

FLEET[©]

Long Range Planning Tool For STUs

USER MANUAL



TABLE OF CONTENTS

PART I FLEET TOOL - OPERATIONS

8

1. CONTEXT

9

1.1 About FLEET	10
1.2 About This User Manual	11
1.3 Getting Started with FLEET	11
1.3.1 Terms of Use	11
1.3.2 Getting Started	11
1.3.3 Other user tips and mandatory instructions for using the tool:	14
1.4 FLEET Tool Architecture	15
1.5 Data Requirements	15

2. FLEET USER FORMS

16

2.1 Splash/Cover Page	17
Thumb Rule Estimator	18
Detailed Estimator	18
Exit Button	18
Developer Button	18
2.2 Thumb Rule Estimator: Functionality	18
2.2.1 Thumb Rule Estimator Form: Part A	22
2.2.2 Thumb Rule Estimator Form: Part B	22
2.2.3 Thumb Rule Estimator Form: Part C	23
2.2.4 Thumb Rule Estimator Form: Part D	24
2.2.5 Thumb Rule Estimator Form:	
Part E – Navigation Buttons	25
2.2.6 Thumb Rule Estimator Form:	
Part F – Outputs	25
2.2.7 Thumb Rule Estimator: Default Form	27

2.3 Detailed Estimator: Functionality	36
2.3.1 Navigation Map	37
2.3.2 Toggle Buttons	37
2.3.3 Manoeuvring Buttons	54
2.4 Detailed Estimator: User Form 1: Basic STU Information	55
2.5 Detailed Estimator: User Form 2: Fleet Data Form	64
2.5.1 User Form 2: Part A	65
2.5.2 User Form 2: Part B	65
2.5.3 User Form 2: Part C	66
2.6 Detailed Estimator: User Form 3: STU Service Data Form	68
2.6.1 User Form 3: Part A	69
2.6.2 User Form 3: Part B	69
2.6.3 User Form 3: Part C	70
2.7 Detailed Estimator: User Form 4: Vision Data Form 1	71
2.7.1 User Form 4: Part A	71
2.7.2 User Form 4: Part B	72
2.7.3 User Form 4: Part C	74
2.8 Detailed Estimator: User Form 5: Vision Data Form 2	76
2.8.1 User Form 5: Part A	77
2.8.2 User Form 5: Part B	78
2.8.3 User Form 5: Part C	79
2.8.4 User Form 5: Part D	79
2.8.5 User Form 5: Part E	80
2.8.6 User Form 5: Part F	81
2.8.7 User Form 5: Part G	81
2.9 Detailed Estimator: User Form 6: Vision Data Form 3 (Mode Share)	83
2.10 Detailed Estimator: User Form 7: Output Form	89

PART B FLEET TOOL - FUNCTIONALITY 94

1. FLEET TOOL FUNCTIONALITY	95	3 STRATEGIES	112
1.1 Methodology	96	3.1 Action Plan	117
		3.2 Planning	117
		3.3 Funding and Financing	121
2. GUIDELINES FOR USE OF FLEET OUTPUTS BY CITY OFFICIALS	102	3.4 Implementation	121
		3.5 Expected Outcomes	122
2.1 Expected EPK (ya)	105		
2.2 Expected Occupancy/Load Factor (Yb)	105	ANNEXURES	123
2.3 Expected vehicle utilisation (Yc)	106		
2.4 Expected fleet utilisation (Yd)	106	Annexure 1: General Data Form	124
2.5 Expected number of routes (Ye)	107	Annexure 2: Service-Specific Data Form	125
2.6 Expected CPK (Yf)	107	Annexure 3: Model Base Values and Assumptions	126
2.7 Expected STU mode share (Yg)	108	Annexure 4: Total Number of Fleet Size in each state and Union Territory of India	130
2.8 Expected other bus mode share (Yh)	108		
2.9 Expected IPT mode share (Yi)	109		
2.10 Expected average passenger trip length (Yj)	110		
2.11 Expected average route length (Yk)	111	REFERENCES	131
2.12 Staff to Bus Ratio (Yl)	111		

TABLE OF FIGURES

Figure 1: Step 1	12	Figure 21: Thumb rule estimator – Default Form (Urban)	28	Figure 39: Manoeuvring buttons	54
Figure 2: Step 2	12	Figure 22: Thumb rule estimator – Default Form (Non-Urban)	32	Figure 40: Detailed estimator – User Form 1	56
Figure 3: Step 3	13	Figure 23: Thumb rule estimator – Default Form (Non-Urban)	33	Figure 41: Detailed estimator – User Form 1 – Additional buttons	56
Figure 4: Step 4	13	Figure 24: Detailed estimator with labelled buttons	36	Figure 42: Detailed estimator – User Form 1 – Create new STU button functionality	57
Figure 5: Disabling protected view feature in Microsoft excel 365	14	Figure 25: User-friendly features in input forms	36	Figure 43: User Form 1 – Extended prefilled data section	58
Figure 6: Splash Page	17	Figure 26: Navigation Map	37	Figure 44: User Form 1 – Show Existing STU list button	60
Figure 7: Splash Page, labelled buttons	18	Figure 27: Toggle buttons in each user form	37	Figure 45: User Form 1 – Show Regional Data button	60
Figure 8: Thumb rule estimator with labelled buttons	18	Figure 28: Detailed estimator – Default Form	38	Figure 46: User Form 1 – Hide Regional Data button	60
Figure 9: Thumb rule estimator form – Urban	19	Figure 29: Detailed Estimator – Default form part A with labelled sub- parts	39	Figure 47: User Form 1 – Primary data information	61
Figure 10: Thumb rule estimator form – Non-urban	20	Figure 30: Detailed estimator – Default Form – Part 1 Subpart A	40	Figure 48: User Form 1 – STU drop-down menu	61
Figure 11: Thumb rule estimator form with labelled parts	21	Figure 31: Detailed estimator – Default Form – Part A Subpart A2	42	Figure 49: User Form 1 – Operation Type drop-down menu	61
Figure 12: Thumb rule estimator form – Part A	22	Figure 32: Detailed estimator – Default Form – Part A Subpart A3	45	Figure 50: User Form 1 – Estimation year details	61
Figure 13: Thumb rule estimator form – Part B	22	Figure 33: Detailed estimator – Default Form – Part A Subpart A4	47	Figure 51: User Form 1 – Regional data year details	62
Figure 14: Selected city population input values in thumb rule estimator form part B	22	Figure 34: Detailed estimator – Default Form – Part 2	48	Figure 52: User Form 1 – Tourist data year details	62
Figure 15: Thumb rule estimator form – Part C	23	Figure 35: Detailed estimator – Default Form – Part 3	51	Figure 53: User Form 1 – Different types of operational services	63
Figure 16: Graphical representations of estimation data used by the tool in urban thumb rule estimator	23	Figure 36: Detailed estimator – Estimation Method Form	52	Figure 54: Scenario Name	63
Figure 17: Thumb rule estimator form – Part D	24	Figure 37: Detailed estimator – STU Infrastructure Data Form	53	Figure 55: User Form 1 – Aggregated secondary data selection	63
Figure 18: Thumb rule estimator form – Navigation Buttons	25	Figure 38: Detailed estimator – STU Infrastructure Data Form – Input data field labels	54	Figure 56: Detailed estimator – User Form 2 – Fleet Data Form	64
Figure 19: Thumb rule estimator form – Part F (Outputs)	26			Figure 57: User Form 2 – Fleet Data Form with labels	64
Figure 20 : Thumb rule estimator – Default Form (Urban)	27				

Figure 58: User Form 2 – Part A – Defining service type	65	Figure 79: User Form 5 – Part A	78	Figure 102: % trips of 7–15 km in Indian cities	101
Figure 59: User Form 2 – Part A – Seating capacity	65	Figure 80: User Form 5 – Part B	78	Figure 103: Estimated bus requirement per 1000 people (Trend based on current data)	101
Figure 60: User Form 2 – Part B – Number of buses by age	65	Figure 81: User Form 5 – Part C	79	Figure 104: Relationship between policy factors and STU operational characteristics	103
Figure 61: User Form 2 – Part C – Total fleet size	66	Figure 82: User Form 5 – Part D	80		
Figure 62: User Form 2 – Part C – Bus cost	66	Figure 83: User Form 5 – Part E	80		
Figure 63: User Form 2 – Part C – Bus scrap value	66	Figure 84: User Form 5 – Part F	81		
Figure 64: User Form 2 – Part C – Bus age limit	66	Figure 85: User Form 5 – Part G	82		
Figure 65: User Form 2 – Part C – Planned STU depots	67	Figure 86: Detailed estimator – User Form 6	83		
Figure 66: User Form 2 – Part C – Bus Technology and Fuel Type	67	Figure 87: User Form 6 – Data input display for STU with intracity operations	83		
Figure 67: Detailed estimator – User Form 3 – STU Service Data Form	68	Figure 88: User Form 6 – Mode share data choices	83		
Figure 68: User Form 3 – Service data entry column labels	68	Figure 89: User Form 6 – Prefilled data fields	85		
Figure 69: User Form 3 – Part A	69	Figure 90: User Form 6 – Parts A, B, & C	85		
Figure 70: User Form 3 – Part B	69	Figure 91: User Form 6 – Part A – STU mode share	85		
Figure 71: User Form 3 – Part C	70	Figure 92: User Form 6 – Part B – Other public transport bus mode share	87		
Figure 72: Detailed Estimator – User Form 4 – Vision Data Form 1	71	Figure 93: User Form 6 – Part C – IPT mode share	87		
Figure 73: User Form 4 – Parts A, B, and C	71	Figure 94: Detailed Estimator – User Form 7 – Output form	89		
Figure 74: User Form 4 – Part A	73	Figure 95: User Form 7 – Output form with labelled parts	89		
Figure 75: User Form 4 – Part B	73	Figure 96: User Form 7 – Output form: Save Output button	91		
Figure 76: User Form 4 – Part C	74	Figure 97: Output Tabs	91		
Figure 77: Detailed estimator – User Form 5 – Vision Data Form 2	76	Figure 98: Output Colour Coding	92		
Figure 78: User Form 5 with labelled parts	77	Figure 99: FLEET tool flowchart	98		
		Figure 100: Four Cases under 2 Estimation Methodologies	100		
		Figure 101: Buses per 1000 population in Indian cities (Trend based on current data and projections)	101		

LIST OF TABLES

Table 1:	
Emission factors for different type of bus technologies	51

Project Director

Vivek Chandran (SSEF)

Project Managers

Avni Mehta (SSEF)

Priti Shukla (SSEF)

Prasanth Narayanan Kailas (SSEF)

Project Team

SG ARCHITECTS

Dr. Sandeep Gandhi, Principal

Satyajit Ganguly, Senior Transport Planner

Kanica Gola, Infrastructure Planner

Kartikay Kochhar, Architect

Communications

Aditi Sinha (SSEF)

Designer

Alpana Khare

Reviewers

Talat Munshi (DTU)

Srikanth Shastry

Abhijit Lokre

Himani Jain(CEEW)

Amit Bhatt (WRI India)

Ashish Ghorpade (ICLEI)

Photo Credits

SG Architects

Contact

Vivek Chandran (SSEF)

Dr. Sandeep Gandhi (SG Architects)

ACKNOWLEDGEMENTS

We would like to thank the various individuals, mobility experts and organizations who helped make this document possible.

We are especially thankful to Prof. Geetam Tiwari from The Transportation Research and Injury Prevention Programme (TRIPP) at Indian Institute of Technology (IIT) Delhi, Dr. Ravi Gadepalli from L'Union Internationale des transports publics (UITP) and Mr. Laghu Parashar from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) for their inputs that helped us immensely at various stages of development of the FLEET tool. We would also like to thank the reviewers for their feedback to improving the FLEET tool and this guidebook.

Finally, we would like to thank the different State Transport Undertakings (STUs) for their participation as case examples. We especially acknowledge Bangalore Metropolitan Transport Corporation (BMTC) and Odisha State Road Transport Undertaking (OSRTC) for their valuable inputs.

DISCLAIMER

This document is for 'Private Circulation' only. The views/analysis expressed in this report/document do not necessarily reflect the views of Shakti Sustainable Energy Foundation. The Foundation also does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.



The work is licensed under a Creative Commons Attribution BY 4.0 License. Feel free to copy, distribute and transmit, as long as you attribute the work

1

FLEET TOOL OPERATIONS

1 **CONTEXT**

Public bus companies form the backbone of bus-based mobility in India. These companies, known as State Transport Undertakings (STUs), are under the control of State Transport Departments and have the objective of serving the mobility needs of the residents in the given state. However, the current state of affairs is that many STUs are only serving a small fraction of the total passenger trips in their region of operation. For example, Jammu and Kashmir State Road Transport Corporation (JKSRTC) is serving less than 1% of the total daily passenger trips in the state, whereas this number for more progressive STUs, such as Maharashtra State Road Transport Corporation (MSRTC) or Andhra Pradesh State Road Transport Corporation (APSRTC), increases to 15–20 percent. Thus, even larger STUs such as APSRTC and MSRTC do not yet cater to a large chunk of the potential bus trips and have significant scope to further expand their operations. It is estimated that this expansion can result in capturing an additional 5–10% of passenger trips in these states. India is thus sitting on a large untapped demand for bus trips in general and public bus trips in particular, along with untapped potential to significantly improve bus operations and services. Not exploiting this opportunity could have severe repercussions in the future. If STUs (and other private operators) are unable to provide affordable bus services to this huge potential commuter base, they will not only hamper the access to opportunities and essential services for a large segment of the population, thereby stunting economic growth, but also risk the capture of new mobility trips by inefficient modes of transport such as motorcycles and cars, leading to higher emissions, an increased carbon footprint, more accidents, and greater congestion.

One of the major challenges that most STUs currently

face is their inability to recover operational costs through their current revenue sources. This is, in part, due to the nature of their business (and thus cannot be addressed beyond a point) and partially due to current financial and operational inefficiencies. Hence, these STUs are completely dependent on government funding to overcome any operational losses, maintain and expand their fleet strength, and develop bus infrastructure. In this scenario, the state budgetary machinery and State Transport Department view each additional bus in the fleet as a liability, and each rupee pledged to the STU as a sunk cost. This generates resistance within the government to investing in the STUs, which is a major bottleneck for any STU expansion and revival plans. In a scenario where financial support from state is hard to come by, these organisations enter a deteriorating spiral.

1.1 ABOUT FLEET

A well-defined roadmap with annual actions and achievable targets, leading to achievement of reduced overall losses and increased profitability in a planned timeframe, can be useful to convince decision makers to commit to the necessary investments in STUs. This would also enable STUs to effectively plan the utilisation of the required resources, leading to improved financial, as well as operational, efficiency and expansion of operations into untapped markets, resulting in increased ridership. Recent studies on developing long range plans for MSRTC and APSRTC have shown that STUs focusing on intercity and mofussil operations have the potential to be profitable and financially independent of state support. This can be achieved in a time period of 5 to 15 years, provided these

STUs adopt a strategic roadmap to achieve this objective. With improved efficiencies, investments in increasing ridership are possible, resulting in a significant increase in mode share for the STUs. The actions required as part of this roadmap focus on improved optimisation (of service value and resources) and increased ridership, through improved planning, better training, and strategic tapping of government and private investments and/or resources.

Furthermore, several STUs have shown keen interest in using electric buses (e-buses), encouraged by different central government flagship schemes. STUs have, however, little or no experience with the use of e-bus fleets and therefore lack an understanding of their impact on the operational, infrastructural, and budgetary (both capital and operational cost) requirements. Therefore, STUs need a way to model the impact of inclusion of a predetermined number of e-buses in their fleet and their impact on the STUs' annual budgetary requirement, operational costs, revenue, operational efficiency, fleet utilisation, staff requirement, etc. An existing spreadsheet-based model developed by SGArchitects (SGA) enables estimation based on a predetermined cost and operational lifespan of internal combustion engine (ICE) and electric buses. However, it does not account for the specific contribution of e-buses to operational costs and revenue or service-/vehicle-specific operational characteristics. It also currently does not account for e-bus-specific infrastructure costs, especially the costs of depots, charging infrastructure, additional substations, etc.

To address these shortcomings, SGA has developed a toolkit known as FLEET, with funding from Shakti Sustainable Energy Foundation (Shakti). FLEET is a spreadsheet-based toolkit with a user-friendly Visual Basic for Applications (VBA)-based interface. The toolkit is designed to facilitate estimation of long-range

resources, as well as intervention requirements, for both a region (such as a city or state) and an STU or a public bus operator. The region-based estimator is known as the thumb rule estimator. It requires regional or city level inputs such as population size, population growth rate, current number of buses in operation, etc. It estimates the bus resource requirements for the region based on an estimate of the number of buses required to serve a given population. The STU-based estimator, known as the detailed estimator in the tool, focuses on the operator and user inputs, such as the current and projected service types, as well as service-specific fleet and operational characteristics (fleet utilisation, load factor, vehicle utilisation, staff-to-bus ratio, etc.). It estimates the resource requirement based on an envisioned mode share, fleet size, or number of passenger trips to be fulfilled by the operator. The long-range requirements generated by the two estimators in the tool cover annual budget, fleet procurement, bus infrastructure (depot and terminal) development, staffing, land, etc. This tool is designed for use by STU officials, as well as their consultants. It can also be of use to researchers, advocacy groups, decision makers, and funding agencies. In this regard, the project team partnered Bangalore Metropolitan Transport Corporation (BMTCL) as an urban STU and Odisha State Road Transport Corporation (OSRTC) as a non-urban STU and developed a long-range plan for both the STUs with different scenarios in Fleet tool to have a credible demonstrating effect.

It is expected that, with large-scale use of this toolkit, STUs will be able to initiate an informed transition to becoming more efficient and profitable organisations. As STUs become more efficient and profitable, they will expand to currently untapped regions (or markets), leading to overall increased ridership in bus services in general and

STUs in particular. This will help check the increased use of unsustainable, carbon-intensive private transport modes and promote public transport throughout the country.

1.2 ABOUT THIS USER MANUAL

In order to assist target users (STU officials and bus operators), the FLEET tool is supported by this user manual. The document has been developed by SGA to guide the user regarding the usability and functionality of the FLEET tool. The user manual explains step-by-step data inputs for each of the user forms, along with the tool's functionality, data requirements, possible input data ranges, and types of outputs that can be derived.

1.3 GETTING STARTED WITH FLEET

FLEET Tool is a VBA-based tool developed in Microsoft Excel 365. This tool is compatible with any Windows 10-based Microsoft Excel version 13 or 365 (2019) and above. It is provided in the form of a downloadable *.xlsb file less than 20 megabytes (MB) in size. This file can be downloaded at www.sgarchitects.in, www.shaktifoundation.in, and other websites.

Space: The FLEET tool requires 3 MB of storage. If hard drive space is limited, one can use the FLEET tool via a Universal Serial Bus (USB) memory stick with at least 10 MB of free space.

Screen Resolution: The FLEET tool will automatically adjust to most screen resolutions. In cases where the FLEET scroll bars and buttons are not visible, the user must exit FLEET and enter the Windows Control Panel to change the screen resolution. One should select 1280 x 800 or 1024 x 768 dots per inch (dpi).

If the forms are bigger than the screen, the users may use the scroll bar in the bottom right corner of the form to access all input boxes. In case the input boxes are not visible, the user should try and move the form on the screen by clicking on the top part of the form and moving the form (while holding down the left mouse button) to view the scroll bars.

1.3.1 TERMS OF USE

The usage and distribution of FLEET and its outputs is free, as long as the tool and its developers are appropriately cited. This user manual may be reproduced and quoted in its entirety or part thereof with due accreditation to the project team and SGArchitects. SGArchitects, 6151/8, Sector D, Pocket 6, Vasant Kunj, New Delhi – 110070
Tel: – +91 11 42147521, Email – design@sgarchitects.in
sgarchitects.in, Web: www.sgarchitects.in

1.3.2 GETTING STARTED

To use the tool, the user will need Excel version 2013 or 365 and above on Windows 10. Users of the tool are urged to carefully go through the following steps before using the FLEET Tool.

1.3.2.1 ENABLE MACROS IN EXCEL

Because this is a VBA-based tool, it uses macros, and thus, users may be prompted to enable macros when the downloaded FLEET file is opened. Users can also enable the macros before they open the file, using the following step-by-step process in Windows-based Microsoft Excel 365 (2019/20 update).

Step 1 (Figure 1): Click on the 'File' tab in the upper left-hand corner of the Microsoft Excel 365 (2019/20) tool bar.

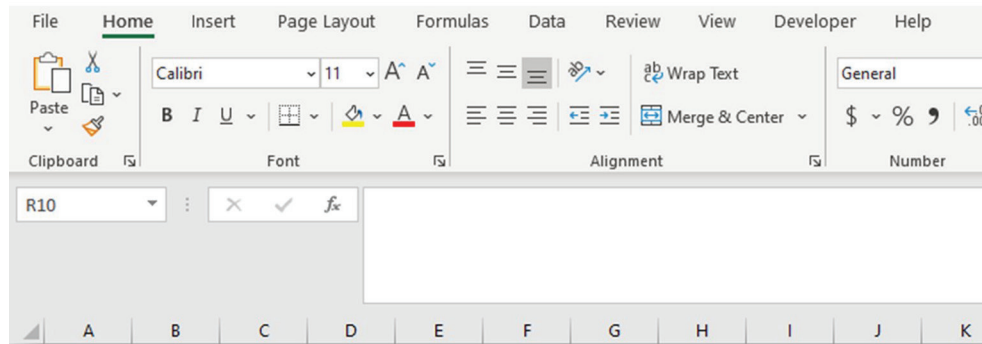


Figure 1 Step 1

1.3.2.2 DISABLE PROTECTED VIEW FEATURE IN EXCEL

Users need to disable the 'Protected View' (Figure 5) feature in Excel before running the file. For this, the user needs to take similar steps to those for enabling macros. The only difference is that after Step 3, the user must click on 'Protected View' under the Trust Center tab and then uncheck 'Enabled Protected View for files originating from the Internet'. The required steps to be taken are listed below.

1. Step 1 – Go to File
2. Step 2 – Options
3. Step 3 – Trust Center
4. Step 4 – Protected View
5. Step 5 -Uncheck 'Enabled Protected View for files originating from the Internet'

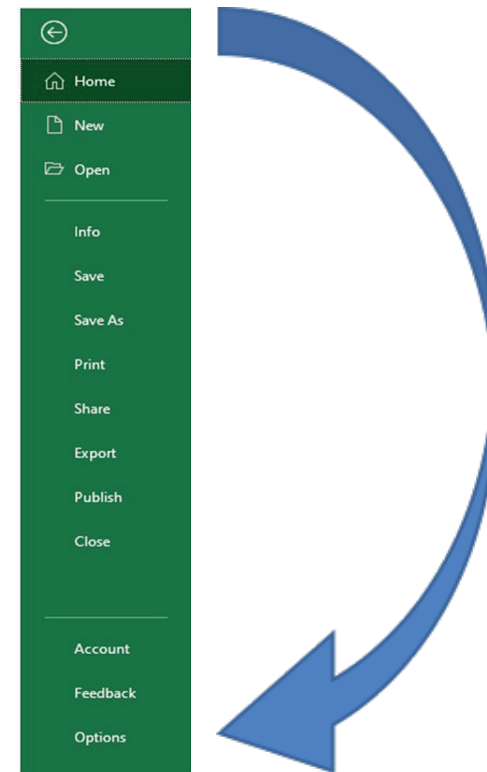


Figure 2

Click on 'Options', displayed at the bottom of the bar.

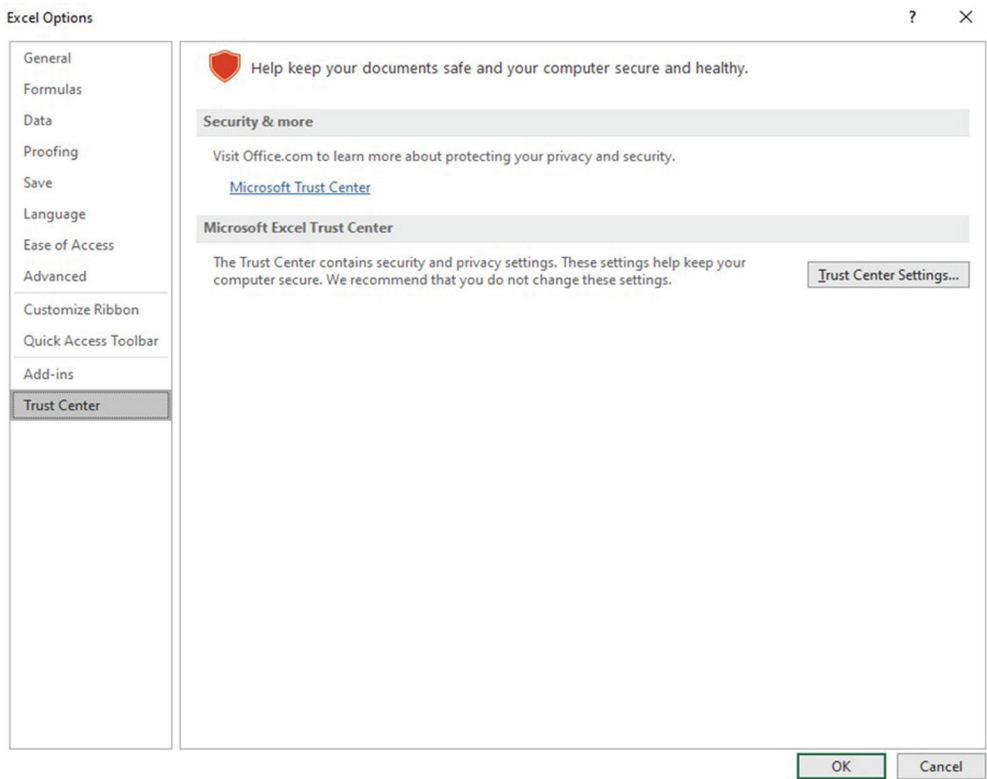


Figure 3 Step 3: Go to 'Trust Center', displayed at the bottom under the 'Options' tab, and click on 'Trust Center Settings'.

