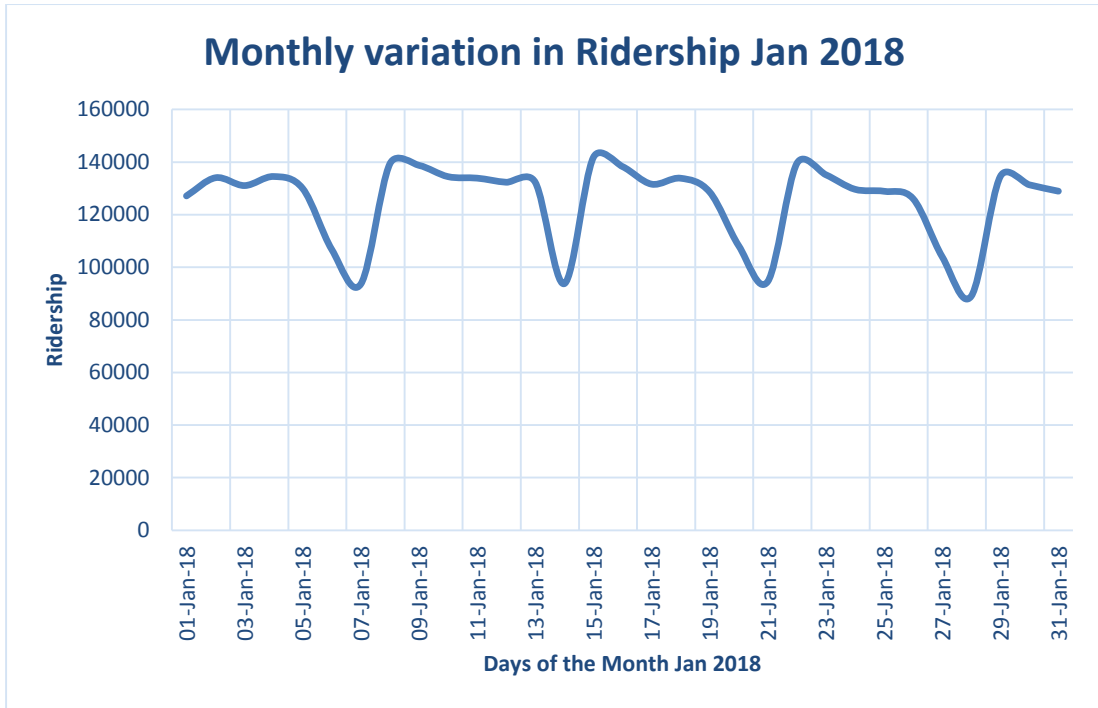


Figure 4.11: Monthly Variation of Ridership Jan 2018

Among these peaks, 17-18 peaks are the highest peak. Since last year data was not available therefore I have selected the 7th of January 2019 (Monday) having 148,654 ridership I.e. Highest for any day for this month. So saturation levels for these peaks are calculated at Faizabad Station (For Pak Secretariat to Saddar Route) being the busiest station throughout the year as;

Saturation Level for 5-6 PM Peak of Monday (Because Monday has the Highest Ridership during a week) and using data from Calculation of Dwell time in the previous section we have:

$$T_o = 17.5 \text{ Seconds}$$

$$N_{\text{Bus}} = 27 \text{ Buses}$$

$$P_b = 856 \text{ Passengers}$$

$$P_a = 519 \text{ Passengers}$$

t_b = Total Boarding Time is 911 Seconds for 856 Passengers for that hour so boarding time per passengers = 1.064 Seconds

t_a = Total alighting Time is 531 Seconds for 519 Passengers for that hour so alighting time per passengers = 1.023 Seconds

By Putting Values in the above equation, the saturation level comes out to be 53.18 %. The saturation level of 40 is recommended (ITDP Planning Guide, 2016, p. 169) and beyond this value, significant queues of vehicles at station may be possible. With the saturation of this level, the condition of the station will be like a queue in the station. We can see it during the peaks that people form queues in the station.

Trunk & Feeder Services: PMBS is “Trunk-Only” services. A 22.4 km BRT Corridor is operational in two cities of Pakistan without “mixed traffic” parallel to the existing corridor of general traffic. Unlike the main countries where “Trunk & Feeder Services” run successfully, PMBS has planned for Feeder Services to integrate with Trunk Services in the future.

Local, Limited & Express Services: PMBS is a single corridor with few rotaries for turning of vehicles and passing lanes at every stops. Passing lanes at stops allow more services to operate. As with PMBS which operates only, Local Service may allow Limited & Express services too.

The provision of passing lane can also be fulfilled by allowing BRT Vehicles to enter with Mixed Traffic lanes where passing lanes are not present like Select Bus Service of New York. But for PMBS there is no need to enter BRT Vehicles to enter in mixed traffic lane because of passing lanes present in all stations.

In PMBS except for Limited or Express service, Early Return & Deadheading are used. For example, in the morning peak i.e. from 7:15 AM to 9:30 AM 18 buses at 8 minutes’ headway are departed from Waris Khan Station by skipping all 4 stations because of high demand. Similarly, during evening peak i.e. 15:15 hours to 17:45 hours first 5 stations are skipped to dock directly from PIMS station because of high demand from other directions. These types of services are called as Early Return & Deadheading service.

Load, Critical Link, Maximum Hourly Load on Critical Link (MaxLoad), Passengers per Hour Per Direction (PPHPD) & Load Factor: The capacity of the BRT system is determined by the capacity of its busiest station section. According to the ITDP, it depends on Vehicle Size, Load Factor & sum of services frequencies. Services frequencies may be of local and limited stops.

Using equation 7.21 given in the ITDP Planning guide, the corridor capacity of PMBS comes out to be 24, 480 PPHPD (See Table 4.10). It means by using all 3 stopping bays of a station and with a service frequency of 60 vehicles per hour, PMBS can handle 24,480 passengers per hour per direction.

**Table 4.10: Corridor Capacity of PMBS using ITDP Planning Guide 2016
Equation 7.21**

Vehicle Size	Load Factor	Frequency of Buses at stops	No of Sub stops of a station	Direct Frequencies	Corridor Capacity (PPHPD)
160	0.85	60	3	-	24,480
160	0.85	27	1	-	3,672

To determine the Load on any link, a matrix of 24x24 (as 24 Stations of PMBS) is need to form. Table 4.11 shows the top 30 links of the 24x24 matrix of Monday, 15th January 2018. The max load of the PMBS, therefore, comes out to be Faizabad to Saddar Link with maximum load from 16:00 Hours to 16:59 Hours with 266 passengers traveled from Faizabad to Saddar only during this hour. The load during this hour is approximately 3,672 PPHPD for this Critical Link which is called as MaxLoad.

It may be noted that the saturation level of Critical Link (Faizabad to Saddar Segment) is 53.18 %. While the MaxLoad is far less than the capacity of the station. It indicates that a smaller modification is required to reduce the saturation level of the station.

Renovation Factor of the Critical Link: Renovation Factor can be determined by dividing the Total Demand of the Route with the Load on Critical Link. For example, for the critical link of Faizabad-Saddar, the total demand of the route Pak-Secretariat to Saddar during 16:00 Hours to 16:59 Hours is 2414 passengers while on Critical Link it is 1111 passengers. So the renovation factor of this link is 2.17 i.e. is 2.17 more than profitable than whole corridor passengers ‘travels.

Table 4.11: Top 30 Links/Segments of PMBS

Sr No.	CheckInStation Name	CheckOutStation Name	Total Trips	Hours of a day																		
				5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	Faizabad	Saddar	3064	0	79	174	198	215	211	202	228	239	221	242	266	199	206	168	116	83	17	0
2	Saddar	Faizabad	2863	2	38	120	153	209	166	192	199	248	251	239	242	253	182	158	118	93	0	0
3	Shamsabad	Saddar	1830	0	33	80	101	100	83	91	111	163	211	181	164	157	117	125	75	37	1	0
4	Rehmanabad	Saddar	1714	0	12	55	79	57	82	100	124	144	161	153	149	176	151	110	81	63	17	0
5	Saddar	Shamsabad	1698	0	11	137	188	134	94	93	106	112	144	112	119	102	131	98	61	56	0	0
6	Chandni Chowk	Saddar	1544	0	11	45	69	52	100	120	142	171	179	137	92	129	108	83	58	43	5	0
7	Saddar	6th Road	1472	0	11	102	96	93	101	104	105	119	106	104	110	107	94	96	68	56	0	0
8	6th Road	Saddar	1456	0	16	63	76	63	59	76	116	119	122	155	168	140	101	99	51	28	4	0
9	Saddar	Chandni Chowk	1421	0	5	64	103	126	143	121	103	97	89	98	103	111	90	78	43	47	0	0
10	Saddar	Rehmanabad	1384	0	0	68	105	84	101	107	148	96	95	106	107	119	90	70	47	41	0	0
11	Faizabad	Committee Chowk	1257	0	34	42	50	55	97	106	100	78	79	116	96	92	100	101	69	30	12	0
12	Committee Chowk	Faizabad	1222	0	21	39	52	67	67	80	73	79	108	117	124	117	88	67	68	53	2	0
13	Faizabad	6th Road	1199	0	12	44	65	83	112	116	110	90	82	85	106	78	77	65	45	28	1	0
14	Committee Chowk	Saddar	1155	0	7	36	63	60	78	95	105	78	79	107	102	97	70	86	51	35	6	0
15	Marrir Chowk	Faizabad	1087	0	29	59	64	75	69	74	82	101	70	97	94	94	65	55	37	22	0	0
16	Saddar	Committee Chowk	1075	0	7	37	48	38	41	70	93	76	91	82	88	103	95	88	74	44	0	0
17	Faizabad	Marrir Chowk	967	0	25	56	81	64	68	51	57	74	56	73	79	92	69	55	37	30	0	0
18	Faizabad	Rehmanabad	943	0	11	25	60	43	90	103	92	79	53	70	86	51	63	54	40	20	3	0
19	Faizabad	Chandni Chowk	941	0	10	51	51	75	120	111	91	89	73	52	57	41	33	30	35	20	2	0
20	Rehmanabad	Faizabad	901	0	9	17	30	28	44	47	64	104	109	94	108	91	59	42	30	25	0	0
21	Saddar	PIMS	900	3	17	63	105	123	82	86	57	71	33	63	46	45	52	24	11	19	0	0
22	Marrir Chowk	Chandni Chowk	877	0	5	55	95	103	109	72	108	51	46	54	47	38	29	37	19	9	0	0
23	PIMS	Saddar	852	0	5	9	9	21	32	56	98	89	129	48	53	89	69	45	53	46	1	0
24	Liaqat Bagh	Faizabad	841	0	7	29	48	38	49	55	48	72	71	90	64	85	58	50	43	34	0	0
25	6th Road	Faizabad	824	0	7	31	42	28	45	69	65	83	84	78	89	66	45	39	22	28	3	0
26	Marrir Chowk	Rehmanabad	806	0	4	70	88	91	81	70	52	55	70	51	51	44	21	21	24	13	0	0
27	Chandni Chowk	Faizabad	782	0	5	19	26	32	52	54	117	81	74	73	67	49	48	39	22	22	2	0
28	Saddar	Stock Exchange	767	2	12	55	158	76	70	49	36	53	37	33	44	42	35	21	22	22	0	0
29	Faizabad	Liaqat Bagh	763	0	11	19	48	51	52	67	90	57	55	55	66	45	53	44	27	15	8	0
30	Saddar	Pak Secretariat	750	3	21	125	147	85	63	58	42	35	31	32	32	22	16	19	10	9	0	0

Irregularity Index (Irr.): According to the ITDP Guide Lines of 2016 equation 6.4, the Irregularity index helps to measure the irregularities in the system i.e. more the irregularity, more will be the Irr.

Irr = Variance of the headway /scheduled headway

$$V_{Hdwy} = \frac{\sum_{i=1}^{N_{obs}} (Hdway_i - Hdway_{average})^2}{N_{obs} - 1}$$

By putting the values, we get the Irregularity Index of PMBS comes out to be 0.101708. This is because of the reason that PMBS has substituted the limit to dock at the station not less than 15 secs and not more than 30% of the headway usually not more than 30 secs.

Therefore, Irr of the PMBS is far less than ITDP Recommendations i.e. 0.3

MaxLoadPerCycle: It is given by the equation 6.6a of ITDP Planning Guide, 2016;

MaxLoadPerCycle = Max load x TC

Where MaxLoadPerCycle = Maximum Demand Load Per Cycle Time

Max Load = Max Hourly Load on Critical Link

TC = Cycle Time i.e. the time required for one complete cycle like time from Saddar terminal to Pak Sec, Pak Sec to Saddar, and come back to Saddar for the next cycle including Rotation time from terminals. In the case of the Faizabad to Saddar segment, this time is 0.68 Hours.

Keep in mind that, if the TC is larger than 1 or less than 1, a correction factor is applied to keep the MaxLoadPerCycle to a length of 1 Hour (ITDP Planning Guide, 2016, p. 184);

MaxLoadPerCycle = Max Load x TC (1-PHtoCCx(TC-1))

Where PHtoCC is the Peak Hour to Correction Factor which is usually taken as 0.1.

For MaxLoad i.e. 3,672 PPHPD and by putting all values in the given equation, MaxLoadPerCycle comes out to be 2576.86.

Waiting Time & Waiting Time Cost: By using equation 6.7 of the ITDP Planning Guide, the waiting time can be calculated as;

$$T_{\text{wait}} = 0.5 \times (1 + \text{Irr}_{\text{route}}) \times H_{\text{way}} = \frac{0.5 \times (1 + \text{Irr})}{\text{Freq}}$$

By putting values in the given equation we have $T_{\text{wait}} = 1.212$ minutes.

For calculating the cost of wait, use equation 6.8a of ITDP Planning Guide, 2016 i.e.

$$\text{WaitCost}_{\text{route}} = D_{\text{route}} \times \text{Cost of Wait} \times T_{\text{wait}}$$

Here,

$D_{\text{route}} = \text{MaxLoad} \times \text{Ren} = 3,672 \times 2.17 = 7968$ passengers from Faizabad to Saddar Link.

Cost of Wait = People are willing to pay twice to avoid delays and usually value their time at about 1/3rd of the average wage rate (ITDP Planning Guide, 2016, p. 185). As per the NESPAK feasibility study, 48% of 2001-4000 Rupees/month income class are using Public Transport (NESPAK, 2015, p. 88). While the minimum wage rate of Pakistan is 15000/ month. So by using these references, the Cost of Wait = 30 Rupees approximately per Hour (By dividing the 1/3rd of 15,000 with 176 Hours of a month).

$T_{\text{wait}} = 1.212$ minutes = 0.02 hours

The Waiting Cost of Passenger per Faizabad to Saddar Route during Peak Hour by assuming a minimum wage rate of 30 rupees per hour = 4,780 PKR in D route /Hour i.e. 1,720,800 PKR per Year.

Service Frequency required for PMBS on Hourly Basis: A comparison of hourly counts for all stations and requirement of bus frequency or headway is given in Table 4.12 and Figure 4.12.

Table 4.12: The variation of count & requirements of Frequency of Buses throughout a day.

Saddar to Pak Secretariat Route							
Saddar To Pak Secretariat Link				Pak Secretariat to Saddar Route Link			
Hours of a day	Count	No. Of Buses Required	Headway (Min)	Hours of a day	Count	No. Of Buses Required	Headway (Min)
6 to 7	878	7	8.57 Mints	6 to 7	571	4	15 Mints
7 to 8	5085	40	1.5 Mints	7 to 8	2414	19	3.16 Mints
8 to 9	7629	60	1 Mints	8 to 9	3125	24	2.5 Mints
9 to 10	6201	48	1.25 Mints	9 to 10	3108	24	2.5 Mints
10 to 11	5594	44	1.36 Mints	10 to 11	3788	30	2 Mints
11 to 12	5484	43	1.4 Mints	11 to 12	4763	37	1.62 Mints
12 to 13	5105	40	1.5 Mints	12 to 13	5770	45	1.33 Mints
13 to 14	5231	41	1.46 Mints	13 to 14	6086	48	1.25 Mints
14 to 15	4825	38	1.58 Mints	14 to 15	6027	47	1.28 Mints
15 to 16	4626	36	1.67 Mints	15 to 16	6143	48	1.25 Mints
16 to 17	4525	35	1.71 Mints	16 to 17	6896	54	1.11 Mints
17 to 18	4475	35	1.71 Mints	17 to 18	6888	54	1.11 Mints
18 to 19	3593	28	2.14 Mints	18 to 19	5775	45	1.33 Mints
19 to 20	2788	22	2.73 Mints	19 to 20	4064	32	1.88 Mints
20 to 21	2254	18	3.33 Mints	20 to 21	3003	23	2.61 Mints
21 to 22	1774	14	4.29 Mints	21 to 22	2054	16	3.75 Mints

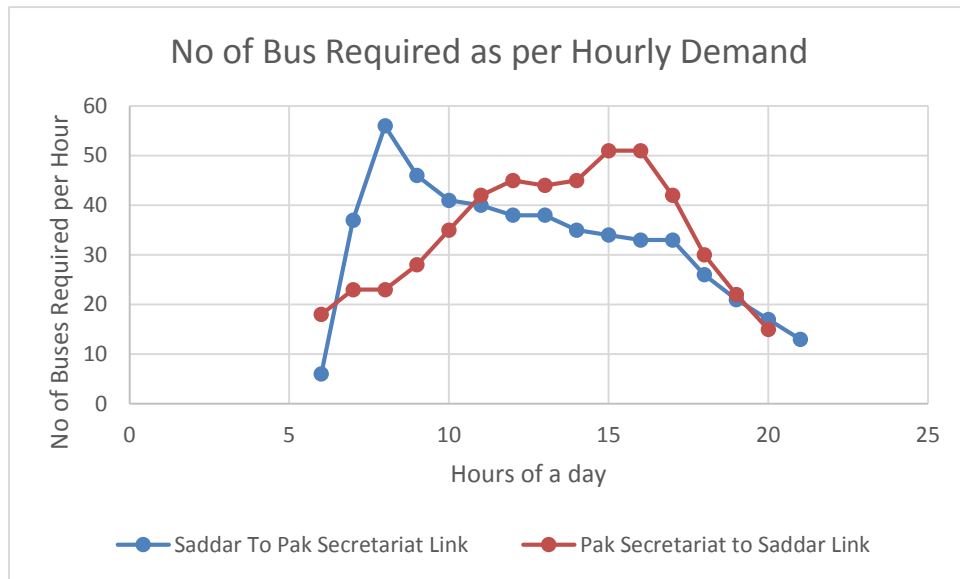


Figure 4.12: No of Bus Required as per hourly demand

4.3. Implementation of Scheduling Model

Regarding the Figure 3.6, the stepwise implementation of the proposed model is given in the following paragraphs;

Step 01: The determination of all possible OD links of PMBS

Using SQL software, all possible links of 24 stations of PMBS are determined. The top 30 such links have already been shown in Table 4.11: Top 30 Links/Segments of PMBS.

Step 02: Hourly Distribution

The next step of the model is the distribution of the links Check-in/out at each station on Hourly Bases. Again in Table 4.11: Top 30 Links/Segments of PMBS the hourly distribution of each link is shown i.e. from 5 AM to 11 PM.

Step 03: Directional Distribution

By calculating the hourly distribution, the data can be split into directional variation. For example, Appendix A4 shows the even distribution of Load in each hour of a day for a Saddar to Pak Secretariat Direction. At the end of this table, the required frequency of buses & headway based on do nothing scenarios are calculated. We can

see that around 23,000 KMs of bus travel is the demand in both directions of PMBS for do-nothing case. Since the existing PMBS structure is running at 14,886 KMs of Bus Travel, therefore further analysis is required.

Step 04: Load Distribution on each link @ given Load Factor

This is the ideal case that is in case if the bus is available to each link of all possible links of PMBS. The next step is the distribution of load to each link uniformly at 0.85 load factor. For Appendix A4 the demand for buses on hourly bases can be seen in Figure 4.13.

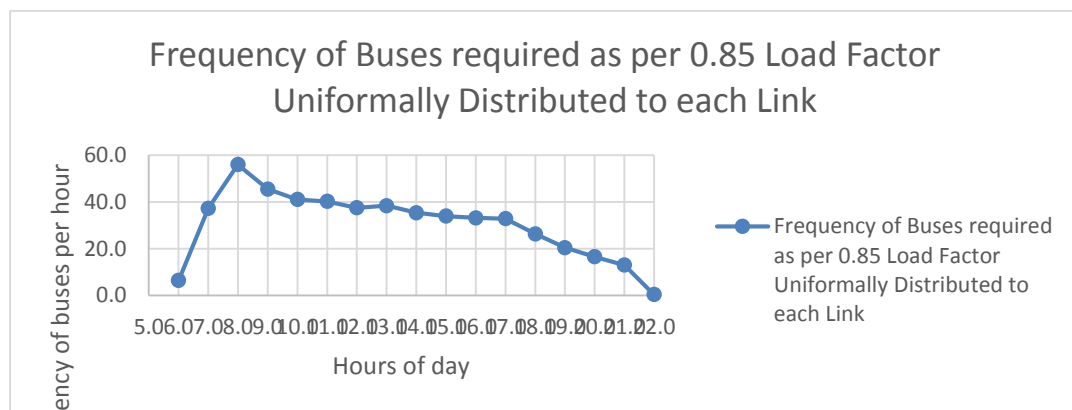


Figure 4.13: Frequency required on an hourly bases if 0.85 is uniformly distributed to each possible link in one direction

Step 05: Determination of Constraints

However, the buses available to each link at every hour of the day as per demand is an ideal case due to the following constraints;

- I. Buses start trips from terminals then available to all other stops/stations as per their distances or sequence.
- II. Directional constraint i.e. scheduling for each direction.
- III. The dispatch plans i.e. the same or feasible number of buses available to a direction as available to its other direction or the abrupt change of bus requirements on an hourly basis.
- IV. Physical entities deciding the express or limited routes. For example, in the case of PMBS, IJP, Potohar, Kashmir Highway & Parade Ground Rotaries are available for rotation of buses.

- V. Capacity of station (For PMBS, this constraint is not used at this level of study)
- VI. Capacity of Buses and comfort level e.g. for safety of passengers & vehicle operating & maintenance cost, the load factor of 0.85 is used.

Step 06: Determination of demand (frequency, headways, etc.)

See Appendix A4.

Step 07: Identification of Junction Point or points for Express or Limited Stop routes (If any)

The next step is the identification of the junction station so that the express or limited-stop routes can be suggested. For this purpose, the following steps have been carried out;

- I. Determination of top links for each direction. For example, for the case of PMBS, top links are Saddar to Faizabad & Faizabad to Saddar.
- II. Determine if there is any section where a sharp change in demand is observed. For example, for PMBS, it is seen that after Faizabad (10th station) station, 11th to 24th stations have significant no of difference in demands as shown in figure;

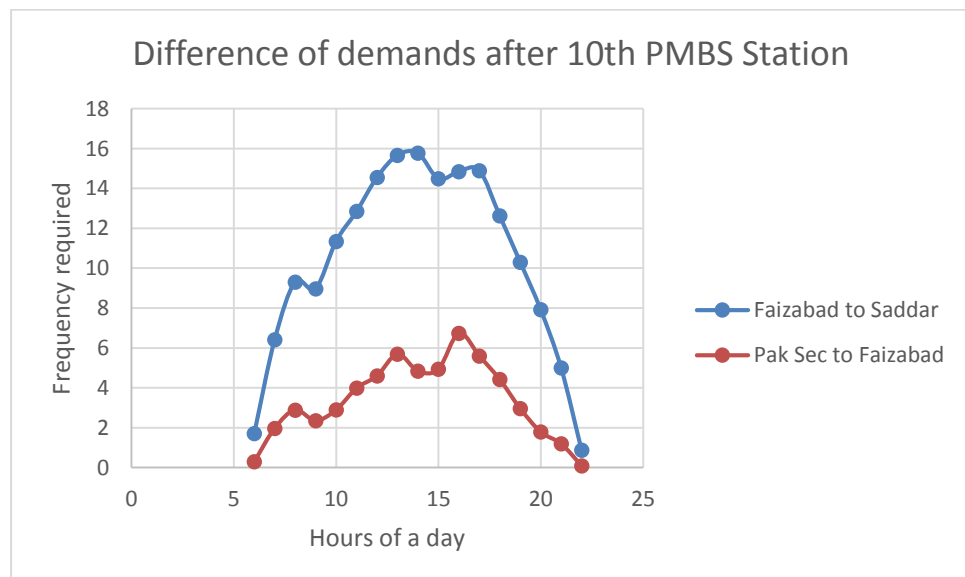


Figure 4.14: Difference of demands b/w two sections of PMBS

- III. See if there any links having the same level demands of both directions.

Step 08: Scheduling for Express or Limited Stop routes.

If junction point or points are identified, the next step is the determination of route for Express & Limited Stops.

4.4. Results

The data for analysis consists of check-in/out reports of passengers from stations' entry or exit points. Two types of fare media are available; Token & Cards. KENTKART helps to store all data in CSV format. For the Year 2018, around 40 Million entries of Check-in/out of passengers are available which requires tools for understanding data. For this purpose, programs are formed in SQL & VBA of Excel and a 24x24 matrix of check-in/out from all stations were generated. The output of the SQL program top ten links can be seen in Table 4.11: Top 30 Links/Segments of PMBS.

The selection of software for analysis is necessary for this thesis work because to date no current demand modeling software has such capabilities. (ITDP Planning Guide, 2016, p. 164) to get the output of all disaggregated trip data available in computer programs. To propose an optimal service plan, its costs and benefits must be known and understanding customers' needs is essential. (ITDP Planning Guide, 2016, p. 164).

For determination of the number of customers transferring b/w routes, we need to determine the OD matrix for the route. For example, if we have 24 stations, we will get 24x24 matrices having data of transferring between routes for a single direction. To generate this OD matrix, we need Structured Query Language Software (SQL). So that to understand the behavior of each user.

For a single day, OD Matrix is obtained for 15th January 2018. The following information has been gathered;

Determination of the Critical Link

As per the above data, there are 3 seasons in a year of PMBS. Among all seasons, the Jan-April season has the highest ridership as compared to the others while the least ridership is observed during May-August because of Ramzan & Eid Holidays.

In Jan-April, January is the most ridership month. And the peak ridership is observed on the 15th of January, 2015. Therefore, 15th Jan data is used for data analysis.

Analysis of Data of Season 1 & 3:

For a single day say 15th Jan 2018, the following information's are collected;

1. PMBS connects Rawalpindi City with Islamabad City with 1 to 9 Stations in Rawalpindi Region & 11 to 14 Stations in Islamabad Region while considering the 10th Station i.e. Faizabad at the middle of two regions that connects them. So 3 types of travel patterns are generated. 1) Passengers travel within Rawalpindi Region 2) Passengers travel within Islamabad Region 3) Passengers travel from Rawalpindi to Islamabad and vice versa. Data shows that passengers who travel within the Rawalpindi-Rawalpindi region comprises of 40% of total ridership. 44 % are traveling from Islamabad to Rawalpindi region & 16% in Islamabad to Islamabad region. However, for weekends, it comes 43%, 43.5% & 13.5 % respectively

Table 4.13: %age of Trip Distribution based on Different Regional Configuration.

Jan 2018	Within Rawalpindi	Within Islamabad	Islamabad-Rawalpindi
Average of all Sat	43.84	12.97	43.00
Average of all Sun	42.02	13.85	43.90
Average of all Mon	39.80	15.89	44.16
Average of all Tue	38.43	17.04	44.38
Average of all Wed	39.50	16.26	44.11
Average of all Thu	40.09	15.92	43.83
Average of all Friday	37.61	17.49	44.75
	40.18	15.63	44.02

2. In the Islamabad-Rawalpindi region, most of the passengers travel in Morning & Evening timings. The 24 x 24 matrix shows that from Saddar to

3. By considering Faizabad as Junction Point, three (03) Routes are present. 1) Saddar to Faizabad Route (Within Rawalpindi Region), 2) Faizabad to Pak Secretariat Route (Within Islamabad Region) & 3) Saddar to Pak Secretariat Route (Trips from Rawalpindi to Islamabad & Vice Versa). As already mentioned, the Critical Link of the 1st route i.e. Saddar to Faizabad Route is Faizabad to Saddar Link with load at Peak Hour (15-16 Hours) 266 Passengers. The Critical Link of 2nd & 3rd Routes are Pak Secretariat to Potohar Link (For Week Days) with load at Peak Hour (15-16 Hours) is 108 Passengers & Saddar to PIMS Link with load at Peak Hour (8-9 Hours) is 123 Passengers respectively.

Route 1 i.e. Saddar to Faizabad (Within Rawalpindi Region)

4. The Faizabad to Saddar Link is the busiest link of a day. For a whole month of January 2018, Faizabad to Saddar Link & Saddar to Faizabad Link is at the top 1st and 2nd positions respectively (seen in Table 4.11: Top 30 Links/Segments of PMBS). The average trips from Faizabad to Saddar Link for a whole month of January are 2,814 Trips & for Saddar to Faizabad Link are 2608 Trips.

Table 4.14: Monthly Daily Average Trips for Faizabad to Saddar & Saddar to Faizabad for Jan 2018

Day of January 2018	Link	
	Trips for Faizabad to Saddar	Trips for Saddar to Faizabad
1	3043	2538
2	2818	2634
3	2740	2492
4	2776	2672
5	2767	2749
6	2610	2477
7	2984	2448
8	3106	2889
9	3028	2859
10	2850	2647
11	2801	2560

Day of January 2018	Link	
	Trips for Faizabad to Saddar	Trips for Saddar to Faizabad
12	2845	2838
13	2667	2417
14	3025	2538
15	3064	2863
16	2885	2777
17	2826	2596
18	2783	2714
19	2840	2794
20	2602	2372
21	2872	2409
22	3153	2825
23	2828	2548
24	2681	2447
26	2673	2637
27	2467	2396
28	2562	2267
29	2959	2716
30	2554	2521
31	2605	2591
Average	2813.8	2607.7

5. For the top 10 Links lie within the Rawalpindi-Rawalpindi region (See Table 4.11: Top 30 Links/Segments of PMBS). For working days i.e. Monday to Friday, Rawalpindi-Rawalpindi type of trips are at the top 15 to 20. While for weekends i.e. Saturdays & Sundays, Saddar to PIMS comes at 11 to 13. Shows recreational or shopping trips these days.
6. The travel pattern on an hourly basis for Faizabad to Saddar Link & Saddar to Faizabad Link is shown in figures Figure 4.15 to Figure 4.21 (For a complete week). The pattern remains the same for Monday-Thursday and different for Friday, Saturday & Sunday.

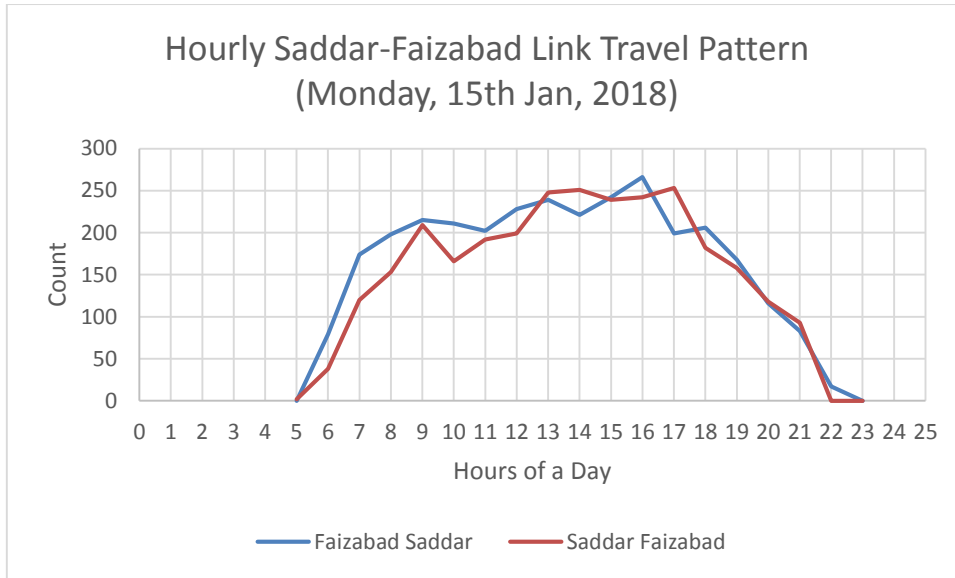


Figure 4.15: Hourly Travel Pattern Saddar to Faizabad Link Monday, 15th Jan 2018

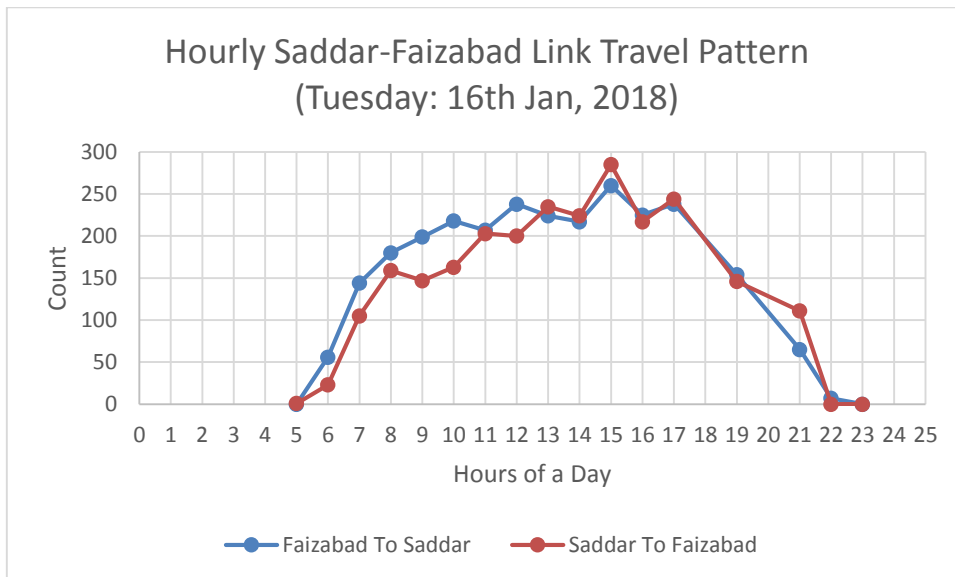


Figure 4.16: Hourly Saddar to Faizabad Link Travel Pattern Tuesday, 16th Jan 2018.

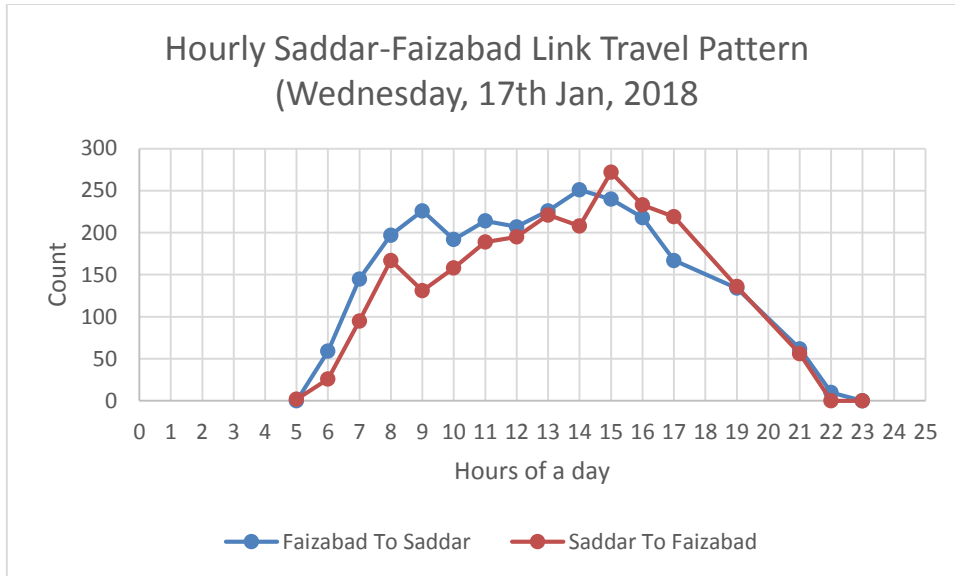


Figure 4.17: Hourly Saddar to Faizabad Link Travel Pattern Wednesday, 17th Jan 2018.

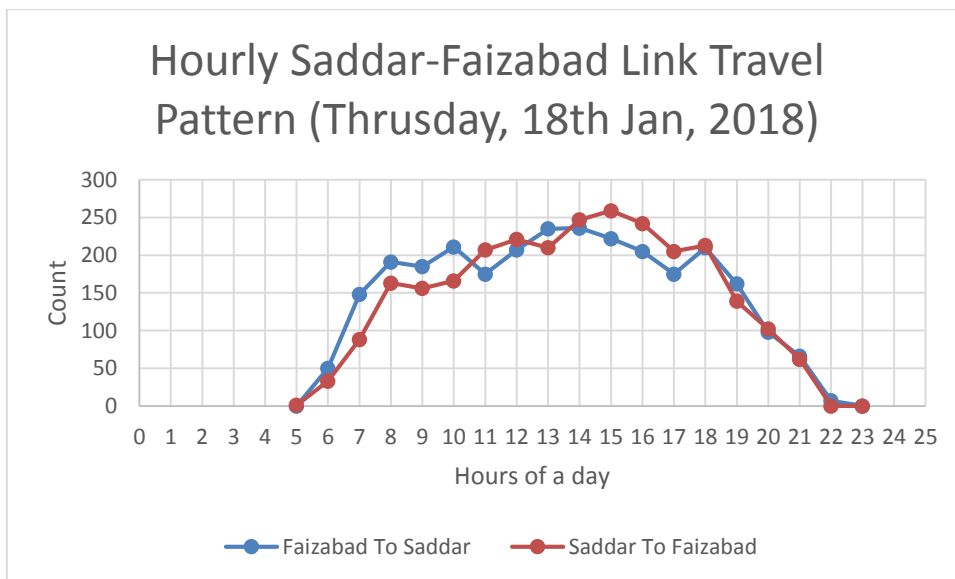


Figure 4.18: Hourly Saddar to Faizabad Link Travel Pattern Thursday, 18th Jan 2018

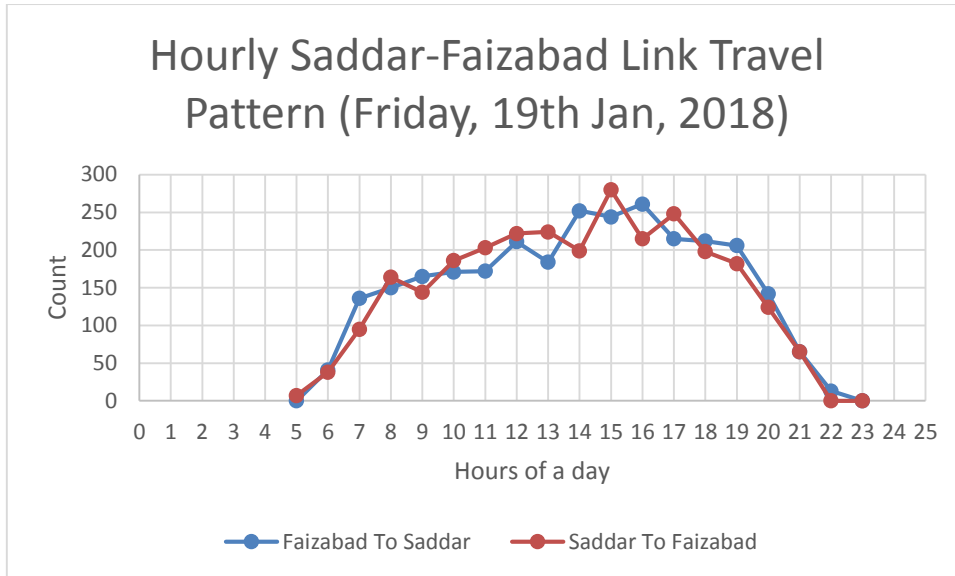


Figure 4.19: Hourly Saddar to Faizabad Link Travel Pattern Friday 19th Jan 2018

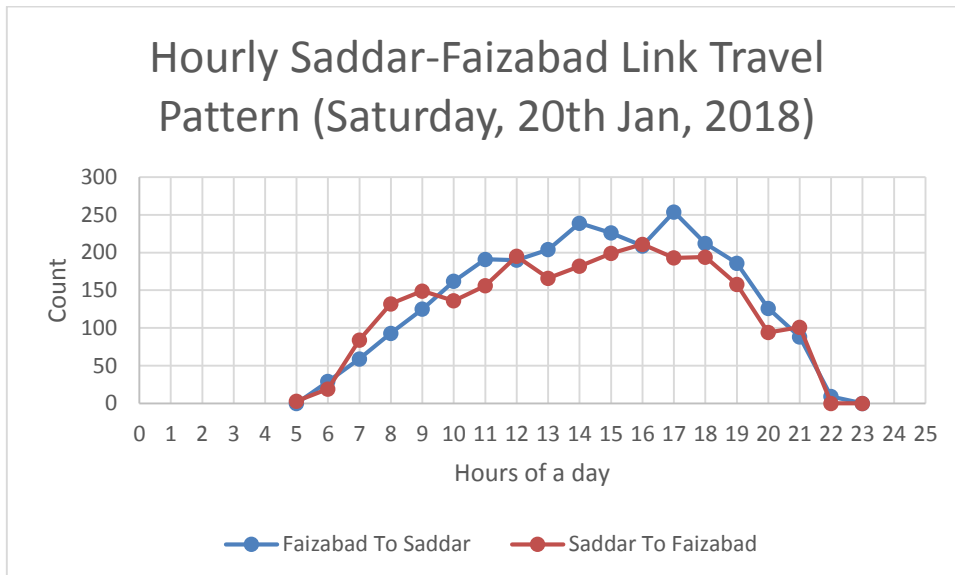


Figure 4.20: Hourly Saddar to Faizabad Link Travel Pattern Saturday 20th Jan 2018

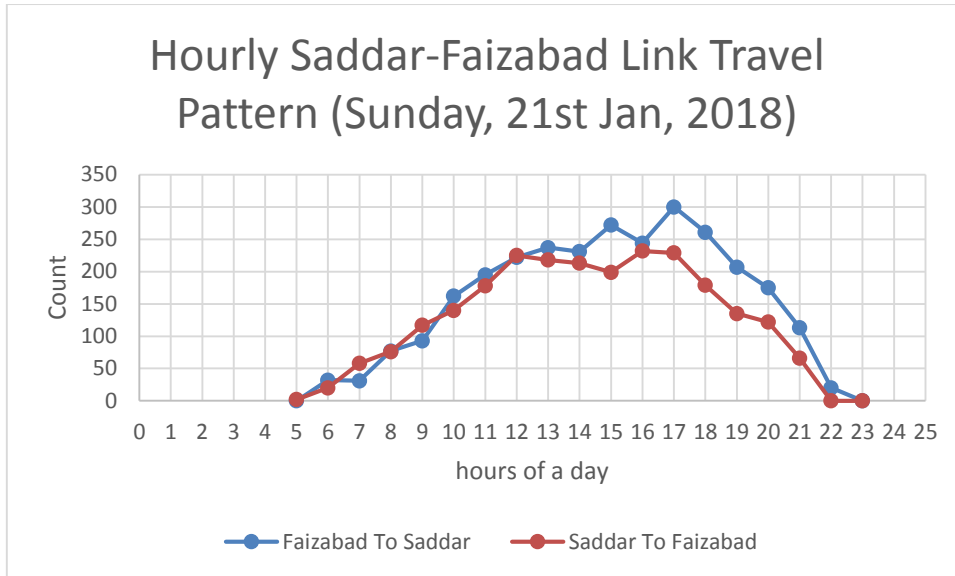


Figure 4.21: Hourly Saddar-Faizabad Link Travel Pattern Sunday 21st Jan 2018

- Observations are collected in the form of the table given below. The average passenger ride for Faizabad to Saddar link is almost the same for working days. Commercial Area availability in the Saddar area which shows shopping trips are executed.

**Table 4.15: Average of Trips from 0700 to 1900 hours for a week of
Jan 2018.**

Day	Link	Average No. of Passengers (7 to 19 Hours of a day)	Day	Link	Average No of Passengers (7 to 19 Hours of a day)
Monday	Faizabad to Saddar	213	Monday	Saddar to Faizabad	200
Tuesday	Faizabad to Saddar	205	Tuesday	Saddar to Faizabad	195
Wednesday	Faizabad to Saddar	199	Wednesday	Saddar to Faizabad	186
Thursday	Faizabad to Saddar	197	Thursday	Saddar to Faizabad	194
Friday	Faizabad to Saddar	198	Friday	Saddar to Faizabad	197
Saturday	Faizabad to Saddar	181	Saturday	Saddar to Faizabad	166
Sunday	Faizabad to Saddar	195	Sunday	Saddar to Faizabad	170

8. An average of 220 passengers per hour is traveling from Faizabad to Saddar from 8AM to 7 PM without significant change & 212 passengers are using Saddar to Faizabad link i.e. 2 buses/ hour demand for this complete cycle for 80% load factor.
9. If a bus travels from Saddar to Faizabad or vice versa while stopping at all stations between Saddar & Faizabad, it takes 17 minutes 50 seconds to reach at endpoints (17.5 secs Average Dead Time + 30 secs boarding/alighting time at station). For a route that boards passengers directly from Faizabad to Saddar or vice versa, it takes 11.25 minutes to reach at endpoints without waiting time at stations. This difference is 6 minutes 40 seconds. It means a passenger can wait up to 23.375 minutes due to which passengers may use Local Route for journey. The scheme is shown in figure;

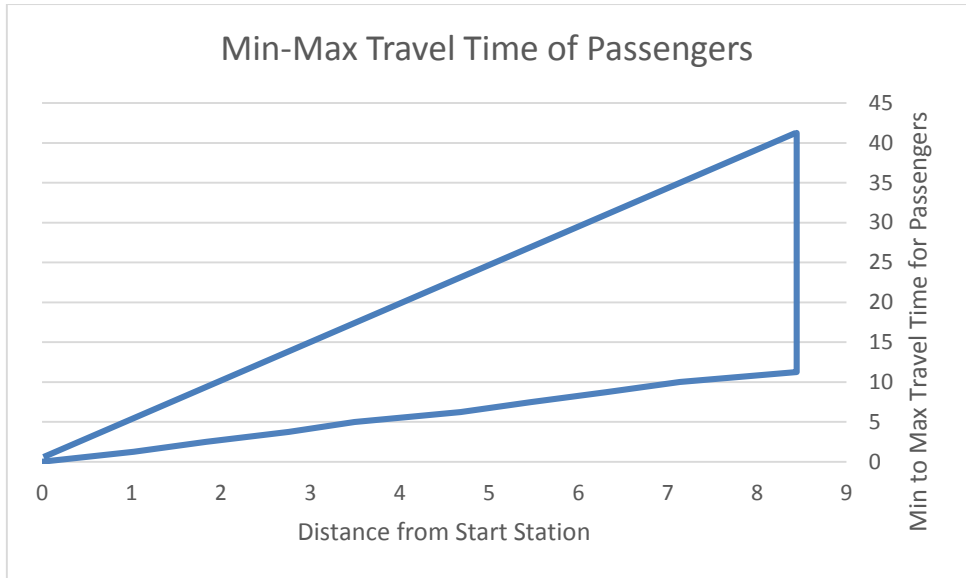


Figure 4.22: Minimum & Maximum Travel Time of Passengers if Faizabad-Saddar Express service is provided.