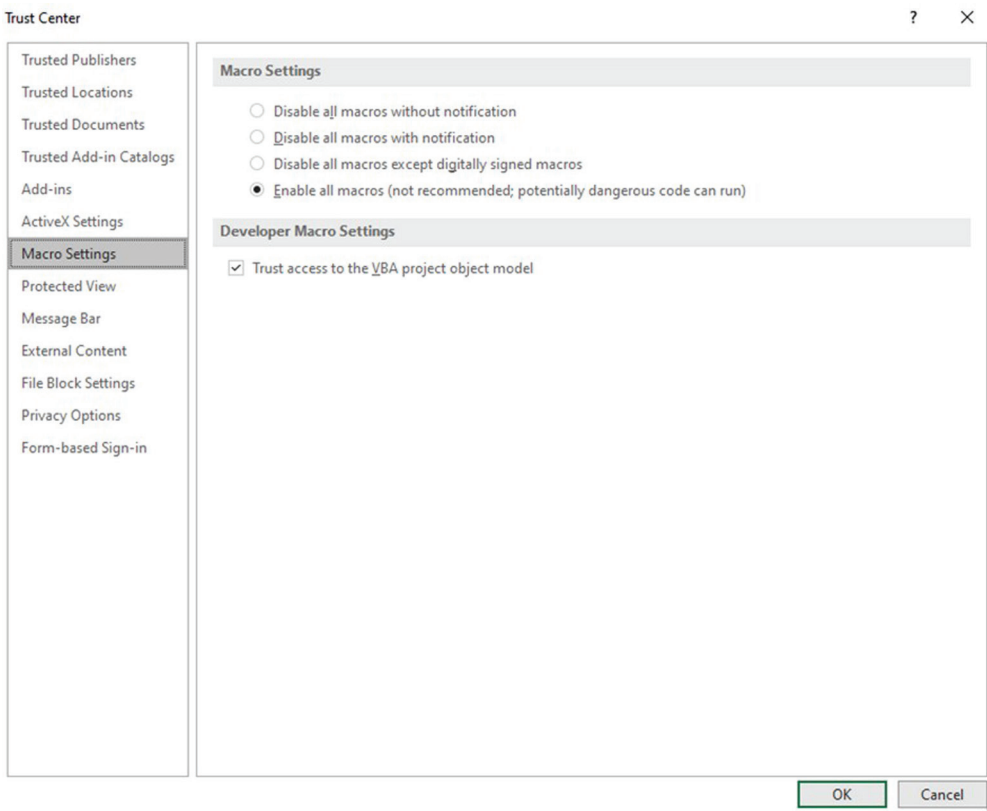
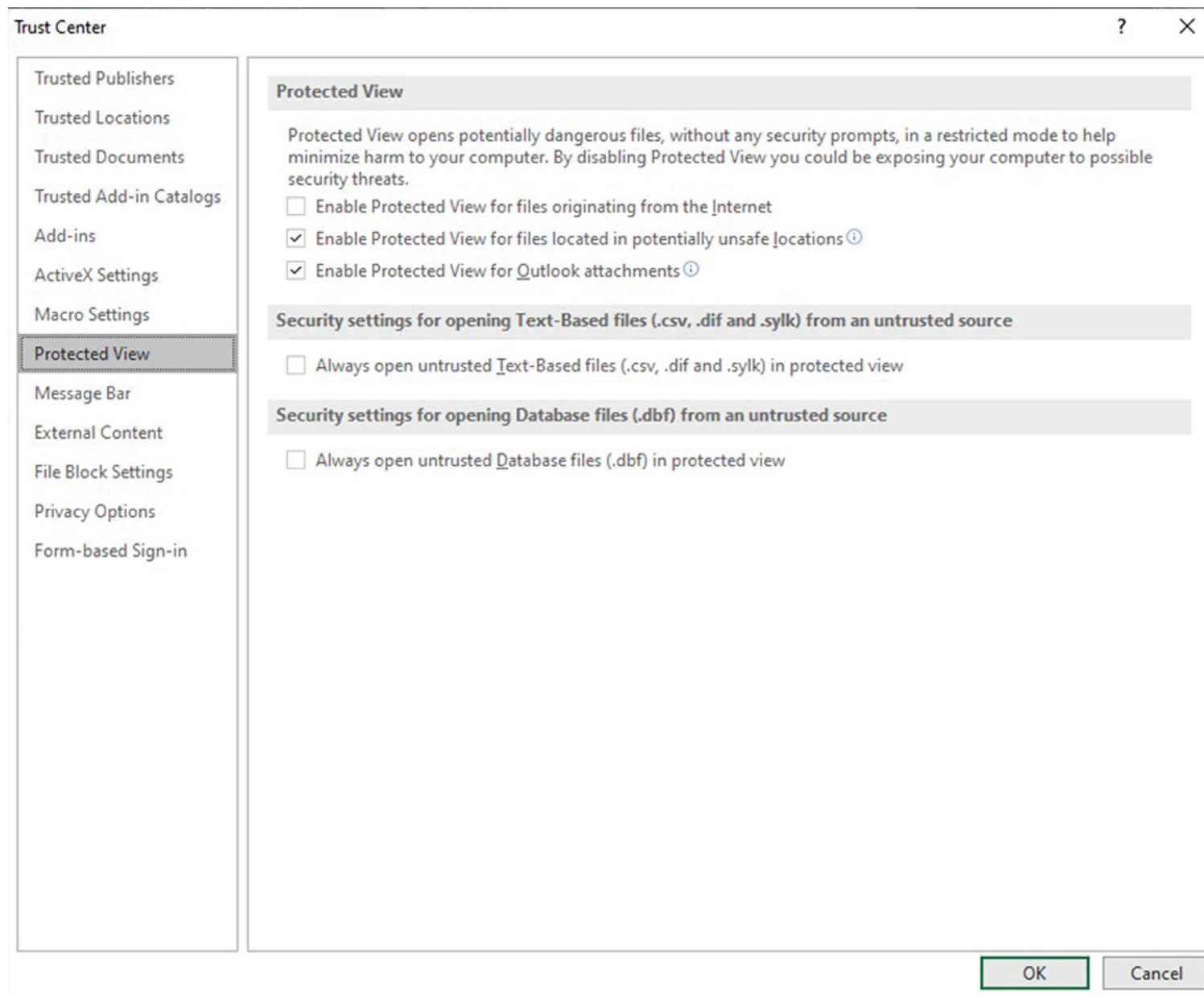


Figure 4 Step 4: (Figure 4) Go to 'Macro Settings' under the 'Trust Center' tab, and select 'Enable all macros'.



1.3.3 OTHER USER TIPS AND MANDATORY INSTRUCTIONS FOR USING THE TOOL:

- The tool currently is not supported on Mac laptops.
- It is recommended to save all your work in any existing Excel/Workbook files and close all other Excel files before opening the FLEET Tool.
- The thumb rule estimator has an 'Urban' button and a 'Non-Urban' button. For bus/population estimation at the city level, the user should click on 'Urban', whereas for regional estimation, the user should click on 'Non-Urban'.
- The detailed estimator has two initial options: 'New' and 'Continue'. The user should click on 'New' to start a fresh analysis, where all inputs need to be filled in by the user. If the user wants to proceed with prefilled data (if any), he/she should click on 'Continue'.
- The data in each user form is automatically saved when the user is switching between forms, and the same can be retrieved by selecting the 'Continue' option in the first form (when the tool is reopened).

Figure 5 Disabling protected view feature in Microsoft excel 365. Click on 'OK', close the excel file, and open the 'FLEET tool' application file.

- The users can save the tool as different scenarios by creating multiple copies of the tool with different names, each containing the input data for a specific scenario.
- The 'Exit' button allows the user to leave the tool as and when desired. The 'Developer' button is not accessible to the user.
- The tool runs background processes when it switches from one user input form to the other. It may therefore take a minute or more between clicking on 'Save and continue' and the next form opening. The user should be patient during this process.
- Each of the input forms has a navigation map at the top, to show the user which form is being filled out.
- For the forward and backward movement of forms in the tool, 'Previous' and 'Next' buttons are provided at the bottom center of each form.
- A set of navigation buttons is provided in the bottom left-hand corner of each form. Through these buttons, the user can access the default values and input infrastructure details, select the fleet estimation method, and exit the tool when desired.
- The user forms can be shifted both vertically and horizontally. For vertical movement, the user simply has to scroll up and down using the mouse, whereas for horizontal movement, the user needs to press the Shift button while scrolling with the mouse.

- To generate input data for the tool, default values have been added based on various secondary sources, such as the Central Institute of Road Transport (CIRT) (CIRT, 2017–18)), national census (CENSUS, 2011), bus terminal guidelines (SGArchitects, 2015), bus depot guidelines (SGArchitects, 2017), state tourist reports, etc.
- The data collection form is provided in the Annexure. Users are encouraged to review this form to better understand the data requirements for the tool.

1.4 FLEET TOOL ARCHITECTURE

The tool's user interface utilises VBA-based input forms for an Microsoft Excel-based model. The user is asked to input parameters related to various bus operation components and STU requirements. The inputs required for the tool have been categorised and grouped in user forms under 2 types of estimators – thumb rule estimator and detailed estimator. For the thumb rule estimator, there is a single input form, whereas for the detailed estimator, there is a set of forms for which the user is required to provide input data to generate the desired outputs.

1.5 DATA REQUIREMENTS

FLEET Tool uses two different in-built datasets for estimation. One set includes data on the population and number of trips in regions covered by STU operations in India. The second set includes aggregated operational, fleet, and service data on all operational STUs or State Road Transport Corporations (SRTC) in India. These datasets have been compiled using secondary sources such as census data and reports available in the public domain. Both of these datasets are used in the detailed estimator, and both datasets can be edited by users.

While the second dataset includes aggregated data for each operational Indian STU, the tool's detailed estimator is also capable of disaggregated estimation. To make use of this feature, users will need to source disaggregated service, fleet, and operational data from the operators. Additional data required for inputs in the detailed estimator include data for scenario building, long-range planning, etc. These data need to be recorded in consultation with key stakeholders, including public bus operators. Annexures 1 and 2 include checklists that can be used to collect input data for the detailed estimator. It is recommended that these forms be printed and used in interviews with STUs and other stakeholders. The data fields in these forms relate to the input fields in the detailed estimator. For ease of use, the data labels and form numbers in these forms are the same as the fields in the user forms described in this manual.

2 FLEET USER FORMS

The following section presents an explanation of the inputs required in each of the user forms used in the tool.

2.1 SPLASH/COVER PAGE

The first page visible when the user opens the FLEET tool is referred to as the 'splash page'. Figure 6 presents the visual of the splash page.

The splash page presents the two estimators (see):

- Thumb Rule Estimator (labelled as A in Figure 7)
- Detailed Estimator (B)

The user can select either option and accordingly generate outputs. Apart from these estimators, the splash page contains two complementary buttons: the 'Exit' button (C) and 'Developer' button (D). The detailed description and functionality of these estimators and buttons are elaborated in the below subsections.



Figure 6 Splash Page

THUMB RULE ESTIMATOR

- A** This estimator is a simple, rule of thumb-based calculator that can be used to estimate the aggregated annual fleet size requirement for a given city/region for a period of 33 years, based on its population and population growth rate. It is designed to provide a quick estimate of a city's or region's bus fleet size requirement. The calculator uses a predefined relationship between the required number of buses and population to estimate the total bus fleet strength.

DETAILED ESTIMATOR

- B** This estimator can be used to calculate detailed operational, infrastructural, and budgetary (both capital and operational cost) requirements for STUs over a period of 33 years. This requires users to provide certain inputs in several user input forms. The detailed estimator uses two different datasets: STU and regional datasets. The functionality of this estimator is explained in the following sections.

EXIT BUTTON

- C** This button is located below the estimator buttons and allows the user to exit the application.

DEVELOPER BUTTON

- D** This button is only accessible to the tool developer, for modification of the spreadsheet models; it is password-protected and not relevant for users.

2.2 THUMB RULE ESTIMATOR: FUNCTIONALITY

This section provides a detailed description of the estimators and their functionality. The thumb rule estimator has two buttons: Urban and Non-Urban (see Figure 8). The function of these buttons is explained below.

1. **Urban** – Clicking on this button will allow user to estimate the aggregated annual fleet size requirement for the city over a period of 33 years, based on its current and projected population.
2. **Non-Urban** – Clicking on this button will allow the user to estimate the aggregated annual fleet size requirement for non-urban operations around the city over a period of 33 years, based on the region's current and projected population.

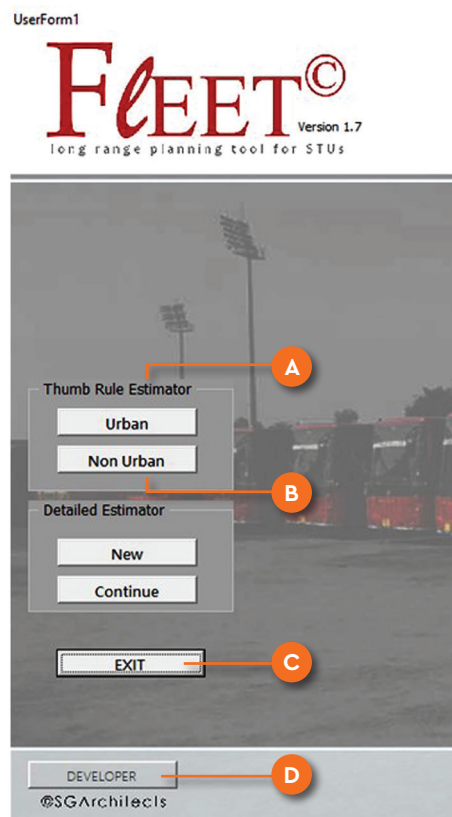


Figure 7 Splash Page, labelled buttons

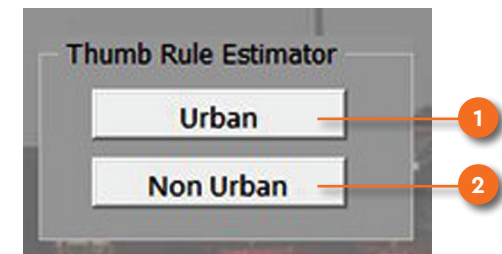


Figure 8 Thumb rule estimator with labelled buttons

The input forms and other additional functionality provided in the urban and non-urban estimators are almost identical. The data inputs required in intercity/non-urban estimator are not based on population, city size, etc.

unlike urban estimator. Non-urban estimator is based on the desired scenario inputs, which is mostly comprised of operational data and readily available with the STUs. Therefore, the assumptions and default values considered

for non-urban estimator are different from that of urban estimator. The screenshot of the thumb rule estimator (for both urban and non-urban forms) are shown in Figure 9.

Thumb Rule Calculator based on (Buses/1K Population) for City Buses

Input

Scenario Name: 1
 Estimation Year: 2020
 Annual Urban population growth: 0.2 %

Data Year: 2020
 Data year population: 300000000
 OR
 Estimation Year Population: []

☐ Calculate by given figure of buses per 1000 population [] Buses/1k pop
☒ estimate buses per 1000 population

Bus technology for primary fleet: ☒ CNG ☐ Diesel ☐ Diesel Hybrid ☐ Electric

Existing fleet size (primary techn. - Diesel/CNG buses) in current estimation year: 202
 Existing fleet size (alternate tech. - electric/hybrid buses) in current estimation year: 0
 Desired share of alternate tech. - electric/hybrid Bus in Fleet (%): 0
 Period for transition to desired alternate tech. - electric/hybrid bus share (years): 1
 Years to achieve desired fleet size: 5

Bus Technology: ☒ Diesel Hybrid ☐ Electric
 Electricity for Electric Bus charging is: ☐ Coal Based ☒ Renewable

Calculate
Save Output
Default Values
Go back
Exit

Year **Population** **Buses per 1k Population** **Fleet size based on buses per 1K population** **Fleet size achievable based on serviceable age of Fleet and current gap** **Primary technology (Electric, Diesel, CNG, Etc.) buses** **Total Alternate technology (Electric, Hybrid, etc.) buses** **Bus Type** **Total trips catered per day** **Mode share**

2020	2,000,000	0.348	733	202	202	0	Urban Bus	121,200	4.04%
2021	2,050,000	0.351	757	335	335	0	Urban Bus	200,918	6.53%
2022	2,101,250	0.354	782	468	468	0	Urban Bus	280,636	8.90%
2023	2,153,781	0.357	809	601	601	0	Urban Bus	360,354	11.15%
2024	2,207,626	0.360	837	733	733	0	Urban Bus	440,072	13.29%
2025	2,262,816	0.363	866	866	866	0	Urban Bus	519,789	15.31%
2026	2,319,387	0.367	897	897	897	0	Urban Bus	538,105	15.47%
2027	2,377,372	0.371	929	929	929	0	Urban Bus	557,684	15.64%
2028	2,436,806	0.375	963	963	963	0	Urban Bus	577,895	15.81%
2029	2,497,726	0.380	999	999	999	0	Urban Bus	599,368	16.00%
2030	2,560,169	0.384	1,037	1,037	1,037	0	Urban Bus	622,105	16.20%
2031	2,624,173	0.389	1,076	1,076	1,076	0	Urban Bus	645,474	16.40%
2032	2,689,778	0.395	1,118	1,118	1,118	0	Urban Bus	670,737	16.62%
2033	2,757,022	0.400	1,162	1,162	1,162	0	Urban Bus	697,263	16.86%
2034	2,825,948	0.406	1,208	1,208	1,208	0	Urban Bus	725,053	17.10%
2035	2,896,596	0.412	1,258	1,258	1,258	0	Urban Bus	754,737	17.37%
2036	2,969,011	0.419	1,309	1,309	1,309	0	Urban Bus	785,684	17.64%
2037	3,043,237	0.426	1,364	1,364	1,364	0	Urban Bus	818,526	17.93%
2038	3,119,317	0.433	1,422	1,422	1,422	0	Urban Bus	853,263	18.24%
2039	3,197,300	0.441	1,483	1,483	1,483	0	Urban Bus	889,895	18.56%
2040	3,277,233	0.449	1,547	1,547	1,547	0	Urban Bus	928,421	18.89%
2041	3,359,164	0.457	1,616	1,616	1,616	0	Urban Bus	969,474	19.24%
2042	3,443,143	0.466	1,688	1,688	1,688	0	Urban Bus	1,013,053	19.61%
2043	3,529,221	0.475	1,764	1,764	1,764	0	Urban Bus	1,058,526	20.00%
2044	3,617,452	0.485	1,845	1,845	1,845	0	Urban Bus	1,107,158	20.40%
2045	3,707,888	0.495	1,932	1,932	1,932	0	Urban Bus	1,158,947	20.84%
2046	3,800,585	0.505	2,021	2,021	2,021	0	Urban Bus	1,212,632	21.27%
2047	3,895,600	0.516	2,117	2,117	2,117	0	Urban Bus	1,270,105	21.74%
2048	3,992,990	0.528	2,219	2,219	2,219	0	Urban Bus	1,331,368	22.23%
2049	4,092,815	0.540	2,326	2,326	2,326	0	Urban Bus	1,395,789	22.74%
2050	4,195,135	0.552	2,439	2,439	2,439	0	Urban Bus	1,463,368	23.26%
2051	4,300,014	0.565	2,559	2,559	2,559	0	Urban Bus	1,535,368	23.80%
2052	4,407,514	0.579	2,686	2,686	2,686	0	Urban Bus	1,611,789	24.38%
2053	4,517,702	0.593	2,821	2,821	2,821	0	Urban Bus	1,692,632	24.98%

Percent of trips with between 7 to 15km trip length
 R² = 0.9442

Bus per 1000 population (trend based on current data)
 R² = 0.94

Figure 9 Thumb rule estimator form – Urban

Thumb Rule Calculator based on (Buses/1K Population) for City Buses

Scenario Name

1

Estimation Year

2020

Annual Urban population growth

0.2

%

Data Year

2020

Estimation Year Population

Data year population

300000000

OR

☐ Calculate by given figure of buses per 1000 population

Bus/1k pop

☒ estimate buses per 1000 population

Bus technology for primary fleet

☒ CNG
 ☐ Diesel
 ☐ Diesel Hybrid
 ☐ Electric

Existing fleet size (primary techn. - Diesel/CNG buses) in current estimation year

5000

Bus Size is

☐ Mini
 ☐ Midi
 ☒ Standard Bus

Existing fleet size (alternate tech. - electric/hybrid buses) in current estimation year

100

Desired share of alternate tech. - electric/hybrid Bus in Fleet (%)

20

Period for transition to desired alternate tech. - electric/hybrid bus share (years)

1

Years to achieve desired fleet size

5

Bus Technology

☒ Diesel Hybrid
 ☐ Electric

Electricity for Electric Bus charging is

☐ Coal Based
 ☒ Renewable

Calculate

Save Output

Default Values

Go back

Exit

Year	Population	Buses per 1k Population	Fleet size based on buses per 1K population	Fleet size achievable based on serviceable age of Fleet and current gap	Primary technology (Electric, Diesel, CNG, Etc.) buses	Total Alternate technology (Electric, Hybrid, etc.) buses	Bus Type	Total trips catered per day	Mode share
2020	300,000,000	0.547	172,632	5,100	5,000	100	Standard Bus	1,453,500	0.48%
2021	300,600,000	0.547	172,977	38,876	31,878	6,998	Standard Bus	11,079,675	3.69%
2022	301,201,200	0.547	173,323	72,749	59,653	13,096	Standard Bus	20,733,495	6.88%
2023	301,803,602	0.547	173,669	106,622	87,429	19,193	Standard Bus	30,387,315	10.07%
2024	302,407,210	0.547	174,017	140,495	115,204	25,291	Standard Bus	40,041,135	13.24%
2025	303,012,024	0.547	174,365	174,368	142,980	31,388	Standard Bus	49,694,955	16.40%
2026	303,618,048	0.547	174,714	174,714	143,263	31,451	Standard Bus	49,793,400	16.40%
2027	304,225,284	0.547	175,063	175,063	143,550	31,513	Standard Bus	49,893,000	16.40%
2028	304,833,735	0.547	175,414	175,414	143,837	31,577	Standard Bus	49,992,900	16.40%
2029	305,443,402	0.547	175,764	175,764	144,124	31,640	Standard Bus	50,092,800	16.40%
2030	306,054,289	0.547	176,116	176,116	144,413	31,703	Standard Bus	50,193,000	16.40%
2031	306,666,398	0.547	176,468	176,468	144,702	31,766	Standard Bus	50,293,500	16.40%
2032	307,279,730	0.547	176,821	176,821	144,991	31,830	Standard Bus	50,394,000	16.40%
2033	307,894,290	0.547	177,175	177,175	145,281	31,894	Standard Bus	50,494,800	16.40%
2034	308,510,078	0.547	177,529	177,529	145,572	31,957	Standard Bus	50,595,900	16.40%
2035	309,127,099	0.547	177,884	177,884	145,863	32,021	Standard Bus	50,697,000	16.40%
2036	309,745,353	0.547	178,240	178,240	146,155	32,085	Standard Bus	50,798,400	16.40%
2037	310,364,843	0.547	178,597	178,597	146,447	32,150	Standard Bus	50,900,100	16.40%
2038	310,985,573	0.547	178,954	178,954	146,740	32,214	Standard Bus	51,001,800	16.40%
2039	311,607,544	0.547	179,312	179,312	147,034	32,278	Standard Bus	51,103,800	16.40%
2040	312,230,759	0.547	179,671	179,671	147,328	32,343	Standard Bus	51,206,100	16.40%
2041	312,855,221	0.547	180,029	180,029	147,622	32,407	Standard Bus	51,308,400	16.40%
2042	313,480,931	0.547	180,389	180,389	147,917	32,472	Standard Bus	51,411,000	16.40%
2043	314,107,893	0.547	180,751	180,751	148,214	32,537	Standard Bus	51,513,900	16.40%
2044	314,736,109	0.547	181,112	181,112	148,510	32,602	Standard Bus	51,616,800	16.40%
2045	315,365,581	0.547	181,474	181,474	148,807	32,667	Standard Bus	51,720,000	16.40%
2046	315,996,312	0.547	181,837	181,837	149,104	32,733	Standard Bus	51,823,500	16.40%
2047	316,628,305	0.547	182,201	182,201	149,403	32,798	Standard Bus	51,927,300	16.40%
2048	317,261,562	0.547	182,565	182,565	149,701	32,864	Standard Bus	52,031,100	16.40%
2049	317,896,085	0.547	182,931	182,931	150,001	32,930	Standard Bus	52,135,200	16.40%
2050	318,531,877	0.547	183,296	183,296	150,301	32,995	Standard Bus	52,239,300	16.40%
2051	319,168,941	0.547	183,663	183,663	150,601	33,062	Standard Bus	52,344,000	16.40%
2052	319,807,279	0.547	184,029	184,029	150,901	33,128	Standard Bus	52,448,400	16.40%
2053	320,446,893	0.547	184,398	184,398	151,204	33,194	Standard Bus	52,553,400	16.40%

Figure 10 Thumb rule estimator form – Non-urban

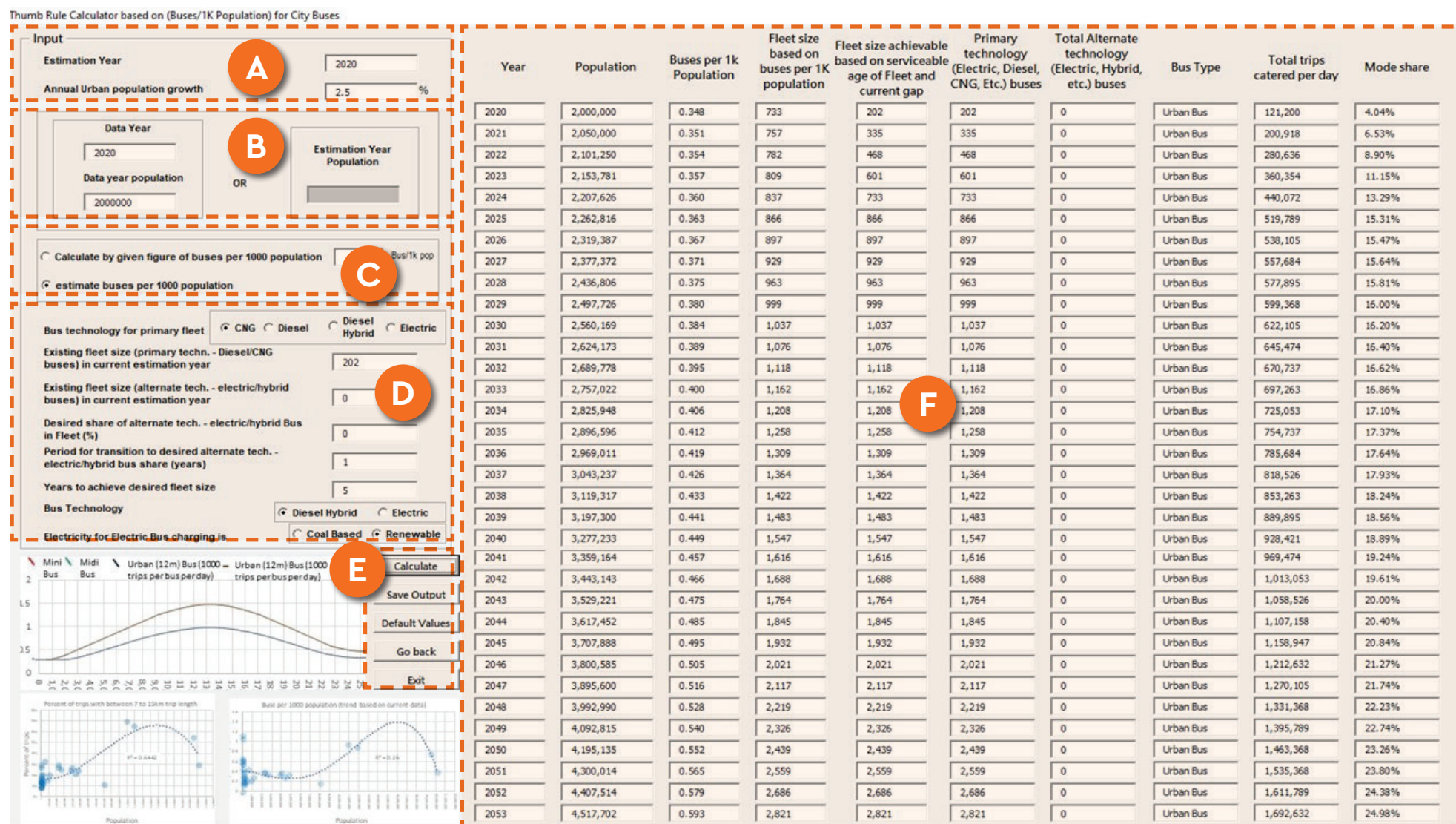


Figure 11 Thumb rule estimator form with labelled parts

For ease of understanding, the six main parts of the form – A, B, C, D, E and F – are labelled in Figure 11. Parts A, B, C, D, and E collect input details from the user, while Part

F presents the annual outputs. The following subsections explain the input requirements in the calculator, along with the outputs generated. The input boxes are coded

in alphabetical order, and the buttons are coded with lowercase letters. The data required in this form and the functions of the buttons are explained below.