Route 2 i.e. Faizabad to Pak-Secretariat (Within Islamabad Region)

10. Strikingly a uniform behavior is observed for Faizabad to Pak Secretariat Route (Only for weekdays, for weekends, PIMS to Potohar seem to be a Critical Link) as shown in the given charts (Figure 4.23 to Figure 4.27).

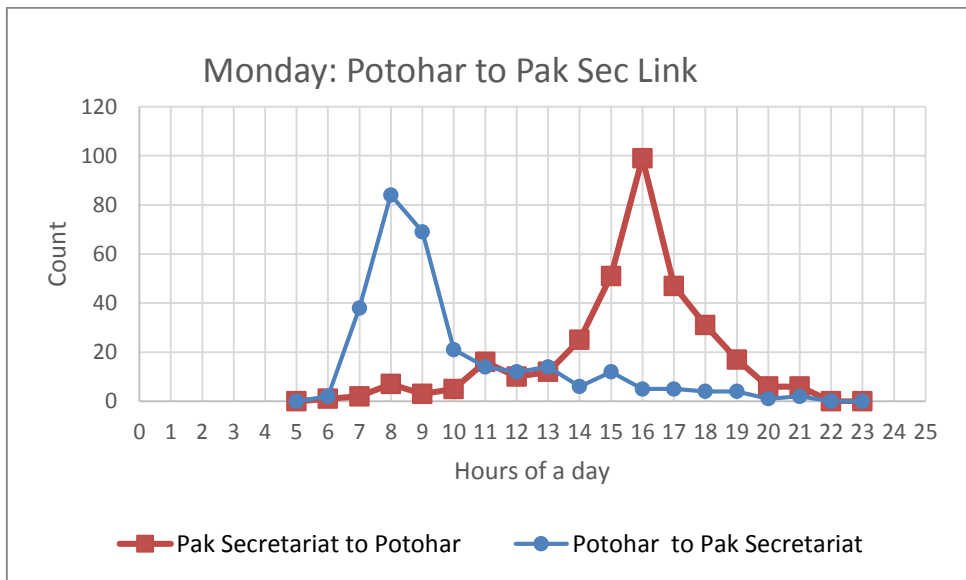


Figure 4.23: Monday: Potohar to Pak Sec Link Travel Pattern

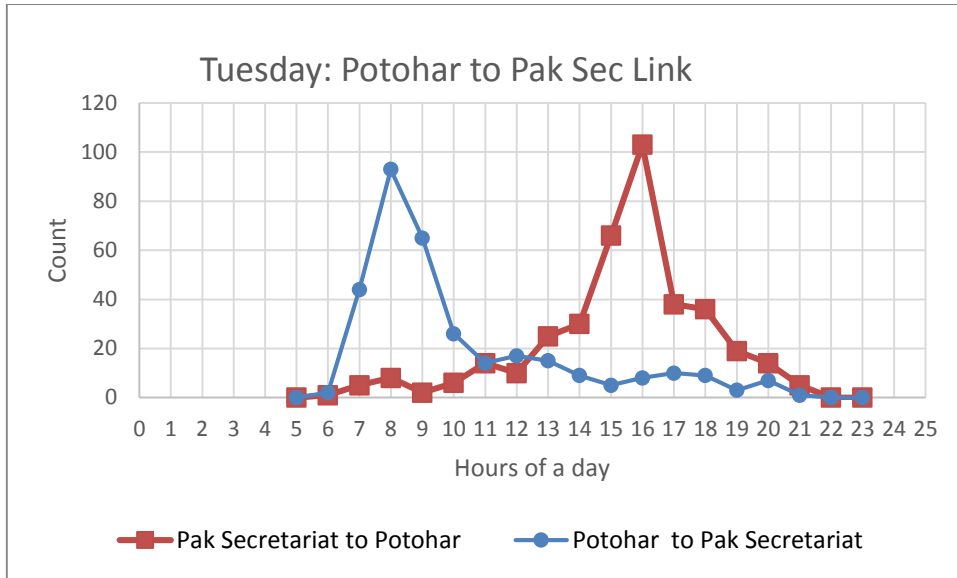


Figure 4.24: Tuesday: Potohar to Pak Sec Link Travel Pattern

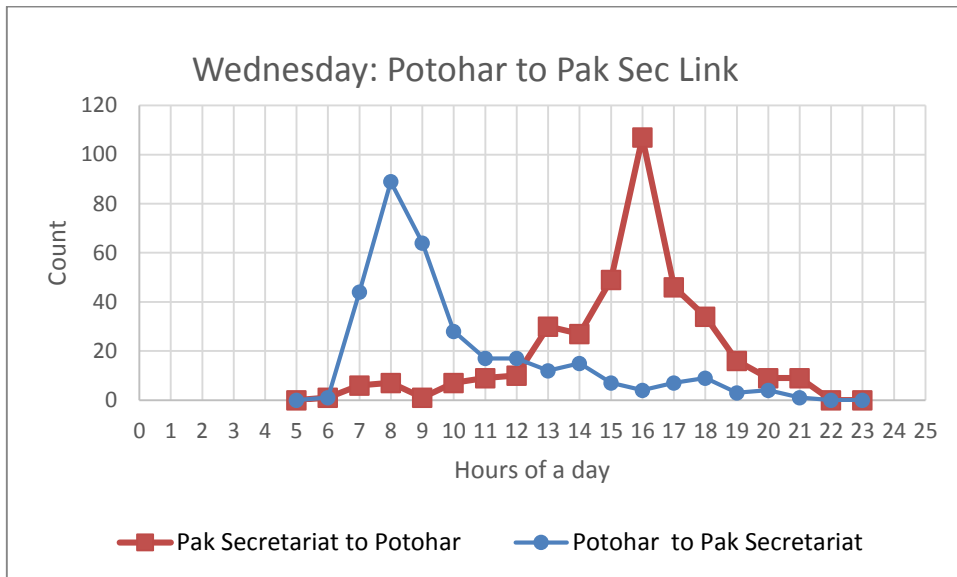


Figure 4.25: Wednesday: Potohar to Pak Sec Link Travel Pattern

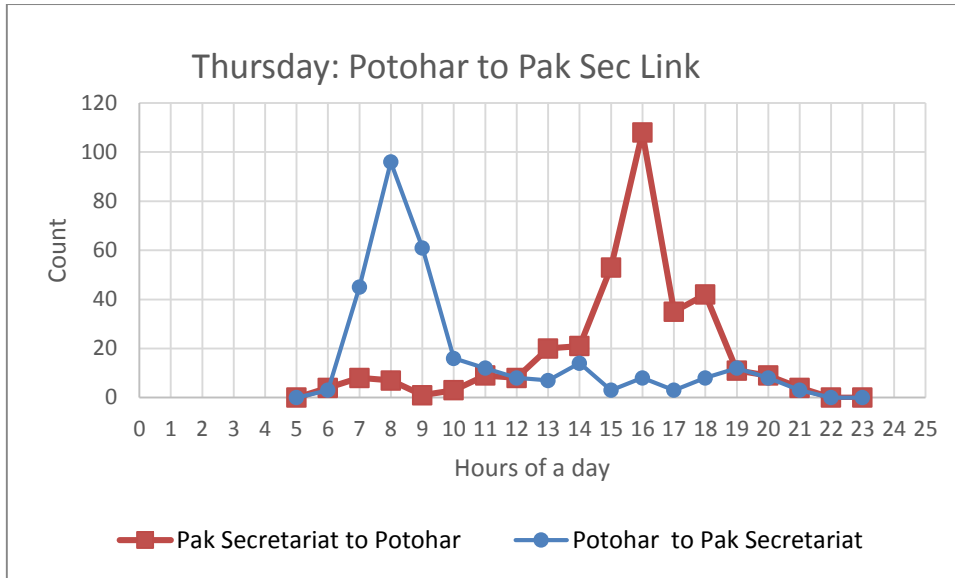


Figure 4.26: Thursday: Potohar to Pak Sec Link Travel Pattern

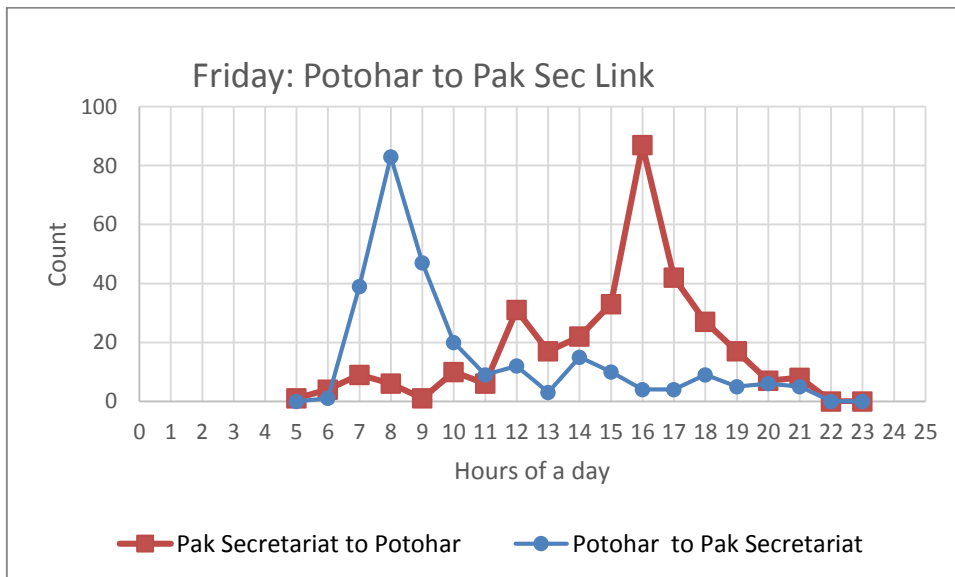


Figure 4.27: Friday: Potohar to Pak Sec Link Travel Pattern

Route 3 i.e. Saddar to Pak-Secretariat (Trips from Rawalpindi to Islamabad and Vice Versa)

11. For Saddar to Pak Secretariat Route; Saddar to PIMS & PIMS to Saddar Links are the busiest of all. The travel behavior of this route is shown in Figure 4.28 to Figure 4.34. It can be seen that almost the same travel pattern observe throughout all days of a month.

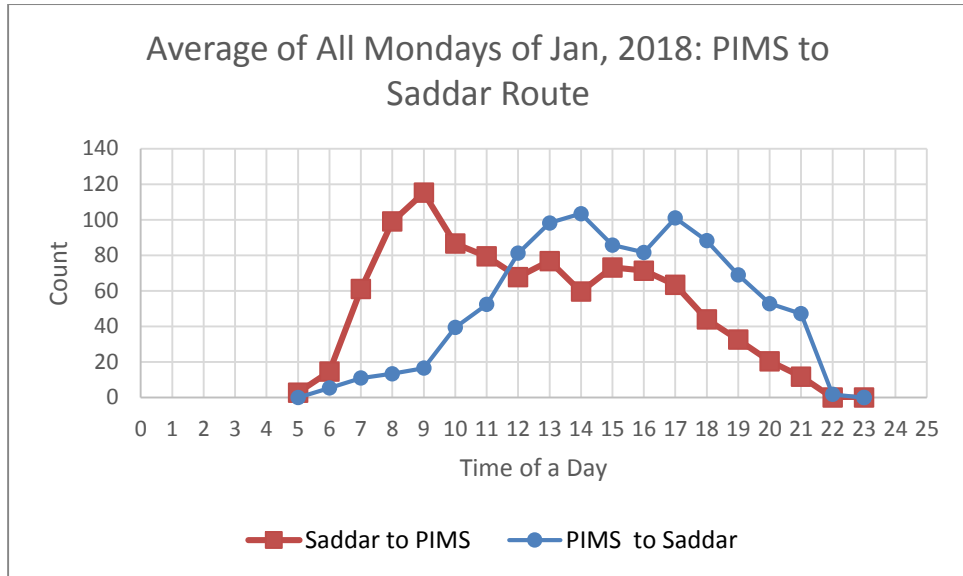


Figure 4.28: Average of all Mondays of Jan 2018 of PIMS to Saddar Route

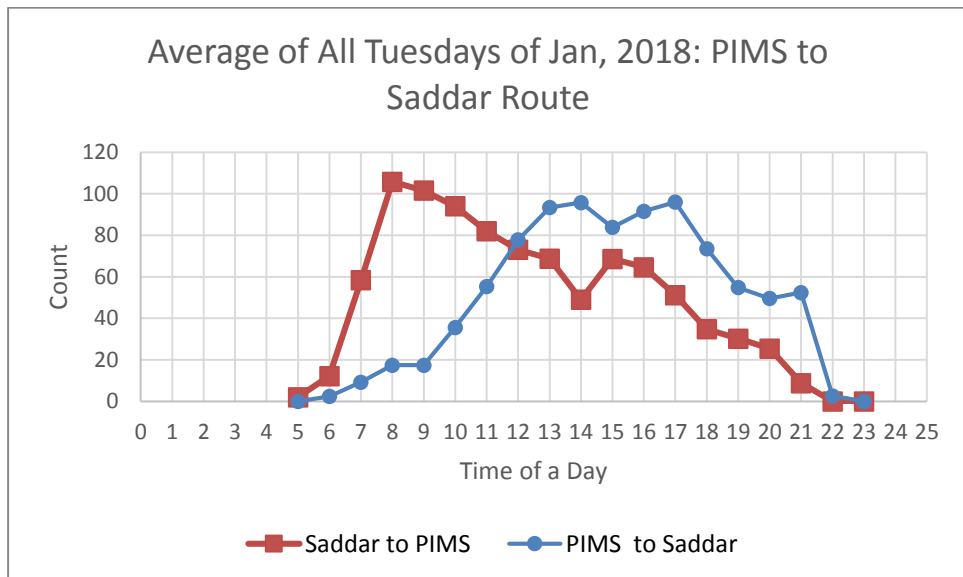


Figure 4.29: Average of all Tuesdays of Jan 2018 of PIMS to Saddar Route

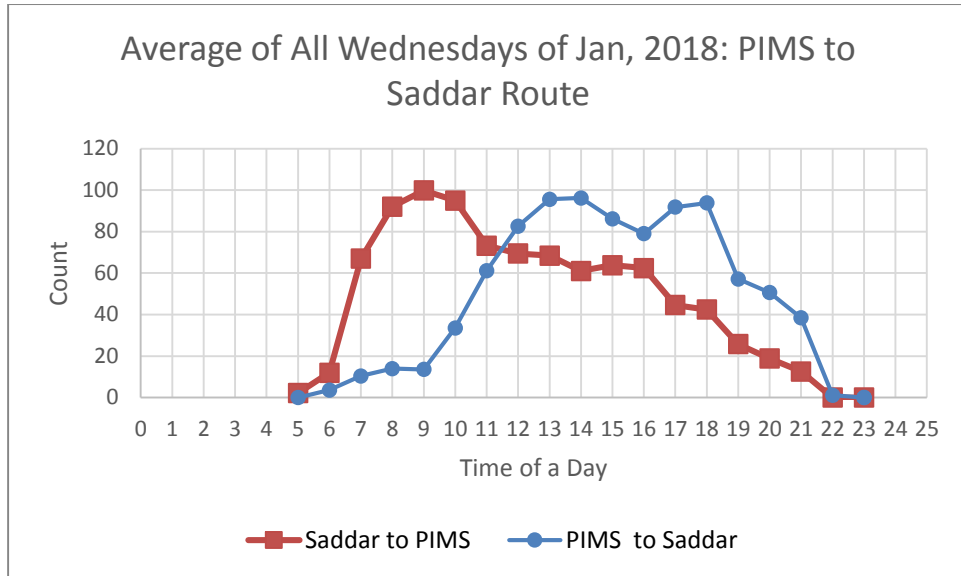


Figure 4.30: Average of all Wednesdays of Jan 2018 of PIMS to Saddar Route

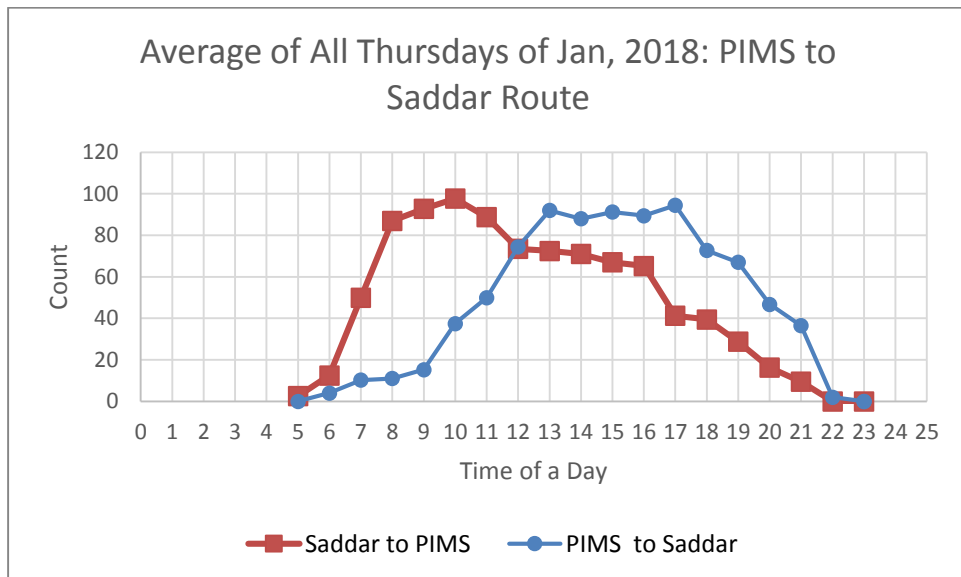


Figure 4.31: Average of all Thursdays of Jan 2018 of PIMS to Saddar Route

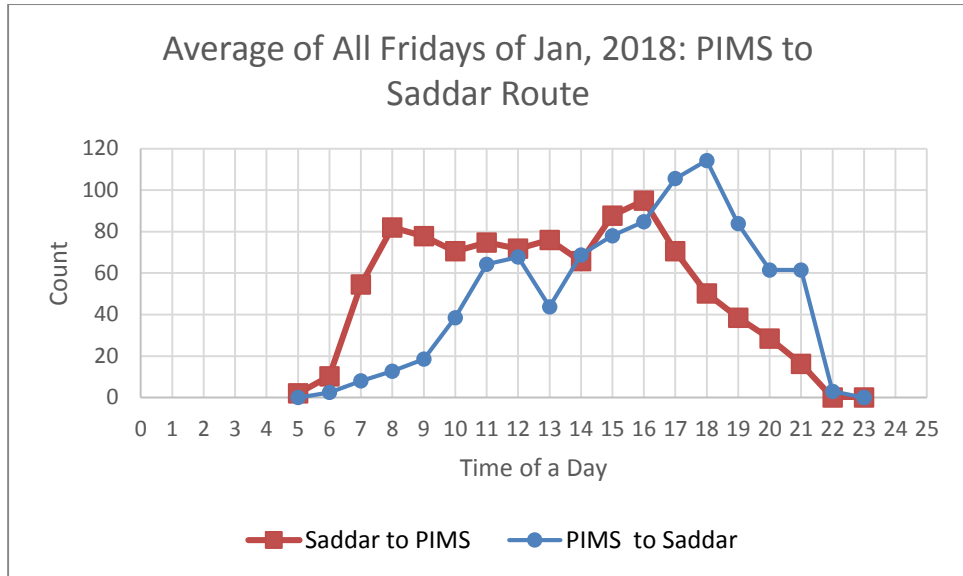


Figure 4.32: Average of all Fridays of Jan 2018 of PIMS to Saddar Route

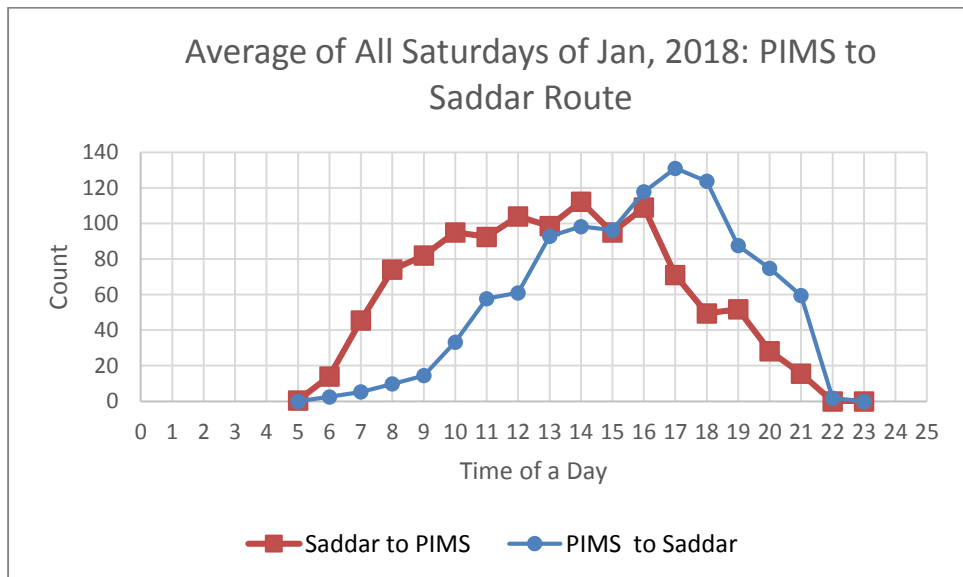


Figure 4.33: Average of all Saturdays of Jan 2018 of PIMS to Saddar Route

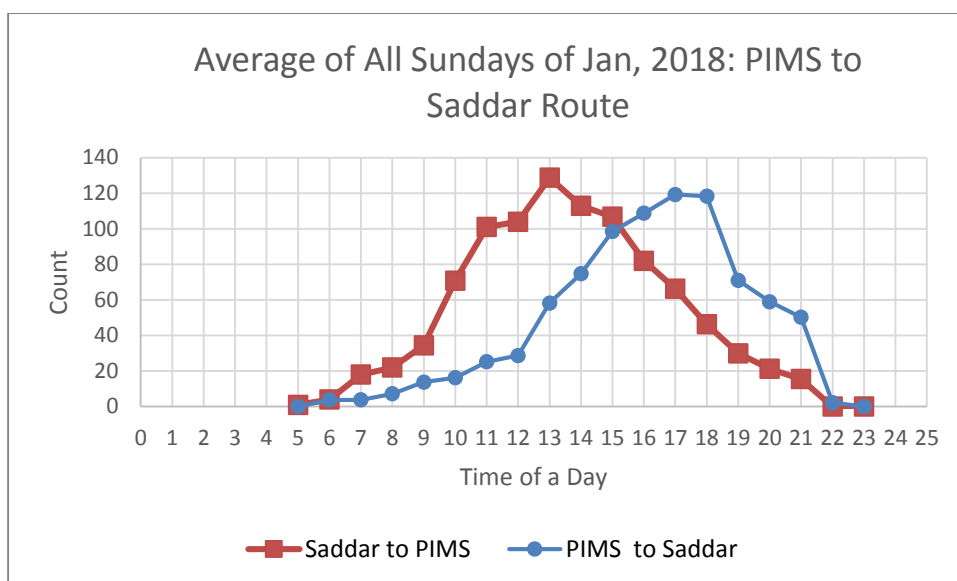


Figure 4.34: Average of all Sundays of Jan 2018 of PIMS to Saddar Route

12. The summary of the above analysis can be seen in Based on the above analysis, the following routes can be formulated in PMBS;

Table 4.16: The Summary of Critical Links & Demands

Sr No.	Route Name	Critical Link	Workday/Weekday	Peak Hour	Peak Load
1	Saddar to Faizabad	Faizabad to Saddar	Both	No Peak observed. From 7 AM to 7 PM almost 200 Passengers are traveling per hour	Average 200 Per Hour
2	Faizabad to Pak Secretariat	Potohar to Pak Secretariat	Workday	Two Peaks i.e. Morning & Evening, 8 Hours & 16 Hours respectively	Average 100 Passengers/ Hour
3	Faizabad to Pak Secretariat	PIMS to Potohar/IJP	Weekday	No significant peak is observed	Average 15 Passengers/Hour for a whole day are traveling

Sr No.	Route Name	Critical Link	Workday/ Weekday	Peak Hour	Peak Load
4	Saddar to Pak Secretariat	Saddar to PIMS	Both	Two Peaks mostly, Morning 8 or 9 Hours and Evening 14 & 17 Hours	100 Passengers/ hour

Analysis of Data of Season 2:

Season 2 is the months of May to August. As shown in Table 4.7: Comparison of Drop of Ridership during Ramzan Season in Years 2015-2018, during this season there is the least ridership due to 4 reasons. 1) Ramzan (Islamic month in which Muslims fast for the whole month), 2) Eid-ul-Fitar (Islamic Festival/ event) & 3) Eid-ul-Azha (Islamic Festival/event) 4) The summer vacation starts from May till End of August in all schools, colleges & universities. The analysis of the data for this season shows the following important information;

13. The top 15 links lie in the Rawalpindi-Rawalpindi region. So this region is the busiest among other regions i.e. Islamabad-Islamabad & Rawalpindi-Islamabad.
14. The critical link for all days of a week during Ramzan remains Faizabad to Saddar link with average 1,938 trips for working days (Mon-Fri) & average 1,443 trips for non-working days (Sat & Sun). While for season 1 & 3 it was 2,813 trips i.e. around 1000 trips less than season 1 & 3. While Saddar to Faizabad being the 2nd highest link.
15. The Travel Pattern for Faizabad to Saddar & Saddar to Faizabad Links for Monday-Sunday are shown in Figure 4.35 to Figure 4.41. It shows only 2 peaks (Morning & Evening) are formed from 0700 to 0759 or 0800 to 0859 hours and 1200 to 1259 or 1300 to 1359 or 1400 to 1459 hours of working days. While on Saturday & Sunday a significant number of riders shows from 0900 to 1700 hours.

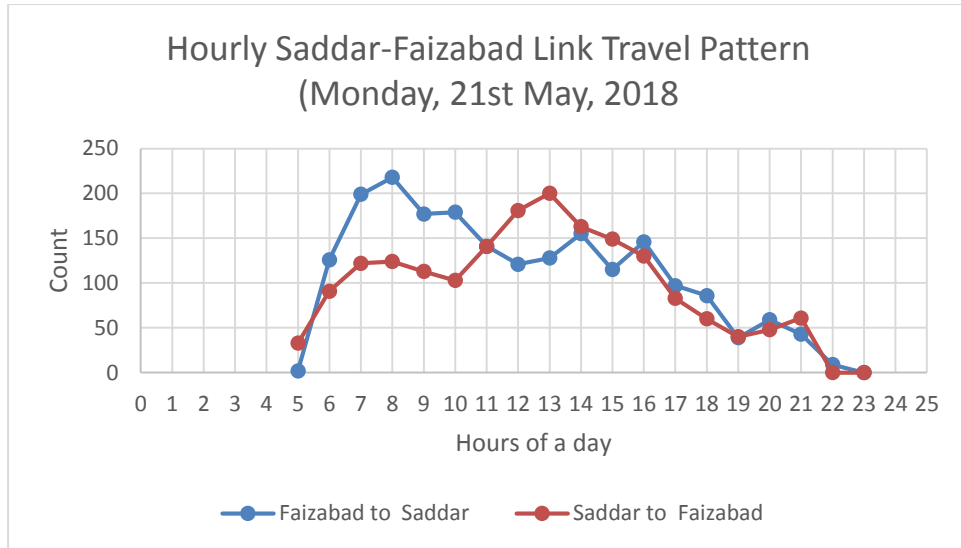


Figure 4.35: Hourly Saddar-Faizabad Route Travel Pattern Monday, 21st May.

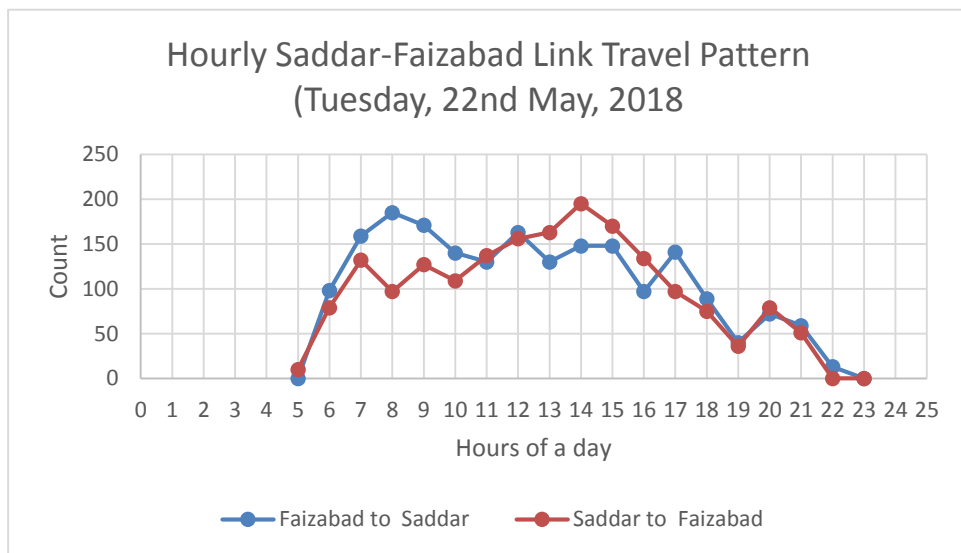


Figure 4.36:: Hourly Saddar-Faizabad Route Travel Pattern Tuesday, 22nd May.

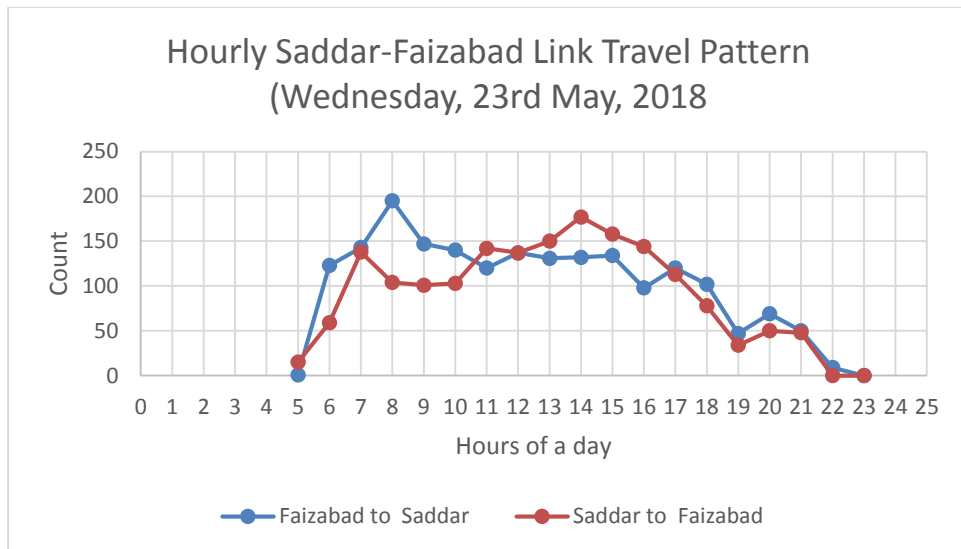


Figure 4.37: Hourly Saddar-Faizabad Route Travel Pattern Wednesday, 23rd May 2018.

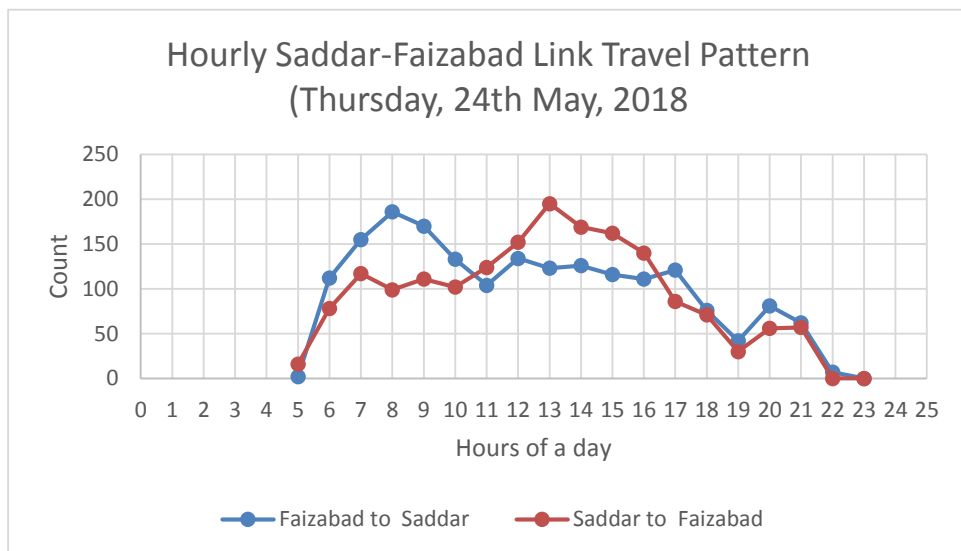


Figure 4.38: Hourly Saddar-Faizabad Route Travel Pattern Thursday, 24th May 2018.

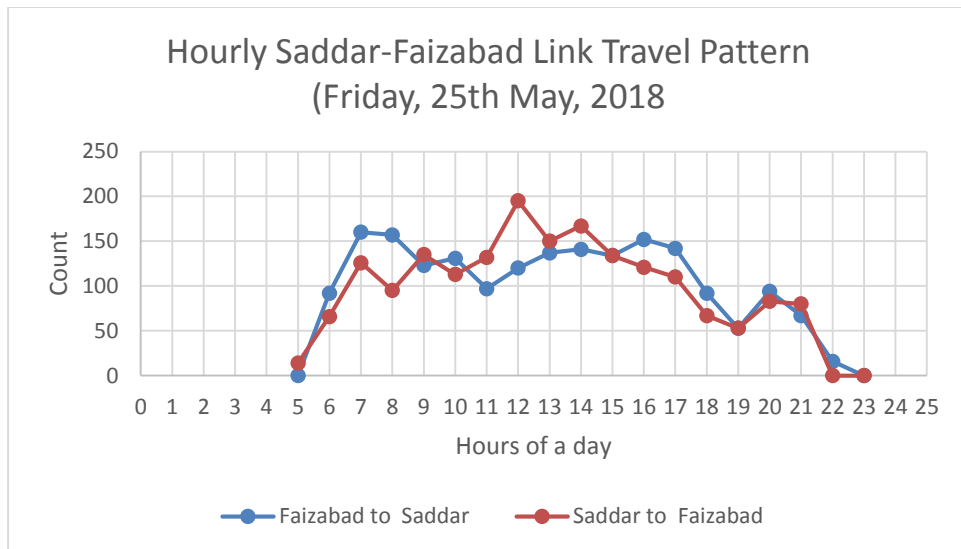


Figure 4.39: Hourly Saddar-Faizabad Route Travel Pattern Friday, 25th May

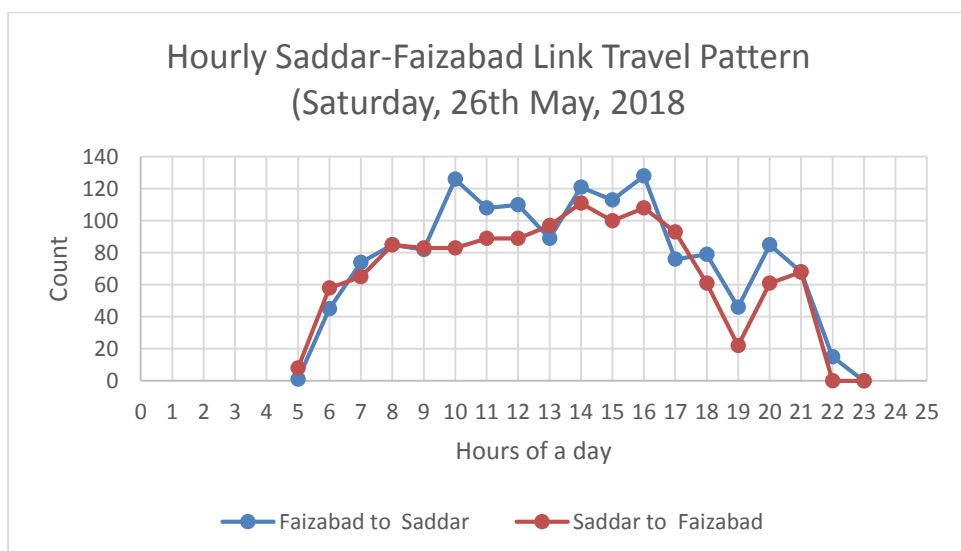


Figure 4.40: Hourly Saddar-Faizabad Route Travel Pattern Saturday, 26th May 2018.

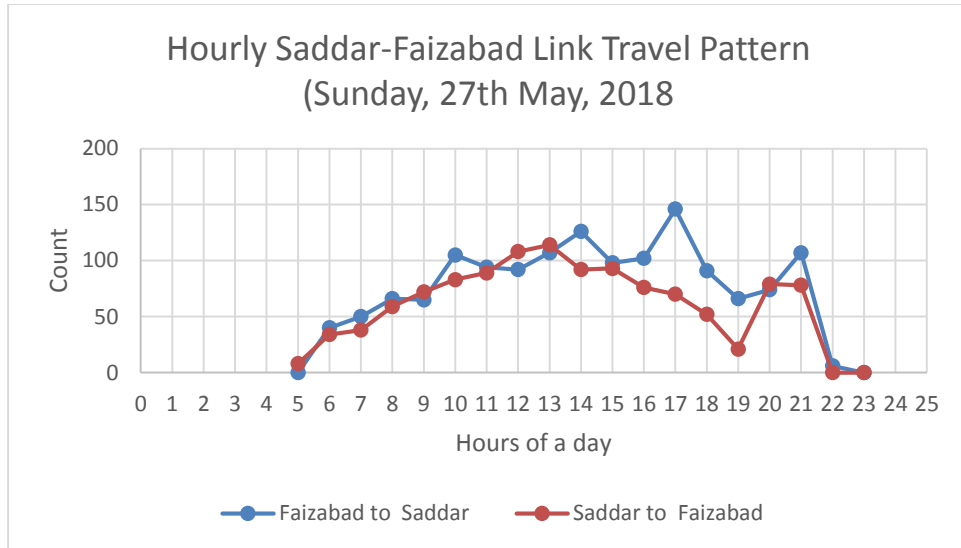


Figure 4.41:: Hourly Saddar-Faizabad Route Travel Pattern Sunday, 27th May 2018.

16. The Travel Pattern for Potohar to Pak Sec Route for Monday to Friday is the same as mentioned for Seasons 1 & 3 with peak timings different i.e. Morning as 0700 to 0859 Hours & Evening as 1400 to 1459 Hours. For example, the peaks for Monday is shown in Figure 4.42. There is no significant number of rides for this link for Sat & Sun.

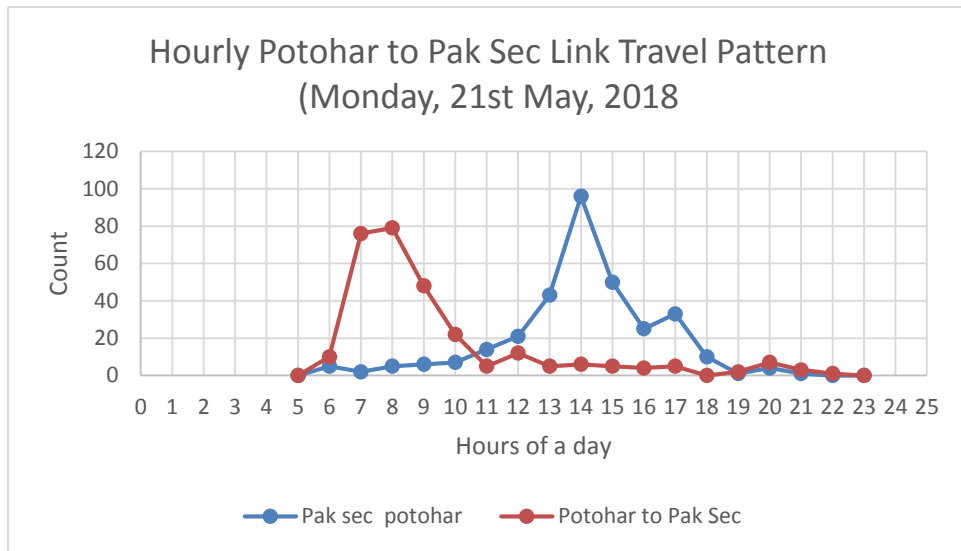


Figure 4.42: Potohar to Pak Sec Route

17. Change in timings of the peaks is due to the changing in timings of the office hours due to Ramzan month.

18. The travel pattern for the Rawalpindi-Islamabad Region does not show any pattern that can analyze.

Savings of Times & KMs

19. By introducing Limited Stops & Express Routes, two types of savings are calculated (The output of the Scheduling model);

I. The Savings in terms of Times for Express & Limited Stops routes are given in

Table 4.17: The introduction of Express & Limited Stops routes and Time Savings

Sr. No.	Route Type	Description of Route		No of Trips (per day)	Travel Time (mm:ss)	Local Route Travel Time (mm:ss)	Savings (Minutes/day)
1	Express Route	Saddar-Faizabad-Pak Secretariat	1-10-24	61	33:46	48:25	885.8
2	Limited Stops Route	Saddar-Committee Chowk-Khyaban-e-Johar-Kashmir Highway-PIMS-Stock Exchange-7 th Avenue-Shaheed-e-Milat	1-4-13-15-19-20-21-22	109	37:00	48:25	1357

II. The current schedule of PMBS is given in Table 2.5: Current Schedule of Bus of PMBS (From Monday to Friday). By applying this schedule to a day (say Monday, 15th January 2018), the total traveled KMs paid to the bus operator was 14,886 KMs. Re-scheduling of the system can bring the cost savings in terms of KMs of buses. The calculations are given in Table 4.18. We can see that around 900 KMs per day can be saved using this schedule.

The Re-Scheduling to save the trips

ROUTE 1 - SADDAR TO PAK SECRETARIAT (Route Distance = 22.4 km)

SADDAR TO PAK SECRETARIAT (FORWARD)					PAK SECRETARIAT TO SADDAR (BACKWARD)				
FROM	TO	HEADWAY (Min)	TRIPS	Bus KMs	FROM	TO	HEADWAY	TRIPS	Bus KMs
6:15:00	7:00:00	20.0	3	67	6:15:00	6:57:00	30.0	2	45
7:02:45	7:57:45	4.0	15	336	7:00:30	8:00:00	9.8	6	137
8:00:30	8:58:15	2.6	23	515	8:02:50	8:59:30	8.4	7	160
9:01:00	9:58:45	3.5	17	381	9:02:20	9:59:00	8.3	7	163
10:01:30	10:58:10	4.0	15	336	10:01:50	10:58:30	7.6	8	177
11:01:00	11:57:40	4.3	14	314	11:01:20	11:59:05	5.3	11	251
12:00:30	13:00:00	5.0	12	269	12:01:50	12:59:35	4.5	13	298
13:02:45	13:57:45	5.5	11	246	13:02:20	13:57:20	4.4	14	309
14:00:30	14:58:15	5.5	11	246	14:00:05	14:57:50	4.3	14	310
15:01:00	15:58:45	6.0	10	224	15:00:35	15:58:20	3.8	16	352
16:01:30	16:59:15	6.0	10	224	16:01:05	16:58:50	3.5	17	385
17:02:00	17:58:00	6.0	10	224	17:01:35	17:59:20	3.3	18	412
18:00:40	18:58:45	8.6	7	157	18:02:05	18:58:55	3.8	16	349
19:02:10	19:58:10	10.0	6	134	19:01:30	19:57:30	6.0	10	224
20:02:10	20:57:10	12.0	5	112	20:01:00	20:59:30	8.4	7	160
21:02:10	21:56:10	15.0	4	90	21:04:00	21:59:00	11.4	5	117
			173.0	3875				171.8	3849

ROUTE 2 - SADDAR TO Faizabad (Route Distance = 10.482 km)

SADDAR TO FAIZABAD (FORWARD)					FAIZABAD TO SADDAR (BACKWARD)				
FROM	TO	HEADWAY (Min)	TRIPS	Bus KMs	FROM	TO	HEADWAY	TRIPS	Bus KMs
6:15:00	7:00:00	30.0	2	21	6:15:00	6:57:00	35.2	2	18
7:02:45	7:57:45	6.6	9	95	7:00:30	8:00:00	9.4	6	67
8:00:30	8:58:15	4.7	13	134	8:02:50	8:59:30	6.4	9	98
9:01:00	9:58:45	5.4	11	117	9:02:20	9:59:00	6.7	9	94
10:01:30	10:58:10	5.0	12	126	10:01:50	10:58:30	5.3	11	119
11:01:00	11:57:40	4.7	13	134	11:01:20	11:59:05	4.7	13	135
12:00:30	13:00:00	4.4	13	141	12:01:50	12:59:35	4.1	15	153
13:02:45	13:57:45	4.1	15	153	13:02:20	13:57:20	3.8	16	164
14:00:30	14:58:15	4.3	14	145	14:00:05	14:57:50	3.8	16	165
15:01:00	15:58:45	4.2	14	148	15:00:35	15:58:20	4.1	14	152
16:01:30	16:59:15	4.3	14	147	16:01:05	16:58:50	4.0	15	156
17:02:00	17:58:00	4.4	14	144	17:01:35	17:59:20	4.0	15	156
18:00:40	18:58:45	5.4	11	116	18:02:05	18:58:55	4.8	13	132
19:02:10	19:58:10	6.6	9	95	19:01:30	19:57:30	5.8	10	108
20:02:10	20:57:10	8.1	7	78	20:01:00	20:59:30	7.6	8	83
21:02:10	21:56:10	10.4	6	60	21:04:00	21:59:00	12.0	5	52