2.2.1 THUMB RULE ESTIMATOR FORM: PART A

Part A of the form includes the estimation year and annual urban population growth (Figure 12)

- a Scenario name:** Enter the desired name of the scenario. The user can insert any alphabetical/ numeric/ alphanumeric input, within a limit of 30 characters.
- b Estimation year:** Enter the desired starting year for estimation or outputs. For example, in the figure, 2040 is selected as the year for estimation of the city bus fleet size. This input informs the tool of the year starting from which outputs need to be generated for a period of 33 years. A user can input any year between 2001 and 2060. If a value outside of this range is entered, the tool displays an error message. An error message is also displayed if the user tries to type inputs in characters other than numbers. Another possible error occurs if the estimation year comes before the data year (Part B input box (a)).
- c Annual urban population growth:** Enter the annual urban population growth rate in this input box. A user can enter any urban growth rate value between -15 and 15 (the unit is percentage). Please note that the user should only input numerical values and no other characters. The value is already considered as a percentage; hence, the user **SHOULD NOT use the % character**.

Please note: The above-mentioned input data fields are same for non-urban estimator form as well.

2.2.2 THUMB RULE ESTIMATOR FORM: PART B

Part B (Figure 13) offers a choice regarding the input data that may be used for estimation. The user may directly provide the current or estimation year's (same year as input in Part A box (a)) population (input box (c)) or provide a population (input box (b)) from a previous year (input box (a)). The tool uses the growth rates provided (in Part A) to project the population in the estimation year.

- a Data Year:** In this input box, the user is required to enter the year for which population data is available and is intended to be used for estimation. This value must be less than the current or estimation year value, as specified in Part A input box (a). The user can input any year between 2000 and 2060.
- b Data Year Population:** In this input box, the user is required to enter the city's current population for the year mentioned in the previous data field. The user can input a value anywhere between 1,000 and 200,00,00,000 (do not use any commas in the input values).
- c Current/Estimation Year Population:** In this input box, the user is required to enter the population for the current/estimation year. This

Figure 12 Thumb rule estimator form – Part A

option can be used if the user has the current or estimation year population data (alternatively, fields (a) and (b) may be filled). A user can input any value between 1,000 and 200,00,00,000 (do not use any commas in the input values).

The user can choose to enter input values either in input boxes (a) and (b) or input box (c); the selected boxes remain active, while the other options become inactive. In the example below, the user has opted to estimate the city bus fleet based on the data year population numbers, and thus, the current/estimation year population input box has become inactive (Figure 14). For both the cases, if an input value is outside the permitted range, the tool displays an error message. An error message is also displayed if the user tries to enter characters other than numbers or the data year value is greater than the current/estimation year value (as defined in Part A input box (a)).

Figure 13 Thumb rule estimator form – Part B

Figure 14 Selected city population input values in thumb rule estimator form part B

2.2.3 THUMB RULE ESTIMATOR FORM: PART C

After the user enters data in Part A and B, two possible fleet estimation methods are presented to the user in Part C (Figure 15). The user may choose to use a specified constant of buses per 1000 population (specified in the input box), or he/she may choose to use the tool-estimated population-specific constant of buses per 1000 population.

Same input data fields are applied in the non-urban estimator user form also.

In urban thumb rule estimator user form, value of buses per 1000 population is derived from the relationship between the desired number of buses and population established using data from 35 Indian cities. For better understanding, the user may refer to graphical illustrations displayed in the urban thumb rule estimator user form.

In case the user wants to calculate the city bus fleet for the estimated year using his/her own data on the number of buses per 1000 population, he/she is required to insert the value in data field (a). Otherwise, the user can select 'Estimate buses per 1000 population'. For better understanding, the user may refer to graphical illustrations displayed in the thumb rule estimator user form.

However, in case of non-urban thumb rule estimator, the tool fetches this value from the regional data which is already incorporated in the backend of the tool. Thus, the non-urban thumb rule estimator user form does not display any graphical representation for the same.

Figure 15 Thumb rule estimator form – Part C

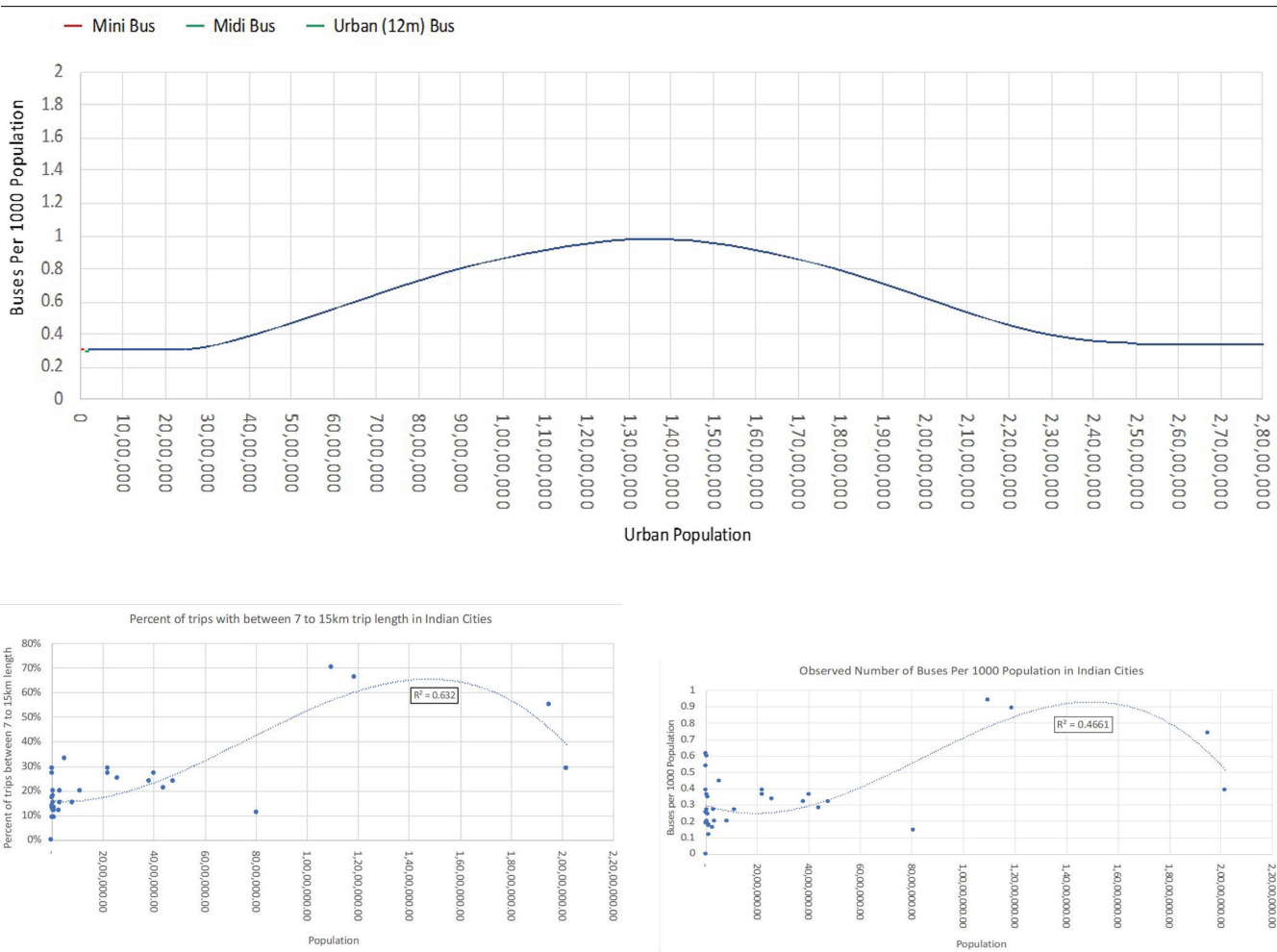


Figure 16 Graphical representations of estimation data used by the tool in urban thumb rule estimator

2.2.4 THUMB RULE ESTIMATOR FORM: PART D

After entering the required data in Part C, the user has to make a choice between different bus technologies in Part D (Figure 17). This is because STUs may have different fleet compositions in terms of bus technologies differing based on the fuel types. Here, "primary" bus fleet refers to the technology used for the majority of buses in the STU's fleet. Alternative bus technology refers to the remainder of the fleet or any technology the STU is envisaging for future. Thus, in the present context, the alternative bus technology can be non-existent (e.g. zero) or may hold a minor share in the fleet composition. The user is required to provide information in the following data fields:

- a Bus technology for primary fleet:** In this field, the user must specify the existing technology of the primary STU bus fleet. The user must select one of the provided options (Diesel/CNG/Diesel Hybrid/Electric).
- b Existing fleet size (primary technology) in current estimation year:** Here, the user must insert the existing fleet size of the primary STU bus technology. The user must input a numerical/ decimal value between 1 and 5000.
- c Existing fleet size (alternative technology) in current estimation year** – Similarly, in this field, the user must insert the existing fleet size of the alternative STU bus technology. The user must input a numerical/ decimal value between 0 and 5000 (0 if there is no alternative technology used).

- d Desired share of alternative technology:** electric/hybrid buses – in fleet– Here, the user must insert the percentage of alternative bus fleet technology desired to be operated by the STU. In this data field, the user must enter a numerical/ decimal value ranging from 0 to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- e Period of transition to desired alternative technology:** electric/hybrid bus share – In this field, the user is required to enter the desired or targeted timeframe (in number of years) of transition of the alternative bus technology to primary bus technology. The user must input a numerical, integer value between 1 and 50.

- f Years to achieve desired fleet size:** In this field, the user is required to enter the targeted number of years to achieve the transition in composition from the current/base year to desired/target fleet size. The user must input a numerical, integer value between 1 and 50.
- g Bus technology:** Here, the user must select the desired bus technology for the future fleet after the transition: Diesel Hybrid or Electric.
- h Electricity for electric bus charging:** In case the user specifies an electric bus fleet as the desired technology, the user is required to mention the source of electricity that will be used for charging—either Coal Based or Renewable.

The form is titled "Thumb rule estimator form - Part D". It contains the following fields and options:

- Bus technology for primary fleet:** Radio buttons for CNG, Diesel, Diesel Hybrid, and Electric. (Label a)
- Existing fleet size (primary techn. - Diesel/CNG buses) in current estimation year:** Text box with value 202. (Label b)
- Existing fleet size (alternate tech. - electric/hybrid buses) in current estimation year:** Text box with value 0. (Label c)
- Desired share of alternate tech. - electric/hybrid Bus in Fleet (%):** Text box with value 0. (Label d)
- Period for transition to desired alternate tech. - electric/hybrid bus share (years):** Text box with value 1. (Label e)
- Years to achieve desired fleet size:** Text box with value 5. (Label f)
- Bus Technology:** Radio buttons for Diesel Hybrid and Electric. (Label g)
- Electricity for Electric Bus charging is:** Radio buttons for Coal Based and Renewable. (Label h)

Figure 17 Thumb rule estimator form – Part D

2.2.5 THUMB RULE ESTIMATOR FORM: PART E - NAVIGATION BUTTONS

The thumb rule estimator form contains 5 navigation buttons. These buttons are: 'Calculate', 'Save Output', 'Default Values', 'Go Back', and 'Exit'. Figure 18 presents the screenshot of these buttons in the form. The functionality of these buttons is explained below.

- 1 Calculate:** After the user clicks on 'Calculate', the tool gives an estimate of the annual city bus fleet size requirement based on population. This is presented in Part E. The user can revise the inputs and use this button to recalculate the outputs at any time, as long as the form/calculator window is open.
- 2 Save Output:** This button allows the user to save the output file in .xls format. This file includes all the input and output data from the thumb rule estimator. The file can be saved in the user's directory of choice on a local computer.
- 3 Default Values:** This button allows the user to access the default value form.
- 4 Go back:** This button allows the user to go back to the main FLEET splash page.
- 5 Exit button:** This button allows the user to exit the tool at any point in time. After pressing the button, the tool will close, and no data will be saved for subsequent use.

Same set of buttons are provided in the non-urban estimator form as well for navigation.

2.2.6 THUMB RULE ESTIMATOR FORM: PART F – OUTPUTS

Figure 19 presents the screenshot of Part F of the form. When the user clicks on 'Calculate,' this part of the form opens, presenting the annual calculated outputs for a period of 33 years. A total of 10 outputs are generated – these have been coded from 'a' to 'j' (see Figure 19) for explanation below.

- a Year:** Displays the estimation year
- b Population:** Presents the annual estimated population, starting from the estimation year
- c Buses per 1K Population:** Presents the annual number of buses required per 1000 people

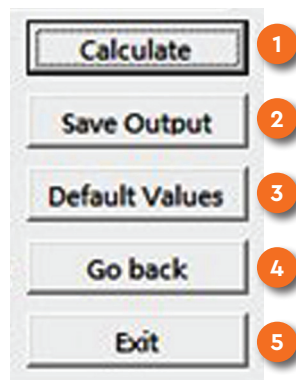


Figure 18 Thumb rule estimator form – Navigation Buttons

- d Fleet size based on buses per 1K population:** Presents the annual estimated fleet size required based on the number of buses per 1k population and projected population
- e Fleet size achievable based on serviceable age of fleet and current gap:** Presents the annual estimated fleet size required considering the retirement age and existing shortfall of fleet.
- f Total primary technology buses:** Presents the annual estimated fleet size of buses with the primary technology, starting from the estimation year
- g Total alternative technology buses:** Presents the annual estimated fleet size of buses with alternative technology, starting from the estimation year
- h Bus type:** Presents the suggested type of bus required
- i Total trips per day:** Presents the total annual estimated trips required to be carried out by the buses
- j Mode share:** Presents the annual estimated mode share attained by the buses

Year	Population	Buses per 1k Population	Fleet size based on buses per 1K population	Fleet size achievable based on serviceable age of Fleet and current gap	Primary technology (Electric, Diesel, CNG, Etc.) buses	Total Alternate technology (Electric, Hybrid, etc.) buses	Bus Type	Total trips catered per day	Mode share
2020	2,000,000	0.348	733	202	202	0	Urban Bus	121,200	4.04%
2021	2,050,000	0.351	757	335	335	0	Urban Bus	200,918	6.53%
2022	2,101,250	0.354	782	468	468	0	Urban Bus	280,636	8.90%
2023	2,153,781	0.357	809	601	601	0	Urban Bus	360,354	11.15%
2024	2,207,626	0.360	837	733	733	0	Urban Bus	440,072	13.29%
2025	2,262,816	0.363	866	866	866	0	Urban Bus	519,789	15.31%
2026	2,319,387	0.367	897	897	897	0	Urban Bus	538,105	15.47%
2027	2,377,372	0.371	929	929	929	0	Urban Bus	557,684	15.64%
2028	2,436,806	0.375	963	963	963	0	Urban Bus	577,895	15.81%
2029	2,497,726	0.380	999	999	999	0	Urban Bus	599,368	16.00%
2030	2,560,169	0.384	1,037	1,037	1,037	0	Urban Bus	622,105	16.20%
2031	2,624,173	0.389	1,076	1,076	1,076	0	Urban Bus	645,474	16.40%
2032	2,689,778	0.395	1,118	1,118	1,118	0	Urban Bus	670,737	16.62%
2033	2,757,022	0.400	1,162	1,162	1,162	0	Urban Bus	697,263	16.86%
2034	2,825,948	0.406	1,208	1,208	1,208	0	Urban Bus	725,053	17.10%
2035	2,896,596	0.412	1,258	1,258	1,258	0	Urban Bus	754,737	17.37%
2036	2,969,011	0.419	1,309	1,309	1,309	0	Urban Bus	785,684	17.64%
2037	3,043,237	0.426	1,364	1,364	1,364	0	Urban Bus	818,526	17.93%
2038	3,119,317	0.433	1,422	1,422	1,422	0	Urban Bus	853,263	18.24%
2039	3,197,300	0.441	1,483	1,483	1,483	0	Urban Bus	889,895	18.56%
2040	3,277,233	0.449	1,547	1,547	1,547	0	Urban Bus	928,421	18.89%
2041	3,359,164	0.457	1,616	1,616	1,616	0	Urban Bus	969,474	19.24%
2042	3,443,143	0.466	1,688	1,688	1,688	0	Urban Bus	1,013,053	19.61%
2043	3,529,221	0.475	1,764	1,764	1,764	0	Urban Bus	1,058,526	20.00%
2044	3,617,452	0.485	1,845	1,845	1,845	0	Urban Bus	1,107,158	20.40%
2045	3,707,888	0.495	1,932	1,932	1,932	0	Urban Bus	1,158,947	20.84%
2046	3,800,585	0.505	2,021	2,021	2,021	0	Urban Bus	1,212,632	21.27%
2047	3,895,600	0.516	2,117	2,117	2,117	0	Urban Bus	1,270,105	21.74%
2048	3,992,990	0.528	2,219	2,219	2,219	0	Urban Bus	1,331,368	22.23%
2049	4,092,815	0.540	2,326	2,326	2,326	0	Urban Bus	1,395,789	22.74%
2050	4,195,135	0.552	2,439	2,439	2,439	0	Urban Bus	1,463,368	23.26%
2051	4,300,014	0.565	2,559	2,559	2,559	0	Urban Bus	1,535,368	23.80%
2052	4,407,514	0.579	2,686	2,686	2,686	0	Urban Bus	1,611,789	24.38%
2053	4,517,702	0.593	2,821	2,821	2,821	0	Urban Bus	1,692,632	24.98%

Figure 19 Thumb rule estimator form – Part F (Outputs)

2.2.7 THUMB RULE ESTIMATOR: DEFAULT FORM

Figure 20 presents the thumb rule estimator default form. As mentioned in the above section, clicking on the Default Values button will take the user to the default form. This form presents the assumed/expected/

commonly accepted or estimated values of various parameters used in the output calculations. The user can edit the provided values in the form as desired and then return to the thumb rule estimator form. The urban and non-urban versions of the thumb rule estimator have almost similar forms and functionality. The default values in respective forms are listed as per bus operations

category (i.e., urban/non-urban). The urban estimator default form has 50 default values whereas non-urban estimator has 46 default values. The defaults forms in both the estimators vary based on the estimation process, which is explained in the following sections. Figure 20 presents the default form for the urban thumb rule estimator.

Default Form_Urban Thumb Rule Estimator

Average service age limit of bus (Diesel/CNG) (years)	12	Average bus scrap value Mini Bus	150000
Average service age limit of bus -Electric (years)	15	Average Daily Vehicle utilization minimum (km)	160
Average cost of urban bus (Diesel/CNG) in INR	3500000	Average daily vehicle utilization maximum (km)	190
Average cost of midi bus (Diesel/CNG) in INR	2400000	Average Fleet utilization (%)	95
Average cost of mini bus (Diesel/CNG) in INR	1800000	Land requirement per bus for terminal development (sqm)	70
Average cost of urban bus (Electric) in INR	12000000	Land requirement per bus for depot development (sqm)	160
Average cost of midi bus (Electric) in INR	10000000	number of years to achieve desired fleet size	1
Average cost of mini bus (Electric) in INR	8500000	Nmber of passenger trips per bus per day [1] for 1000 and [2] for 600	2
Expected earning per km (urban bus) in INR	32	Per capita trip rate	1.5
Expected earning per km (midi bus) in INR	26	GHG emission per km of CNG Bus use (in Co2E kg/km)	1.5
Expected earning per km (mini bus) in INR	18	GHG emission per km of Diesel Bus use (in CO2E kg/km)	1.55
Expected cost per km - Diesel Urban bus in INR	36	GHG emission per km of Diesel Hybrid Bus use (in CO2E kg/km)	1.45
Expected cost per km - Diesel midi bus in INR	34	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is coal based	1.31
Expected cost per km - Diesel mini bus in INR	32	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is renewable	0
Expected cost per km - Electric Urban bus in INR	50	Minimum population for bus service (public or private)	100000
Expected cost per km - Electric midi bus in INR	42	Maximum population for feasible mini bus operations	180000
Expected cost per km - Electric mini bus in INR	35	Maximum Poplation for feasible midi bus operations	260000
Buses per depot (maximum)	120	Daily passenger trips for urban bus daily avg. occupancy 70%	600
Buses per depot (minimum)	80	Daily passenger trips for urban bus daily avg. occupancy 120%	1000
Buses per terminal (maximum)	50	Daily passenger trips for midi bus daily avg. occupancy 70%	460
Buses per terminal (minimum)	15	Daily passenger trips for midi bus daily avg. occupancy 120%	800
Depot Development cost per Bus (INR)	1650000	Daily passenger trips for mini bus daily avg. occupancy 70%	320
Terminal Development cost per bus (INR)	800000	Daily passenger trips for mini bus daily avg. occupancy 120%	540
Staff to Bus Ratio	5.2	Pop. Growth rate - [1] for user defined, [2] for long-range national average urban pop. growth rate	1
Average bus scrap value Urban Bus	200000		
Average bus scrap value Midi Bus	175000		

Set Default Values

OK

Figure 20 Thumb rule estimator – Default Form (Urban)

Default Form_Urban Thumb Rule Estimator

Average service age limit of bus (Diesel/CNG) (years)	1	12	Average bus scrap value Mini Bus	27	150000
Average service age limit of bus -Electric (years)	2	15	Average Daily Vehicle utilization minimum (km)	28	160
Average cost of urban bus (Diesel/CNG) in INR	3	3500000	Average daily vehicle utilization maximum (km)	29	190
Average cost of midi bus (Diesel/CNG) in INR	4	2400000	Average Fleet utilization (%)	30	95
Average cost of mini bus (Diesel/CNG) in INR	5	1800000	Land requirement per bus for terminal development (sqm)	31	70
Average cost of urban bus (Electric) in INR	6	12000000	Land requirement per bus for depot development (sqm)	32	160
Average cost of midi bus (Electric) in INR	7	10000000	number of years to achieve desired fleet size	33	1
Average cost of mini bus (Electric) in INR	8	8500000	Nmber of passenger trips per bus per day [1] for 1000 and [2] for 600	34	2
Expected earning per km (urban bus) in INR	9	32	Per capita trip rate	35	1.5
Expected earning per km (midi bus) in INR	10	26	GHG emission per km of CNG Bus use (in Co2E kg/km)	36	1.5
Expected earning per km (mini bus) in INR	11	18	GHG emission per km of Diesel Bus use (in CO2E kg/km)	37	1.55
Expected cost per km - Diesel Urban bus in INR	12	36	GHG emission per km of Diesel Hybrid Bus use (in CO2E kg/km)	38	1.45
Expected cost per km - Diesel midi bus in INR	13	34	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is coal based	39	1.31
Expected cost per km - Diesel mini bus in INR	14	32	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is renewable	40	0
Expected cost per km - Electric Urban bus in INR	15	50	Minimum population for bus service (public or private)	41	100000
Expected cost per km - Electric midi bus in INR	16	42	Maximum population for feasible mini bus operations	42	180000
Expected cost per km - Electric mini bus in INR	17	35	Maximum Population for feasible midi bus operations	43	260000
Buses per depot (maximum)	18	120	Daily passenger trips for urban bus daily avg. occupancy 70%	44	600
Buses per depot (minimum)	19	80	Daily passenger trips for urban bus daily avg. occupancy 120%	45	1000
Buses per terminal (maximum)	20	50	Daily passenger trips for midi bus daily avg. occupancy 70%	46	460
Buses per terminal (minimum)	21	15	Daily passenger trips for midi bus daily avg. occupancy 120%	47	800
Depot Development cost per Bus (INR)	22	1650000	Daily passenger trips for mini bus daily avg. occupancy 70%	48	320
Terminal Development cost per bus (INR)	23	800000	Daily passenger trips for mini bus daily avg. occupancy 120%	49	540
Staff to Bus Ratio	24	5.2	Pop. Growth rate - [1] for user defined, [2] for long-range national average urban pop. growth rate	50	1
Average bus scrap value Urban Bus	25	200000			
Average bus scrap value Midi Bus	26	175000			

Set Default Values

OK

Figure 21 Thumb rule estimator – Default Form (Urban)

A total of 50 default values appear in the urban thumb rule estimator default form, with two additional buttons provided at the bottom of the form. The default values are coded in numerical order, and the buttons are labelled in alphabetical order, as presented in Figure 21. Below are the details of the 50 default values, as numbered in Figure 21:

- 1 Average service age limit of diesel/CNG bus in years:** This field includes the default value of the average service age of Diesel and CNG buses: 12 years.
- 2 Average service age limit of electric bus in years:** This field includes the default value of the average service age of electric buses: 15 years.
- 3 Average cost of diesel/CNG urban bus in INR:** This field includes the default value of the average cost of diesel and CNG urban buses: Indian Rupees (INR) 35,00,000 per bus.
- 4 Average cost of diesel/CNG midi bus in INR:** This field includes the default value of the average cost of diesel and CNG midi buses: INR 24,00,000 per bus.
- 5 Average cost of diesel/CNG minibus in INR:** This field includes the default value of the average cost of diesel and CNG minibuses: INR 18,00,000 per bus.
- 6 Average cost of electric urban bus in INR:** This field includes the default value of the average cost of electric urban buses: INR 1,20,00,000 per bus.
- 7 Average cost of electric midi bus in INR:** This field includes the default value of the average cost of electric midi buses: INR 1,00,00,000 per bus.
- 8 Average cost of electric minibus in INR:** This field includes the default value of the average cost of electric minibuses: INR 85,00,000 per bus.
- 9 Expected earnings/ kilometre (km) (EPK) of urban bus in INR:** This field includes the default value of urban bus EPK: INR 32.
- 10 Expected EPK of midi bus in INR:** This field includes the default value of midi bus EPK: INR 26.
- 11 Expected EPK of minibus in INR:** This field includes the default value of minibus EPK: INR 18.
- 12 Expected cost/km (CPK) of urban diesel bus in INR:** This field includes the default value of diesel urban bus CPK: INR 36.
- 13 Expected CPK of diesel midi bus in INR:** This field includes the default value of diesel midi bus CPK: INR 34.
- 14 Expected CPK of diesel minibus in INR:** This field includes the default value of diesel minibus CPK: INR 32.
- 15 Expected CPK of electric urban bus in INR:** This field includes the default value of electric urban bus CPK: INR 50.
- 16 Expected CPK of electric midi bus in INR:** This field includes the default value of electric mid bus CPK: INR 42.
- 17 Expected CPK of electric minibus in INR:** This field includes the default value of electric minibus CPK: INR 35.
- 18 Maximum buses per depot:** This field includes the default value of the maximum bus capacity per depot: 120 buses.
- 19 Minimum buses per depot:** This field includes the default value of the minimum bus capacity per depot: 80 buses.
- 20 Maximum buses per terminal:** This field includes the default value of the maximum bus capacity per terminal: 50 buses.
- 21 Minimum buses per terminal:** This field includes the default value of the minimum bus capacity per terminal: 15 buses.
- 22 Depot development cost per bus in INR:** This field includes the default value of the depot development cost per bus: INR 16,50,000.
- 23 Terminal development cost per bus in INR:** This field includes the default value of the terminal development cost per bus: INR 8,00,000.
- 24 Staff to bus ratio:** This field includes the default staff to bus ratio: 5.2.

- 25 Average scrap value of urban bus in INR:** This field includes the default urban bus scrap value: INR 2,00,000.
- 26 Average scrap value of midi bus in INR:** This field includes the default midi bus scrap value: INR 1,75,000.
- 27 Average scrap value of minibus in INR:** This field includes the default minibus scrap value: INR 1,50,000.
- 28 Average minimum daily vehicle utilisation in km:** This field includes the default minimum daily vehicle utilisation: 160 km.
- 29 Average maximum daily vehicle utilisation in km:** This field includes the default maximum daily vehicle utilisation: 190 km.
- 30 Average fleet utilisation in %:** This field includes the default average fleet utilisation: 95 percent.
- 31 Land requirement per bus for terminal development in sqm:** This field includes the default land required per bus in a terminal: 70 square metres (sqm).
- 32 Land requirement per bus for depot development in sqm:** This field includes the default land required per bus in a depot: 160 sqm.
- 33 Number of years to achieve desired fleet size:** This field includes the default number of years in which the desired fleet size can be achieved: 1 year.
- 34 Number of passenger trips per bus per day (1) 1000 or (2) 600:** This field allows user to select the default number of daily passenger trips per bus per day for urban buses between two pre-defined choices
- 35 Per capita trip rate:** This field includes the default per capita trip rate: 1.5.
- 36 CO₂ emissions per km of CNG bus use in kg/km CO₂e:** This field includes the default carbon dioxide (CO₂) emissions for a CNG bus: 1.5 kilogramme (kg)/km CO₂e.
- 37 CO₂ emissions per km of diesel bus use in kg/km CO₂e:** This field includes the default CO₂ emissions for a diesel bus: 1.55 kg/km CO₂e.
- 38 CO₂ emissions per km of diesel hybrid bus use in kg/km CO₂e:** This field includes the default CO₂ emissions for a diesel hybrid bus: 1.45 kg/km CO₂e.
- 39 CO₂ emissions per km of electric bus use with coal-based electricity in kg/km CO₂e:** This field includes the default CO₂ emissions for a coal-based electric bus: 1.31 kg/km CO₂e.
- 40 CO₂ emissions per km of electric bus use with renewable energy-based electricity in kg/km CO₂e:** This field includes the default CO₂ emissions for a renewable energy-based electric bus: 0 kg/km CO₂e.
- 41 Minimum population for bus service (Public or private):** This field includes the default minimum population required by a city to have bus service: 1,00,000 in numbers.
- 42 Maximum Population for feasible minibus operations:** This field includes the default maximum population required by a city to have minibus service: 1,80,000 in numbers.
- 43 Maximum Population for feasible midi bus operations:** This field includes the default maximum population required by a city to have midi bus service: 2,60,000 in numbers.
- 44 Daily passenger trips for urban bus daily avg occupancy 70%:** This field includes the default daily passenger trips for urban bus with daily average occupancy of 70%: 600 in numbers.
- 45 Daily passenger trips for urban bus daily avg occupancy 120%:** This field includes the default daily passenger trips for urban bus with daily average occupancy of 120%: 1000 in numbers.
- 46 Daily passenger trips for midi bus daily avg occupancy 70%:** This field includes the default daily passenger trips for midi bus with daily average occupancy of 70%: 460 in numbers.
- 47 Daily passenger trips for midi bus daily avg occupancy 120%:** This field includes the default daily passenger trips for midi bus with daily average occupancy of 70%: 800 in numbers.
- 48 Daily passenger trips for minibus daily avg occupancy 70%:** This field includes the default daily passenger trips for minibus with daily average occupancy of 70%: 320 in numbers.

49 Daily passenger trips for minibus daily avg occupancy 120%: This field includes the default daily passenger trips for minibus with daily average occupancy of 70%: 540 in numbers.

50 Population growth rate [1] user defined, [2] national average population growth rate: This field allows user to select the default population growth rate between two pre-defined choices.

Similarly, the intercity/non-urban estimator default form is presented below. The non-urban thumb rule estimator default form presents similar parameters but with different values. For example, the average cost assumed for standard bus (diesel/CNG) is 65,00,000 INR in case of urban whereas for the same default parameter, the cost is assumed to be 42,00,000 INR in case of non-urban operations. Figure 22 presents the default form for the non-urban thumb rule estimator. Similarly, the intercity/non-urban estimator default form is presented below. The non-urban thumb rule estimator default form presents similar parameters but with different values. For example, the average cost assumed for standard bus (diesel/CNG) is 65,00,000 INR in case of urban whereas for the same default parameter, the cost is assumed to be 42,00,000 INR in case of non-urban operations. Figure 22 presents the default form for the non-urban thumb rule estimator.

Default Form_Non-Urban Thumb Rule Estimator ×

Average service age limit of bus (Diesel/CNG) (years)	12	Staff to Bus Ratio	5.2
Average service age limit of bus -Electric (years)	15	Average bus scrap value Urban Bus	200000
Average cost of standard bus (Diesel/CNG) in INR	6000000	Average bus scrap value Midi Bus	175000
Average cost of midi bus (Diesel/CNG) in INR	2400000	Average bus scrap value Mini Bus	150000
Average cost of mini bus (Diesel/CNG) in INR	1800000	Average Daily Vehicle utilization minimum (km)	300
Average cost of standard bus (Electric) in INR	12000000	Average daily vehicle utilization maximum (km)	300
Average cost of midi bus (Electric) in INR	10000000	Average Fleet utilization (%)	95
Average cost of mini bus (Electric) in INR	8500000	Land requirement per bus for terminal development (sqm)	150
Expected earning per km (standard bus) in INR	52	Land requirement per bus for depot development (sqm)	160
Expected earning per km (midi bus) in INR	42	Nmber of passenger trips per bus per day [1] for 1000 and [2] for 600	1
Expected earning per km (mini bus) in INR	32	GHG emission per km of CNG Bus use (in Co2E kg/km)	1.5
Expected cost per km - Diesel Urban bus in INR	49	GHG emission per km of Diesel Bus use (in CO2E kg/km)	1.55
Expected cost per km - Diesel midi bus in INR	40	GHG emission per km of Diesel Hybrid Bus use (in CO2E kg/km)	1.45
Expected cost per km - Diesel mini bus in INR	31	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is coal based	1.5
Expected cost per km - Electric Urban bus in INR	51	GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is renewable	0
Expected cost per km - Electric midi bus in INR	42	Expected total bus mode share in non-urban trips (%)	20
Expected cost per km - Electric mini bus in INR	33	Passenger trips per bus per day in non-urban buses (44 seater)	300
Buses per depot (maximum)	120	Terrain type - [1] for plains, [2] for hills and islands	1
Buses per depot (minimum)	80	Per capita trip rate for plains	
Buses per terminal (maximum)	50	Per capita trip rate for hills and islands	0.7
Buses per terminal (minimum)	15	Per capita trip rate for union territories or cit states	0.79
Depot Development cost per Bus (INR)	1650000	Pop. Growth rate - [1] for user defined, [2] for long-range national average pop. growth rate	1
Terminal Development cost per bus (INR)	800000		

Set Default Values
OK

Figure 22 Thumb rule estimator – Default Form (Non-Urban)

Default Form_Non-Urban Thumb Rule Estimator



Average service age limit of bus (Diesel/CNG) (years)	1	12
Average service age limit of bus -Electric (years)	2	15
Average cost of standard bus (Diesel/CNG) in INR	3	6000000
Average cost of midi bus (Diesel/CNG) in INR	4	2400000
Average cost of mini bus (Diesel/CNG) in INR	5	1800000
Average cost of standard bus (Electric) in INR	6	12000000
Average cost of midi bus (Electric) in INR	7	10000000
Average cost of mini bus (Electric) in INR	8	8500000
Expected earning per km (standard bus) in INR	9	52
Expected earning per km (midi bus) in INR	10	42
Expected earning per km (mini bus) in INR	11	32
Expected cost per km - Diesel Urban bus in INR	12	49
Expected cost per km - Diesel midi bus in INR	13	40
Expected cost per km - Diesel mini bus in INR	14	31
Expected cost per km - Electric Urban bus in INR	15	51
Expected cost per km - Electric midi bus in INR	16	42
Expected cost per km - Electric mini bus in INR	17	33
Buses per depot (maximum)	18	120
Buses per depot (minimum)	19	80
Buses per terminal (maximum)	20	50
Buses per terminal (minimum)	21	15
Depot Development cost per Bus (INR)	22	1650000
Terminal Development cost per bus (INR)	23	800000

Staff to Bus Ratio	24	5.2
Average bus scrap value Urban Bus	25	200000
Average bus scrap value Midi Bus	26	175000
Average bus scrap value Mini Bus	27	150000
Average Daily Vehicle utilization minimum (km)	28	300
Average daily vehicle utilization maximum (km)	29	300
Average Fleet utilization (%)	30	95
Land requirement per bus for terminal development (sqm)	31	150
Land requirement per bus for depot development (sqm)	32	160
Nmber of passenger trips per bus per day [1] for 1000 and [2] for 600	33	1
GHG emission per km of CNG Bus use (in Co2E kg/km)	34	1.5
GHG emission per km of Diesel Bus use (in CO2E kg/km)	35	1.55
GHG emission per km of Diesel Hybrid Bus use (in CO2E kg/km)	36	1.45
GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is coal based	37	1.5
GHG emission per km of Electric Bus use (in CO2E kg/km) - Electricity is renewable	38	0
Expected total bus mode share in non-urban trips (%)	39	20
Passenger trips per bus per day in non-urban buses (44 seater)	40	300
Terrain type - [1] for plains, [2] for hills and islands	41	1
Per capita trip rate for plains	42	
Per capita trip rate for hills and islands	43	0.7
Per capita trip rate for union territories or cit states	44	0.79
Pop. Growth rate - [1] for user defined, [2] for long-range national average pop. growth rate	45	1

Set Default Values

a

OK

b

Figure 23 Thumb rule estimator – Default Form (Non-Urban)

A total of 46 default values appears in the thumb rule estimator default form, with two additional buttons provided at the bottom of the form. The default values are coded in numerical order, and the buttons are labelled in alphabetical order, as presented in Figure 23.

Below are the details of the 46 default values, as numbered in Figure 23:

- 1 Average service age limit of diesel/CNG bus in years:** This field includes the default value of the average service age of Diesel and CNG buses: 12 years.
- 2 Average service age limit of electric bus in years:** This field includes the default value of the average service age of electric buses: 15 years.
- 3 Average cost of diesel/CNG urban bus in INR:** This field includes the default value of the average cost of diesel and CNG urban buses: Indian Rupees (INR) 42,00,000 per bus.
- 4 Average cost of diesel/CNG midi bus in INR:** This field includes the default value of the average cost of diesel and CNG midi buses: INR 26,00,000 per bus.
- 5 Average cost of diesel/CNG minibus in INR:** This field includes the default value of the average cost of diesel and CNG minibuses: INR 15,00,000 per bus.
- 6 Average cost of electric urban bus in INR:** This field includes the default value of the average cost of electric urban buses: INR 1,20,00,000 per bus.
- 7 Average cost of electric midi bus in INR:** This field includes the default value of the average cost of electric midi buses: INR 75,00,000 per bus.
- 8 Average cost of electric minibus in INR:** This field includes the default value of the average cost of electric minibuses: INR 35,00,000 per bus.
- 9 Expected earnings/ kilometre (km) (EPK) of urban bus in INR:** This field includes the default value of urban bus EPK: INR 41.
- 10 Expected EPK of midi bus in INR:** This field includes the default value of midi bus EPK: INR 28.
- 11 Expected EPK of minibus in INR:** This field includes the default value of minibus EPK: INR 14.
- 12 Expected cost/km (CPK) of urban diesel bus in INR:** This field includes the default value of diesel urban bus CPK: INR 45.
- 13 Expected CPK of diesel midi bus in INR:** This field includes the default value of diesel midi bus CPK: INR 41.
- 14 Expected CPK of diesel minibus in INR:** This field includes the default value of diesel minibus CPK: INR 38.
- 15 Expected CPK of electric urban bus in INR:** This field includes the default value of electric urban bus CPK: INR 50.
- 16 Expected CPK of electric midi bus in INR:** This field includes the default value of electric mid bus CPK: INR 46.
- 17 Expected CPK of electric minibus in INR:** This field includes the default value of electric minibus CPK: INR 423.
- 18 Maximum buses per depot:** This field includes the default value of the maximum bus capacity per depot: 120 buses.
- 19 Minimum buses per depot:** This field includes the default value of the minimum bus capacity per depot: 80 buses.
- 20 Maximum buses per terminal:** This field includes the default value of the maximum bus capacity per terminal: 50 buses.
- 21 Minimum buses per terminal:** This field includes the default value of the minimum bus capacity per terminal: 15 buses.
- 22 Depot development cost per bus in INR:** This field includes the default value of the depot development cost per bus: INR 16,50,000.
- 23 Terminal development cost per bus in INR:** This field includes the default value of the terminal development cost per bus: INR 8,00,000.
- 24 Staff to bus ratio:** This field includes the default staff to bus ratio: 5.2.

- 25 Average scrap value of urban bus in INR:** This field includes the default urban bus scrap value: INR 2,00,000.
- 26 Scrap value of midi bus in INR:** This field includes the default midi bus scrap value: INR 1,75,000.
- 27 Average scrap value of minibus in INR:** This field includes the default minibus scrap value: INR 1,50,000.
- 28 Average minimum daily vehicle utilisation in km:** This field includes the default minimum daily vehicle utilisation: 300 km.
- 29 Average maximum daily vehicle utilisation in km:** This field includes the default maximum daily vehicle utilisation: 300 km.
- 30 Average fleet utilisation in %:** This field includes the default average fleet utilisation: 95 percent.
- 31 Land requirement per bus for terminal development in sqm:** This field includes the default land required per bus in a terminal: 70 square metres (sqm).
- 32 Land requirement per bus for depot development in sqm:** This field includes the default land required per bus in a depot: 160 sqm.
- 33 Number of years to achieve desired fleet size:** This field includes the default number of years in which the desired fleet size can be achieved: 1 year.
- 34 Number of passenger trips per bus per day (1) 1000 or (2) 600:** This field allows user to select the default number of daily passenger trips per bus per day for urban buses between two pre-defined choices.
- 35 CO₂ emissions per km of CNG bus use in kg/km CO₂e:** This field includes the default carbon dioxide (CO₂) emissions for a CNG bus: 1.5 kilogramme (kg)/km CO₂e.
- 36 CO₂ emissions per km of diesel bus use in kg/km CO₂e:** This field includes the default CO₂ emissions for a diesel bus: 1.55 kg/km CO₂e.
- 37 CO₂ emissions per km of diesel hybrid bus use in kg/km CO₂e:** This field includes the default CO₂ emissions for a diesel hybrid bus: 1.45 kg/km CO₂e.
- 38 CO₂ emissions per km of electric bus use with coal-based electricity in kg/km CO₂e:** This field includes the default CO₂ emissions for a coal-based electric bus: 1.31 kg/km CO₂e.
- 39 CO₂ emissions per km of electric bus use with renewable energy-based electricity in kg/km CO₂e:** This field includes the default CO₂ emissions for a renewable energy-based electric bus: 0 kg/km CO₂e.
- 40 Expected total bus mode share in non-urban trips in %:** This field includes the default desired mode share of bus in the non-urban trips: 20
- 41 Passenger trips per bus per day in non-urban buses (40-seater):** This field includes the default value of per bus per day passenger trips by non-urban buses: 300
- 42 Terrain type [1] for plains and [2] for hilly and islands:** This field allows user to select the default terrain type between two pre-defined choices.
- 43 Per capita trip rate for plains:** This field includes the default per capita trip rate for plain terrain: 0.82.
- 44 Per capita trip rate for hills and Islands:** This field includes the default per capita trip rate for hills and Islands: 0.7.
- 45 Per capita trip rate for union territories and city states:** This field includes the default per capita trip rate for union territories and city states: 0.79.
- 46 Population growth rate [1] user defined, [2] national average population growth rate:** This field allows user to select the default population growth rate between two pre-defined choices.
- The additional buttons have the following functions:
- a Set Default Values** — If the user wants to use the older default values provided in the tool, he/she must click on 'Set Default Values'. The tool will then restore the prior default values and recalculate the outputs.
- b OK** — After viewing the default values in the form, the user needs to click on 'OK' to go back to the thumb rule estimator form. In case the user changes any default values and wants to continue further, he/she must also click on 'OK'. The tool will automatically incorporate the modified default values into its calculations.

2.3 DETAILED ESTIMATOR: FUNCTIONALITY

When the user opens the detailed estimator, there are two buttons – New and Continue (see Figure 24). The function of these buttons is explained below.

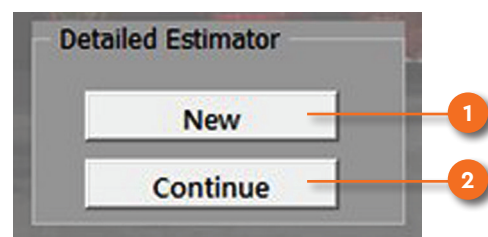


Figure 24 Detailed estimator with labelled buttons

- 1 New:** This button allows a user to start a new analysis using the detailed estimator. When the user clicks on 'New', he/she is directed to the FLEET detailed estimator user forms (starting with User Form 2), and all boxes are blank, ready for new data entry.
- 2 Continue:** This button allows the user to start from where he/she last exited the primary estimator in the FLEET Tool. All data and inputs up to the last entry (before closing the file in the most recent previous session) are retained by the tool. When the user clicks on 'Continue', he/she is directed to User Form 2, which, along with the subsequent forms, displays previously entered inputs, which can be modified or retained.

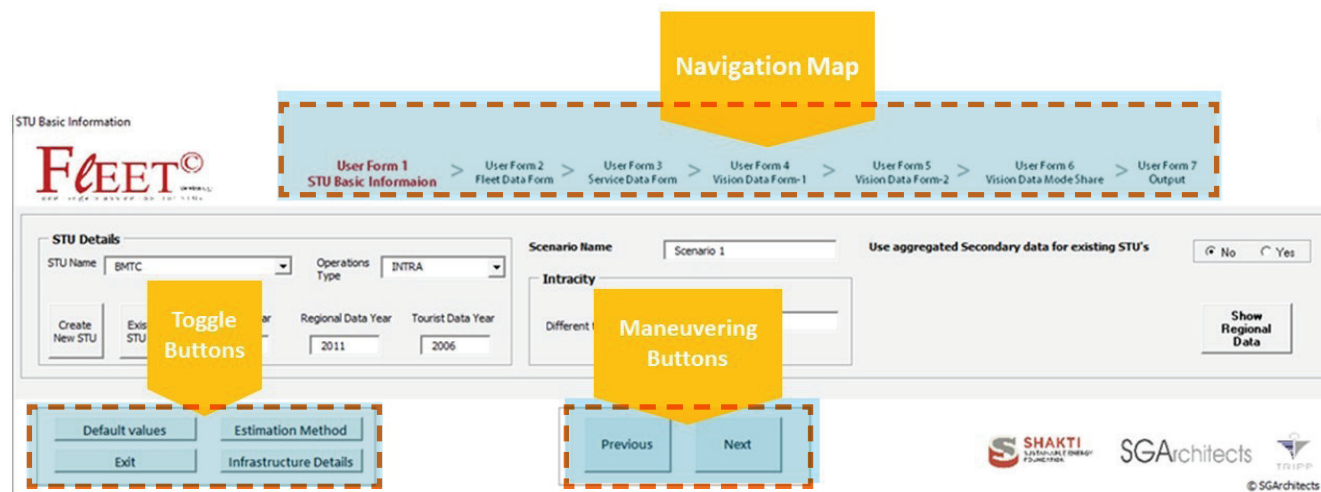


Figure 25 User-friendly features in input forms

When the user clicks on either of the two abovementioned buttons, the tool starts displaying the detailed estimator user forms. Unlike the thumb rule estimator, the detailed estimator has a sequence of 6 user input forms. The 7th user form displays the outputs. The forms all focus on different types of data and are named accordingly, as listed below.

1. User Form 1: Basic STU Information
2. User Form 2: Fleet Data Form
3. User Form 3: STU Service Data Form
4. User Form 4: Vision Data Form 1

5. User Form 5: Vision Data Form 2
6. User Form 6: Mode Share Vision Data Form (expected mode share)
7. User Form 7: Output Form

These inputs and the functionality of these user forms are detailed in the following sections. Additionally, for the ease of the user, all these user forms are equipped with uniform user-friendly features. Figure 25 presents the user-friendly features provided in the forms.

These features are described in the following section.

2.3.1 NAVIGATION MAP

Excluding the splash page (which has a different set of toggle buttons), each of the user forms (from 1 to 6) have the same set of toggle buttons. These buttons are: 'Default Values', 'Estimation Method', 'Infrastructure Details', and 'Exit'. Figure 27 provides the screenshot of these buttons. The functionality of these buttons is explained below.

Each of the user forms includes a navigation map at the top of the form (Figure 26). The navigation map panel is labelled with all the six user forms, in sequential order. The user form currently being used is highlighted through red text. This navigation map helps the user keep track of which form he/she is currently filling out, which one was most recently completed, and which is going to come next.

2.3.2 TOGGLE BUTTONS

Excluding the splash page (which has a different set of toggle buttons), each of the user forms (from 1 to 6) have the same set of toggle buttons. These buttons are: 'Default Values', 'Estimation Method', 'Infrastructure Details', and 'Exit'. Figure 27 provides the screenshot of these buttons. The functionality of these buttons is explained below.



Figure 26 Navigation Map



Figure 27 Toggle buttons in each user form

2.3.2.1 'DEFAULT VALUES' BUTTON

By clicking on 'Default Values' (which is provided in all user forms), the user can access the default values in that particular form at any time (opens in a pop-up window). The default form includes a description of all the values, along with additional calculated values, used by the tool in various processes. The user can edit the given values in the default form as desired. After making changes to the default form, the user can go back to the original form. Figure 28 presents the detailed estimator default form. The default form has been divided into three parts (A, B, and C).