The Re-Scheduling to save the trips									
				176.8	1853			176.6	1851
LESS KMS DUE TO SHIFT OF LOAD TO SADDAR-PAK SECRETARIAT ROUTE BUSES					695.2				
					1158.3				
ROUTE 3 - (EXPRESS ROUTE) SADDAR TO FAIZABAD TO PAK SEC (Route Distance = 22.4 km)									
SADDAR TO FAIZABAD TO PAK SEC (FORWARD)					PAK SEC TO FAIZABAD TO SADDAR (BACKWARD)				
FROM	TO	HEADWAY (Min)	TRIPS	Bus KMs	FROM	TO	HEADWAY	TRIPS	Bus KMs
8:00:30	8:58:15	22.8	3	59	8:02:50	8:59:30			0
9:01:00	9:58:45	22.5	3	60	9:02:20	9:59:00	32.8	2	41
10:01:30	10:58:10	28.3	2	47	10:01:50	10:58:30	31.8	2	42
11:01:00	11:57:40	27.4	2	49	11:01:20	11:59:05	32.1	2	42
12:00:30	13:00:00	29.5	2	46	12:01:50	12:59:35	26.9	2	50
13:02:45	13:57:45	26.6	2	51	13:02:20	13:57:20	25.5	2	53
14:00:30	14:58:15	27.3	2	49	14:00:05	14:57:50	25.5	2	53
15:01:00	15:58:45	28.6	2	47	15:00:35	15:58:20	20.8	3	65
16:01:30	16:59:15	27.8	2	48	16:01:05	16:58:50	17.4	3	77
17:02:00	17:58:00	28.9	2	46	17:01:35	17:59:20	23.4	3	57
18:00:40	18:58:45				18:02:05	18:58:55	26.2	2	51
			22.4	502.5				23.7	531
ROUTE 4 - (LIMITED STOPS ROUTE) SADDAR-COMMITTEE CHOWK-KHYABAN-E-JOHAR-KASHMIR HIGHWAY-PIMS-STOCK EXCHANGE-7TH AVENUE-SHAHEED-E-MILAT (Route Distance = 22.4 km (20.1236 KM ACTUAL ROUTE + 2.27 KM AS DEAD MILAGE))									
(FORWARD)					(BACKWARD)				
FROM	TO	HEADWAY (Min)	TRIPS	Bus KMs	FROM	TO	HEADWAY	TRIPS	Bus KMs
8:00:30	8:58:15	13.4	4	101	8:02:50	8:59:30			0
9:01:00	9:58:45	8.3	7	161	9:02:20	9:59:00	25.3	2	53
10:01:30	10:58:10	10.4	6	130	10:01:50	10:58:30	20.1	3	67
11:01:00	11:57:40	13.5	4	100	11:01:20	11:59:05	15.0	4	90
12:00:30	13:00:00	12.3	5	109	12:01:50	12:59:35	11.0	5	122
13:02:45	13:57:45	13.9	4	97	13:02:20	13:57:20	11.6	5	116
14:00:30	14:58:15	14.9	4	90	14:00:05	14:57:50	11.1	5	121
15:01:00	15:58:45	15.5	4	87	15:00:35	15:58:20	12.5	5	108
16:01:30	16:59:15	16.0	4	84	16:01:05	16:58:50	10.6	6	126
17:02:00	17:58:00	16.1	4	84	17:01:35	17:59:20	9.6	6	140
18:00:40	18:58:45	16.2	4	83	18:02:05	18:58:55	12.3	5	109
19:02:10	19:58:10	19.0	3	71	19:02:10	19:58:10	16.5	4	82
			50.2	1125				47.0	1053
					TOTAL KMS		13,945.75		
					PMBS KMS ON MONDAY				
					15TH JAN, 2018		14,886.00		

The Re-Scheduling to save the trips							
				SAVINGS IN BUS KMS	940.25		

Table 4.18: Re-Schedule of PMBS & Trips Savings in KMs

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The overall working can be concluded as follows:

1. The PMBS has a corridor capacity of 22,480 PPHPD. It is running on 3,672 PPHPD in peak hours i.e. at only 16% of capacity. Even at this level, passengers are waiting for buses during peak hours up to 9-10 minutes and formed queues. So re-scheduling is required.
2. The proposed Scheduling Model has provided procedures for scheduling the system with maximum optimization output i.e. Travel time savings up to 2,243 minutes from all trips of a day or 310,242 minutes of Passengers-Minutes per day.
3. Two section has been identified in the PMBS corridor having an abrupt change in ridership i.e. Islamabad Section & Rawalpindi Section (see Figure 4.14). So by considering Faizabad as a junction of two sections, three routes are proposed;
 - I. Rawalpindi-Rawalpindi region i.e. Saddar to Faizabad Route (app. 40 % of total ridership)
 - II. Islamabad-Islamabad region i.e. IJP to Pak Secretariat Route (app. 16% of total ridership)
 - III. Rawalpindi-Islamabad region i.e. Saddar to Pak Secretariat Route (app. 44% of total ridership)
4. The re-scheduling of all three suggested routes is shown in Table 4.18: Re-Schedule of PMBS & Trips Savings in KMs.
5. Table 4.18 shows that around 900 KMs per day can be saved after the implementation of this schedule. Since PMBS is paying 325 per KM to the bus operator company, so around 100 million rupees can be saved per annum.
6. Express & Limited Stops routes can be introduced in PMBS (See Table 4.18). Express route is the Saddar-Faizabad-Pak Sec route & the Limited Stops route is the Saddar-Committee Chowk-Khyaban-e-Johar-Kashmir Highway-PIMS-Stock Exchange-7th Avenue-Shaheed-e-Milat route (see Table 4.17).

5.2.Future Recommendations

1. The Dispatch Plan can increase the frequency of buses due to physical constraints of the corridor like directional constraints, terminals' bus parking capacity, and demand constraints like abrupt change in hourly demand. So the optimization of the scheduling is required that can accommodate these features too.
2. The suggested scheduling model has provided the KMs & Travel Time savings at the end. A mathematical representation of this model is required so that a dispatch plan software can be formulated.
3. The farebox recovery ration of PMBS is 0.27, it means around 73% of the total expenditures of the system is subsidized. When it was compared with the world's fares (as shown in Figure 5.1) of BRT systems, it is observed that the fare of PMBS (0.18) is far less than the worlds' average (1.393). Since PMBS is already a politically highlighted department in the current socio-political environment of the country, the fare structure can be revised. PMBS is running a flat PKR 20 fare structure. Other fare structures of the world are Zonal & Distances Based.

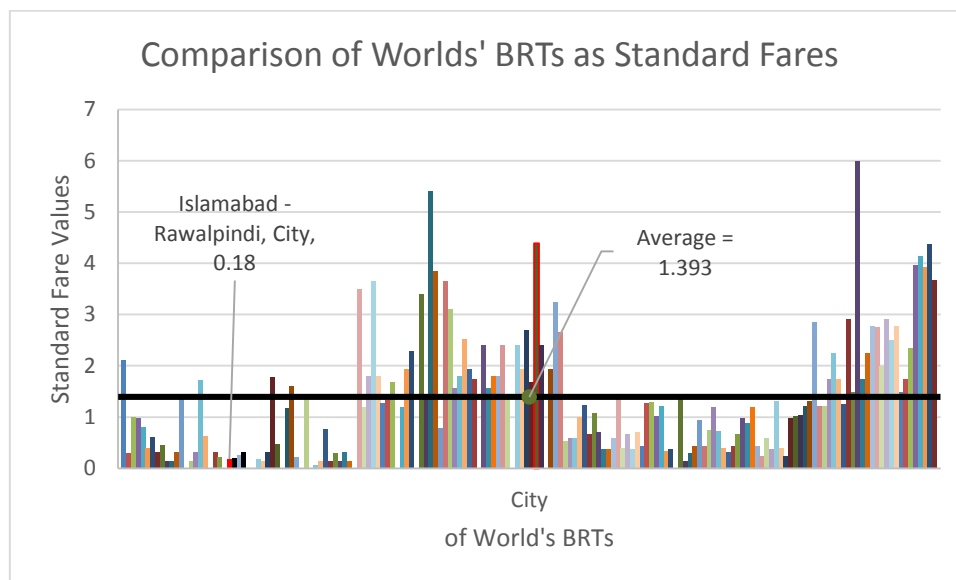


Figure 5.1: Comparison of Worlds' BRTs as Standard Fares (Source: (Global BRT, 2019))

4. The fare structure of the PMBS can be revised by determining;
 - I. The willingness to pay by the users.
 - II. The income level of the passengers.

Because it is also obvious that the increase in fare might risk the per day ridership of the PMBS.

5. The BRT standards give name to the system based on features of Bus, Corridor & Structure (see Table 4.1). The 4 categories of the standards with scores out of 100 are;
 - I. Gold (if a system scores 85 or above)
 - II. Silver (If a system scores 70-84.9)
 - III. Bronze (If a system scores 55-69.9)
 - IV. Basic BRT (If a system is fulfilling the basic definition of BRT)

PMBS has scored 72 so lies in the Silver category (according to this research work see Table 4.1). Following are the recommendations for PMBS which may lead PMBS to Gold standard in the future;

- a) No Park & Ride facility in PMBS. If we provide this facility on some locations based on surveys, PMBS will not only get more marks in standards but can attract more riders to use its service.
 - b) No Bicycle and Walking lanes. Provide bicycle & walking lanes where possible.
 - c) The maintenance of pavement requires special attention. Poor pavement causes more depreciation in the life of the bus.
 - d) Use up-to-date and environmental-friendly buses for PMBS. PMBS is using Euro III type bus engines i.e. Yuchai 6MK 340-30. While the world is running Euro IV or above models of buses.
 - e) Introduce Express & Limited Stop routes as per this thesis work.
 - f) There is no feeder service in twin cities where PMBS is running. Feeder bus service should be introduced as PMBS is only 1% of total trips generated in twin cities.
 - g) More BRT lines should be introduced in twin cities. One line (Orange Line) is under construction in the Islamabad region. So it should be integrated with PMBS in the future.
6. The boarding and alighting time of passengers can be improved by designing the sub-stops. The geometry design of the stations' sub-stops and docking bays are key factors for passengers waiting time. E.g. the Yichang metro bus, the design

of the station which has multiple subs stops due to the junction of multiple routes has a special type of geometry that can accommodate a maximum number of buses using all docking bays at a time. Such a design for safety and waiting time is very important. For the PMBS case, the Faizabad Station being the busiest among all stations requires special consideration from a geometry design point of view.

7. We can further decrease the waiting time of passengers by introducing a mobile application for the BRT ticketing system so that passengers can enter the Metrobus station and ride without waiting at the ticket counter.
8. Route of PMBS should be published in GTFS (General Transit Feed Specification) format in google map. A working is required so that PMBS can be accessible to tourists.
9. bi-articulated buses can be introduced to reduce the frequency of buses which reduces the operational total cost of the Metrobus system. So, PMBS stations can be re-designed accordingly.
10. The operational total cost of the system can be reduced by the commercialization of the BRT Stations. The trip time of passengers can be reduced by reducing the Dwell Time of the system. Each Boarding and alighting time of the passengers is different from the Dwell Time of buses at each station. According to the ITDP, dwell time is the summation of dead and variable Time of buses where dead time is the time of vehicle slowing down to dock at the station and acceleration time to move away from the docking station to the next station (including door open and close time) and Variable. Such impacts need to study.
11. The operational total cost can be reduced by introducing renewable energy resources. For example, by converting the roofs of stations into solar panels.
12. BRT is very important for sustainable cities. It brings many changes in the existing transportation structure of the cities e.g. it reduces travel time, traffic accidents, etc. Traffic impacts on the socio-economic life of the cities may also change to a significant level. For example, the movement of people from a residential area to work zones using Public Transport changes due to the construction of BRT. Such post-construction impacts on the cities of Rawalpindi and Islamabad need to study like the study of reduction in traffic accidents after BRT construction, the impacts of BRT on the Social and economic life of the twin cities, the overall success of the BRT, etc.

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APPENDIX

6. A1

Parameter of Pakistan Metro Bus System							
General Parameters							
Sr #	Services Provider Name	Services	Total Buses	68	Headway	2.5 Min during peak hours (Mon to Fri) in regular routes (sadder to Pak sec) and additional 18 buses @ rate of 6 mint from Peak Stations	
1	Platform	Procurement, Operation & Maintenance of Buses	Total Length of Corridor	22.419			
2	Inbox	Automated Fair Collection System-Bus Scheduling System	Total No of Stations	24			
3	Interactive	IT & Surveillance System	TRIPS WITHIN PINDI	41.53%			
4	SMJ	Emergency Diesel Generator Sets	TRIPS WITHIN ISB	14.97%	Bus Specs	18 m length single articulated 2.5 m width No of Axle= 3 3 Automated Doors max. 30k lbs. empty bus weight	
5	RWMC	Housekeeping and Janitorial Services	TRIPS BETWEEN PINDI AND ISB	43.03%			PMBS Design Capacity
	Messi	Platform Screen Door System	Capacity of Buses	total = 160 Sitting= 44	Station Specs	3 available bays in each direction while currently only 1 bay is operational in each direction	
7	Marin	Escalators & Elevators	Design of Operation (85% of capacity of buses per hour)	Average 130 Passengers/Bus i.e. during Peak hours on average 1 bus can take 130 Passengers			No of rotaries other than Saddar and Pak Sec. Terminals (bus parking or route selection)
8	Security 2000	Security Services					
Ridership Summary							
	Yearly Ridership	Average Annual Daily Trip	Seasonal Trips and Ridership		Avg. Cost per KM	Avg. Revenue Per KM	
2015	22,363,389.00	665.85	5th June 2015 to 30th Sept 2015	81,939.00	12,267,983.00	539.56	148.16
			1st Oct 2015 to 31st December 2015	58,557.00	10,095,406.00		
2016	39,335,133.00	634.44	Jan-16 to April-16	74,189.00	13,291,116.00		

			May-16 to Aug-16	76,825.00	12,558,007.00		
			Sept-16 to Dec-16	76,020.00	13,486,010.00		
2017 Up to Nov	39,024,691.00	628.07	Jan-17 to April-17	77,035.00	15,301,579.00		
			May-17 to Aug-17	75,263.00	13,187,228.00		
			Sept-17 to Nov-17	46,230.00	10,535,884.00		

* Other than this we have Per hour Ridership, Ridership of everyday of a week & per month ridership & of/or from every station since start of operation (4th June 2015) in terms of Token or card data from every stations of PMBS

PMBS Trip Length Distribution (of 2015-2016)			
Sr No.	Trip Length	Percentage of Distribution	
1	<=4	22	
2	4--8	33	
3	8--12	21	
4	12--16	14	
5	16--20	8	
6	20--24	3	
Following Reports are available since 4th June 2015 on Kentkart Software			
1	Stop In Out Report	11	Driver Behavior Report
2	Territory KM report	12	Online Monitoring
3	KM summary Report	13	Online Time Distance Graph (half an hour data transmission upper limit)
4	Mileage Report	14	On Line tracking of Buses
5	Card usage report	15	Data transmission report
6	Trip Status Report	16	Ridership summary (of both Rwp & Isb)
7	General Ride report by hours		
8	General Passenger Transfer Report		
9	Origin Destination Report		
10	General Ride summary Report		

7. A2

KM SUMMARY FOR THE MONTH OF JANUARY 2018		
ROUTES	TRIPS	KMS
ROUTE-1: SADDAR TO PAK SECRETARIAT (22.4903 KM)	18698	420523.6294
ROUTE-2: SADDAR TO DEPOT (14.2264 KM)	2278	32407.7392
ROUTE-3: PAK SECRETARIAT TO DEPOT (9.756 KM)	611	5960.9160
ROUTE-4: DEPOT TO FAIZ AHMAD FAIZ (1.8123 KM)	320	579.9360
ROUTE-5: FAIZ AHMAD FAIZ TO SADDAR (12.4141 KM)	320	3972.5120
ROUTE-6: DEPOT TO KASHMIR HIGHWAY (0.9297 KM)	347	322.6059
ROUTE-7: KASHMIR HIGHWAY TO PAK SECRETARIAT (8.8263 KM)	347	3062.7261
ROUTE-8: LIAQAT BAGH TO PAK SECRETARIAT (20.6556 KM)	414	8551.4184
ROUTE-9: SADDAR TO PIMS (16.9163 KM)	414	7003.3482
ROUTE-10: PGP TO PIMS (4.7747 KM)	414	1976.7258
ROUTE-11: SADDAR TO LIAQAT BAGH (1.8359 KM)	414	760.0626
ROUTE-12: PAK-SEC TO PGP (0.8004)	414	331.3656
ROUTE-13: IJP TO SADDAR (10.3077 KM)	28	288.6156
INCOMPLETE TRIPS KM	0	21.7331
TOTAL	25019	485763.3339

RWP	ISB	Total
157841.0368	262682.5926	420523.6294
19229.9648	13177.7744	32407.7392
	5960.9160	5960.9160
	579.9360	579.9360
2701.312	1271.2000	3972.5120
	322.6059	322.6059
	3062.7261	3062.7261
2734.7598	5816.6586	8551.4184
3494.8224	3508.5258	7003.3482
	1976.7258	1976.7258
760.0626		760.0626
	331.3656	331.3656
236.3648	52.2508	288.6156
8.4416	13.2915	21.7331
187006.7648	298756.5691	485763.3339

#	Vehicle ID	Plate	Trip No	Planned	Difference	Start Date Time	Trip Start Time	Driver	Bay	Plan	34010 - Saddar	Out	Bay	Plan
1	23001	2300 1	121176 2	6:15:00	0	15.01.2018 06:12:08	15.01.2018 06:15:13	80007 - Javed - Iqbal	34011-Saddar Bay 1	6:15:0 1	6:12:39	6:15:1 3	34021-Marrir Chowk Bay 3	6:16:5 7
2	23002	2300 2	121176 3	6:18:00	4	15.01.2018 06:19:06	15.01.2018 06:19:06	80008 - Safdar - Ali		6:18:0 1	6:15:20	6:18:0 0	34021-Marrir Chowk Bay 3	6:19:5 7
3	23003	2300 3	121176 4	6:21:00	0	15.01.2018 06:18:39	15.01.2018 06:21:11	80017 - Basit - Mehmood	34011-Saddar Bay 1	6:21:0 1	6:19:00	6:21:1 1	34021-Marrir Chowk Bay 3	6:22:5 7
4	23005	2300 5	121176 5	6:24:00	-1	15.01.2018 06:21:10	15.01.2018 06:23:58	80025 - Abid - Ali	34011-Saddar Bay 1	6:24:0 1	6:21:30	6:23:5 8	34021-Marrir Chowk Bay 3	6:25:5 7
5	23006	2300 6	121176 6	6:27:00	0	15.01.2018 06:23:48	15.01.2018 06:27:02	80032 - Muhammad - Ajaz	34011-Saddar Bay 1	6:27:0 1	6:24:10	6:27:0 2	34021-Marrir Chowk Bay 3	6:28:5 7
6	23004	2300 4	121176 7	6:30:00	0	15.01.2018 06:27:14	15.01.2018 06:30:11	80020 - Sajid - Mehmood	34011-Saddar Bay 1	6:30:0 1	6:27:14	6:30:1 1	34021-Marrir Chowk Bay 3	6:31:5 7
7	23007	2300 7	121176 8	6:33:00	0	15.01.2018 06:29:56	15.01.2018 06:33:11	80035 - waheed - Ahmed	34011-Saddar Bay 1	6:33:0 1	6:30:12	6:33:1 1	34021-Marrir Chowk Bay 3	6:34:5 7
8	23008	2300 8	121176 9	6:36:00	-1	15.01.2018 06:33:01	15.01.2018 06:35:58	80042 - Sajad - Haider	34011-Saddar Bay 1	6:36:0 1	6:33:22	6:35:5 8	34021-Marrir Chowk Bay 3	6:37:5 7
9	23009	2300 9	121177 0	6:39:00	0	15.01.2018 06:35:48	15.01.2018 06:39:21	80045 - Abid - Hussain	34011-Saddar Bay 1	6:39:0 1	6:36:50	6:39:2 1	34021-Marrir Chowk Bay 3	6:40:5 7
10	23014	2301 4	121177 1	6:42:00	0	15.01.2018 06:39:20	15.01.2018 06:42:16	80177 - M Saqib Iqbal -	34011-Saddar Bay 1	6:42:0 1	6:39:54	6:42:1 6	34021-Marrir Chowk Bay 3	6:43:5 7
11	23015	2301 5	121177 2	6:45:00	0	15.01.2018 06:42:05	15.01.2018 06:45:13	80016 - Toufeeque Ahmed - Abbasi	34011-Saddar Bay 1	6:45:0 1	6:42:30	6:45:1 3	34021-Marrir Chowk Bay 3	6:46:5 7
12	23017	2301 7	121177 3	6:48:00	0	15.01.2018 06:45:01	15.01.2018 06:48:06	80100 - Muhammad - Saeed	34011-Saddar Bay 1	6:48:0 1	6:45:15	6:48:0 6	34021-Marrir Chowk Bay 3	6:49:5 7
13	23030	2303 0	121177 4	6:51:00	0	15.01.2018 06:48:01	15.01.2018 06:51:13	80166 - M Hanif -	34011-Saddar Bay 1	6:51:0 1	6:48:30	6:51:1 3	34021-Marrir Chowk Bay 3	6:52:5 7
14	23031	2303 1	121177 5	6:54:00	0	15.01.2018 06:51:17	15.01.2018 06:54:00	80172 - Haq Nawaz -	34011-Saddar Bay 1	6:54:0 1	6:51:50	6:54:0 0	34021-Marrir Chowk Bay 3	6:55:5 7
15	23033	2303 3	121177 6	6:57:00	0	15.01.2018 06:53:50	15.01.2018 06:57:00	80142 - Gul - Shahzad	34011-Saddar Bay 1	6:57:0 1	6:54:08	6:57:0 0	34021-Marrir Chowk Bay 3	6:58:5 7
16	23040	2304 0	121177 7	7:00:00	0	15.01.2018 06:57:13	15.01.2018 07:00:08	80273 - Muhamad Hussain -	34011-Saddar Bay 1	7:00:0 1	6:57:34	7:00:0 8	34021-Marrir Chowk Bay 3	7:01:5 7
17	23043	2304 3	121177 8	7:02:45	0	15.01.2018 07:00:09	15.01.2018 07:02:52	80280 - Azam - Masih	34011-Saddar Bay 1	7:02:4 6	7:00:39	7:02:5 2	34021-Marrir Chowk Bay 3	7:04:4 2
18	23045	2304 5	121177 9	7:05:30	0	15.01.2018 07:02:51	15.01.2018 07:05:37	80108 - Muhammad - Saeed	34011-Saddar Bay 1	7:05:3 1	7:03:11	7:05:3 7	34021-Marrir Chowk Bay 3	7:07:2 7
19	23049	2304 9	121178 0	7:08:15	0	15.01.2018 07:05:03	15.01.2018 07:08:14	80152 - Iftikhar - Ahmed	34011-Saddar Bay 1	7:08:1 6	7:05:40	7:08:1 4	34021-Marrir Chowk Bay 3	7:10:1 2
20	23052	2305 2	121178 1	7:11:00	0	15.01.2018 07:08:14	15.01.2018 07:11:14	80083 - Mohammad Anwar - Awan	34011-Saddar Bay 1	7:11:0 1	7:08:24	7:11:1 4	34021-Marrir Chowk Bay 3	7:12:5 7