STU Default Data

Item	Value	Item	Value
> 10km Work Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Percent of STU Inter-city trips > 10km as percent of total inter-city trips by bus	60.57%
> 10km Education Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Work SPT trips origin from outside state (travelling to state) as percent of work SPT trips in state	1.00%
> 10km Non work (and non tourist) trips bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Percent of same day education trips less than 10km by SPT in urban areas	4.00%
Percent of education trips less than 10km in urban areas	65.00%	Intra city non work trips < 10km by SPT	47.23%
Percent of education trips less than 10km in rural areas	70.00%	Percent of same day education trips less than 10km by SPT in rural areas	0.50%
Percent of inter city work trips > 10km originating from urban area	10%	Inter city non work trips < 10km by SPT	20.17%
Percent of inter city education trips > 10km originating from urban area	10%	Percent of same day education trips more than 10km by SPT in urban areas	15.00%
Percent of inter city non-work trips > 10km originating from urban area	10%	Intra city non work trips > 10km by SPT	8.95%
Percent of education trips less than 10km by buses in urban areas	14.52%	Percent of same day education trips more than 10km by SPT in rural areas	4.00%
Percent of non-work trips less than 10km by buses in urban areas	39.90%	Inter city non work trips > 10km by SPT	23.65%
Percent of non-work trips less than 10km by buses in rural/non-urban areas	22.50%		
Percent of non-work trips more than 10km by buses in urban areas	0.00%		
Percent of non-work trips more than 10km by buses in rural/non-urban areas	1.00%		
Percent of same day education trips less than 10km by public buses in rural areas	20.00%		
Percent of same day education trips more than 10km by public buses in urban areas	21.00%		
Percent of same day education trips more than 10km by public buses in rural areas	37.00%		
Inter city non work trips < 10km by bus	10.27%		
Inter city non work trips > 10km by bus	36.17%		
Percent of STU Intra city trips < 10km as percent of total intra city trips by bus	62.64%		
Percent of STU Inter city trips < 10km as percent of total inter city trips by bus	19.43%		
Percent of STU Intra city trips > 10km as percent of total intra city trips by bus	37.36%		

Item	Value	Item	Value
Urban trip rate	1.35	< 10km share in intra city non-work trips (non urban STU)	90.7
Non Urban Trip Rate	0.69	< 10km share in inter city non-work trips (non urban STU)	61.53
Urban work trips as share of total trips	38.46	< 10km share in intra city non-work trips (urban STU)	86.22
Urban education trips as share of total trips	31.52	> 10km share in intra city non-work trips (urban STU)	40.37
Urban tourist trips as share of total trips	1.22	> 10km share in inter city non-work trips (urban STU)	73.22
Urban non work trips as share of total trips	28.8	> 10km share in intra-city bus trips (all trip types)	31.04
Non-urban work trips as share of total trips	37.2	> 10km share in intercity bus trips (all trip types)	83.36
Non-urban education trips as share of total trips	32.01	> 10km share in intra-city SPT trips (all trip types)	45.35
Non-urban tourist trips as share of total trips	2.89	> 10km share in intercity SPT trips (all trip types)	32.88
Non-urban non work trips as share of total trips	27.9	Share of intra-city trips from outside State of total < 10km tourist tourist trips	28.77
< 10km share in intra city work trips (non urban STU)	90.7	Share of tourist trips from outside State of total intercity > 10km tourist trips	34.23
< 10km share in inter city work trips (non urban STU)	61.53	Share of tourist trips from outside State of total intercity < 10km tourist trips	31.25
< 10km share in intra city work trips (urban STU)	86.75	Share of tourist trips from outside State of total intercity > 10km tourist trips	88.21
< 10km share in inter city work trips (urban STU)	44.96	Percent of intra-city tourist trips > 10km out of total intra-city tourist trips	11.18

Name - Bus Technology and Fuel Used	Description - Bus Technology and Fuel Used	Total CO2E Emission (kg/km)	Nox (g/km)	PM (g/km)	SOx (g/km)
Diesel > 150ppm with OC	Diesel bus with oxidation catalyst with > 150ppm sulphur diesel fuel	1.14	10.2	0.292	1.42
Diesel 50 with DPF	Diesel bus with diesel particulate filter with < 50ppm sulphur diesel fuel	1.28	10.8	0.146	1.42
Diesel 0.15 with DPF	Diesel bus with diesel particulate filter with < 15ppm sulphur diesel fuel	1.41	13	0.032	1.42
CNG	B5 2 to B5 3 CNG fuel bus	1.51	15	0.03	1.42
CNG with OC	CNG fuel bus with Oxidation Catalyst	1.37	9.8	0.01	1.42
CNG with 3WC	CNG fuel bus with 3 way catalytic converter	1.2	1.4	0.024	1.42
Hybrid ICE	Hybrid electric bus with Diesel 15 DPF	1.46	9.5	0.036	1.42
Electric - Thermal Power	Battery electric bus powered with electricity from thermal power plant	1.52	0	0	1.42
Electric - Renewable Power	Battery electric bus powered with renewable electricity	0	0	0	0

Set Default Values

OK

Figure 28 Detailed estimator - Default Form

DETAILED ESTIMATOR: DEFAULT FORM

Figure 29 presents the screenshot of the labelled default form, with three different main sections. The tool uses a total of 75 editable default parameters. These parameters have assigned values in the tool, i.e. default values. Users can edit these values based on the data they have collected, if any. The edited values are saved in the tool and available when the tool is opened again in the 'CONTINUE' mode. Although users can edit default values, changes to the same are not recommended unless required for research and academic applications. The first set of default values i.e., Part A of the default form which has 38 default fields, labelled in lowercase alphabetical order. For better legibility, Part A is further divided into 4 parts – A1, A2, A3, and A4, where each of the labelled default fields in the figure have been explained below.

STU Default Data

Item	Value	Item	Value
> 10km Work Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Percent of STU Inter city trips >10km as percent of total intercity trips by bus	80.57%
> 10km Education Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Work IPT trips origin from outside state (travelling to state) as percent of work IPT trips in state	1.00%
> 10km Non work (and non tourist) trips bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	Percent of same day education trips less than 10km by IPT in urban areas	4.00%
Percent of education trips less than 10km in urban areas	85.00%	Intra city non work trips <10km by IPT	47.23%
Percent of education trips less than 10km in rural areas	70.00%	Percent of same day education trips less than 10km by IPT in rural areas	0.50%
Percent of inter city work trips >10km originating from urban area	10%	Inter city non work trips <10km by IPT	20.17%
Percent of inter city education trips >10km originating from urban area	10%	Percent of same day education trips more than 10km by IPT in urban areas	15.00%
Percent of inter city non-work trips >10km originating from urban area	10%	Intra city non work trips >10km by IPT	8.95%
Percent of education trips less than 10km by buses in urban area	14.52%	Percent of same day education trips more than 10km by IPT in rural areas	4.00%
Percent of non-work trips less than 10km by buses in urban areas	39.90%	Inter city non work trips >10km by IPT	23.65%
Percent of non-work trips less than 10km by buses in rural/non-urban areas	22.50%		
Percent of non-work trips more than 10km by buses in urban areas	0.00%		
Percent of non-work trips more than 10km by buses in rural/non-urban areas	1.00%		
Percent of same day education trips less than 10km by public buses in rural areas	20.00%		
Percent of same day education trips more than 10km by public buses in urban areas	21.00%		
Percent of same day education trips more than 10km by public buses in rural areas	37.00%		
Inter city non work trips <10km by bus	10.27%		
Inter city non work trips >10km by bus	36.17%		
Percent of STU Intra city trips <10km as percent of total intra city trips by bus	62.64%		
Percent of STU Inter city trips <10km as percent of total inter city trips by bus	19.43%		
Percent of STU Intra city trips >10km as percent of total intra city trips by bus	37.36%		

Item	Value
Land Required per bus for depot development (sqm)	160.00
Average Depot Capacity (buses)	100.00
% of non local STU buses using inter city terminal (as % of STU buses)	0%
Cost per bus for developing depot (rs)	1650000.00

	Urban	Non-Urban
Land Required per bus for terminal development	70.00	150.00
Average terminal capacity	40.00	40.00
Cost per bus for developing terminal (rs)	800000.00	1500000
Factor to relate terminal capacity to bus fleet (Fleet/(Capacity*X), where	1.25	1.25

Figure 29 Detailed Estimator – Default form part A with labelled sub- parts

DETAILED ESTIMATE -
DEFAULT FORM – PART A

As mentioned above, the part A of the default form is divided into four parts for the ease of explanation. The below section elaborates these default values in the sequential order.

DEFAULT VALUES - PART A1 OF PART A

Figure 30 shows Part A1 of part A in the default form.

A1

> 10km Work Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	a
> 10km Education Bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	b
> 10km Non work (and non tourist) trips bus trips origin from other states (travelling to state) as percent of work bus trips in state	2.50%	c
Percent of education trips less than 10km in urban areas	85.00%	d
Percent of education trips less than 10km in rural areas	70.00%	e
Percent of inter city work trips >10km originating from urban area	10%	f
Percent of inter city education trips >10km originating from urban area	10%	g
Percent of inter city non-work trips >10km originating from urban area	10%	h
Percent of education trips less than 10km by buses in urban area	14.52%	i
Percent of non-work trips less than 10km by buses in urban areas	39.90%	j

a >10 km work bus trips originating from other region/state (travelling to region/state) as % of total work-related bus trips in state: This is an assumed value referring to the work-related passenger trips that are greater than 10 km in length and originate from another region/ state, as a percentage of the total work-related bus trips in the region/state served by the STU. The tool adds these trips to its estimate of the total trips that need to be accounted for. The default value for this field is 2.50 percent.

b >10 km educational bus trips originating from other region/state (travelling to region/state) as % of total educational bus trips in state: This is an assumed value referring to the educational passenger trips that are greater than 10 km in length and originate from another region/state, as a percentage of the total educational bus trips in the region/state served by the STU. The tool adds these trips to its estimate of the total trips that need to be accounted for. The default value for this field is **2.50 percent**.

c >10 km non-work (and non-tourist) bus trips originating from other region/state (travelling to region/state) as % of total non-work bus trips in state: This is an assumed value referring to the passenger trips other than work, education, and tourist trips that are greater than 10 km in length and originate from another region/state, as a percentage of the total such trips in the region/state served by the STU. The tool adds these trips to its estimate of total trips that need to be accounted for. The default value for this field is 2.50 percent.

d Percentage of educational trips <10 km in urban areas: This field refers to the percentage of intracity educational (passenger) trips that are less than or equal to 10 km in length, out of the total educational trips in the urban area served by the STU. The default value for this field is **85.00 percent**. This implies that 15.00% of educational trips will be greater than 10 km in length in urban areas. This default value is based on the census data on educational bus trips.

Figure 30 Detailed estimator – Default Form – Part 1 Subpart A

- e Percentage of educational trips <10 km in rural areas:** This field refers to the percentage of intercity or non-urban educational (passenger) trips that are less than or equal to 10 km in length, out of the total educational trips in non-urban areas served by the STU. The default value for this field is **70.00 percent**. This implies that 30.00% of education trips will be greater than 10 km in length in non-urban areas. This default value is based on the census data on educational bus trips.
- f Percentage of intercity work trips >10 km originating from urban areas:** This field refers to the percentage of intercity or non-urban work (passenger) trips that are greater than 10 km in length and originate from or terminate in an urban area, out of the total work trips in non-urban areas served by the STU. The default value for this field is **10.00 percent**.
- g Percentage of intercity educational trips >10 km originating from urban areas:** This field refers to the percentage of intercity or non-urban educational (passenger) trips that are greater than 10 km in length and originate from or terminate in an urban area, out of the total educational trips in non-urban areas served by the STU. The default value for this field is **10.00 percent**.
- h Percentage of intercity non-work trips >10 km originating from urban areas:** This field refers to the percentage of intercity or non-urban non-work and non-educational (passenger) trips (including tourist trips) that are greater than 10 km in length and originate from or are headed to an urban area, out of the total non-work and non-educational trips in non-urban areas served by the STU. The default value for this field is **10.00 percent**.
- i Percentage of educational trips <10 km by buses in urban areas:** This field refers to the percentage of intracity educational (passenger) bus trips that are less than or equal to 10 km in length, out of the total intracity (or sum of all the trips in the urban area served by the STU) educational trips that are less than or equal to 10 km in length. The default value for this field is **14.52 percent**.
- j Percentage of non-work trips <10 km by buses in urban areas:** This field refers to the percentage of intracity 'other than work, education, and tourist (passenger) trips' that are less than or equal to 10 km in length, out of the total intracity (or sum of all the trips in the urban area served by the STU) 'other than work, education, and tourist (passenger) bus trips' that are less than or equal to 10 km in length. As a default, the tool uses the same value as the 'percent of intracity work-related bus trips less than or equal to 10 km, out of all intracity work trips less than or equal to 10 km'. This value is derived from the census and included in the tool database for a listed STU or specified by the user in User Form 2 for a new STU. If the user accesses the default form before inputting values in User Form 2, then the default value of 25.00% will be displayed in this field.

DEFAULT VALUES - PART A2 OF PART A

Figure 31 shows Part A2 of part A in the default form.

- a

Percentage of non-work trips <10 km by buses in rural/non-urban areas: This field refers to the percentage of rural/non-urban 'other than work, education, and tourist bus (passenger) trips' that are less than or equal to 10 km in length, out of the total rural/non-urban 'other than work, education, and tourist (passenger) trips' (in the region served by the STU) that are less than or equal to 10 km in length. As a default, the tool uses the **same value as the percentage of rural/non-urban work bus trips less than or equal to 10 km**, out of all rural/non-urban (passenger) work trips less than or equal to 10 km. This value is derived from the census and included in the tool database for a listed STU or is specified by the user in User Form 2 for a new STU. If the user accesses the default form before inputting values in User Form 2, then the default value of 22.50% will be displayed in this field.
- b

Percentage of non-work trips >10 km by buses in urban areas: This field refers to the percent of intracity 'other than work, education, and tourist bus (passenger) trips' that are greater than 10 km in length, out of the total intracity (or sum of all the trips in the urban area served by the STU) 'other than work, education, and tourist (passenger) trips' that are greater than 10 km in length. As a default, the tool uses the **same value as the percentage of intracity work trips greater than 10 km, out of all intracity work trips greater than 10 km**. This value is derived from the census and included in the tool database

for a listed STU or is specified by the user in User Form 2 for a new STU. If the user accesses the default form before inputting values in User Form 2, then the default value of 0% will be displayed in this field.

- c

Percentage of non-work trips >10 km by buses in rural/non-urban areas: This field refers to the percentage of rural/non-urban 'other than work, education, and tourist bus (passenger) trips' that are greater than 10 km in length, out of the total rural/non-urban 'other than work, education, and tourist

(passenger) trips' (in the region served by the STU) that are greater than 10 km in length. As a default, the tool uses the **same value as the percent of rural/non-urban work bus trips greater than 10 km**, out of all rural/non-urban (passenger) work trips greater than 10 km. This value is derived from the census and included in the tool database for a listed STU or is specified by the user in User Form 2 for a new STU. If the user accesses the default form before inputting values in User Form 2, then the default value of 1.00% will be displayed in this field.

A2

Percent of non-work trips less than 10km by buses in rural/non-urban areas	22.50%	a
Percent of non-work trips more 10km by buses in urban areas	0.00%	b
Percent of non-work trips more than 10km by buses in rural/non-urban areas	1.00%	c
Percent of same day education trips less than 10km by public buses in rural areas	20.00%	d
Percent of same day education trips more than 10km by public buses in urban areas	21.00%	e
Percent of same day education trips more than 10km by public buses in rural areas	37.00%	f
Inter city non work trips <10km by bus	10.27%	g
Inter city non work trips >10km by bus	36.17%	h
Percent of STU Intra city trips <10km as percent of total intra city trips by bus	62.36%	i
Percent of STU Inter city trips <10km as percent of total inter city trips by bus	19.43%	j
Percent of STU Intra city trips >10km as percent of total intra city trips by bus	37.64%	k

Figure 31 Detailed estimator – Default Form – Part A Subpart A2

- d Percentage of same day educational trips <10 km by public buses in rural/non-urban areas:** This field refers to the percentage of intercity or non-urban same day educational public bus (passenger) trips that are less than or equal to 10 km in length, out of the total intercity or non-urban educational trips (in the region served by the STU) that are less than or equal to 10 km in length. The default value for this field is **20.00 percent**.
- e Percentage of same day educational trips >10 km by public buses in urban areas:** This field refers to the percentage of intracity same day educational (passenger) public bus trips that are greater than 10 km in length, out of the total intracity (or sum of all the trips in the urban area served by the STU) educational trips that are greater than 10 km in length. The default value for this field is **21.00 percent**.
- f Percentage of same day educational trips >10 km by public buses in rural/non-urban areas:** This field refers to the percentage of intercity or non-urban same day educational public bus (passenger) trips that greater than 10 km in length, out of the total intercity or non-urban educational trips (in the region served by the STU) that are greater than 10 km in length. The default value for this field is **37.00 percent**.
- g Intercity non-work bus trips <10 km:** This field refers to the percentage of intercity/non-urban non-work STU bus (passenger) trips that are less than or equal to 10 km in length, out of the total intercity/non-urban STU bus (passenger) trips in the region/
- area served by the STU. **This value is derived (and presented in this field) from tool-estimated values on all bus trips (for all purposes), i.e. percent of all intercity/non-urban bus trips less than or equal to 10 km in length, out of all intercity/non-urban bus trips.** It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) in the region/area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 10.27% will be displayed in this field. In case the field is edited, the **user must ensure that the sum of this field and the value in 'r' (explained below) equals 100 percent**.
- h Intercity non-work bus trips >10 km:** This field refers to the percentage of intercity/non-urban non-work STU bus (passenger) trips that are greater than or equal to 10 km in length, out of the total intercity/non-urban STU bus (passenger) trips in the region/area served by the STU. **This value is derived (and presented in this field) from tool-estimated values on all bus trips (for all purposes), i.e. percent of all intercity/non-urban bus trips greater than 10 km in length, out of all intercity/non-urban bus trips.** It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) in the region/area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this
- the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 36.17% shall be displayed in this field. In case the field is edited, the **user must ensure that the sum of this field and the value in 'q' above equals 100 percent**.
- i Percentage of intracity STU trips <10 km out of total intracity STU bus trips:** This field refers to the percentage of intracity/urban STU bus (passenger) trips that are less than or equal to 10 km in length, out of the total intracity/urban STU bus (passenger) trips in the region/ area served by the STU. **This value is derived (and presented in this field) from tool-estimated values on all bus trips (for all purposes), i.e. percent of all intracity/urban bus trips less than or equal to 10 km in length, out of all intracity/urban bus trips.** It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) in the region/area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this

modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 62.36% will be displayed in this field.

- j** **Percentage of intercity STU trips <10 km out of total intercity STU bus trips:** This field refers to the percentage of intercity STU bus (passenger) trips that are less than or equal 10 km in length, out of the total intercity STU bus (passenger) trips in the non-urban area served by the STU. **This value is derived (and presented in this field) from tool-estimated values on all bus trips (for all purposes), i.e. percent of all intercity bus trips less than or equal to 10 km in length, out of all intercity bus trips.** It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) outside the city/urban area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 19.43% will be displayed in this field.

- k** **Percentage of intracity STU trips >10 km out of total intracity STU bus trips:** This field refers to the percentage of intracity STU bus (passenger) trips that are greater than 10 km in length, out of the total intracity STU bus (passenger) trips in the city/urban area served by the STU. **This value is derived (and**

presented in this field) from tool-estimated values on all bus trips (for all purposes), i.e. percent of all intracity bus trips greater than 10 km in length out of all intracity bus trips. It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) in the city/urban area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification applies to estimation of all STU bus trips. This modification will also affect the value/number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus trips by purpose (not affected by this modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 28.37% shall be displayed in this field. In case the field is edited, the **user must ensure that the sum of this field and the value in 's' above equals 100 percent.**

DEFAULT VALUES - PART A3 OF PART A

Figure 32 shows Part A3 of part A in the default form.

a Percentage of intercity STU trips >10 km out of total intercity STU bus trips: This field refers to the percentage of intercity/non-urban STU bus (passenger) trips that are greater than 10 km in length, out of the total intercity/non-urban STU bus (passenger) trips in the region/ area served by the STU. **This value is derived (and presented in this field) from tool-estimated values on all bus trips**

(for all purposes), i.e. percent of all intercity/non-urban bus trips greater than 10 km in length, out of all intercity/non-urban bus trips. It is assumed that this share is the same for trips made by STU buses for all purposes (work, education, tourist, non-work) in the region/area. Therefore, the value is calculated by the tool and presented as the default value in the default form. Users can edit this value, and this modification will apply to estimation of all STU bus trips. This modification will also affect the value/ number of 'other bus' trips, as the same is calculated by subtracting STU bus trips by purpose from all bus

trips by purpose (not affected by this modification). If the user accesses the default form before inputting values in User Form 2, then the default value of 80.57% will be displayed in this field. In case the field is edited, **the user must ensure that the sum of this field and the value in 't' above equals 100 percent.**

b Work IPT trips origin from outside state (traveling to state) as percent of work IPT trips in state: The default value of 1.00% will be displayed in this field.

c Percentage of educational trips <10 km by IPT in urban areas: The tool estimates the total number of intracity educational trips less than or equal to 10 km in length in the region served by the STU based on the data provided in User Form 2. The mode share of these trips by intermediate public transport (IPT) is an assumed value based on census data on the IPT mode share of all intracity work-related trips less than or equal to 10 km in length. The default value for this field is **4.00 percent**.

d Percentage of non-work trips <10 km by IPT in urban areas: The tool estimates the total number of intracity non-work trips less than or equal to 10 km in length in the region served by the STU based on the data provided in User Form 2. The IPT mode share of all intracity non-work trips less than or equal to 10 km is the same as that of work trips. The estimated mode share of intracity IPT work trips, out of all intracity work-related trips less than or equal to 10 km, is based on the census data and included in the database of listed STUs. The same is available in User Form 2 when working in the 'Existing STU List' mode or can

A3	Item	Value	
	Percent of STU Intercity trips >10km as percent of total intercity trips by bus	80.57%	a
	Work IPT trips origin from outside state (travelling to state) as percent of work IPT trips in state	1.00%	b
	Percent of same day education trips less than 10km by IPT in urban areas	4.00%	c
	Intra city non work trips <10km by IPT	47.23%	d
	Percent of same day education trips less than 10km by IPT in rural areas	0.50%	e
	Inter city non work trips <10km by IPT	20.17%	f
	Percent of same day education trips more than 10km by IPT in urban areas	15.00%	g
	Intra city non work trips >10km by IPT	8.95%	h
	Percent of same day education trips more than 10km by IPT in rural areas	4.00%	i
	Inter city non work trips >10km by IPT	23.65%	j

Figure 32 Detailed estimator – Default Form – Part A Subpart A3

be added by the user in the 'New STU' mode.

If the user accesses the default form before inputting values in User Form 2, then the default value of 47.23% will be displayed in this field.

- e Percentage of educational trips <10 km by IPT in rural/non-urban areas:** The tool estimates the total number of intercity/non-urban educational trips less than or equal to 10 km in length in the region served by the STU based on the data provided in User Form 2. The IPT mode share of these trips is an assumed value based on census data on the IPT mode share of all intercity/non-urban work trips less than or equal to 10 km in length. The default value for this field is **0.50 percent**.

- f Percentage of non-work trips <10 km by IPT in rural/non-urban areas:** The tool estimates the total number of intercity/non-urban non-work trips less than or equal to 10 km in length in the region served by the STU based on the data provided in User Form 2. **The IPT mode share of all non-work trips less than or equal to 10 km is the same as that of intercity/non-urban work trips.** The IPT mode share of intercity/non-urban work trips, out of all intercity/non-urban work trips less than or equal to 10 km, is based on the census data and included in the STU database. The same is available in User Form 2 when working in the 'Existing STU List' mode or can be added by the user in the 'New STU' mode. If the user accesses the default form before inputting values in User Form 2, then the default value of 20.17% will be displayed in this field.

- g Percentage of educational trips >10 km by IPT in urban areas:** The tool estimates the total number of intracity educational trips greater than 10 km in length in the region served by the STU based on the data provided in User Form 2. The IPT mode share of these trips is an assumed value based on the census data on the IPT mode share of all intracity work trips greater than 10 km in length. The default value for this field is **15.00 percent**.

- h Percentage of non-work trips >10 km by IPT in urban areas:** The tool estimates the total number of intracity non-work trips greater than 10 km in length in the region served by the STU based on the data provided in User Form 2. **The IPT mode share of all intracity non-work trips greater than 10 km is assumed to be the same as that of work trips.** The IPT mode share of all intracity work trips greater than 10 km is based on the census data and included in the STU database. The same is available in User Form 2 when working in the 'Existing STU List' mode or can be added by the user in the 'New STU' mode. If the user accesses the default form before inputting values in User Form 2, then the default value of 8.95% will be displayed in this field.

- i Percentage of educational trips >10 km by IPT in rural/non-urban areas:** The tool estimates the total number of intercity/non-urban educational trips greater than 10 km in length in the region served by the STU based on the data provided in User Form 2. The IPT mode share of these trips is an assumed value based on the census data on the IPT mode share of all intercity/non-urban work trips greater than 10 km in length. The default value for this field is **4.00 percent**.

- j Percentage of non-work trips >10 km by IPT in rural/non-urban areas:** The tool estimates the total number of intercity/non-urban non-work trips greater than 10 km in length in the region served by the STU based on the data provided in User Form 2. **The IPT mode share of all non-work trips greater than 10 km is assumed to be the same as that of intercity/non-urban work trips.** The IPT mode share of all intercity/non-urban work trips greater than 10 km is based on the census data and included in the STU database. The same is available in User Form 2 when working in the 'Existing STU List' mode or can be added by the user in the 'New STU' mode. If the user accesses the default form before inputting values in User Form 2, then the default value of 23.65% will be displayed in this field.

DEFAULT VALUES - PART A4 OF PART A

Figure 33 shows Part A4 of part A in the default form.

a Land required per bus for bus depot development (sqm): This field includes the default value of per bus land requirement for a depot with a capacity of 100 buses. This value is derived from the Association of State Road Transport Undertakings (ASRTU) Depot Design Guidelines (SGArchitects, 2017). The default value is **160 sqm**.

b Average bus depot capacity (no. of buses): This field includes the default value of the bus depot capacity considered per depot proposed for development.

A4

Land Required per bus for depot development (sqm)	160.00	160.00	a
Average Depot Capacity (buses)	100.00	100.00	b
% of non local STU buses using inter city terminal (as % of STU buses)	0%	5%	c
Cost per bus for developing depot (rs)	1650000.00	1650000	d
	Urban	Non-Urban	
Land Required per bus for terminal development	70.00	150.00	e
Average terminal capacity	40.00	40.00	f
Cost per bus for developing terminal (rs)	800000.00	1500000	g
Factor to relate terminal capacity to bus fleet (Fleet/(Capacity*X), where	1.25	1.25	h

This value is derived from the ASRTU Depot Design Guidelines based on the ideal depot size (SGArchitects, 2017). The default value is **100 buses**.

c Land required per bus for terminal development: This field includes the default value of the per bus land requirement for a depot with a capacity of 40 buses per hour and an average dwell time of 20 minutes per bus. This value is derived from the ASRTU Terminal Design Guidelines (SGArchitects, 2015). The default value is 70 sqm and relates to the total number of buses per hour (entering or exiting the terminal), rather than the number of buses accommodated in the terminal at a given time.

d Percentage of non-local STU buses using intercity terminal out of all STU buses: This field includes the default value of the number of non-local STU buses using the terminals operated by STU as a percentage of all STU buses and is specific to intercity STUs. The default value is **5 percent**.

e Average terminal capacity in buses per hour: This field includes the default value of the bus terminal capacity: **40** buses per hour (assuming an average 20-minute dwell time per bus).

f Cost per bus for depot development in INR: This field includes the default value of the per bus cost for developing a bus depot. It is based on the estimated depot land area requirement of 160 sqm per bus for a 100-bus capacity depot, based on ASRTU Depot Design Guidelines (SGArchitects, 2017). The default value is INR **8,00,000**.

g Cost per bus for terminal development in INR: This field includes the default value of the per bus cost for developing a bus terminal. It is based on the estimated terminal land area requirement of 70 sqm per bus for a 40-bus per hour capacity terminal, based on ASRTU Bus Terminal Design Guidelines (SGArchitects, 2015). The default value is INR **2,50,000**.

h Factor to relate terminal capacity to bus fleet (fleet/(capacity*X)): This field includes the default value of the factor used in the equation relating terminal capacity to the bus fleet. The default value is 1.25.