8. A3

9. A4

Station No.	CheckInStationName	CheckOutStationName	Station No.	Total Trips	Hours of a day																		
					5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0
1.0	Saddar	Faizabad	10.0	2863.0	2.0	38.0	120.0	153.0	209.0	166.0	192.0	199.0	248.0	251.0	239.0	242.0	253.0	182.0	158.0	118.0	93.0	0.0	0.0
1.0	Saddar	Shamsabad	9.0	1698.0	0.0	11.0	137.0	188.0	134.0	94.0	93.0	106.0	112.0	144.0	112.0	119.0	102.0	131.0	98.0	61.0	56.0	0.0	0.0
1.0	Saddar	6th Road	8.0	1472.0	0.0	11.0	102.0	96.0	93.0	101.0	104.0	105.0	119.0	106.0	104.0	110.0	107.0	94.0	96.0	68.0	56.0	0.0	0.0
1.0	Saddar	Chandni Chowk	6.0	1421.0	0.0	5.0	64.0	103.0	126.0	143.0	121.0	103.0	97.0	89.0	98.0	103.0	111.0	90.0	78.0	43.0	47.0	0.0	0.0
1.0	Saddar	Rehmanabad	7.0	1384.0	0.0	0.0	68.0	105.0	84.0	101.0	107.0	148.0	96.0	95.0	106.0	107.0	119.0	90.0	70.0	47.0	41.0	0.0	0.0
1.0	Saddar	Committee Chowk	4.0	1075.0	0.0	7.0	37.0	48.0	38.0	41.0	70.0	93.0	76.0	91.0	82.0	88.0	103.0	95.0	88.0	74.0	44.0	0.0	0.0
1.0	Saddar	Waris Khan	5.0	620.0	0.0	3.0	13.0	29.0	38.0	31.0	39.0	46.0	56.0	37.0	51.0	59.0	66.0	57.0	35.0	33.0	27.0	0.0	0.0
1.0	Saddar	Liaqat Bagh	3.0	542.0	0.0	3.0	6.0	16.0	27.0	33.0	35.0	33.0	65.0	50.0	64.0	49.0	61.0	31.0	26.0	28.0	15.0	0.0	0.0
1.0	Saddar	IJP	11.0	324.0	1.0	3.0	4.0	18.0	14.0	12.0	12.0	21.0	19.0	24.0	26.0	32.0	41.0	32.0	29.0	17.0	19.0	0.0	0.0
1.0	Saddar	Marrir Chowk	2.0	120.0	0.0	1.0	2.0	4.0	3.0	5.0	5.0	11.0	14.0	7.0	7.0	11.0	16.0	13.0	8.0	7.0	6.0	0.0	0.0
1.0	Saddar	PIMS	19.0	900.0	3.0	17.0	63.0	105.0	123.0	82.0	86.0	57.0	71.0	33.0	63.0	46.0	45.0	52.0	24.0	11.0	19.0	0.0	0.0
1.0	Saddar	Stock Exchange	20.0	767.0	2.0	12.0	55.0	158.0	76.0	70.0	49.0	36.0	53.0	37.0	33.0	44.0	42.0	35.0	21.0	22.0	22.0	0.0	0.0
1.0	Saddar	Pak Secretariat	24.0	750.0	3.0	21.0	125.0	147.0	85.0	63.0	58.0	42.0	35.0	31.0	32.0	32.0	22.0	16.0	19.0	10.0	9.0	0.0	0.0
1.0	Saddar	Khyaban-e-Johar	13.0	678.0	0.0	12.0	109.0	130.0	74.0	72.0	73.0	39.0	37.0	40.0	28.0	19.0	13.0	13.0	6.0	6.0	7.0	0.0	0.0
1.0	Saddar	Chaman	16.0	619.0	1.0	11.0	31.0	38.0	46.0	49.0	36.0	42.0	53.0	36.0	50.0	50.0	47.0	40.0	34.0	26.0	29.0	0.0	0.0
1.0	Saddar	7th Avenue	21.0	611.0	1.0	9.0	57.0	100.0	72.0	34.0	60.0	31.0	36.0	36.0	40.0	32.0	29.0	25.0	18.0	19.0	12.0	0.0	0.0
1.0	Saddar	Kashmir Highway	15.0	593.0	2.0	11.0	58.0	75.0	67.0	61.0	40.0	52.0	34.0	32.0	30.0	40.0	33.0	20.0	15.0	13.0	10.0	0.0	0.0
1.0	Saddar	Shaheed-e-Milat	22.0	565.0	0.0	12.0	58.0	99.0	103.0	49.0	35.0	33.0	17.0	26.0	31.0	39.0	22.0	14.0	12.0	6.0	9.0	0.0	0.0
1.0	Saddar	Potohar	12.0	552.0	1.0	10.0	43.0	59.0	57.0	31.0	27.0	32.0	34.0	28.0	33.0	42.0	50.0	31.0	31.0	18.0	25.0	0.0	0.0
1.0	Saddar	Parade Ground	23.0	548.0	0.0	16.0	78.0	135.0	72.0	50.0	38.0	26.0	39.0	16.0	16.0	20.0	27.0	4.0	2.0	4.0	5.0	0.0	0.0
1.0	Saddar	Ibn-e-Sina	17.0	469.0	0.0	23.0	40.0	28.0	36.0	37.0	38.0	32.0	31.0	28.0	32.0	32.0	36.0	20.0	19.0	16.0	21.0	0.0	0.0
1.0	Saddar	Katchery	18.0	456.0	0.0	13.0	56.0	47.0	52.0	54.0	42.0	34.0	21.0	19.0	16.0	21.0	27.0	20.0	15.0	9.0	10.0	0.0	0.0
1.0	Saddar	Faiz Ahmad Faiz	14.0	290.0	1.0	7.0	54.0	66.0	30.0	25.0	25.0	22.0	14.0	15.0	4.0	9.0	4.0	2.0	4.0	6.0	2.0	0.0	0.0
2.0	Marrir Chowk	Faizabad	10.0	1087.0	0.0	29.0	59.0	64.0	75.0	69.0	74.0	82.0	101.0	70.0	97.0	94.0	94.0	65.0	55.0	37.0	22.0	0.0	0.0
2.0	Marrir Chowk	Chandni Chowk	6.0	877.0	0.0	5.0	55.0	95.0	103.0	109.0	72.0	108.0	51.0	46.0	54.0	47.0	38.0	29.0	37.0	19.0	9.0	0.0	0.0
2.0	Marrir Chowk	Rehmanabad	7.0	806.0	0.0	4.0	70.0	88.0	91.0	81.0	70.0	52.0	55.0	70.0	51.0	51.0	44.0	21.0	21.0	24.0	13.0	0.0	0.0
2.0	Marrir Chowk	6th Road	8.0	746.0	0.0	8.0	73.0	101.0	72.0	66.0	61.0	62.0	66.0	50.0	60.0	47.0	25.0	20.0	17.0	9.0	9.0	0.0	0.0
2.0	Marrir Chowk	Shamsabad	9.0	669.0	0.0	11.0	60.0	96.0	50.0	36.0	44.0	47.0	60.0	53.0	39.0	54.0	34.0	28.0	25.0	25.0	7.0	0.0	0.0
2.0	Marrir Chowk	Waris Khan	5.0	398.0	0.0	2.0	14.0	20.0	23.0	33.0	40.0	26.0	27.0	34.0	33.0	34.0	35.0	22.0	28.0	19.0	8.0	0.0	0.0
2.0	Marrir Chowk	Committee Chowk	4.0	339.0	0.0	1.0	7.0	11.0	19.0	32.0	31.0	31.0	33.0	23.0	29.0	31.0	35.0	14.0	17.0	16.0	9.0	0.0	0.0
2.0	Marrir Chowk	IJP	11.0	130.0	0.0	4.0	3.0	13.0	2.0	6.0	8.0	8.0	8.0	13.0	12.0	9.0	19.0	8.0	10.0	2.0	5.0	0.0	0.0
2.0	Marrir Chowk	Liaqat Bagh	3.0	61.0	0.0	2.0	2.0	3.0	4.0	7.0	6.0	4.0	5.0	7.0	2.0	6.0	4.0	2.0	4.0	3.0	0.0	0.0	0.0
2.0	Marrir Chowk	PIMS	19.0	388.0	0.0	4.0	22.0	47.0	54.0	53.0	33.0	26.0	24.0	25.0	16.0	35.0	11.0	14.0	12.0	7.0	5.0	0.0	0.0

2.0	Marrir Chowk	Kashmir Highway	15.0	288.0	0.0	4.0	36.0	46.0	38.0	33.0	40.0	29.0	13.0	19.0	4.0	6.0	5.0	7.0	4.0	2.0	2.0	0.0	0.0
2.0	Marrir Chowk	Khyaban-e-Johar	13.0	278.0	0.0	8.0	56.0	55.0	31.0	38.0	19.0	23.0	12.0	7.0	7.0	10.0	6.0	2.0	1.0	3.0	0.0	0.0	0.0
2.0	Marrir Chowk	Potohar	12.0	274.0	0.0	9.0	32.0	48.0	22.0	16.0	23.0	16.0	22.0	15.0	25.0	11.0	14.0	11.0	7.0	3.0	0.0	0.0	0.0
2.0	Marrir Chowk	Stock Exchange	20.0	271.0	0.0	9.0	17.0	44.0	33.0	27.0	23.0	23.0	14.0	14.0	9.0	18.0	13.0	15.0	4.0	5.0	3.0	0.0	0.0
2.0	Marrir Chowk	Chaman	16.0	249.0	0.0	2.0	14.0	26.0	22.0	24.0	21.0	17.0	20.0	16.0	20.0	18.0	24.0	9.0	7.0	8.0	1.0	0.0	0.0
2.0	Marrir Chowk	Ibn-e-Sina	17.0	231.0	0.0	11.0	32.0	29.0	24.0	14.0	19.0	19.0	13.0	9.0	13.0	13.0	15.0	6.0	7.0	3.0	4.0	0.0	0.0
2.0	Marrir Chowk	Pak Secretariat	24.0	213.0	0.0	8.0	33.0	27.0	27.0	26.0	11.0	8.0	16.0	22.0	6.0	3.0	6.0	6.0	5.0	5.0	4.0	0.0	0.0
2.0	Marrir Chowk	7th Avenue	21.0	187.0	0.0	2.0	13.0	21.0	16.0	21.0	20.0	29.0	9.0	12.0	9.0	5.0	9.0	9.0	3.0	3.0	6.0	0.0	0.0
2.0	Marrir Chowk	Katchery	18.0	177.0	0.0	5.0	26.0	30.0	18.0	25.0	13.0	14.0	4.0	16.0	9.0	5.0	0.0	5.0	1.0	4.0	2.0	0.0	0.0
2.0	Marrir Chowk	Shaheed-e-Milat	22.0	162.0	0.0	2.0	17.0	19.0	18.0	20.0	18.0	7.0	4.0	7.0	12.0	21.0	6.0	5.0	2.0	4.0	0.0	0.0	0.0
2.0	Marrir Chowk	Parade Ground	23.0	155.0	0.0	7.0	24.0	34.0	19.0	16.0	17.0	11.0	5.0	4.0	5.0	5.0	4.0	2.0	1.0	1.0	0.0	0.0	0.0
2.0	Marrir Chowk	Faiz Ahmad Faiz	14.0	142.0	0.0	1.0	15.0	23.0	15.0	18.0	18.0	17.0	11.0	8.0	5.0	2.0	3.0	1.0	2.0	3.0	0.0	0.0	0.0
3.0	Liaqat Bagh	Faizabad	10.0	841.0	0.0	7.0	29.0	48.0	38.0	49.0	55.0	48.0	72.0	71.0	90.0	64.0	85.0	58.0	50.0	43.0	34.0	0.0	0.0
3.0	Liaqat Bagh	Shamsabad	9.0	449.0	0.0	3.0	21.0	56.0	27.0	26.0	37.0	20.0	37.0	33.0	57.0	27.0	27.0	24.0	22.0	19.0	13.0	0.0	0.0
3.0	Liaqat Bagh	6th Road	8.0	433.0	0.0	1.0	40.0	31.0	35.0	24.0	25.0	25.0	31.0	33.0	40.0	33.0	34.0	30.0	16.0	17.0	18.0	0.0	0.0
3.0	Liaqat Bagh	Rehmanabad	7.0	396.0	0.0	2.0	27.0	20.0	25.0	32.0	28.0	49.0	33.0	25.0	16.0	33.0	35.0	31.0	15.0	7.0	18.0	0.0	0.0
3.0	Liaqat Bagh	Chandni Chowk	6.0	355.0	0.0	0.0	15.0	37.0	25.0	41.0	37.0	28.0	29.0	32.0	24.0	20.0	18.0	18.0	17.0	7.0	7.0	0.0	0.0
3.0	Liaqat Bagh	Waris Khan	5.0	175.0	0.0	0.0	4.0	22.0	12.0	15.0	10.0	14.0	9.0	19.0	13.0	15.0	17.0	10.0	5.0	8.0	2.0	0.0	0.0
3.0	Liaqat Bagh	IJP	11.0	92.0	0.0	4.0	8.0	5.0	4.0	6.0	3.0	5.0	6.0	10.0	5.0	4.0	8.0	12.0	5.0	3.0	4.0	0.0	0.0
3.0	Liaqat Bagh	Committee Chowk	4.0	75.0	0.0	0.0	4.0	1.0	0.0	5.0	4.0	8.0	5.0	5.0	4.0	8.0	12.0	8.0	6.0	2.0	3.0	0.0	0.0
3.0	Liaqat Bagh	PIMS	19.0	267.0	0.0	3.0	20.0	23.0	30.0	22.0	22.0	23.0	28.0	13.0	48.0	11.0	9.0	7.0	3.0	3.0	2.0	0.0	0.0
3.0	Liaqat Bagh	Stock Exchange	20.0	176.0	0.0	2.0	16.0	27.0	19.0	20.0	18.0	8.0	12.0	6.0	5.0	12.0	12.0	7.0	7.0	4.0	1.0	0.0	0.0
3.0	Liaqat Bagh	Khyaban-e-Johar	13.0	171.0	0.0	6.0	27.0	27.0	30.0	16.0	9.0	14.0	10.0	10.0	8.0	4.0	8.0	1.0	0.0	1.0	0.0	0.0	0.0
3.0	Liaqat Bagh	Pak Secretariat	24.0	171.0	0.0	4.0	28.0	28.0	24.0	12.0	20.0	8.0	10.0	11.0	8.0	8.0	2.0	3.0	2.0	1.0	2.0	0.0	0.0
3.0	Liaqat Bagh	Kashmir Highway	15.0	163.0	0.0	1.0	12.0	23.0	13.0	10.0	16.0	16.0	10.0	8.0	10.0	6.0	8.0	8.0	4.0	7.0	11.0	0.0	0.0
3.0	Liaqat Bagh	Chaman	16.0	163.0	0.0	2.0	8.0	9.0	10.0	13.0	9.0	5.0	17.0	23.0	11.0	7.0	17.0	13.0	11.0	4.0	4.0	0.0	0.0
3.0	Liaqat Bagh	Potohar	12.0	162.0	0.0	3.0	27.0	18.0	12.0	9.0	8.0	16.0	9.0	11.0	8.0	10.0	13.0	3.0	9.0	2.0	4.0	0.0	0.0
3.0	Liaqat Bagh	7th Avenue	21.0	136.0	0.0	3.0	10.0	21.0	11.0	6.0	9.0	15.0	17.0	4.0	8.0	8.0	13.0	5.0	2.0	1.0	3.0	0.0	0.0
3.0	Liaqat Bagh	Shaheed-e-Milat	22.0	124.0	0.0	2.0	13.0	16.0	12.0	8.0	18.0	10.0	7.0	4.0	5.0	9.0	9.0	3.0	3.0	3.0	2.0	0.0	0.0
3.0	Liaqat Bagh	Ibn-e-Sina	17.0	122.0	0.0	0.0	6.0	9.0	8.0	13.0	1.0	13.0	9.0	6.0	11.0	10.0	7.0	15.0	7.0	4.0	3.0	0.0	0.0
3.0	Liaqat Bagh	Parade Ground	23.0	105.0	1.0	0.0	18.0	17.0	17.0	6.0	3.0	12.0	3.0	6.0	6.0	8.0	4.0	0.0	2.0	1.0	1.0	0.0	0.0
3.0	Liaqat Bagh	Katchery	18.0	87.0	0.0	1.0	10.0	14.0	10.0	13.0	7.0	2.0	8.0	7.0	2.0	3.0	2.0	2.0	3.0	2.0	1.0	0.0	0.0
3.0	Liaqat Bagh	Faiz Ahmad Faiz	14.0	67.0	0.0	0.0	12.0	12.0	7.0	3.0	9.0	3.0	7.0	1.0	3.0	2.0	4.0	3.0	0.0	1.0	0.0	0.0	0.0
4.0	Committee Chowk	Faizabad	10.0	1222.0	0.0	21.0	39.0	52.0	67.0	67.0	80.0	73.0	79.0	108.0	117.0	124.0	117.0	88.0	67.0	68.0	53.0	2.0	0.0
4.0	Committee Chowk	Shamsabad	9.0	694.0	0.0	1.0	45.0	55.0	27.0	35.0	50.0	39.0	49.0	54.0	38.0	45.0	55.0	53.0	51.0	55.0	42.0	0.0	0.0
4.0	Committee Chowk	6th Road	8.0	653.0	0.0	2.0	47.0	44.0	29.0	25.0	56.0	36.0	42.0	43.0	76.0	47.0	47.0	48.0	29.0	37.0	45.0	0.0	0.0
4.0	Committee Chowk	Rehmanabad	7.0	585.0	0.0	0.0	31.0	36.0	33.0	41.0	53.0	58.0	35.0	33.0	30.0	35.0	52.0	49.0	31.0	43.0	25.0	0.0	0.0
4.0	Committee Chowk	Chandni Chowk	6.0	419.0	0.0	0.0	28.0	22.0	16.0	35.0	36.0	27.0	43.0	23.0	37.0	29.0	31.0	37.0	22.0	23.0	10.0	0.0	0.0
4.0	Committee Chowk	IJP	11.0	108.0	0.0	1.0	0.0	7.0	2.0	10.0	10.0	5.0	11.0	14.0	8.0	5.0	13.0	4.0	8.0	4.0	6.0	0.0	0.0

4.0	Committee Chowk	Waris Khan	5.0	89.0	0.0	0.0	0.0	4.0	3.0	4.0	5.0	6.0	7.0	3.0	11.0	10.0	6.0	7.0	10.0	9.0	4.0	0.0	0.0
4.0	Committee Chowk	PIMS	19.0	328.0	0.0	1.0	20.0	20.0	43.0	43.0	25.0	21.0	22.0	27.0	16.0	28.0	40.0	6.0	8.0	4.0	4.0	0.0	0.0
4.0	Committee Chowk	Stock Exchange	20.0	259.0	0.0	4.0	13.0	26.0	13.0	19.0	22.0	27.0	14.0	25.0	15.0	13.0	13.0	19.0	7.0	17.0	12.0	0.0	0.0
4.0	Committee Chowk	Chaman	16.0	241.0	0.0	4.0	11.0	12.0	16.0	11.0	17.0	19.0	9.0	13.0	23.0	24.0	27.0	16.0	19.0	10.0	10.0	0.0	0.0
4.0	Committee Chowk	Kashmir Highway	15.0	217.0	0.0	1.0	12.0	31.0	21.0	19.0	17.0	22.0	12.0	12.0	20.0	11.0	10.0	11.0	5.0	8.0	5.0	0.0	0.0
4.0	Committee Chowk	Khyaban-e-Johar	13.0	208.0	0.0	5.0	43.0	46.0	22.0	12.0	10.0	12.0	10.0	9.0	12.0	6.0	2.0	11.0	1.0	4.0	3.0	0.0	0.0
4.0	Committee Chowk	Potohar	12.0	198.0	0.0	4.0	19.0	20.0	18.0	9.0	22.0	10.0	14.0	7.0	11.0	9.0	17.0	9.0	15.0	7.0	7.0	0.0	0.0
4.0	Committee Chowk	7th Avenue	21.0	197.0	0.0	2.0	8.0	18.0	20.0	7.0	24.0	15.0	9.0	10.0	19.0	8.0	17.0	13.0	10.0	10.0	7.0	0.0	0.0
4.0	Committee Chowk	Pak Secretariat	24.0	186.0	0.0	4.0	27.0	24.0	15.0	14.0	13.0	6.0	11.0	18.0	9.0	8.0	9.0	6.0	13.0	6.0	3.0	0.0	0.0
4.0	Committee Chowk	Shaheed-e-Milat	22.0	169.0	0.0	2.0	16.0	19.0	23.0	15.0	20.0	11.0	8.0	12.0	9.0	7.0	3.0	5.0	9.0	8.0	2.0	0.0	0.0
4.0	Committee Chowk	Ibn-e-Sina	17.0	144.0	0.0	5.0	9.0	7.0	10.0	14.0	12.0	5.0	7.0	13.0	5.0	4.0	17.0	16.0	8.0	4.0	8.0	0.0	0.0
4.0	Committee Chowk	Parade Ground	23.0	136.0	0.0	2.0	13.0	30.0	15.0	10.0	11.0	8.0	6.0	8.0	12.0	3.0	9.0	3.0	1.0	4.0	1.0	0.0	0.0
4.0	Committee Chowk	Katchery	18.0	117.0	0.0	3.0	12.0	6.0	7.0	9.0	12.0	11.0	7.0	6.0	6.0	2.0	12.0	10.0	7.0	3.0	4.0	0.0	0.0
4.0	Committee Chowk	Faiz Ahmad Faiz	14.0	87.0	0.0	1.0	9.0	13.0	8.0	7.0	7.0	7.0	10.0	5.0	5.0	4.0	3.0	0.0	8.0	0.0	0.0	0.0	0.0
5.0	Waris Khan	Faizabad	10.0	440.0	0.0	7.0	18.0	29.0	22.0	25.0	23.0	26.0	47.0	32.0	27.0	30.0	41.0	36.0	23.0	27.0	27.0	0.0	0.0
5.0	Waris Khan	Shamsabad	9.0	323.0	0.0	2.0	13.0	27.0	18.0	23.0	15.0	18.0	34.0	31.0	17.0	15.0	16.0	23.0	32.0	19.0	19.0	1.0	0.0
5.0	Waris Khan	6th Road	8.0	210.0	0.0	0.0	22.0	16.0	16.0	8.0	14.0	9.0	17.0	18.0	13.0	19.0	12.0	15.0	7.0	11.0	13.0	0.0	0.0
5.0	Waris Khan	Rehmanabad	7.0	176.0	0.0	0.0	5.0	14.0	14.0	10.0	19.0	17.0	13.0	18.0	13.0	17.0	15.0	11.0	3.0	3.0	4.0	0.0	0.0
5.0	Waris Khan	Chandni Chowk	6.0	87.0	0.0	0.0	8.0	5.0	4.0	4.0	8.0	10.0	8.0	4.0	10.0	7.0	4.0	7.0	5.0	2.0	1.0	0.0	0.0
5.0	Waris Khan	IJP	11.0	27.0	0.0	1.0	0.0	0.0	0.0	0.0	3.0	4.0	1.0	4.0	1.0	4.0	0.0	2.0	2.0	4.0	1.0	0.0	0.0
5.0	Waris Khan	PIMS	19.0	160.0	0.0	6.0	5.0	27.0	21.0	11.0	15.0	3.0	13.0	11.0	31.0	3.0	8.0	3.0	2.0	0.0	1.0	0.0	0.0
5.0	Waris Khan	Stock Exchange	20.0	135.0	0.0	2.0	6.0	18.0	17.0	19.0	5.0	11.0	6.0	12.0	11.0	5.0	6.0	3.0	6.0	5.0	3.0	0.0	0.0
5.0	Waris Khan	Chaman	16.0	103.0	0.0	1.0	7.0	4.0	6.0	9.0	14.0	5.0	5.0	6.0	7.0	12.0	3.0	7.0	5.0	5.0	7.0	0.0	0.0
5.0	Waris Khan	Shaheed-e-Milat	22.0	100.0	0.0	1.0	11.0	19.0	23.0	10.0	5.0	4.0	2.0	6.0	4.0	6.0	2.0	0.0	1.0	5.0	1.0	0.0	0.0
5.0	Waris Khan	Potohar	12.0	98.0	0.0	3.0	12.0	8.0	8.0	8.0	2.0	7.0	6.0	5.0	13.0	5.0	11.0	3.0	1.0	5.0	1.0	0.0	0.0
5.0	Waris Khan	7th Avenue	21.0	98.0	0.0	3.0	8.0	10.0	14.0	10.0	8.0	5.0	8.0	2.0	4.0	5.0	6.0	5.0	8.0	0.0	2.0	0.0	0.0
5.0	Waris Khan	Kashmir Highway	15.0	97.0	0.0	1.0	7.0	11.0	16.0	14.0	5.0	4.0	7.0	5.0	12.0	4.0	7.0	4.0	0.0	0.0	0.0	0.0	0.0
5.0	Waris Khan	Khyaban-e-Johar	13.0	92.0	0.0	0.0	25.0	22.0	9.0	6.0	7.0	4.0	8.0	5.0	2.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	Waris Khan	Pak Secretariat	24.0	72.0	0.0	5.0	21.0	14.0	12.0	2.0	3.0	3.0	3.0	4.0	1.0	2.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
5.0	Waris Khan	Parade Ground	23.0	65.0	0.0	3.0	3.0	15.0	7.0	4.0	10.0	6.0	4.0	0.0	1.0	1.0	4.0	3.0	0.0	2.0	2.0	0.0	0.0
5.0	Waris Khan	Katchery	18.0	63.0	0.0	2.0	7.0	10.0	6.0	7.0	9.0	1.0	1.0	2.0	5.0	3.0	6.0	1.0	2.0	0.0	1.0	0.0	0.0
5.0	Waris Khan	Ibn-e-Sina	17.0	48.0	0.0	2.0	3.0	3.0	9.0	6.0	3.0	4.0	3.0	3.0	4.0	1.0	0.0	2.0	1.0	4.0	0.0	0.0	0.0
5.0	Waris Khan	Faiz Ahmad Faiz	14.0	25.0	0.0	0.0	11.0	4.0	3.0	1.0	0.0	1.0	0.0	0.0	1.0	2.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
6.0	Chandni Chowk	Faizabad	10.0	782.0	0.0	5.0	19.0	26.0	32.0	52.0	54.0	117.0	81.0	74.0	73.0	67.0	49.0	48.0	39.0	22.0	22.0	2.0	0.0
6.0	Chandni Chowk	Shamsabad	9.0	273.0	0.0	0.0	8.0	16.0	13.0	19.0	35.0	23.0	30.0	32.0	11.0	16.0	29.0	16.0	9.0	8.0	8.0	0.0	0.0
6.0	Chandni Chowk	6th Road	8.0	159.0	0.0	1.0	7.0	8.0	7.0	13.0	16.0	12.0	14.0	10.0	12.0	20.0	9.0	9.0	10.0	8.0	3.0	0.0	0.0
6.0	Chandni Chowk	IJP	11.0	91.0	0.0	0.0	1.0	2.0	10.0	3.0	4.0	13.0	11.0	6.0	8.0	5.0	12.0	3.0	5.0	4.0	4.0	0.0	0.0
6.0	Chandni Chowk	Rehmanabad	7.0	57.0	0.0	0.0	1.0	3.0	1.0	2.0	8.0	6.0	14.0	8.0	3.0	2.0	3.0	1.0	3.0	2.0	0.0	0.0	0.0
6.0	Chandni Chowk	PIMS	19.0	286.0	0.0	1.0	11.0	17.0	32.0	36.0	42.0	28.0	27.0	25.0	9.0	16.0	15.0	16.0	4.0	7.0	0.0	0.0	0.0

6.0	Chandni Chowk	Stock Exchange	20.0	219.0	0.0	2.0	9.0	17.0	33.0	16.0	21.0	18.0	18.0	15.0	17.0	10.0	17.0	13.0	6.0	4.0	3.0	0.0	0.0
6.0	Chandni Chowk	Pak Secretariat	24.0	157.0	0.0	1.0	24.0	28.0	18.0	26.0	10.0	6.0	6.0	14.0	3.0	12.0	3.0	2.0	1.0	1.0	2.0	0.0	0.0
6.0	Chandni Chowk	Potohar	12.0	145.0	0.0	2.0	2.0	9.0	13.0	8.0	8.0	14.0	18.0	20.0	2.0	5.0	11.0	10.0	9.0	11.0	3.0	0.0	0.0
6.0	Chandni Chowk	Khyaban-e-Johar	13.0	143.0	0.0	0.0	21.0	26.0	13.0	21.0	14.0	15.0	4.0	11.0	2.0	3.0	3.0	0.0	4.0	2.0	4.0	0.0	0.0
6.0	Chandni Chowk	Chaman	16.0	135.0	0.0	1.0	2.0	4.0	3.0	4.0	17.0	9.0	19.0	10.0	17.0	4.0	18.0	14.0	1.0	5.0	7.0	0.0	0.0
6.0	Chandni Chowk	Kashmir Highway	15.0	126.0	0.0	2.0	9.0	17.0	11.0	7.0	16.0	10.0	7.0	6.0	7.0	11.0	2.0	11.0	2.0	3.0	5.0	0.0	0.0
6.0	Chandni Chowk	7th Avenue	21.0	121.0	0.0	3.0	7.0	16.0	11.0	7.0	14.0	10.0	10.0	7.0	9.0	6.0	3.0	0.0	5.0	9.0	4.0	0.0	0.0
6.0	Chandni Chowk	Katchery	18.0	116.0	0.0	1.0	14.0	15.0	7.0	17.0	10.0	6.0	10.0	9.0	4.0	5.0	6.0	4.0	5.0	2.0	1.0	0.0	0.0
6.0	Chandni Chowk	Ibn-e-Sina	17.0	115.0	0.0	1.0	8.0	10.0	8.0	7.0	12.0	5.0	6.0	9.0	11.0	17.0	3.0	9.0	2.0	4.0	3.0	0.0	0.0
6.0	Chandni Chowk	Shaheed-e-Milat	22.0	115.0	0.0	0.0	7.0	12.0	7.0	17.0	10.0	12.0	12.0	7.0	8.0	7.0	2.0	2.0	6.0	4.0	2.0	0.0	0.0
6.0	Chandni Chowk	Parade Ground	23.0	105.0	0.0	0.0	9.0	26.0	7.0	6.0	15.0	9.0	5.0	2.0	7.0	4.0	3.0	2.0	5.0	5.0	0.0	0.0	0.0
6.0	Chandni Chowk	Faiz Ahmad Faiz	14.0	55.0	0.0	3.0	11.0	15.0	4.0	2.0	4.0	4.0	3.0	1.0	4.0	0.0	1.0	1.0	1.0	0.0	1.0	0.0	0.0
7.0	Rehmanabad	Faizabad	10.0	901.0	0.0	9.0	17.0	30.0	28.0	44.0	47.0	64.0	104.0	109.0	94.0	108.0	91.0	59.0	42.0	30.0	25.0	0.0	0.0
7.0	Rehmanabad	Khyaban-e-Johar	13.0	278.0	0.0	2.0	45.0	54.0	23.0	25.0	20.0	23.0	17.0	29.0	13.0	11.0	2.0	0.0	4.0	6.0	4.0	0.0	0.0
7.0	Rehmanabad	Shamsabad	9.0	319.0	0.0	1.0	6.0	28.0	11.0	8.0	17.0	15.0	36.0	30.0	24.0	30.0	30.0	24.0	19.0	28.0	12.0	0.0	0.0
7.0	Rehmanabad	Stock Exchange	20.0	258.0	0.0	6.0	13.0	50.0	23.0	27.0	23.0	26.0	8.0	17.0	17.0	10.0	8.0	10.0	6.0	6.0	6.0	2.0	0.0
7.0	Rehmanabad	PIMS	19.0	257.0	0.0	7.0	19.0	21.0	24.0	30.0	23.0	22.0	16.0	12.0	27.0	20.0	12.0	7.0	8.0	7.0	2.0	0.0	0.0
7.0	Rehmanabad	IJP	11.0	120.0	0.0	0.0	2.0	6.0	2.0	9.0	7.0	12.0	13.0	8.0	10.0	10.0	16.0	6.0	10.0	4.0	4.0	1.0	0.0
7.0	Rehmanabad	Chaman	16.0	245.0	0.0	1.0	4.0	14.0	17.0	15.0	14.0	14.0	19.0	22.0	21.0	21.0	16.0	20.0	13.0	13.0	20.0	1.0	0.0
7.0	Rehmanabad	Potohar	12.0	226.0	0.0	3.0	15.0	20.0	16.0	10.0	16.0	16.0	19.0	18.0	10.0	25.0	24.0	12.0	9.0	11.0	2.0	0.0	0.0
7.0	Rehmanabad	Kashmir Highway	15.0	211.0	0.0	3.0	10.0	37.0	25.0	17.0	24.0	16.0	20.0	13.0	10.0	3.0	9.0	10.0	6.0	6.0	2.0	0.0	0.0
7.0	Rehmanabad	Parade Ground	23.0	207.0	0.0	3.0	18.0	62.0	33.0	19.0	15.0	11.0	13.0	6.0	8.0	3.0	6.0	1.0	4.0	2.0	2.0	1.0	0.0
7.0	Rehmanabad	6th Road	8.0	51.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	3.0	5.0	7.0	9.0	3.0	5.0	1.0	5.0	6.0	3.0	0.0	0.0
7.0	Rehmanabad	Shaheed-e-Milat	22.0	187.0	0.0	2.0	19.0	32.0	19.0	10.0	14.0	11.0	20.0	12.0	3.0	10.0	7.0	10.0	5.0	5.0	7.0	1.0	0.0
7.0	Rehmanabad	Pak Secretariat	24.0	182.0	0.0	1.0	25.0	30.0	25.0	18.0	24.0	17.0	6.0	4.0	2.0	10.0	3.0	2.0	4.0	7.0	3.0	1.0	0.0
7.0	Rehmanabad	7th Avenue	21.0	150.0	0.0	0.0	11.0	22.0	13.0	14.0	15.0	3.0	12.0	7.0	7.0	10.0	15.0	12.0	2.0	2.0	5.0	0.0	0.0
7.0	Rehmanabad	Ibn-e-Sina	17.0	144.0	0.0	0.0	7.0	11.0	15.0	9.0	17.0	10.0	10.0	11.0	7.0	7.0	9.0	10.0	7.0	8.0	6.0	0.0	0.0
7.0	Rehmanabad	Katchery	18.0	130.0	0.0	2.0	9.0	20.0	16.0	20.0	9.0	7.0	5.0	6.0	14.0	4.0	5.0	4.0	3.0	2.0	4.0	0.0	0.0
7.0	Rehmanabad	Faiz Ahmad Faiz	14.0	87.0	0.0	1.0	13.0	13.0	5.0	8.0	13.0	8.0	8.0	5.0	1.0	2.0	5.0	0.0	2.0	0.0	3.0	0.0	0.0
8.0	6th Road	Khyaban-e-Johar	13.0	352.0	0.0	2.0	55.0	85.0	33.0	45.0	28.0	22.0	20.0	22.0	12.0	7.0	2.0	10.0	5.0	1.0	3.0	0.0	0.0
8.0	6th Road	Stock Exchange	20.0	276.0	0.0	3.0	8.0	61.0	26.0	20.0	15.0	12.0	25.0	18.0	15.0	20.0	18.0	9.0	10.0	4.0	12.0	0.0	0.0
8.0	6th Road	PIMS	19.0	258.0	0.0	1.0	10.0	28.0	24.0	27.0	18.0	21.0	18.0	12.0	23.0	15.0	21.0	9.0	16.0	8.0	7.0	0.0	0.0
8.0	6th Road	Potohar	12.0	248.0	0.0	1.0	28.0	22.0	12.0	7.0	20.0	19.0	18.0	15.0	17.0	17.0	16.0	25.0	8.0	10.0	12.0	1.0	0.0
8.0	6th Road	Chaman	16.0	244.0	0.0	1.0	8.0	17.0	9.0	13.0	14.0	18.0	18.0	19.0	12.0	39.0	25.0	17.0	10.0	10.0	14.0	0.0	0.0
8.0	6th Road	Shaheed-e-Milat	22.0	232.0	0.0	4.0	45.0	36.0	25.0	23.0	9.0	19.0	22.0	2.0	12.0	3.0	5.0	13.0	6.0	4.0	3.0	1.0	0.0
8.0	6th Road	Pak Secretariat	24.0	201.0	0.0	5.0	27.0	40.0	23.0	16.0	12.0	13.0	9.0	14.0	4.0	10.0	3.0	13.0	9.0	3.0	0.0	0.0	0.0
8.0	6th Road	Kashmir Highway	15.0	187.0	0.0	0.0	7.0	21.0	15.0	10.0	11.0	16.0	18.0	22.0	12.0	16.0	10.0	5.0	8.0	8.0	7.0	1.0	0.0
8.0	6th Road	Faizabad	10.0	824.0	0.0	7.0	31.0	42.0	28.0	45.0	69.0	65.0	83.0	84.0	78.0	89.0	66.0	45.0	39.0	22.0	28.0	3.0	0.0
8.0	6th Road	7th Avenue	21.0	177.0	0.0	2.0	11.0	23.0	15.0	12.0	15.0	6.0	7.0	6.0	27.0	10.0	13.0	7.0	11.0	5.0	6.0	1.0	0.0

8.0	6th Road	Shamsabad	9.0	164.0	0.0	0.0	4.0	9.0	8.0	8.0	7.0	15.0	14.0	15.0	11.0	17.0	25.0	9.0	10.0	6.0	6.0	0.0	0.0
8.0	6th Road	IJP	11.0	100.0	0.0	0.0	4.0	6.0	4.0	9.0	3.0	4.0	14.0	5.0	9.0	9.0	12.0	7.0	6.0	4.0	4.0	0.0	0.0
8.0	6th Road	Parade Ground	23.0	150.0	0.0	1.0	21.0	40.0	24.0	11.0	5.0	12.0	7.0	7.0	2.0	0.0	9.0	5.0	3.0	3.0	0.0	0.0	0.0
8.0	6th Road	Katchery	18.0	149.0	0.0	7.0	18.0	11.0	7.0	12.0	26.0	18.0	9.0	8.0	5.0	6.0	5.0	4.0	5.0	2.0	5.0	1.0	0.0
8.0	6th Road	Ibn-e-Sina	17.0	142.0	0.0	0.0	7.0	15.0	14.0	5.0	15.0	10.0	10.0	12.0	7.0	11.0	8.0	6.0	8.0	8.0	5.0	1.0	0.0
8.0	6th Road	Faiz Ahmad Faiz	14.0	103.0	0.0	1.0	13.0	21.0	12.0	7.0	5.0	11.0	7.0	1.0	5.0	2.0	5.0	3.0	1.0	4.0	5.0	0.0	0.0
9.0	Shamsabad	PIMS	19.0	335.0	0.0	4.0	17.0	32.0	33.0	51.0	35.0	33.0	29.0	22.0	19.0	18.0	12.0	8.0	6.0	10.0	6.0	0.0	0.0
9.0	Shamsabad	Chaman	16.0	310.0	0.0	2.0	9.0	26.0	33.0	19.0	11.0	14.0	28.0	34.0	36.0	28.0	32.0	16.0	4.0	14.0	4.0	0.0	0.0
9.0	Shamsabad	Potohar	12.0	276.0	0.0	0.0	24.0	39.0	28.0	11.0	12.0	19.0	31.0	21.0	23.0	14.0	13.0	16.0	10.0	12.0	3.0	0.0	0.0
9.0	Shamsabad	Khyaban-e-Johar	13.0	266.0	0.0	5.0	32.0	50.0	23.0	26.0	19.0	17.0	10.0	34.0	8.0	19.0	8.0	5.0	2.0	7.0	1.0	0.0	0.0
9.0	Shamsabad	Kashmir Highway	15.0	250.0	0.0	9.0	32.0	44.0	25.0	23.0	17.0	18.0	19.0	16.0	8.0	14.0	9.0	8.0	2.0	6.0	0.0	0.0	0.0
9.0	Shamsabad	Stock Exchange	20.0	230.0	0.0	4.0	23.0	36.0	27.0	18.0	7.0	11.0	14.0	14.0	17.0	11.0	22.0	9.0	7.0	6.0	4.0	0.0	0.0
9.0	Shamsabad	Shaheed-e-Milat	22.0	219.0	0.0	3.0	35.0	26.0	34.0	21.0	14.0	12.0	18.0	11.0	12.0	9.0	13.0	6.0	2.0	2.0	0.0	1.0	0.0
9.0	Shamsabad	7th Avenue	21.0	183.0	0.0	2.0	12.0	41.0	17.0	13.0	19.0	5.0	10.0	13.0	8.0	9.0	6.0	16.0	5.0	6.0	1.0	0.0	0.0
9.0	Shamsabad	Pak Secretariat	24.0	171.0	0.0	4.0	38.0	37.0	19.0	16.0	4.0	2.0	9.0	10.0	6.0	11.0	3.0	2.0	3.0	2.0	5.0	0.0	0.0
9.0	Shamsabad	Ibn-e-Sina	17.0	163.0	0.0	1.0	14.0	20.0	23.0	10.0	10.0	10.0	12.0	8.0	15.0	8.0	10.0	13.0	3.0	4.0	2.0	0.0	0.0
9.0	Shamsabad	Parade Ground	23.0	150.0	0.0	5.0	11.0	39.0	30.0	11.0	14.0	9.0	3.0	5.0	6.0	3.0	8.0	1.0	0.0	3.0	2.0	0.0	0.0
9.0	Shamsabad	Katchery	18.0	134.0	0.0	2.0	18.0	23.0	13.0	13.0	9.0	11.0	4.0	15.0	5.0	5.0	4.0	3.0	4.0	0.0	5.0	0.0	0.0
9.0	Shamsabad	Faizabad	10.0	560.0	0.0	3.0	13.0	43.0	31.0	29.0	21.0	40.0	52.0	49.0	66.0	55.0	49.0	32.0	30.0	35.0	12.0	0.0	0.0
9.0	Shamsabad	Faiz Ahmad Faiz	14.0	115.0	0.0	0.0	23.0	29.0	10.0	7.0	7.0	1.0	6.0	5.0	3.0	2.0	6.0	6.0	1.0	8.0	0.0	1.0	0.0
9.0	Shamsabad	IJP	11.0	94.0	0.0	1.0	5.0	2.0	6.0	4.0	6.0	1.0	11.0	15.0	6.0	9.0	8.0	11.0	3.0	5.0	1.0	0.0	0.0
10.0	Faizabad	PIMS	19.0	569.0	0.0	14.0	50.0	48.0	61.0	56.0	32.0	40.0	49.0	34.0	58.0	17.0	34.0	21.0	27.0	10.0	17.0	1.0	0.0
10.0	Faizabad	Kashmir Highway	15.0	496.0	0.0	10.0	33.0	75.0	73.0	42.0	55.0	32.0	28.0	22.0	20.0	19.0	32.0	13.0	21.0	11.0	10.0	0.0	0.0
10.0	Faizabad	Stock Exchange	20.0	477.0	0.0	5.0	31.0	43.0	32.0	62.0	50.0	39.0	30.0	36.0	22.0	32.0	21.0	20.0	21.0	19.0	14.0	0.0	0.0
10.0	Faizabad	Pak Secretariat	24.0	459.0	0.0	15.0	41.0	58.0	69.0	59.0	48.0	36.0	24.0	17.0	14.0	20.0	7.0	16.0	13.0	15.0	6.0	1.0	0.0
10.0	Faizabad	Chaman	16.0	454.0	0.0	7.0	20.0	43.0	33.0	38.0	34.0	32.0	31.0	26.0	30.0	37.0	15.0	29.0	32.0	26.0	21.0	0.0	0.0
10.0	Faizabad	Khyaban-e-Johar	13.0	367.0	0.0	8.0	37.0	79.0	47.0	43.0	44.0	24.0	18.0	20.0	14.0	7.0	8.0	7.0	4.0	2.0	4.0	1.0	0.0
10.0	Faizabad	Ibn-e-Sina	17.0	335.0	0.0	6.0	22.0	26.0	36.0	27.0	22.0	14.0	15.0	24.0	23.0	26.0	22.0	25.0	18.0	17.0	10.0	2.0	0.0
10.0	Faizabad	7th Avenue	21.0	303.0	0.0	2.0	20.0	27.0	30.0	31.0	24.0	23.0	19.0	24.0	10.0	18.0	29.0	11.0	15.0	8.0	8.0	4.0	0.0
10.0	Faizabad	Katchery	18.0	292.0	0.0	6.0	17.0	32.0	35.0	30.0	31.0	20.0	23.0	19.0	10.0	17.0	10.0	18.0	10.0	6.0	5.0	3.0	0.0
10.0	Faizabad	Potohar	12.0	285.0	0.0	2.0	13.0	33.0	27.0	33.0	38.0	16.0	9.0	22.0	13.0	16.0	10.0	20.0	9.0	12.0	9.0	3.0	0.0
10.0	Faizabad	Shaheed-e-Milat	22.0	263.0	0.0	5.0	19.0	27.0	32.0	31.0	31.0	11.0	17.0	12.0	13.0	13.0	14.0	19.0	7.0	4.0	8.0	0.0	0.0
10.0	Faizabad	Faiz Ahmad Faiz	14.0	239.0	0.0	8.0	21.0	37.0	39.0	28.0	34.0	11.0	16.0	7.0	3.0	15.0	5.0	6.0	6.0	2.0	0.0	1.0	0.0
10.0	Faizabad	Parade Ground	23.0	180.0	0.0	4.0	10.0	30.0	18.0	19.0	21.0	16.0	9.0	2.0	8.0	10.0	9.0	7.0	10.0	3.0	4.0	0.0	0.0
10.0	Faizabad	IJP	11.0	50.0	0.0	1.0	1.0	1.0	1.0	1.0	2.0	8.0	7.0	5.0	1.0	3.0	4.0	1.0	7.0	2.0	4.0	1.0	0.0
11.0	IJP	Stock Exchange	20.0	290.0	0.0	6.0	19.0	56.0	33.0	42.0	28.0	18.0	16.0	9.0	16.0	12.0	6.0	6.0	11.0	8.0	4.0	0.0	0.0
11.0	IJP	Pak Secretariat	24.0	290.0	0.0	4.0	43.0	56.0	57.0	36.0	24.0	14.0	8.0	7.0	3.0	1.0	7.0	7.0	9.0	9.0	3.0	2.0	0.0
11.0	IJP	PIMS	19.0	276.0	0.0	7.0	14.0	35.0	32.0	35.0	31.0	13.0	24.0	21.0	22.0	12.0	5.0	3.0	10.0	3.0	9.0	0.0	0.0
11.0	IJP	Shaheed-e-Milat	22.0	254.0	0.0	10.0	49.0	29.0	35.0	31.0	12.0	8.0	28.0	5.0	11.0	5.0	10.0	3.0	6.0	6.0	5.0	1.0	0.0