Figure 33 Detailed estimator – Default Form – Part A Subpart A4

DEFAULT FORM – PART B

Figure 34 presents the screenshot of Part 2 of the default form. In this form, 28 default fields are labelled in lowercase alphabetical order. Each of the labelled input fields in the figure is explained below.

- a Urban trip rate:** This field includes the default value of the urban trip rate: 1.35 trips.
- b Non-urban trip rate:** This field includes the default value of the non-urban trip rate: 0.69 trips.
- c Urban work trip share of total trips:** This field includes the default value of urban work trips

as a percentage of the total trips. The default value is 38.46 percent. The unit of this value/ input is percentage and hence the value inserted is used as percentage value in the tool. For example, value entered 38.46 would be used as 38.46% in the tool. The user can change the value to any number from 1 to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- d Urban educational trip share of total trips:** This field includes the default value of urban educational trips as a percentage of the total trips. The default value is 31.52 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- e Urban tourist trip share of total trips:** This field includes the default value of urban tourist trips as a percentage of the total trips. The default value is 1.22 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- f Urban non-work trip share of total trips:** This field includes the default value of urban non-work trips as a percentage of the total trips. The default value is 28.8 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- g Non-urban work trip share of total trips:** This field includes the default value of non-urban work trips as a percentage of the total trips. The default value is 37.2 percent. The user can change the value to any number from 1 to 100 but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- h Non-urban educational trip share of total trips:** This field includes the default value of non-urban educational trips as a percentage of the total trips. The default value is 32.01 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

B			
Item	Value	Item	Value
Urban trip rate	1.35	<10km share in intra city non-work trips (non urban STU)	90.7
Non Urban Trip Rate	0.69	<10km share in inter city non-work trips (non urban STU)	61.53
Urban work trips as share of total trips	38.46	<10km share in intra city non-work trips (urban STU)	86.22
Urban education trips as share of total trips	31.52	>=10km share in intra city non-work trips (urban STU)	40.37
Urban tourist trips as share of total trips	1.22	>=10km share in inter city non-work trips (urban STU)	73.22
Urban non work trips as share of total trips	28.8	>=10km share in intracity bus trips (all trip types)	31.04
Non-urban work trips as share of total trips	37.2	>=10km share in intercity bus trips (all trip types)	83.36
Non-urban education trips as share of total trips	32.01	>=10km share in intracity IPT trips (all trip types)	45.35
Non-urban tourist trips as share of total trips	2.89	>=10km share in intercity IPT trips (all trip types)	32.88
Non-urban non work trips as share of total trips	27.9	Share of intracity trips from outside State of total <10km tourist trips	28.77
<10km share in intra city work trips (non urban STU)	90.7	Share of tourist trips from outside State of total intracity >=10km tourist trips	34.23
<10km share in inter city work trips (non urban STU)	61.53	Share of tourist trips from outside State of total intercity <10km tourist trips	31.25
<10km share in intra city work trips (urban STU)	85.75	Share of tourist trips from outside State of total intercity >=10km tourist trips	88.21
<10km share in inter city work trips (urban STU)	44.96	Percent of intracity tourist trips >=10km out of total intracity tourist trips	11.18

Figure 34 Detailed estimator – Default Form – Part 2

- i Non-urban tourist trip share of total trips:** This field includes the default value of non-urban tourist trips as a percentage of the total trips: 2.89 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- j Non-urban non-work trip share of total trips:** This field includes the default value of non-urban, non-work trips as a percentage of the total trips: 27.9 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- k <10 km intracity work trip share of total non-urban STU trips:** This field includes the default value of intracity work trips less than 10 km in length as a percentage of the total trips by a non-urban STU: 90.7 percent. The user can change the value to any number ranging 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- l <10 km intercity work trip share of total non-urban STU trips:** This field includes the default value of intercity work trips less than 10 km in length as a percentage of the total trips by a non-urban STU: 61.53 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- m <10 km intracity work trip share of total urban STU trips:** This field includes the default value of intracity work trips less than 10 km in length as a percentage of the total trips by an urban STU: 85.75 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- n <10 km intercity work trip share of total urban STU trips:** This field includes the default value of intercity work trips less than 10 km in length as a percentage of the total trips by an urban STU: 44.96 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- o <10 km intracity non-work trip share of total non-urban STU trips:** This field includes the default value of intracity non-work trips less than 10 km in length as a percentage of the total trips by a non-urban STU: 90.7 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- p <10 km intercity non-work trip share of total non-urban STU trips:** This field includes the default value of intercity non-work trips less than 10 km in length as a percentage of the total trips by a non-urban STU: 61.53 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- q <10 km intracity non-work trip share of total urban STU trips:** This field includes the default value of intracity non-work trips less than 10 km in length as a percentage of the total trips by an urban STU: 86.22 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- r >=10 km intracity non-work trip share of total urban STU trips:** This field includes the default value of intracity non-work trips greater than/equal to 10 km in length as a percentage of the total trips by an urban STU: 40.37 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- s >=10 km intercity non-work trip share of total urban STU trips:** This field includes the default value of intercity non-work trips greater than/equal to 10 km in length as a percentage of the total trips by an urban STU: 73.22 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- t >=10 km intracity bus trip share of all trips:** This field includes the default value of intracity bus trips greater than/equal to 10 km in length as a percentage of all trip types: 31.04 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

- u** **>=10 km intercity bus trip share of all trips:** This field includes the default value of intercity bus trips greater than/equal to 10 km in length as a percentage of all trip types: 83.36 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- v** **>=10 km intracity IPT trip share of all trips:** This field includes the default value of intracity IPT trips greater than/equal to 10 km in length as a percentage of all trip types: 45.35 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- w** **>=10 km intercity IPT trip share of all trips:** This field includes the default value of intercity IPT trips greater than/equal to 10 km in length as a percentage of all trip types: 32.88 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- x** **Share of total intracity <10 km tourist trips originating outside state:** This field includes the default value of tourist trips originating outside the given state as a percentage of the total intracity tourist trips less than 10 km in length: 28.77 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- y** **Share of total intracity >=10 km tourist trips originating outside state:** This field includes the default value of tourist trips originating outside the given state as a percentage of the total tourist trips greater than/equal to 10 km in length: 34.23 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- z** **Share of total intercity <10 km tourist trips originating outside state:** This field includes the default value of tourist trips originating outside the given state as a percentage of the total tourist trips less than 10 km in length: 31.25 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- aa** **Share of total intercity >=10 km tourist trips originating outside state:** This field includes the default value of tourist trips originating outside the given state as a percentage of the total tourist trips greater than/equal to 10 km in length: 88.21 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- bb** **Share of intracity tourist trips >=10 km:** This field includes the default value of intracity tourist trips greater than/equal to 10 km in length as a percentage of the total intracity tourist trips: 11.88 percent. The user can change the value to any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

DEFAULT FORM – PART C

Figure 35 presents the screenshot of

Part 3 of the default form.

This part covers the 4 types (CO₂E, NO_x, SO_x and PM) of emissions factors for 9 different type of bus technologies. The 9 bus technologies have been labelled in lowercase alphabetical order along with their elaborated descriptions. The respective emission factors against each technology are listed in Table 1.

The default form also incorporates two additional buttons (labelled (a) and (b) in the Figure 29), provided at the bottom of the form:

S. No.	Bus technology	Description	Total CO ₂ e emissions (Kg/Km)	NO _x (g/km)	PM (g/km)	SO _x (g/km)
a	Diesel bus >150ppm with OC	This field includes the default value for a bus using greater than 150 parts per million (ppm) sulphur diesel fuel with an oxidation catalyst (OC).	1.14	10.2	0.292	1.42
b	Diesel bus 50 with DPF	This field includes the default value for a bus using less than 50 ppm sulphur diesel fuel with a diesel particulate filter (DPF).	1.28	10.8	0.146	1.42
c	Diesel bus 0.15 with DPF	This field includes the default value for a bus using less than 15 ppm sulphur diesel fuel with a DPF.	1.41	13	0.032	1.42
d	CNG	This field includes the default value for a bus using BS2/BS3 technology	1.51	15	0.03	1.42
e	CNG with OC	This field includes the default value for a diesel bus using BS2/BS3 technology with an OC.	1.37	9.8	0.01	1.42
f	CNG with 3WC	This field includes the default value for a bus using BS2/BS3 technology with a 3-way catalytic converter (3WC).	1.2	1.4	0.024	1.42
g	Hybrid ICE	This field includes the default value for a hybrid electric bus using 15 ppm sulphur diesel fuel with a DPF.	1.46	9.5	0.036	1.42
h	Electric with thermal power	This field includes the default value for a thermal electricity-based battery-powered electric bus.	1.52	0	0	1.42
i	Electric with Renewable power	This field includes the default value for a renewable electricity-based battery-powered electric bus.	0	0	0	1.42

Table 1 Emission factors for different type of bus technologies

	Name - Bus Technology and Fuel Used	Description - Bus Technology and Fuel Used	Total CO ₂ E Emission (kg/km)	Nox (g/km)	PM (g/km)	SO _x (g/km)
a	Diesel >150ppm with OC	Diesel bus with oxidatoin catalyst with >150ppm sulphur diesel fuel	1.14	10.2	0.292	1.42
b	Diesel 50 with DPF	Diesel bus with diesel particulate filter with <50ppm sulphur diesel fuel	1.28	10.8	0.146	1.42
c	Diesel 0.15 with DPF	Diesel bus with diesel particulate filter with <15ppm sulphur diesel fuel	1.41	13	0.032	1.42
d	CNG	BS 2 to BS 3 CNG fuel bus	1.51	15	0.03	1.42
e	CNG with OC	CNG fuel Bus with Oxidation Catalyst	1.37	9.8	0.01	1.42
f	CNG with 3WC	CNG fuel bus with 3 way catalytic convertor	1.2	1.4	0.024	1.42
g	Hybrid ICE	Hybrid electric bus with Diesel 15 DPF	1.46	9.5	0.036	1.42
h	Electric + Thermal Power	Battery electric bus powered with electricity from thermal power plant	1.52	0	0	1.42
i	Electric + Renewable Power	Battery electric bus powered with renewable electricity	0	0	0	0

Figure 35 Detailed estimator – Default Form – Part 3

- a. **Set Default Values button** – In case the user wants to use the default values automatically provided in the tool, he/she must click on 'Set Default Values'. This will prompt restoration of the original default values and recalculation of the outputs.
- The following sections present the details of all the 75 default values partwise. The default data fields have been labelled in lowercase alphabetical order for explanation below.
- b. **OK button** – After checking the default values in the form, the user needs to click on 'OK' to go back to the detailed estimator form. In case the user changes any default values and wants to continue further, he/she must also click on 'OK'. The tool will incorporate the modified default values and generate new outputs.

2.3.2.2 ESTIMATION METHOD BUTTON

This button is provided in all user forms and can be clicked on at any time (in any form) to access the estimation method form (opens in a pop-up window). In this form, the users make a choice between the estimation method for either intracity or intercity calculations, in terms of two dimensions/criteria. These criteria are detailed in the sub-sections below. Specifically, the user has to select composition based on the bus fleet or passenger trips, as well as the service transition type—generating an unutilised fleet or using the existing fleet at all costs until the bus lifetime is complete (Figure 36). The form also has a 'SAVE AND EXIT' button at the bottom, which should be clicked on after the user has made his/her choices to save the selected estimation

method, exit the form, and return to the original user form.

Estimation Criteria – The selection of the estimation method is based on two basic criteria, as described below.

1) **Composition:** The total annual fleet size requirement for an STU is estimated by the tool based on the mode share and other parameters. This overall demand (in either passenger trips or buses required to address the total demand) is divided into different services, as per a defined composition based on the projected transition (in composition) using the inputs provided by the user. The user is required to choose whether to base the estimation of STU service-wise composition on the number of buses, i.e. the fleet assigned (or estimated to be assigned) to each service ('Bus Fleet'), or on the number of daily passenger trips undertaken (or estimated to be undertaken) by each service ('Passenger Trips'). The selected option is used to estimate the future/projected

composition and fleet size, etc. Depending on the selected option, all base and horizon year (future) projections are based on the overall STU composition, either according to the number of buses in different services or passenger trips by different services.

2) **Service transition type:** The service-wise composition of an STU (either based on the number of buses or passenger trips) can differ in the future. For example, a current service option entailing operating 50% of buses or carrying out 60% of passenger trips may need to be reduced to 25% fleet operations or provision of 30% of passenger trips in the future. Similarly, the fleet size of the second service may be projected to increase from 50% to 75% (or passenger trips increased from 60% to 70%). This transition in fleet size for the two services can be projected theoretically, but may not be practically achievable, because the service that should reduce its composition in terms of buses or passenger trips (and thus likely reduce the fleet size) may not be able to reduce the existing number of buses without prematurely retiring some of them before they reach their defined age limit. If a strict transition as per the estimated composition for each year were enforced, the STU would most likely generate what can be defined as redundant or negative fleet inventory, i.e. buses in the inventory that will not be operated even though they have not yet reached their end of life. Therefore, the tool allows users to choose how they want to estimate and achieve this transition, by selecting either 'generate unutilised fleet' or 'use existing fleet at all costs until retirement age'. The 'generate unutilised fleet' option refers to generating a redundant fleet. In contrast, the 'use existing fleet at all costs until retirement age' option refers to using all

The screenshot shows a form titled "Estimation Method". It is divided into two main sections: "Intracity" and "Intercity". Each section contains two sub-sections: "Composition By" and "Service Transition type". In the "Composition By" sub-sections, "Passenger Trips" is selected with a radio button. In the "Service Transition type" sub-sections, "use existing fleet at all cost till service age" is selected with a radio button. At the bottom center of the form is a button labeled "SAVE & EXIT".

Figure 36 Detailed estimator – Estimation Method Form

the buses in the operational inventory until they reach their retirement age – thus modifying the transition process based on the age of the existing fleet.

2.3.2.3 INFRASTRUCTURE DETAILS BUTTON

This button is provided in all user forms and can be clicked on at any time (in any form) to access the infrastructure details form (opens in a pop-up window). The screenshot of this form, i.e. the STU infrastructure data form, is shown below in Figure 37. This form captures the details of all bus infrastructure owned and operated by the STU (total for all services). This includes bus terminals, depots, and any additional land for use in developing these facilities in the future. The data fields in this form are divided into two parts for explanation. Part A is dedicated to depot infrastructure-related data, while Part B covers terminal infrastructure-related data, with individual data fields labelled alphabetically, as shown in Figure 38.

The input field details and requirements for the STU infrastructure data form are presented below.

PART A: DEPOT INFRASTRUCTURE DETAILS

- a Total number of developed depot sites – In each specific form for each operation type, i.e. intercity and intracity, the user is required to provide the current total number of operational depots owned/operated by the STU (for all services). The input range for the number of STU depots is 1 to 9999, and inputs must be integers.

Infrastructure Details

Depot

Total No of Developed Depot Sites	Total Area under active Depot (hectare)	Total land area allocated to depot including developed and undeveloped (hectare)
45	3375	3375

Terminal

Total No of Developed Terminal Sites	Total Area under active Terminals (hectare)	Total land area allocated to Terminals including developed and undeveloped (hectare)
54	5400	5400

SAVE & EXIT

Figure 37 Detailed estimator – STU Infrastructure Data Form

- b Total area under active depots – The user is required to enter the total area (in hectares) currently under use by all operational depots (for all services). The input range is 1 to 99999.
- c Total developed and undeveloped area allocated to depots– In this field, the user is required to enter the total land dedicated to depot development (for all services) currently under the control of the STU (in hectares). This includes both the land that is already being used by bus depots and currently vacant land allocated for depot development. The input range is 1 to 99999.

PART B: TERMINAL INFRASTRUCTURE DETAILS

- d Total number of developed terminal sites – In each specific form for each operation type, i.e. intercity and intracity, the user is required to provide the current total number of operational bus terminals owned/operated by the STU (for all services). The input range for the number of terminals owned/operated by the STU is 1 to 9999, and inputs must be integers.

- e Total area under active terminals – The user is required to enter the total area (in hectares) currently under use by all operational terminals (for all services). The input range is 1 to 99999 (Figure 38).
- f Total developed and undeveloped area allocated to terminals- In this field, the user is required to enter the total land (in hectares) dedicated to terminal development (for all services) currently under the control of the STU. This includes both the land that is already being used by bus terminals and currently vacant land allocated for terminal development. The input range is 1 to 99999.

2.3.2.4 EXIT BUTTON

This is the last button in the cluster of toggle buttons. The button allows the user to exit the tool at any point. Pressing the button will close the tool, but data from all saved forms will be retained. This data will be displayed next time the user opens the tool if he/she clicks on 'Continue' on the splash page.

2.3.3 MANOEUVRING BUTTONS

Apart from the toggle buttons, each of the user forms has two manoeuvring buttons – Previous and Next. These buttons are located at the bottom centre of the user forms and help the user go forward and back as desired. Figure 39 presents the screenshot of these buttons in the user form. The functionality of these buttons is explained below.

The screenshot shows a web form titled "STU Infrastructure Data" with a close button (X) in the top right corner. The form is divided into two main sections: "Depot" and "Terminal". Each section contains three input fields. In the "Depot" section, the first field is labeled "Total No of Developed Depot Sites" with a value of 45 (labeled 'a'), the second is "Total Area under active Depot (hectare)" with a value of 3375 (labeled 'b'), and the third is "Total land area allocated to depot including developed and undeveloped (hectare)" with a value of 3375 (labeled 'c'). A large orange circle with the letter 'A' is positioned to the left of the first field. In the "Terminal" section, the first field is labeled "Total No of Developed Terminal Sites" with a value of 54 (labeled 'a'), the second is "Total Area under active Terminals (hectare)" with a value of 5400 (labeled 'b'), and the third is "Total land area allocated to Terminals including developed and undeveloped (hectare)" with a value of 5400 (labeled 'c'). A large orange circle with the letter 'B' is positioned to the left of the first field. At the bottom of the form is a button labeled "SAVE & EXIT".

Figure 38 Detailed estimator – STU Infrastructure Data Form – Input data field labels

- a) **Previous** – This button allows the user to go back to the previous page, which displays previously entered inputs that can be modified or retained.
- b) **Next** – This button allows the user to save the data entered by the user and proceed to the next user form. In the case of an error in the form, including empty cells, the tool will display a dialogue box, and the user will be automatically redirected to the original form, where he/she will be required to correct all input errors before proceeding to the next form. Please note: In the last user form, i.e. Output Form, the 'Next' button is replaced by the 'Save Output' button, to save the outputs generated by the tool.



Figure 39 Manoeuvring buttons

2.4 DETAILED ESTIMATOR: USER FORM 1: BASIC STU INFORMATION

The following section explains the data input fields and functionality of each of the user forms that need to be filled out in the detailed estimator.

Figure 40 shows the screenshot of User Form 1 – basic STU information. This form is designed to capture general STU-related data. The user must enter data inputs like scenario name, STU details, and the number of services (separately for intercity and intracity services) operated by the selected STU.

Apart from the common toggle and manoeuvring buttons (explained in the above sections), this form also has 4 additional buttons based on the user selection. Figure 41 presents User Form 1 with the numbered buttons.

These buttons are provided to assist the user in choosing between defining a new STU or working with the predefined data of a given (in the tool) STU. These buttons are: **Create New STU**, **Use Existing STU List**, and **Show Regional Data**. The fourth button – **Calculate** – appears when the user clicks on 'Create new STU'. However, when this form opens, by default, the 'Show existing STU list' mode is active. The functions of these buttons are explained in greater detail below.

- 1 Create New STU** – Clicking on this button allows the user to add the data of a new STU that is not listed in the tool. When the user clicks on this button, he/she is prompted to enter data for a set of 9 parameters.

These 9 parameters are labelled in lowercase alphabetical order (see Figure 42) and explained below:

- a** Urban Population – Here, the user is required to provide the urban population of the respective STU/state selected for estimation.
- b** Rural Population – In this field, the user is required to enter the rural population of the STU/state.
- c** Urban bus trip share of all trips – Here, the user is required to provide the mode share of all urban bus trips as a percentage of the total trips. The user can enter any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- d** Non-urban bus trip share of all trips – Here, the user is required to provide the mode share of all non-urban bus trips as a percentage of the total trips. The user can enter any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- e** IPT urban trip share of all trips – In this field, the user is required to enter the mode share of all urban IPT trips as a percentage of the total trips. The user can enter any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- f** IPT non-urban trip share of all trips – Here, the user is required to provide the mode share of all non-urban IPT trips as a percentage of the total trips. The user can enter any number from 1 to 100, but should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.
- g** Urban growth rate – In this field, the user is required to enter the urban growth rate of the STU/state selected for estimation. The user can enter any decimal/numeric value between 1 and 10, but should enter the percent value without inserting the % sign, as 10 is interpreted as 10% by the tool.
- h** Rural growth rate – Here, the user is required to provide the rural growth rate of the selected STU/state. The user can enter any decimal/numeric value between 1 and 10, but should enter the percent value without inserting the % sign, as 10 is interpreted as 10% by the tool.
- i** Tourist growth rate – In this field, the user is required to enter the tourist growth rate of the selected STU/state. The user can enter any decimal/numeric value between 1 and 10, but should enter the percent value without inserting the % sign, as 10 is interpreted as 10% by the tool.
- 2 Calculate Data Button** – When the user is done entering the data for the 9 parameters (a-i in Figure 42), he/she must click on 'Calculate Data', located to the right of the parameters. When the user clicks on this button, an extended form is displayed with prefilled region-specific data such as population, number of trips, etc. Figure 43 shows the screenshot of the extended part of User Form 1.

This part of the form includes 15 input boxes, populated with relevant data calculated based on the 9 above parameters, as provided in the internal tool database.

STU Basic Information

FLEET WINNING
FOR THE PEOPLE OF THE WORLD

User Form 1 > User Form 2 > User Form 3 > User Form 4 > User Form 5 > User Form 6 > User Form 7

STU Basic Information

STU Details

STU Name: Operations Type:

Create New STU Existing STU List Estimation Year: Regional Data Year: Tourist Data Year:

Scenario Name: Use aggregated Secondary data for existing STU's: ☐ No ☐ Yes

Intracity

Different types of operational services:

Show Regional Data

Default values Estimation Method Exit Infrastructure Details Previous Next

SHAKTI SUSTAINABLE ENERGY FOUNDATION SGArchitects TRIPP © SGArchitects

Figure 40 Detailed estimator – User Form 1

STU Details

STU Name: Operations Type:

Create New STU Existing STU List Estimation Year: Regional Data Year: Tourist Data Year:

Scenario Name: Use aggregated Secondary data for existing STU's: ☐ No ☐ Yes

Intracity

Different types of operational services:

Intercity

Different types of operational services:

Show Regional Data

1 3 4 2

Urban Population: Mode Share of All Bus in urban Trips (all trip types): % Mode Share of IPT in urban Trips (all trip types): % Urban Growth rate: %

Rural Population: Mode Share of All Bus in non-urban Trips (all trip types): % Mode Share of IPT in non-urban Trips (all trip types): % Rural Growth rate: %

Tourist Growth rate: % Calculate Data

Figure 41 Detailed estimator – User Form 1 – Additional buttons

However, the users can edit the displayed data in this section. In this case, the edited data is saved for use in the tool and displayed when the tool is re-opened in the 'Continue' mode. Please note that 'intercity operations' in this document and the tool refers to all non-urban operations. Furthermore, it should be noted that the data in this part of the form needs to be entered for the region under the operational and administrative control of the selected STU. The given list of regional data parameters also specifies the accepted value ranges when data is required to be input by users in these boxes.

- a** Population – 'Urban', 'Rural' and 'Total'. This refers to the population in the region served by the STU. The accepted range is 20,000 to 200,00,00,000 for all fields. The value in the 'Total' box should be the exact sum of the 'Urban' and 'Rural' values.
- b** Total Educational Trips (All Modes) – Intracity and Intercity. These fields correspond to all urban and non-urban educational passenger trips by all modes (including walking). The accepted range is 10,000 to 400,00,00,000 for all fields.
- c** Total Work Trips (All Modes) – Intracity (>10 km), Intracity (<= 10 Km), Intercity (>10 km), Intercity (<= 10 Km). These fields correspond to all work-related passenger trips by type (intra- vs. intercity) and distance. Separate inputs are required for intra- and intercity (or non-urban) trips (including walking) less than or equal to 10 km and greater than 10 km in length. The accepted range is 10,000 to 400,00,00,000 for all fields.
- d** Total Non-Work Trips (All Modes) – Intracity (>10 km), Intracity (<= 10 Km), Intercity (>10 km), Intercity (<= 10 Km). These fields correspond to all non-work-related passenger trips by type (intra- vs. intercity) and distance. Separate inputs are required for intra- and intercity (or non-urban) trips (including walking) less than or equal to 10 km and greater than 10 km in length. The accepted range is 10,000 to 400,00,00,000 for all fields.
- e** Total Work Trips by Bus – intracity (>10 km), Intracity (<=10 Km), Intercity (>10 km), Intercity (<=10 Km). These fields correspond to the number of passenger work trips by all buses, including STU and private buses, based on type and distance. Separate inputs are required for intra- and intercity bus trips less than or equal to 10 km and greater than 10 km in length. The accepted range is 10,000 to 400,00,00,000 for all fields.