11.0	IJP	7th Avenue	21.0	177.0	0.0	1.0	20.0	28.0	20.0	19.0	15.0	11.0	13.0	8.0	10.0	14.0	3.0	2.0	4.0	4.0	4.0	1.0	0.0
11.0	IJP	Katchery	18.0	157.0	0.0	4.0	25.0	14.0	19.0	16.0	15.0	16.0	11.0	10.0	3.0	8.0	3.0	5.0	4.0	2.0	2.0	0.0	0.0
11.0	IJP	Parade Ground	23.0	143.0	0.0	1.0	13.0	34.0	20.0	29.0	10.0	7.0	7.0	4.0	4.0	4.0	2.0	3.0	2.0	1.0	2.0	0.0	0.0
11.0	IJP	Kashmir Highway	15.0	120.0	0.0	3.0	16.0	17.0	11.0	14.0	11.0	7.0	8.0	7.0	4.0	8.0	1.0	1.0	5.0	3.0	4.0	0.0	0.0
11.0	IJP	Khyaban-e-Johar	13.0	111.0	0.0	3.0	11.0	17.0	9.0	13.0	11.0	12.0	9.0	9.0	6.0	3.0	2.0	3.0	1.0	1.0	1.0	0.0	0.0
11.0	IJP	Chaman	16.0	76.0	0.0	0.0	6.0	7.0	7.0	6.0	4.0	4.0	6.0	6.0	5.0	4.0	10.0	4.0	1.0	2.0	4.0	0.0	0.0
11.0	IJP	Ibn-e-Sina	17.0	62.0	0.0	3.0	10.0	7.0	3.0	13.0	3.0	3.0	6.0	3.0	1.0	4.0	1.0	0.0	2.0	1.0	2.0	0.0	0.0
11.0	IJP	Faiz Ahmad Faiz	14.0	48.0	0.0	0.0	3.0	4.0	5.0	8.0	14.0	1.0	3.0	5.0	0.0	0.0	2.0	1.0	1.0	0.0	1.0	0.0	0.0
11.0	IJP	Potohar	12.0	16.0	0.0	0.0	4.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	2.0	2.0	0.0	1.0	0.0	0.0
12.0	Potohar	Pak Secretariat	24.0	354.0	0.0	3.0	48.0	105.0	61.0	28.0	24.0	22.0	9.0	14.0	9.0	2.0	8.0	8.0	6.0	7.0	0.0	0.0	0.0
12.0	Potohar	Shaheed-e-Milat	22.0	289.0	0.0	1.0	65.0	27.0	29.0	36.0	21.0	13.0	28.0	12.0	8.0	17.0	13.0	6.0	6.0	6.0	0.0	1.0	0.0
12.0	Potohar	Stock Exchange	20.0	250.0	0.0	3.0	17.0	26.0	13.0	24.0	24.0	13.0	19.0	20.0	10.0	9.0	20.0	28.0	11.0	10.0	3.0	0.0	0.0
12.0	Potohar	PIMS	19.0	238.0	0.0	0.0	8.0	24.0	40.0	11.0	18.0	23.0	20.0	14.0	8.0	21.0	14.0	12.0	11.0	5.0	9.0	0.0	0.0
12.0	Potohar	Parade Ground	23.0	169.0	0.0	2.0	13.0	20.0	27.0	13.0	22.0	13.0	6.0	5.0	15.0	9.0	9.0	7.0	6.0	1.0	1.0	0.0	0.0
12.0	Potohar	7th Avenue	21.0	155.0	0.0	0.0	12.0	20.0	12.0	10.0	14.0	14.0	6.0	11.0	12.0	9.0	12.0	14.0	3.0	3.0	3.0	0.0	0.0
12.0	Potohar	Katchery	18.0	146.0	0.0	1.0	15.0	16.0	20.0	8.0	4.0	7.0	8.0	14.0	14.0	11.0	8.0	10.0	4.0	4.0	2.0	0.0	0.0
12.0	Potohar	Kashmir Highway	15.0	91.0	0.0	0.0	3.0	10.0	7.0	9.0	1.0	4.0	16.0	2.0	9.0	7.0	6.0	8.0	3.0	5.0	1.0	0.0	0.0
12.0	Potohar	Chaman	16.0	82.0	0.0	0.0	5.0	5.0	4.0	3.0	3.0	6.0	5.0	7.0	5.0	6.0	7.0	12.0	6.0	6.0	2.0	0.0	0.0
12.0	Potohar	Ibn-e-Sina	17.0	51.0	0.0	0.0	4.0	7.0	2.0	4.0	4.0	4.0	3.0	3.0	4.0	5.0	3.0	2.0	4.0	1.0	1.0	0.0	0.0
12.0	Potohar	Khyaban-e-Johar	13.0	36.0	0.0	0.0	3.0	1.0	3.0	4.0	4.0	5.0	3.0	4.0	2.0	2.0	2.0	1.0	2.0	0.0	0.0	0.0	0.0
12.0	Potohar	Faiz Ahmad Faiz	14.0	36.0	0.0	0.0	2.0	13.0	3.0	3.0	3.0	1.0	0.0	2.0	0.0	2.0	2.0	1.0	0.0	4.0	0.0	0.0	0.0
13.0	Khyaban-e-Johar	Stock Exchange	20.0	168.0	0.0	2.0	1.0	15.0	3.0	15.0	9.0	16.0	17.0	14.0	15.0	21.0	18.0	16.0	4.0	1.0	1.0	0.0	0.0
13.0	Khyaban-e-Johar	PIMS	19.0	136.0	0.0	0.0	1.0	3.0	3.0	4.0	24.0	33.0	15.0	6.0	14.0	11.0	11.0	3.0	3.0	1.0	4.0	0.0	0.0
13.0	Khyaban-e-Johar	Pak Secretariat	24.0	115.0	0.0	0.0	6.0	15.0	13.0	11.0	15.0	15.0	12.0	3.0	4.0	4.0	4.0	9.0	3.0	0.0	1.0	0.0	0.0
13.0	Khyaban-e-Johar	Shaheed-e-Milat	22.0	108.0	0.0	0.0	11.0	7.0	12.0	5.0	10.0	16.0	10.0	3.0	8.0	0.0	10.0	7.0	6.0	2.0	1.0	0.0	0.0
13.0	Khyaban-e-Johar	7th Avenue	21.0	100.0	0.0	1.0	4.0	6.0	7.0	4.0	7.0	10.0	13.0	4.0	8.0	5.0	9.0	14.0	6.0	2.0	0.0	0.0	0.0
13.0	Khyaban-e-Johar	Chaman	16.0	74.0	0.0	0.0	0.0	2.0	1.0	2.0	1.0	11.0	16.0	8.0	4.0	8.0	8.0	7.0	4.0	0.0	2.0	0.0	0.0
13.0	Khyaban-e-Johar	Parade Ground	23.0	69.0	0.0	3.0	1.0	10.0	3.0	2.0	8.0	4.0	15.0	2.0	4.0	5.0	6.0	4.0	1.0	1.0	0.0	0.0	0.0
13.0	Khyaban-e-Johar	Katchery	18.0	65.0	0.0	0.0	3.0	6.0	1.0	5.0	2.0	8.0	5.0	7.0	3.0	6.0	8.0	5.0	4.0	0.0	1.0	1.0	0.0
13.0	Khyaban-e-Johar	Kashmir Highway	15.0	64.0	0.0	0.0	1.0	0.0	0.0	3.0	7.0	5.0	9.0	13.0	2.0	5.0	5.0	11.0	2.0	0.0	1.0	0.0	0.0
13.0	Khyaban-e-Johar	Ibn-e-Sina	17.0	44.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	2.0	8.0	5.0	3.0	5.0	6.0	7.0	2.0	3.0	0.0	0.0	0.0
13.0	Khyaban-e-Johar	Fayz Ahmad Faiz	14.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Stock Exchange	20.0	88.0	0.0	0.0	4.0	7.0	7.0	7.0	8.0	14.0	11.0	7.0	6.0	10.0	1.0	4.0	2.0	0.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Shaheed-e-Milat	22.0	88.0	0.0	0.0	2.0	3.0	8.0	7.0	9.0	5.0	16.0	8.0	10.0	11.0	2.0	1.0	4.0	1.0	1.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Pak Secretariat	24.0	79.0	0.0	0.0	3.0	13.0	6.0	7.0	6.0	23.0	8.0	6.0	2.0	2.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	PIMS	19.0	73.0	0.0	0.0	2.0	3.0	6.0	5.0	8.0	6.0	12.0	11.0	6.0	6.0	1.0	7.0	0.0	0.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	7th Avenue	21.0	73.0	0.0	0.0	2.0	4.0	3.0	7.0	8.0	6.0	4.0	12.0	8.0	8.0	5.0	4.0	0.0	1.0	1.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Parade Ground	23.0	66.0	0.0	1.0	3.0	6.0	2.0	2.0	3.0	8.0	20.0	7.0	5.0	4.0	1.0	3.0	0.0	1.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Katchery	18.0	49.0	0.0	0.0	1.0	1.0	4.0	3.0	8.0	8.0	10.0	6.0	2.0	2.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0

14.0	Faiz Ahmad Faiz	Chaman	16.0	48.0	0.0	0.0	0.0	0.0	1.0	3.0	9.0	17.0	4.0	2.0	5.0	5.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	Faiz Ahmad Faiz	Kashmir Highway	15.0	33.0	0.0	0.0	0.0	0.0	2.0	3.0	3.0	9.0	2.0	6.0	0.0	2.0	2.0	2.0	0.0	1.0	0.0	1.0	0.0
14.0	Faiz Ahmad Faiz	Ibn-e-Sina	17.0	22.0	0.0	0.0	1.0	2.0	2.0	0.0	4.0	5.0	2.0	3.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	Kashmir Highway	Pak Secretariat	24.0	160.0	0.0	3.0	12.0	30.0	31.0	20.0	15.0	7.0	5.0	7.0	9.0	3.0	8.0	5.0	2.0	1.0	2.0	0.0	0.0
15.0	Kashmir Highway	Shaheed-e-Milat	22.0	135.0	0.0	4.0	19.0	11.0	10.0	8.0	10.0	8.0	11.0	9.0	3.0	18.0	7.0	7.0	9.0	0.0	1.0	0.0	0.0
15.0	Kashmir Highway	Stock Exchange	20.0	134.0	0.0	0.0	4.0	24.0	11.0	7.0	11.0	12.0	6.0	6.0	12.0	12.0	13.0	9.0	2.0	4.0	1.0	0.0	0.0
15.0	Kashmir Highway	7th Avenue	21.0	117.0	0.0	2.0	3.0	15.0	18.0	7.0	11.0	7.0	8.0	5.0	7.0	12.0	14.0	2.0	1.0	3.0	2.0	0.0	0.0
15.0	Kashmir Highway	Parade Ground	23.0	98.0	0.0	0.0	6.0	16.0	17.0	6.0	13.0	10.0	6.0	2.0	4.0	8.0	5.0	2.0	0.0	0.0	2.0	1.0	0.0
15.0	Kashmir Highway	PIMS	19.0	89.0	0.0	1.0	3.0	5.0	4.0	9.0	3.0	5.0	14.0	12.0	8.0	7.0	6.0	6.0	1.0	0.0	5.0	0.0	0.0
15.0	Kashmir Highway	Katchery	18.0	58.0	0.0	2.0	2.0	10.0	7.0	2.0	5.0	2.0	10.0	2.0	2.0	4.0	5.0	1.0	1.0	1.0	2.0	0.0	0.0
15.0	Kashmir Highway	Chaman	16.0	16.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	3.0	0.0	5.0	3.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	Kashmir Highway	Ibn-e-Sina	17.0	16.0	0.0	1.0	0.0	2.0	0.0	1.0	0.0	2.0	1.0	0.0	1.0	3.0	4.0	0.0	1.0	0.0	0.0	0.0	0.0
16.0	Chaman	Pak Secretariat	24.0	309.0	0.0	4.0	16.0	57.0	56.0	51.0	23.0	20.0	12.0	15.0	14.0	17.0	4.0	8.0	6.0	5.0	1.0	0.0	0.0
16.0	Chaman	Shaheed-e-Milat	22.0	223.0	0.0	1.0	47.0	40.0	20.0	10.0	13.0	12.0	17.0	14.0	8.0	6.0	11.0	11.0	4.0	2.0	7.0	0.0	0.0
16.0	Chaman	7th Avenue	21.0	175.0	0.0	4.0	13.0	28.0	27.0	11.0	13.0	6.0	14.0	8.0	7.0	3.0	7.0	9.0	6.0	13.0	6.0	0.0	0.0
16.0	Chaman	Stock Exchange	20.0	162.0	0.0	1.0	1.0	32.0	18.0	22.0	15.0	12.0	10.0	12.0	5.0	9.0	5.0	8.0	2.0	7.0	2.0	1.0	0.0
16.0	Chaman	Parade Ground	23.0	152.0	0.0	2.0	9.0	32.0	25.0	11.0	23.0	6.0	11.0	5.0	6.0	6.0	5.0	5.0	6.0	0.0	0.0	0.0	0.0
16.0	Chaman	PIMS	19.0	82.0	0.0	0.0	6.0	6.0	13.0	5.0	11.0	8.0	4.0	11.0	5.0	3.0	4.0	2.0	0.0	4.0	0.0	0.0	0.0
16.0	Chaman	Katchery	18.0	39.0	0.0	0.0	6.0	5.0	3.0	4.0	2.0	4.0	4.0	1.0	3.0	3.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
16.0	Chaman	Ibn-e-Sina	17.0	8.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0	3.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
17.0	Ibn-e-Sina	Pak Secretariat	24.0	160.0	0.0	0.0	18.0	29.0	21.0	21.0	14.0	10.0	5.0	15.0	6.0	2.0	4.0	5.0	3.0	4.0	3.0	0.0	0.0
17.0	Ibn-e-Sina	Shaheed-e-Milat	22.0	110.0	0.0	0.0	17.0	16.0	12.0	10.0	10.0	4.0	4.0	10.0	3.0	4.0	5.0	3.0	2.0	6.0	4.0	0.0	0.0
17.0	Ibn-e-Sina	Parade Ground	23.0	66.0	0.0	1.0	2.0	13.0	10.0	2.0	0.0	13.0	9.0	2.0	4.0	1.0	3.0	3.0	2.0	1.0	0.0	0.0	0.0
17.0	Ibn-e-Sina	7th Avenue	21.0	59.0	0.0	0.0	7.0	4.0	6.0	10.0	4.0	4.0	5.0	3.0	4.0	1.0	5.0	2.0	2.0	0.0	1.0	1.0	0.0
17.0	Ibn-e-Sina	Stock Exchange	20.0	58.0	0.0	1.0	1.0	7.0	10.0	9.0	6.0	2.0	4.0	7.0	2.0	1.0	1.0	4.0	1.0	1.0	0.0	1.0	0.0
17.0	Ibn-e-Sina	PIMS	19.0	34.0	0.0	0.0	2.0	5.0	3.0	3.0	4.0	0.0	5.0	4.0	0.0	1.0	0.0	5.0	0.0	2.0	0.0	0.0	0.0
17.0	Ibn-e-Sina	Katchery	18.0	17.0	0.0	0.0	0.0	3.0	0.0	0.0	1.0	3.0	2.0	1.0	4.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
18.0	Katchery	Pak Secretariat	24.0	114.0	0.0	1.0	8.0	12.0	14.0	10.0	5.0	10.0	11.0	14.0	6.0	5.0	9.0	5.0	2.0	1.0	1.0	0.0	0.0
18.0	Katchery	Shaheed-e-Milat	22.0	92.0	0.0	1.0	5.0	9.0	6.0	7.0	5.0	7.0	14.0	12.0	7.0	4.0	4.0	2.0	4.0	4.0	1.0	0.0	0.0
18.0	Katchery	7th Avenue	21.0	85.0	0.0	0.0	2.0	4.0	3.0	8.0	8.0	5.0	10.0	6.0	11.0	8.0	6.0	6.0	5.0	3.0	0.0	0.0	0.0
18.0	Katchery	Parade Ground	23.0	72.0	0.0	1.0	2.0	6.0	6.0	5.0	6.0	8.0	8.0	6.0	4.0	6.0	6.0	2.0	3.0	0.0	2.0	1.0	0.0
18.0	Katchery	Stock Exchange	20.0	71.0	0.0	0.0	1.0	6.0	3.0	0.0	4.0	17.0	2.0	6.0	10.0	3.0	6.0	5.0	5.0	2.0	1.0	0.0	0.0
18.0	Katchery	PIMS	19.0	8.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
19.0	PIMS	Pak Secretariat	24.0	175.0	0.0	0.0	3.0	13.0	27.0	12.0	17.0	8.0	21.0	10.0	9.0	8.0	17.0	16.0	8.0	5.0	1.0	0.0	0.0
19.0	PIMS	Parade Ground	23.0	114.0	0.0	0.0	1.0	11.0	8.0	8.0	12.0	16.0	7.0	9.0	5.0	11.0	10.0	2.0	4.0	3.0	7.0	0.0	0.0
19.0	PIMS	Shaheed-e-Milat	22.0	99.0	0.0	1.0	11.0	9.0	7.0	5.0	7.0	8.0	6.0	11.0	6.0	7.0	3.0	6.0	6.0	4.0	0.0	2.0	0.0
19.0	PIMS	Stock Exchange	20.0	93.0	0.0	0.0	1.0	2.0	1.0	3.0	4.0	10.0	11.0	28.0	10.0	3.0	7.0	4.0	3.0	4.0	0.0	2.0	0.0
19.0	PIMS	7th Avenue	21.0	90.0	0.0	0.0	1.0	2.0	4.0	2.0	9.0	1.0	10.0	7.0	2.0	13.0	6.0	6.0	9.0	13.0	5.0	0.0	0.0
20.0	Stock Exchange	Pak Secretariat	24.0	245.0	0.0	3.0	10.0	35.0	31.0	16.0	13.0	21.0	22.0	14.0	11.0	12.0	24.0	15.0	3.0	11.0	3.0	1.0	0.0

20.0	Stock Exchange	Parade Ground	23.0	102.0	0.0	2.0	0.0	10.0	4.0	9.0	11.0	8.0	14.0	10.0	8.0	4.0	5.0	4.0	7.0	4.0	2.0	0.0	0.0
20.0	Stock Exchange	Shaheed-e-Milat	22.0	91.0	0.0	0.0	1.0	4.0	6.0	5.0	11.0	6.0	10.0	9.0	8.0	3.0	6.0	11.0	5.0	2.0	4.0	0.0	0.0
20.0	Stock Exchange	7th Avenue	21.0	56.0	0.0	0.0	0.0	1.0	4.0	3.0	6.0	1.0	6.0	5.0	3.0	7.0	9.0	8.0	1.0	1.0	1.0	0.0	0.0
21.0	7th Avenue	Pak Secretariat	24.0	246.0	0.0	4.0	16.0	54.0	31.0	20.0	12.0	16.0	15.0	14.0	18.0	11.0	15.0	10.0	1.0	7.0	2.0	0.0	0.0
21.0	7th Avenue	Parade Ground	23.0	57.0	0.0	1.0	0.0	3.0	4.0	7.0	5.0	9.0	4.0	2.0	8.0	3.0	3.0	3.0	3.0	1.0	1.0	0.0	0.0
21.0	7th Avenue	Shaheed-e-Milat	22.0	34.0	0.0	0.0	1.0	0.0	2.0	2.0	4.0	2.0	2.0	4.0	5.0	2.0	7.0	1.0	1.0	0.0	1.0	0.0	0.0
22.0	Shaheed-e-Milat	Pak Secretariat	24.0	139.0	0.0	1.0	0.0	20.0	20.0	19.0	13.0	11.0	12.0	9.0	5.0	8.0	13.0	4.0	2.0	1.0	1.0	0.0	0.0
22.0	Shaheed-e-Milat	Parade Ground	23.0	13.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	4.0	1.0	2.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0
23.0	Parade Ground	Pak Secretariat	24.0	126.0	0.0	0.0	0.0	10.0	9.0	14.0	15.0	13.0	11.0	7.0	7.0	14.0	11.0	14.0	1.0	0.0	0.0	0.0	0.0
				70120.0	18.0	878.0	5082.0	7626.0	6198.0	5592.0	5483.0	5105.0	5229.0	4822.0	4626.0	4525.0	4474.0	3590.0	2787.0	2254.0	1774.0	57.0	0.0
			No of Trips	515.6	0.1	6.5	37.4	56.1	45.6	41.1	40.3	37.5	38.4	35.5	34.0	33.3	32.9	26.4	20.5	16.6	13.0	0.4	0.0
	Route Distance		Headway	0.1	453.3	9.3	1.6	1.1	1.3	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.8	2.3	2.9	3.6	4.6	143.2	#DIV/0!
	22.4		Total KM Travels	11549.2	3.0	144.6	837.0	1256.0	1020.8	921.0	903.1	840.8	861.2	794.2	761.9	745.3	736.9	591.3	459.0	371.2	292.2	9.4	0.0

10. A5

Important Terminologies & Definitions

Busway: The segregated lane of the road where vehicles operate. Usually, BRT has a single lane for each direction of the vehicle in the BRT corridor with passing lanes at BRT Stations.

Sub-stops: The structural element of BRT stations where bus docks for alighting or boarding of passengers. It may contain one or more docking bays e.g. sub-stops of PMBS have 3 docking bays in each direction.

Docking bay: Where vehicles stop for boarding or alighting of vehicles.

Transfer station: According to the ITDP Standard Planning guide of 2016, transfer station is also called as an interchange station where customers can transfer from one service or route to another within the BRT system (ITDP Planning Guide, 2016, p. 696).

Platform: The area of BRT infrastructure which may or may not have sub-stops and where passengers wait for vehicles to use BRT service. In many cities, Sub-stops are constructed as separate entity from Platform.

Access & Arrival Areas: The integration of passengers from the Urban Environment to the BRT system by using physical elements like stairs, elevators, escalators, etc. According to the ITDP standard guidelines of 2016, At-Grade integration of the Urban Environment with the BRT system is the ideal condition. However, The BRT system may contain Tunnels, Bridges, and Underpasses, etc. for access & arrivals of the passengers.

Terminals: Larger facility at the ends of BRT Corridor for parking, cleanliness of vehicles, rest areas of drivers or changing vehicles, etc. This facility may be used for interchange points for various modes of transportation.

Station Local Capacity & Global Capacity: or Boarding Capacity of a station which is defined as the maximum number of passengers that can enter the system through that station for one hour without allowing queue formation (ITDP Planning

Guide, 2016, p. 820). While the maximum number of passengers leaving or arriving at station BRT regardless of boarding or alighting in vehicles during one hour is called the Global Capacity of a Station.

Saturation Level: According to the ITDP Planning Guide, saturation is the percentage of time that a vehicle stopping bay is occupied.

Dwell Time: According to the ITDP Planning Guide, the amount of time that a vehicle occupies a docking bay is called a Dwell Time. It is the sum of three separate times i.e. Dead Time, Average Boarding time, and Average Alighting Time

Local Service: Local service means that BRT is covering all stops of the BRT corridors to serve the people.

Limited & Express Service: To increase speed and to reduce delays as in the case with Local Service of BRT, BRT planners may skip stations of less demand. Service that skip few stations is called “Limited” and if service is skipping many station then it is called as “Express Service”.

Early Return & Deadheading: Early Return helps the BRT service to skip stations to stations with high demand while Deadheading is the use of Vehicle fleet to Peak-Direction as for two-directional traffic, two peaks are formed at different timings of the day.

Load: For a given interval of time, the demand of passengers for a given link or segment is called the Load of that segment.

Critical Link: The maximum load link of the system is called the Critical Link.

max load: MaxLoad is the Maximum Hourly Load on the Critical Link for a given interval of time usually for an Hour.

PPHPD: is the Passengers per Hour per Direction is the expression to express load on a segment or link for an hour and one direction.

Load Factor: is the percentage of the Vehicle’s capacity that is occupied for any interval of time.

Renovation Factor: It is the total demand of the route divided by the demand in a critical link/segment. The more the renovation factor, more will be the profitable the route.

Irregularity Index: To check the irregularity in the system, we use the irregularity index. The higher the value more are the irregularities in bus operations. So zero irregularity index means the system is 100 % precise when are scheduled.

Waiting Time & Waiting Time Cost: The waiting of passengers to board in vehicles is called the waiting time of passengers. While the monetary value of this time is called Waiting Time Cost.

Fare Box Recovery Ratio: Ratio of service fare revenue to expenditures.

Passengers-minutes: The number of passengers traveled multiple by the minutes of travel.

Forward Direction: The direction of PMBS routes from Saddar (1st Station) station to Pak Secretariat (24th station) station.

Backward Direction: The direction of PBMS routes from Pak Secretariat (24th Station) station to Saddar (1st Station) station.