STU Details

STU Name: ** New STU Name ** Operations Type: INTRA + INTER

Create New STU Existing STU List Estimation Year: 2019 Regional Data Year: 2011 Tourist Data Year: 2006

Scenario Name Scenario 1

Use aggregated Secondary data for existing STU's No Yes

Intracity

Different types of operational services: 4

Intercity

Different types of operational services: 4

Show Regional Data

Regional Data

Urban Population: 8443675 Rural Population: 990923

Mode Share of All Bus in urban Trips (all trip types): 18 % Mode Share of IPT in urban Trips (all trip types): 28 %

Mode Share of All Bus in non-urban Trips (all trip types): 16 % Mode Share of IPT in non-urban Trips (all trip types): 26 %

Urban Growth rate: 2.72 % Rural Growth rate: 0.74 % Tourist Growth rate: 2.50 %

Calculate Data

Figure 42 Detailed estimator – User Form 1 – Create new STU button functionality

a Population <table border="1"> <tr> <td>Urban</td> <td>Rural</td> <td>Total</td> </tr> <tr> <td>8443675</td> <td>990923</td> <td>9434598</td> </tr> </table>	Urban	Rural	Total	8443675	990923	9434598	b Total No of Trips (educational) <table border="1"> <tr> <td>Intracity</td> <td>Intercity</td> </tr> <tr> <td>5000000</td> <td>73388</td> </tr> </table>	Intracity	Intercity	5000000	73388	c Total Work Trips by All Modes <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>4582028</td> <td>1026451</td> <td>44720.9</td> <td>44720.90</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	4582028	1026451	44720.9	44720.90						
Urban	Rural	Total																								
8443675	990923	9434598																								
Intracity	Intercity																									
5000000	73388																									
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
4582028	1026451	44720.9	44720.90																							
d Total Non-Work Trips by All Modes <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>3407149</td> <td>763258</td> <td>395600</td> <td>821812</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	3407149	763258	395600	821812	e Total Work Trips by Bus <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>1102314</td> <td>413740</td> <td>15556</td> <td>15556</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	1102314	413740	15556	15556	f Total Work Trips by IPT <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>101375</td> <td>44165</td> <td>5431</td> <td>5431</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	101375	44165	5431	5431
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
3407149	763258	395600	821812																							
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
1102314	413740	15556	15556																							
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
101375	44165	5431	5431																							
g Mode Share of Bus from total work trips (All modes) <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>24.06 %</td> <td>40.31 %</td> <td>34.79 %</td> <td>34.79 %</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	24.06 %	40.31 %	34.79 %	34.79 %	h Mode Share of IPT from total work trips (All modes) <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>2.21 %</td> <td>4.30 %</td> <td>12.14 %</td> <td>12.14 %</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	2.21 %	4.30 %	12.14 %	12.14 %	i Mode Share of Bus from total bus trips <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>71.25 %</td> <td>26.74 %</td> <td>1.01 %</td> <td>1.01 %</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	71.25 %	26.74 %	1.01 %	1.01 %
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
24.06 %	40.31 %	34.79 %	34.79 %																							
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
2.21 %	4.30 %	12.14 %	12.14 %																							
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
71.25 %	26.74 %	1.01 %	1.01 %																							
j Mode Share of IPT from total IPT trips <table border="1"> <tr> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> </tr> <tr> <td>64.82 %</td> <td>28.24 %</td> <td>3.47 %</td> <td>3.47 %</td> </tr> </table>	Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)	64.82 %	28.24 %	3.47 %	3.47 %	k Total Tourist trips by Bus <table border="1"> <tr> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> </tr> <tr> <td>90708</td> <td>583734</td> <td>10254</td> <td>522125</td> </tr> </table>	Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)	90708	583734	10254	522125	l Total Tourist trips by IPT <table border="1"> <tr> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> </tr> <tr> <td>6397</td> <td>62982</td> <td>557504</td> <td>109633</td> </tr> </table>	Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)	6397	62982	557504	109633
Intracity (<10KM)	Intracity (>10KM)	Intercity (<10KM)	Intercity (>10KM)																							
64.82 %	28.24 %	3.47 %	3.47 %																							
Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)																							
90708	583734	10254	522125																							
Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)																							
6397	62982	557504	109633																							
m Tourist Trips from State - All modes <table border="1"> <tr> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> </tr> <tr> <td>64205</td> <td>405762</td> <td>592536</td> <td>73202</td> </tr> </table>	Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)	64205	405762	592536	73202	n Total State+ outside State all tourist trips - All Modes <table border="1"> <tr> <td>Intercity (<10KM)</td> <td>Intercity (>10KM)</td> <td>Intracity (<10KM)</td> <td>Intracity (>10KM)</td> </tr> <tr> <td>605010</td> <td>644176</td> <td>103313</td> <td>708803</td> </tr> </table>	Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)	605010	644176	103313	708803	o Average Annual Exponential Growth Rate <table border="1"> <tr> <td>Urban</td> <td>Rural</td> <td>Tourist</td> </tr> <tr> <td>2.72 %</td> <td>0.74 %</td> <td>2.50 %</td> </tr> </table>	Urban	Rural	Tourist	2.72 %	0.74 %	2.50 %		
Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)																							
64205	405762	592536	73202																							
Intercity (<10KM)	Intercity (>10KM)	Intracity (<10KM)	Intracity (>10KM)																							
605010	644176	103313	708803																							
Urban	Rural	Tourist																								
2.72 %	0.74 %	2.50 %																								

Figure 43 User Form 1 – Extended prefilled data section

f Total Work Trips by IPT – Intracity (>10 km), (Intracity <= 10 Km), (Intercity >10 km), (Intercity <=10 Km). These fields correspond to the number of IPT-based passenger work trips by type and distance. Separate inputs are required separately for intra- and intercity IPT trips less than or equal to 10 km and greater than 10 km in length. The accepted range is 10,000 to 400,00,00,000 for all fields.

g Bus Mode Share of Total Work Trips (All Modes) – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to the bus mode share of total passenger work trips by type and distance. Separate inputs are required for the shares of intra- and intercity passenger bus trips less than or equal to 10 km and greater than 10 km in length, out of all the intra- and intercity trips of those

lengths. For example, if there are 2,00,000 intercity bus trips greater than 10 km in length and 10,00,000 intercity passenger trips in the region greater than 10 km in length by all modes (including bus and walking), then the bus mode share of intercity trips >10 km is 20 percent. The accepted range is 1–80 for all fields, and the user should not insert the % sign.

h IPT Mode Share of All Work Trips (All Modes) – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to the IPT mode share of total passenger work trips by type and distance. Separate inputs are for the shares of intra- and intercity IPT passenger trips less than or equal to 10 km and greater than 10 km in length, out of all the intra- and intercity trips of those lengths. For example, if there are 2,00,000 intercity IPT trips greater than 10 km in length and 10,00,000 intercity passenger trips in the region greater than 10 km in length by all modes (including bus and walking), then the IPT mode share of intercity trips >10 km is 20 percent. The accepted range is 1–80 for all fields, and the user should not insert the % sign.

i Distance Share of Bus Trips – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). The inputs comprise the percentage breakup of all bus passenger trips in the region (by all types of buses, including STU buses) in terms of type and distance—i.e. the percentage of inter- and intracity bus passenger trips in the region with lengths less than or equal to 10 km and greater than 10 km, out of the total passenger bus trips in the region. The sum of these percentages (in all four input boxes) should be 100 percent, and the input range for each box is 1 to 80; the user should not insert the % sign.

j Distance Share of IPT Trips – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). The inputs comprise the percentage breakup of all IPT passenger trips in the region in terms of type and distance—i.e. the percentage of inter- and intracity IPT passenger trips in the region with

lengths less than or equal to 10 km and greater than 10 km, out of the total IPT passenger trips in the region. The sum of these percentages (in all four input boxes) should be 100 percent, and the input range for each box is 1 to 80; the user should not insert the % sign.

k Total Tourist Trips by Bus – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to all tourist passenger bus trips in the region, divided by type and distance (in the region). Separate inputs are required for intra- and intercity tourist bus trips less than or equal to 10 km and greater than 10 km in length (both from within the region and to/from the region). The accepted range is 1,000 to 400,00,00,000 for all fields.

l Total Tourist Trips by IPT – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to all IPT-based tourist passenger trips in the region, divided by type and distance (in the region). Separate inputs are required for IPT-based intra- and intercity tourist trips less than or equal to 10 km and greater than 10 km in length (both from within the region and to/from the region). The accepted range is 1,000 to 400,00,00,000 for all fields.

m Tourist Trips from State/Region Only (All Modes) – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to all tourist trips from the given state/region by all modes (including walking), divided by type and distance (in the region). Separate inputs are required

for intra- and intercity tourist trips less than or equal to 10 km and greater than 10 km in length. The accepted range is 1,000 to 400,00,00,000 for all fields.

n Total In-State and Outside State Tourist Trips (All Modes) – Intracity (>10 km), Intracity (<=10 km), Intercity (>10 km), Intercity (<=10 km). These fields correspond to all tourist trips (including both those travelling with the region and those travelling from outside the region to the region), divided by type and distance (in the region). Separate inputs are required for intra- and intercity tourist trips (of all modes, including walking) less than or equal to 10 km and greater than 10 km in length. The accepted range is 1,000 to 400,00,00,000 for all fields.

Average Annual Exponential Growth Rates for Trips – Urban, Rural, and Tourist. The growth rates of urban and rural trips are considered the same as the respective population growth rates. The user should enter the percent value without inserting the % sign, as 15 is interpreted as 15% by the tool, and the accepted range for each growth rate is -15% to 15%

“IPT refers to intermediate public transport and includes travel modes such as taxis, auto rickshaw, cycle rickshaw, shared transport modes, etc.

These values will be available to the user the next time the user opens the Tool and selects 'Continue' in User Form 1.

- 1 **Show Existing STU List** – Clicking on this button allows the user to view the listed STUs in the tool and select the STU to be analysed (from the drop-down menu). As a default setting, the form opens in this mode (Figure 44).
- 2 **Show Regional Data** – The tool has a database with basic information for 56 Indian STUs, and the same can be recalled by the user as an alternative to filling in the required details by him/herself. A separate 'Show Regional Data' button (Figure 45) is provided in the form to access this regional data.

When the user clicks on this button, the same extended form is displayed that appeared when clicking on 'Create new STU', but in this case, the form displays prefilled region-specific data based on the STU name selected from the drop-down list. The data in the boxes are derived from publicly available secondary datasets such as the census, published reports (such as tourist statistics), Comprehensive Mobility Plans (CMPs) and City Development Plans (CDPs), etc. Once clicked, this 'Show Regional Data' button name changes to 'Hide Regional Data'. In order to hide the extended form once again user must click on this 'Hide Regional Data' button. indicating clicking the same button will hide the extended part from the form as it appeared earlier.

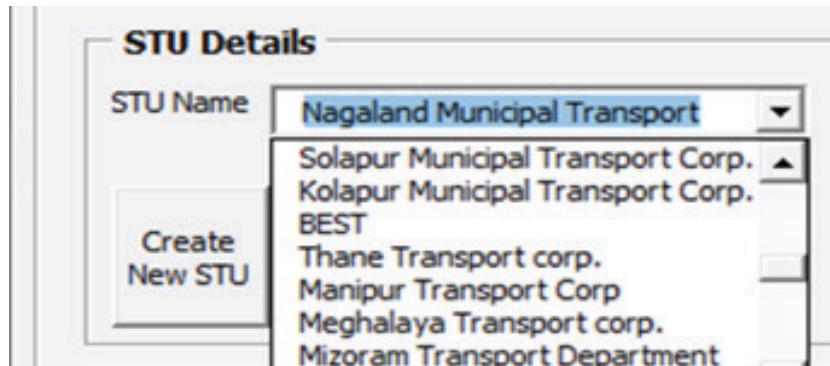


Figure 44 User Form 1 – Show Existing STU list button

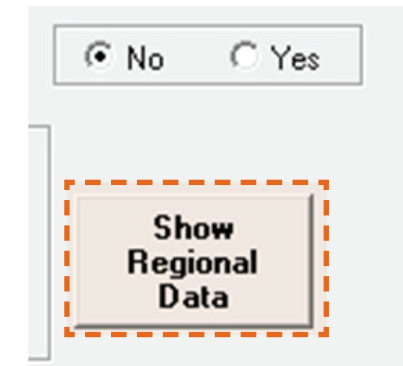


Figure 45 User Form 1 – Show Regional Data button

Figure 46 User Form 1 – Hide Regional Data button

The following subsections explain the other input requirements in the form. The input boxes are coded in alphabetical order, as presented in Figure 47, and the different fields are explained below.

- a STU Name** (see Figure 48) – The user can select the name of the STU from a list of STUs already included in the tool database using the drop-down menu provided in the box. After the user selects the STU from the list, the values corresponding to the selected STU are displayed in all input boxes.
- b Operation Type** (see Figure 49) – The user is required to select the bus operation type using the drop-down menu provided in the box. The choices are 'INTRA + INTER' (city) operations, 'INTRA' (city) operations, and 'INTER' (city) operations. Here, intercity refers to regional and mofussil operations, and intracity refers to urban or city-bound operations. The user cannot use this drop-down menu when the form is in 'Existing STU List' mode; in this case, an appropriate option will be displayed with reference to the selected STU, as derived from the database included in the tool.
- c Estimation Year** (see Figure 50) – The user is required to enter (in 'Create New STU' mode) or may need to edit (in 'Show Existing STU List' mode) the current/evaluation year, i.e. estimation year, in this input box. This input informs the tool of the starting year for the outputs to be generated. The usual input here would be the current year. However, to generate historical trends or for validation exercises, a past year can be entered. Similarly, when a user wants to forecast changes in a future year, they may need to generate

Figure 47 User Form 1 – Primary data information

Figure 48 User Form 1 – STU drop-down menu

Figure 49 User Form 1 – Operation Type drop-down menu

Figure 50 User Form 1 – Estimation year details

- d Regional Data Year** (see Figure 51) – The user is required to enter (in 'Create New STU' mode) or may need to edit (in 'Existing STU List' mode) the data year or the year for which data is available in this input box. For example, population data is derived

separate projections for different time periods (with outputs of one period used as inputs in the subsequent period), and, hence, an evaluation year in the future may need to be defined. A user can input the current year as anywhere between 2001 and 2050. However, the current year should be equal to or greater than the 'Data Year' and 'Tourist Data Year' inputs ((d) and (e) in Figure 47). If a value outside this range is entered, the tool displays an error message when 'Error Check' is initiated before going to the next form. An error message is also displayed if the user tries to enter characters other than numbers.

from Census 2011. The tool uses input growth rates to project the population or number of trips in the current year/evaluation year from the data provided for the data year. The value entered in this field should be less than or equal to the value of 'Current Year' (c) and should be between 2000 and the present year. If a value outside this range is entered, the tool displays an error message when 'Error Check' is initiated before going to the next form. An error message is also displayed if the user tries to enter characters other than numbers.

e Tourist Data Year (see Figure 52) – The user is required to enter (in 'Create New STU' mode) or may need to edit (in 'Existing STU List' mode) the data year or the year for which tourist data is available, in this input box. The tool uses input growth rates to project the population or number of trips in the current/evaluation year from the data provided for the data year. The value entered in this field should be less than or equal to the value of 'Current Year' (c) and should be between 2000 and the present year. If a value outside this range is entered, the tool displays an error message when 'Error Check' is initiated before going to the next form. An error message is also displayed if the user tries to enter characters other than numbers.

Number of Operational Services (see Figure 53) – Based on the type of bus operations undertaken by the STU (as derived from the database or input by the user) specified in (e), the form displays one or two input boxes ((f) for Intracity and (g) for Intercity, as marked in Figure 47). The user is required to enter the number of services operated by the selected STU. The tool allows up to 24 different

Figure 51 User Form 1 – Regional data year details

types of services to be evaluated for each operation type (intercity and intracity), and, hence, the user must input a value between 1 and 24.

Different services may be defined based on not only the different types of services (example, air-conditioned (AC), non-AC, express, etc.) operated by the STU, but also different service, operational, and financial criteria. For example, a regular non-AC bus service may be operated by electric minibuses and diesel low-floor urban buses, meaning that for this service, two different sets of operational and financial characteristics exist for the two different bus types. Each vehicle type may yield a different load factor and have a different seating capacity, vehicle utilisation, fleet utilisation, earnings per km (EPK), cost per km (CPK), etc. In such a scenario, the user can define the services as separate (e.g. as electric regular minibus and diesel low-floor urban bus) and input separate data for these redefined services. This allows the tool to yield more accurate projections and enables users to develop scenarios for transitions to different technologies, fleet types, etc. **The user may also define services that are planned to be initiated/operated but are not yet operational. For example, a user can define an e-bus service, which does not exist today, with specific operational and service characteristics (with the current**

Figure 52 User Form 1 – Tourist data year details

fleet size as 'o', and the future fleet size as per the user's plan). The services can be characterised based on parameters such as:

- EPK
- CPK
- Load factor/occupancy
- Vehicle utilisation/ efficiency
- Fleet utilisation
- Type of bus (AC, non-AC mini, high-floor, low-floor)
- Fuel type (petrol, diesel, or electric)
- Nature of trips (shuttle service, religious service, or general route-wise service).

Both the input boxes (f) and (g) will appear on the user form if the STU operates intra- and intercity services; otherwise, the form shall display only one of the (f) and 'g' input fields. For example, in the case of STUs like KSRTC, which operates both regional and city services, both the input boxes (f) and (g) will appear, as shown in Figure 53. In contrast, for STUs like BMTC, which is an urban STU, only the input box (f) will appear in the form.

The number of services – **inputs (f) and (g)** – allows the user to select the level of granularity of inputs and outputs. A user can define the number of services based on different vehicle types (e.g. minibus, midi bus, 12m

urban bus, etc.), type of operations (e.g. AC service, non-AC service, express service, regular service, etc.), or type of bus technology (e.g. diesel bus, electric bus, etc.). Users may disaggregate or detail the inputs into different numbers of services based on differences in these vehicle and operational characteristics, differing cost and revenue characteristics, or any other differences. The tool allows the user to estimate service-specific outputs and enables the modelling of variations in service composition in the overall STU/operator fleet. **Please note that once the users define the number of services and exit this form, they will not be able to edit this field. In this case, a new study must be initiated when a change in the number of services is required.**

- f Number of Intracity Services** –The user is required to enter the number of city/urban services operated by the STU. In case the STU only has intracity operations, the form will only show this input box (f). The input value must be between 1 and 24.
- g Number of Intercity Services** - The user is required to enter the number of regional and mofussil services operated by the STU. In case the STU only has intercity operations, the form will only show this input box (g). The input value must be between 1 and 24.
- h Scenario Name:** Here (see Figure 54), the user must input the desired name of the scenario. The user can insert any alphabetical/numeric/alphanumeric input, with a limit of 30 characters.
- i Use aggregated secondary data for existing STUs:** Here, the tool presents the user with a choice

between defining different STU services or working with aggregated data as a single service (in the tool) (see Figure 55). The user has to select Yes or No. However, as a default setting, the form opens with 'No' selected, assuming that the STU will be operating more than one service. In case the user selects 'Yes', then, by default, this will be interpreted by the tool as a single service, the number '1' will automatically be entered in (f) and/or (g), and the user will not be able to edit these fields. To edit them, the user has to select 'No.' Once the user proceeds to the next form on the single service, he/she will be required to enter data for all parameters for a single operation. However, the user can come back to User Form 1 and edit his/her selection from 'Yes' to 'No' and proceed forward again with multiple services. The inserted values (single/multiple service) will be available to the user the next time he/she opens the tool and selects 'Continue' in User Form

1. Please note that the user may enter aggregated data separately for intercity and intracity operation types. Additionally, the user has the flexibility to enter service-wise data and aggregated data in case the STU operates a combined intercity + intracity service. For example, users can use aggregated data for intracity operations as a single service and different service data for intercity services.

Note: In User Form 1, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages.

Figure 53 User Form 1 – Different types of operational services

Figure 54 Scenario Name

Figure 55 User Form 1 – Aggregated secondary data selection

2.5 DETAILED ESTIMATOR: USER FORM 2: FLEET DATA FORM

The types of operations undertaken by an STU, i.e. intracity, intercity, or both, determines how User Forms 2–7 are presented to the user. For example, if the operations are only intercity or only intracity, a single set

of User Forms 2–7, i.e. either for intra- or intercity operations, is presented. In case the operations are both intra- and intercity, the user is first presented with a set of intercity user forms (User Forms 2–7), followed by a set of intracity user forms (also User Forms 2–7). For simplicity, the sections explaining User Forms 2–7 refer to intracity operations only. However, the forms and requirements for filling them out are same for intercity operations. Figure 56

shows the screenshot of the second user form – Fleet Data Form. Here, the user is required to enter data related to the STU bus fleet.

The following inputs are required: types of buses operated by the STU, seating capacity, age-wise distribution of the fleet, cost, scrap value, and age limit for each bus type. For better understanding, these fields are grouped into three parts – A, B and C (as marked in Figure

STU Fleet Data

FLEET

User Form 1 > **User Form 2** > User Form 3 > User Form 4 > User Form 5 > User Form 6 > User Form 7

STU Basic Information > **Fleet Data Form** > Service Data Form > Vision Data Form-1 > Vision Data Form-2 > Vision Data Mode Share > Output

Fleet Data (Intracity)

Service Name	Seating Capacity	No of Buses by Age																Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
		> 15 yr	15 yr	14 yr	13 yr	12 yr	11 yr	10 yr	9 yr	8 yr	7 yr	6 yr	5 yr	4 yr	3 yr	2 yr	1 yr						
High Floor Standard	41.3	34	34	136	230	428	677	659	82	538	647	430	86	0	502	1134	15	5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
AC low floor	38.8	0	0	19	22	108	171	60	25	109	87	9	0	0	128	4	0	742	8574000	200000	15	☒ Y ☐ N	CNG
AC express Low floor	38.8	0	0	3	3	16	24	9	4	16	13	1	0	0	19	0	0	108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
Electric	41.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Default values | Estimation Method | Exit | Infrastructure Details

Previous | Next

SHAKTI SUSTAINABLE ENERGY FOUNDATION | SGAarchitects | TRIPP | © SGAarchitects

Figure 56 Detailed estimator – User Form 2 – Fleet Data Form

STU Fleet Data

FLEET

User Form 1 > **User Form 2** > User Form 3 > User Form 4 > User Form 5 > User Form 6 > User Form 7

STU Basic Information > **Fleet Data Form** > Service Data Form > Vision Data Form-1 > Vision Data Form-2 > Vision Data Mode Share > Output

Fleet Data (Intracity)

Service Name	Seating Capacity	No of Buses by Age																Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
		> 15 yr	15 yr	14 yr	13 yr	12 yr	11 yr	10 yr	9 yr	8 yr	7 yr	6 yr	5 yr	4 yr	3 yr	2 yr	1 yr						
High Floor Standard	41.3	34	34	136	230	428	677	659	82	538	647	430	86	0	502	1134	15	5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
AC low floor	38.8	0	0	19	22	108	171	60	25	109	87	9	0	0	128	4	0	742	8574000	200000	15	☒ Y ☐ N	CNG
AC express Low floor	38.8	0	0	3	3	16	24	9	4	16	13	1	0	0	19	0	0	108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
Electric	41.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

1 2 3 4 5 6 7 8 9

Default values | Estimation Method | Exit | Infrastructure Details

Previous | Next

SHAKTI SUSTAINABLE ENERGY FOUNDATION | SGAarchitects | TRIPP | © SGAarchitects

Figure 57 User Form 2 – Fleet Data Form with labels

57). The input boxes are numbered 1–9 under Part A, B, & C. The data input requirements are detailed in the following subsections.

2.5.1 USER FORM 2: PART A

- 1 **Service Name** – The number of rows displayed in this form corresponds to number of different service types entered in User Form 1. The user is required to define and insert the name of each service type (as explained for User Form 1) operated by the STU (see Figure 58). The user is required to insert the specific name of the bus type in alphanumeric characters (no decimal or special characters), with a maximum length of 40 characters. Here, the user may also define a new/proposed (i.e. currently non-operational) service.
- 2 **Seating Capacity** – The user is required to enter the average seating capacities for the different bus/service types (see Figure 59). Seating capacity is an indicator of the sizes of buses in use and can thus vary considerably, from around 10 to 90 passengers. A high figure for average bus capacity, e.g. 40 or more, usually indicates that a high proportion of buses are conventional 12m buses. A figure below 20 indicates that the majority of buses are minibuses. For a new/proposed service, the average seating capacity or planned average seating capacity has to be entered. The input can be an absolute or average numerical or decimal value, and the range is 1 to 90.

Service Name	Seating Capacity
High Floor Standard	41.3
AC low floor	38.8
AC express Low floor	38.8
Electric	41.3

Figure 58 User Form 2 – Part A – Defining service type

Service Name	Seating Capacity
High Floor Standard	41.3
AC low floor	38.8
AC express Low floor	38.8
Electric	41.3

Figure 59 User Form 2 – Part A – Seating capacity

2.5.2 USER FORM 2: PART B

- 3 **Age-wise fleet distribution** – Part B includes 16 age-specific columns of input boxes for each service type (see Figure 60). The user is required to insert age and service-wise fleet size in these boxes. Thus, the number of buses operated under each defined service type is specified according to their age – i.e. up to 1 year old (under column entitled '1 yr'), 1–2 years old ('2 yr'), 2–3 years old ('3 yr'), and so on, up to greater than 15 year old ('>15 yr'). Thus, the users enter the number of buses based on age group (column) and service (row).

For example, out of the total bus fleet of the selected STU, 15 'regular' buses are up to 1 year old. Here, 'regular' is the defined service name, and the age category is 1 year, so the user must enter a value of 15 in the cell in the '1 yr' data column and corresponding service type. The input range is 0 to 20,000, and the user can only enter integers—no decimals are allowed. For a proposed (not yet operational) service, the number of buses for all age categories will be zero (see Row 4 in Figure 60).

No of Buses by Age															
> 15 yr	15 yr	14 yr	13 yr	12 yr	11 yr	10 yr	9 yr	8 yr	7 yr	6 yr	5 yr	4 yr	3 yr	2 yr	1 yr
34	34	136	230	428	677	659	82	538	647	430	86	0	502	1134	15
0	0	19	22	108	171	60	25	109	87	9	0	0	128	4	0
0	0	3	3	16	24	9	4	16	13	1	0	0	19	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 60 User Form 2 – Part B – Number of buses by age

2.5.3 USER FORM 2: PART C

Part C of User Form 2 includes 6 different input boxes for each type of bus mentioned based on the given data.

- 4 Total Fleet Size** – The user is required to click on the box for each service type under the 'Total Fleet Size' column in order to view the total number of buses (all age groups), as calculated by the tool (see Figure 61). These cells will autofill, but only if the user clicks on them. If the user does not click on these cells, they will not autofill, and the tool will prevent the user

from accessing the next form. It is thus imperative that the users click on each cell in this column. The total fleet size for a new/proposed service will be zero.

- 5 Bus Cost** – The user is required to enter the cost of the bus used for each defined service type (see Figure 62). The figure presents sample inputs for data field (5). The input range is 0 to 9,00,00,000. For a new service, the known or estimated/expected cost of the bus on the date of the first order should be inserted.

- 6 Scrap Value** – The scrap value is the vehicle's value (sale cost in scrap) when the asset itself is deemed no longer usable/operable. The user is required to enter the estimated average scrap value for buses in each defined service type. For a new/proposed service, the estimated scrap value should be inserted. The user is required to enter numerical values (no decimal values) from 1 to 10,00,000. Figure 63 shows the sample inputs for data field (6).

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 61 User Form 2 – Part C – Total fleet size

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 63 User Form 2 – Part C – Bus scrap value

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 62 User Form 2 – Part C – Bus cost

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 64 User Form 2 – Part C – Bus age limit

7 Bus Age Limit – Here, the user is required to provide the currently established or expected operational age for each service type. The user is required to insert numerical values (no decimal values) from 1 to 50. Figure 64 shows the sample inputs for data field (7). For a new/proposed service, the expected operational age of the bus should be inserted.

8 Planned STU Depots – In this field, the user is required to state whether depots are planned/going to be developed by the STU for each service type. Here, the user must select 'Y' for yes or 'N' for no based on the information the user has related to depot infrastructure. Figure 65 shows the sample inputs for data field (8).

9 Bus Technology & Fuel Type – Here, the user is required to mention the existing technology and fuel types for bus fleets plying under each specific service operated by the STU. The user needs to select the bus technology and fuel type options using the dropdown menu provided in the field. The dropdown menu includes different options (Diesel /CNG/ Diesel Hybrid or Electric) the user can select; only one option can be selected per input box.

Note: In User Form 2, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages.

⁵The cost of the bus may be defined as zero in case the bus is operated under a service contract where the STUs do not bear the capital cost of the bus, but, rather, pay a per km operational cost to the operator.

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 65 User Form 2 – Part C – Planned STU depots

Total (click to calculate)	Cost of Bus	Scrap Value of Bus	Age limit for bus	Depot to be Developed by STU	Bus technology and fuel type
5632	3273000	200000	11	☒ Y ☐ N	Diesel 50 with DPF
742	8574000	200000	15	☒ Y ☐ N	CNG
108	8574000	200000	15	☒ Y ☐ N	Diesel 50 with DPF
0	18000000	200000	15	☒ Y ☐ N	Electric + Thermal Power

Figure 66 User Form 2 – Part C – Bus Technology and Fuel Type

2.6 DETAILED ESTIMATOR: USER FORM 3: STU SERVICE DATA FORM

Figure 67 presents the screenshot of the third user form, i.e. the STU Service Data form.

In this form, the user is required to input the existing bus operational parameters of the STU for the base (usually current) year (as defined in User Form 1) for each defined service type. These parameters, represented by 15 columns (each row denotes a separate service type),

include following, in order from left to right (see Figure 68):

1. Service Name
2. Fleet Strength
3. Fleet Utilization
4. Average EPK
5. Average CPK
6. Average Daily Km (Scheduled)
7. Average Route Length
8. Daily Passenger Trips (Ticket Sales)
9. % Pass Holders

10. Average Km Achieved per Day
11. Total Operational Hours
12. % Load Factor
13. Total Operational Routes
14. Staff to Bus Ratio
15. Average Daily Dead Km

For better understanding, the 15 data fields are grouped into three parts – A, B, and C (Figure 68). The inputs boxes are coded in alphabetical order (from a to o) under Parts A, B, & C. The data input requirements are detailed in the following subsections.

STU Service Data

FLEET SOFTWARE SOLUTIONS

User Form 1 > User Form 2 > **User Form 3 Service Data Form** > User Form 4 > User Form 5 > User Form 6 > User Form 7

STU Basic Information > Fleet Data Form > **Service Data Form** > Vision Data Form-1 > Vision Data Form-2 > Vision Data Mode Share > Output

Service Data (Intracity)

Service Name	Fleet Strength	Fleet Utilization (%)	Avg EPK (Rs)	Avg CPK (Rs)	Avg Daily Km (Scheduled)	Avg Route length	Daily Passenger Trips (ticket sale)	% share of pass holders	Average Km achieved per day	Total Operational Hours	% Load factor	Total Operational Routes	Staff to Bus ratio
High Floor Standard	5632	89.23	42.74	58.45	221.6	50.48	1900000	75.00	199.00	16	65.00	2220	5.32
AC low floor	742	77.89	57.35	78.7	240.4	33.7	100000	75.00	199.00	16	53.90	27	4.25
AC express Low floor	108	77.89	79.68	78.7	240.4	53.4	12000	75.00	199.00	16	53.90	16	4.25
Electric	0	89.23	42.74	85	221.6	50.48	0	75.00	170.00	16	65.00	0	5.32

Figure 67 Detailed estimator – User Form 3 – STU Service Data Form

STU Service Data

FLEET SOFTWARE SOLUTIONS

User Form 1 > User Form 2 > **User Form 3 Service Data Form** > User Form 4 > User Form 5 > User Form 6 > User Form 7

STU Basic Information > Fleet Data Form > **Service Data Form** > Vision Data Form-1 > Vision Data Form-2 > Vision Data Mode Share > Output

Service Data (Intracity)

Service Name	Fleet Strength	Fleet Utilization (%)	Avg EPK (Rs)	Avg CPK (Rs)	Avg Daily Km (Scheduled)	Avg Route length	Daily Passenger Trips (ticket sale)	% share of pass holders	Average Km achieved per day	Total Operational Hours	% Load factor	Total Operational Routes	Staff to Bus ratio
High Floor Standard	5632	89.23	42.74	58.45	221.6	50.48	1900000	75.00	199.00	16	65.00	2220	5.32
AC low floor	742	77.89	57.35	78.7	240.4	33.7	100000	75.00	199.00	16	53.90	27	4.25
AC express Low floor	108	77.89	79.68	78.7	240.4	53.4	12000	75.00	199.00	16	53.90	16	4.25
Electric	0	89.23	42.74	85	221.6	50.48	0	75.00	170.00	16	65.00	0	5.32

Labels: A, B, C (Parts); a, b, c, d, e, f, g, h, i, j, k, l, m, n (Columns)

Figure 68 User Form 3 – Service data entry column labels

2.6.1 USER FORM 3: PART A

The input requirements for the Part A parameters are explained below.

- a Service Name** – This field cannot be edited. All service names defined in the previous form (User Form 2) shall be displayed.
- b Fleet Strength:** This field can also not be edited. Based on the data entered by the user in the previous form under age-wise fleet data for each service, the tool self-generates the fleet strength data.
- c Fleet Utilisation:** Fleet utilisation is defined as the ratio of the average number of operational buses on the road to the total number of buses held (in the fleet). The user is required to insert the existing service fleet utilisation as a percentage for each service type in numerical/decimal values from 1 to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. For a new/proposed service, the user should input a value corresponding to the expected or estimated fleet utilisation.
- d Average EPK:** Average EPK is defined as the per km revenue for each service type. It includes both fare box and non-fare box revenue (i.e. the total fare and non-fare box revenue divided by the total km operated by the service per unit of time). Here, the user must enter the average EPK for each service type in numerical/ decimal values from 1 to 200. For a new/proposed service, the user should enter the expected or estimated EPK on the day/in the month

when the service first becomes operational.

- e Average CPK:** CPK is defined as the average expenditure per km for operating buses for each service. It includes the cost of fuel, maintenance, manpower, etc. The user is required to insert the average CPK for each service type in numerical/ decimal values from 1 to 300. For a new/proposed service, the user should enter the expected or estimated CPK on the day/in the month when the service first becomes operational.

2.6.2 USER FORM 3: PART B

- f Average Daily Scheduled Km:** The user is required to enter the average daily scheduled km per bus for each service type. 'Scheduled kilometres' are the average number of km that each bus (operating under a certain service type) is estimated to cover in a day. This includes the 'dead miles', or the distance operated to access the bus terminal, over which no new passengers are accepted. Typically, the average daily scheduled km for urban services is in the range of 200

km. The user must enter data in numerical/ decimal values from 1 to 999. For a new/proposed service, the user should enter the planned or expected average daily scheduled km per bus.

- g Average Route Length:** The average route length is the sum of the lengths of all routes divided by the total number of routes per service type. The user is required to input data in numerical/ decimal values from 1 to 999. For a new/proposed service, the user should enter the planned or expected average route length.

- h Daily Passenger Trips (Ticket Sales):** This data is generally derived by the STUs from annual/daily ticket sales, usually from electronic ticketing machines. The average daily number of tickets represents the average daily passenger trips (excluding pass holders) for each defined service type. The user must enter the data in numerical/ decimal values from 0 to 9000000. For a new/proposed (not yet operational) service, this value must be zero.

A

Service Name	Fleet Strength	Fleet Utilization (%)	Avg EPK (Rs)	Avg CPK (Rs)
High Floor Standard	5632	89.23	42.74	58.45
AC low floor	742	77.89	57.35	78.7
AC express Low floor	108	77.89	79.68	78.7
Electric	0	89.23	42.74	85

a b c d e

Figure 69 User Form 3 – Part A

B

Avg Daily Km (Scheduled)	Avg Route length	Daily Passenger Trips (ticket sale)	% share of pass holders	Average Km achieved per day
221.6	50.48	1900000	75.00	199.00
240.4	33.7	100000	75.00	199.00
240.4	53.4	12000	75.00	199.00
221.6	50.48	0	75.00	170.00

f g h i j

Figure 70 User Form 3 – Part B

i Percentage of Pass Holders: This data is derived by the STUs from the 'ticket checkers' or through other surveys. It represents the average share of pass holders in each bus for each service type as a percentage of daily ticket sales-based trips. For example, if the total number of daily tickets purchased on a bus service is 1,00,000, and the number of pass holder trips per day is estimated to be 10,000, then the ratio of pass holders to individual ticket sales is $10000/100000 = 10$ percent. The user must enter data for each bus service type in numerical/ decimal values from 1 to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. For a new/proposed service, the user should enter the expected percentage of pass holders.

2.6.3 USER FORM 3: PART C

j Average Km Achieved per Day: In this field, the user is required to input the actual number of km achieved (including dead mileage) by each bus. For example, the typical daily achieved km per bus for urban buses is usually in the range of 200 km. The user is required to provide the input in numerical/decimal values from 0 to 999. The ratio of this value and the 'average daily scheduled km' (f) for each service yields the vehicle utilisation for that service (in percentage); this is automatically calculated by the tool and presented in subsequent forms. For a new/proposed service, the user should enter the expected or estimated average service km (including dead mileage) that will be achieved by each bus (when the service becomes operational).

k Total Operational Hours: The user is required to enter the number of operational hours per day for each service. For example, bus services are typically operational 16 hours per day. The user is required to enter a numerical value between 1 and 24. For a new/proposed service, the expected number of operational hours should be entered.

l % Load Factor: This parameter determines the carrying capacity of the bus and is defined in percentage as the ratio of average number of passengers in the bus (at any point in time, throughout the day and different legs of the journey) to the seating capacity provided for each service. For example, a load factor of 100% in a 50-seater bus would mean that, on average, 50 people would be using the bus at any point in time. The input has to be a numerical/decimal value from 1 to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. For a new/proposed service, the user should enter the expected load factor for the service.

m Total Operational Routes: The user is required to enter the number of operational routes serviced by each defined service. Routes that overlap for more than 90% of the route length should be treated as the same (when counting the total number of operational routes). Inputs have to be integers between 0 and 9999. For a new/proposed (not yet operational) service, the number of total operational routes should be entered as zero. The tool calculates the number of operational routes in each successive year based on the projected trend and target number of routes (included in later forms) to be achieved.

n Staff to Bus Ratio: The user is required to enter the ratio of total staff per bus service, including all on-roll and contractual crew, maintenance staff, administrative and management staff, etc., to the total fleet (number of buses, including both operational and non-operational buses) under the service. The user is required to enter data in numerical/ decimal values from 0 to 10. For a new/proposed service, the user should enter the expected staff to bus ratio for the service.

Note: In User Form 3, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages

‘Please note that all costs and financial numbers provided or generated by the tool do not include adjusting for inflation or the current value of money.’

Total Operational Hours	% Load factor	Total Operational Routes	Staff to Bus ratio
16	65.00	2220	5.32
16	53.90	27	4.25
16	53.90	16	4.25
16	65.00	0	5.32

Figure 71 User Form 3 – Part C

2.7 DETAILED ESTIMATOR: USER FORM 4: VISION DATA FORM 1

Forms 4, 5, and 6 are referred to as the vision data forms, as they allow the users to define different future scenarios for an STU based on the vision for the same. Data from the outputs in each scenario can be used to develop a scenario-specific long-range plan or generate comparative findings between scenarios. Figure 72 presents the screenshot of the fourth user form, i.e., Vision Data Form 1. This form consists of 17 fields designed to capture an expected scenario or a vision for the STU in terms of different service type-specific target values of service and operational parameters such as load factor, fleet utilisation, staff to bus ratio, etc. This form displays base/current year data and requires inputs on the target value

of different parameters, their trajectory of change, and the time (number of years) in which the change/transition is to be achieved.

For explanation of all input fields, this form is divided into three parts: A, B and C (see Figure 73). Each part is discussed separately below.

2.7.1 USER FORM 4: PART A

Figure 74 presents the screenshot of the input fields in User Form 4 Part A. This form includes data on the intended/desired composition.

a Service Name: In this column, the tool displays the name of each service type as defined in User Form 3.

These fields cannot be edited by the user and are only in this form for reference.

b Current Fleet Composition: In this column, the tool presents an estimate of the share of the fleet dedicated to each service (of the total fleet) or the share of average per day passenger trips undertaken by each service (of the total daily passenger trips), depending on whether the estimation method is based on 'Bus Fleet' or 'Passenger Trips'. These fields cannot be edited by the user and are only in this form for reference.

c Desired Fleet Composition: In this column, the user is required to input the desired or targeted composition for each defined service type, by fleet or passenger trips in % share. The user must enter numerical/

TU Vision Data (Entry) - 1

Service Composition (Inputs)

Service Name	Current Fleet Composition (%)	Desired Fleet Composition (%)	Years to achieve target	Trajectory of Change
High Floor Standard	26.00	26.00	10	Linear
AC Low Floor	77.80	96.00	10	Linear
AC High Floor	77.60	96.00	10	Linear
Bus	18.00	26.00	10	Linear

(Values for all scenarios)

Indicative Figure differentiating the different growth rates

Linear - Rate of change remains same over period
 Exponential - Rate of change steadily increases over growth period
 Logarithmic - Rate of change steadily reduces over growth period

Figure 72 Detailed Estimator – User Form 4 – Vision Data Form 1

Service Composition (Intracity)

Service Name	Current Fleet Composition (%)	Desired Fleet Composition (%)	Years to achieve target	Trajectory of Change
High Floor Standard	86.89%	0.00	10	Linear
AC low floor	11.45%	0.00	(Same for all services)	
AC express Low floor	1.67%	0.00		
Electric	0.00%	100.00		

Indicative figure differentiating the different growth curves:
 Linear - Rate of change remains same over growth period
 Exponential - Rate of change steadily increases over growth period
 Logarithmic - Rate of change steadily reduces over growth period

Current Fleet Utilization (%)

Service Name	Current Fleet Utilization (%)	Desired Fleet Utilization (%)	Years to achieve target	Trajectory of Change
High Floor Standard	89.23	89.23	10	Linear
AC low floor	77.89	80.00	10	Linear
AC express Low floor	77.89	80.00	10	Linear
Electric	89.23	89.23	10	Linear

Current Avg Vehicle Utilization (%)

Service Name	Current Avg Vehicle Utilization (%)	Desired Avg Vehicle Utilization (%)	Years to achieve target	Trajectory of Change
High Floor Standard	89.80	89.80	10	Linear
AC low floor	82.78	87.34	10	Linear
AC express Low floor	82.78	87.34	10	Linear
Electric	76.71	76.71	10	Linear

Current Avg Occupancy (%)

Service Name	Current Avg Occupancy (%)	Desired Avg Occupancy (%)	Years to achieve target	Trajectory of Change
High Floor Standard	65.00	65.00	10	Linear
AC low floor	53.90	54.10	10	Linear
AC express Low floor	53.90	54.10	10	Linear
Electric	65.00	65.00	10	Linear

Figure 73 User Form 4 – Parts A, B, and C

decimal values between 0 and 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. Additionally, the user should ensure that the sum of 'desired composition' values for all services is 100. If this is not the case, the tool will generate an error message during the error check stage.

- d Years to Achieve Target:** In this field, the user is required to input the desired or targeted timeframe (in number of years), from the current/base year, to achieve the transition in (fleet or passenger trip) composition to the desired/target composition. The user must enter a numerical, integer value from 1 to 50. The user only has to enter this value once, as the tool applies the same timeframe for the transition in composition for all defined services.

- e Change Trajectory:** The trajectory of transition between the base year and targeted composition can either be linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user can select one of these three transition types from the drop-down menu, and the tool will use the selected input in the estimates. The trajectory input is common for all the services, and the tool applies the same trajectory for transition in composition for all defined services.

2.7.2 USER FORM 4: PART B

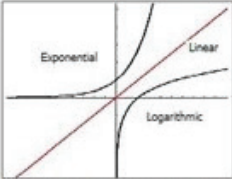
Figure 75 presents the screenshot of the data fields in User Form 4 Part B. Part B includes 8 data fields (for each defined service type) – 4 each for fleet and vehicle utilisation, labelled from (f) to (m). The input requirements for each of these fields are explained below.

- f Current Fleet Utilisation:** In this column, the tool presents the current or base year 'fleet utilisation' for each service type, as input by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.
- g Desired/Target Fleet Utilisation:** In this column, the user is required to enter the desired or targeted percentage 'fleet utilisation' for all defined services. The user must input numerical/ decimal values from 1

A

Service Name	Current Fleet Composition (%)	Desired Fleet Composition (%)	Years to achieve target	Trajectory of Change
High Floor Standard	86.89%	0.00	10	Linear
AC low floor	11.45%	0.00		
AC express Low floor	1.67%	0.00		
Electric	0.00%	100.00		

(Same for all services)



Indicative figure differentiating the different growth curves
 Linear - Rate of change remains same over growth period
 Exponential - Rate of change steadily increases over growth period
 Logarithmic - Rate of change steadily reduces over growth period

Figure 74 User Form 4 – Part A

to 100. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

It is important to note that changes (positive or negative) in fleet utilisation can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in 'fleet utilisation' to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.4 discusses the policy, financing, and planning interventions that could affect 'fleet utilisation,' and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

B

Current Fleet Utilization (%)	Desired Fleet Utilization (%)	Years to achieve target	Trajectory of Change	Current Avg Vehicle Utilization (%)	Desired Avg Vehicle Utilization (%)	Years to achieve target	Trajectory of Change
89.23	89.23	10	Linear	89.80	89.80	10	Linear
77.89	80.00	10	Linear	82.78	87.34	10	Linear
77.89	80.00	10	Linear	82.78	87.34	10	Linear
89.23	89.23	10	Linear	76.71	76.71	10	Linear

Figure 75 User Form 4 – Part B

- h Years to Achieve Target:** Here, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in fleet utilisation to the desired/target utilisation, for each defined service type. The user must input numerical, integer values from 1 to 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for fleet utilisation transitions for all services.
- i Change Trajectory:** The trajectory of transition between the base year and targeted fleet utilisation can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu, individually for each service (each service can have a different defined trajectory of change in fleet utilisation).
- j Current Vehicle Utilisation:** In this column, the tool presents an estimate of the current or base year 'vehicle utilisation' for each service type based on inputs (average scheduled and actual covered km for each service) by the user in User Form 3. These fields cannot be edited by the user and are only in the form for reference.
- k Desired Vehicle Utilisation:** Here, the user is required to enter the desired or targeted percentage vehicle utilisation for all defined services, i.e. the ratio of desired actual km covered to current scheduled km. The user must input numerical/ decimal values between 1 and 999. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. The percentage value inserted is used to calculate the average desired/ targeted actual covered km at the end of the defined time period of transition (for each service), by multiplying the percentage vehicle utilisation with the average scheduled km (for each service) given in User Form 3. Since the future number of km covered may be higher than the current scheduled km, this input value can be above 100 percent.

It is important to note that changes (positive or negative) in vehicle utilisation can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in vehicle utilisation to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.3 discusses the policy, financing, and planning interventions that could affect vehicle utilisation, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

l Years to Achieve Target: In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in vehicle utilisation to the desired/target utilisation, for each defined service type. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for vehicle utilisation transitions in for all services.

m Trajectory of Change: The trajectory of transition between the base year and targeted vehicle utilisation can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three

transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in vehicle utilisation).

2.7.3 USER FORM 4: PART C

Figure 76 presents the screenshot of the 4 data fields in User Form 4 Part C, labelled from (n) to (q). The input requirements for each of these fields are explained below.

n Current Average Occupancy: In this column, the tool presents an estimate of the current or base year 'average occupancy' (also known as 'load factor') for each service type, based on inputs by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.

o Desired/Target Average Occupancy: Here, the user is required to enter the desired or targeted percentage 'average occupancy' or 'load factor' for all defined services. The user must input numerical/ decimal values between 1 and 999. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool. The percentage value inserted is used to calculate the average desired/ targeted number of commuters in the bus at the end of the defined time period of transition (for each service), by multiplying the average occupancy percentage with the average seating capacity (for each service) given in User Form 3 and User Form 4. Since the average number of people in the bus in the future may be greater than the current seating capacity, this input value can be higher than 100 percent.

It is important to note that changes (positive or negative) in average occupancy can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in average occupancy to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.3 discusses the policy, financing, and planning interventions that could affect average occupancy, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

p Years to Achieve Target: In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in average occupancy to the desired/target occupancy, for each defined service type. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually

Current Avg Occupancy (%)	Desired Avg Occupancy (%)	Years to achieve target	Trajectory of Change
65.00	65.00	10	Linear
53.90	54.10	10	Linear
53.90	54.10	10	Linear
65.00	65.00	10	Linear

Figure 76 User Form 4 – Part C

defined timeframes for average occupancy transitions for all services.

q Trajectory of Change: The trajectory of transition between the base year and targeted average occupancy can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in average occupancy).

Note: In User Form 4, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages.

2.8 DETAILED ESTIMATOR: USER FORM 5: VISION DATA FORM 2

Figure 77 presents the screenshot of the fifth user form, i.e. Vision Data Form 2. This form consists of a total of 29 fields designed to capture an expected scenario or a vision for

the STU in terms of different service type-specific target values of financial, passenger, and bus trip parameters, such as EPK, CPK, bus cost, passenger trip length, total route length, etc. This form displays the base/current year data and requires inputs on target parameter values, their trajectory of change, and the time period (number of years) in which the change/transition is to be achieved.

For explanation of all input fields, this form has been divided into six parts: A, B, C, D, E, F, and G (see Figure 78). Each part is discussed separately below.

STU Vision Data (Intracity) 2



Service Composition (Intracity)

Service Name	Current EPK (Rs)	Desired EPK (Rs)	Years to achieve target	Trajectory of Change	Current CPK (Rs)	Desired CPK (Rs)	Years to achieve target	Trajectory of Change	Current staff to bus ratio	Desired staff to bus ratio	Years to achieve target	Trajectory of Change
High Floor Standard	42.74	43	10	Linear	58.45	58.48	10	Linear	5.32	5.32	10	Linear
AC Low Floor	57.35	57	10	Linear	78.7	70.7	10	Linear	4.25	4.25	10	Linear
AC Express Low Floor	70.68	80	10	Linear	78.7	78.7	10	Linear	4.25	4.25	10	Linear
Electric	42.74	42.74	10	Linear	85	70	10	Linear	5.32	5.29	10	Linear

Current Operational routes	Desired Operational routes	Years to achieve target	Trajectory of Change	Current Avg. Route length	Desired Avg. Route length	Years to achieve target	Trajectory of Change
2220	0	10	Linear	50.48	25	10	Linear
77	0	10	Linear	33.7	25	10	Linear
16	0	10	Linear	53.4	25	10	Linear
0	2264	10	Linear	50.48	25	10	Linear

Current Cost	Expected Cost	Years to achieve target	Trajectory of Change	Current Pass. Trip Length	Expected Pass. Trip Length	Years to achieve target	Trajectory of Change
3273000	3273000	10	Linear	8.07	9.65	10	Linear
8574000	8574000	10	Linear	13.74	13.74	10	Linear
8574000	8574000	10	Linear	16.67	15.57	10	Linear
10000000	10000000	10	Linear	8.87	10.41	10	Linear

Figure 77 Detailed estimator – User Form 5 – Vision Data Form 2

Service Composition (Intracity)

Service Name	Current EPK (Rs)	Desired EPK (Rs)	Years to achieve target	Trajectory of Change	Current EPK (Rs)	Desired EPK (Rs)	Years to achieve target	Trajectory of Change	Current staff to bus ratio	Desired staff to bus ratio	Years to achieve target	Trajectory of Change
High Floor Standard	42.74	43	10	Linear	58.45	58.48	10	Linear	5.32	5.32	10	Linear
AC Low Floor	57.35	57	10	Linear	78.7	70.7	10	Linear	4.25	4.25	10	Linear
AC Express Low Floor	70.68	80	10	Linear	78.7	78.7	10	Linear	4.25	4.25	10	Linear
Electric	42.74	42.74	10	Linear	05	70	10	Linear	5.32	5.29	10	Linear

Operational routes

Current Operational routes	Desired Operational routes	Years to achieve target	Trajectory of Change	Current Avg. Route length	Desired Avg. Route length	Years to achieve target	Trajectory of Change
2220	0	10	Linear	50.48	25	10	Linear
77	0	10	Linear	33.7	25	10	Linear
16	0	10	Linear	53.4	25	10	Linear
0	2264	10	Linear	50.48	25	10	Linear

Cost

Current Cost	Expected Cost	Years to achieve target	Trajectory of Change	Current Pass. Trip Length	Expected Pass. Trip Length	Years to achieve target	Trajectory of Change
3273000	3273000	10	Linear	8.07	9.65	10	Linear
8574000	8574000	10	Linear	13.74	13.74	10	Linear
8574000	8574000	10	Linear	16.67	16.67	10	Linear
10000000	10000000	10	Linear	8.87	10.41	10	Linear

Figure 78 User Form 5 with labelled parts

2.8.1 USER FORM 5: PART A

Figure 79 presents the screenshot of the input fields in User Form 5 (Vision Data Form 2) Part A. This form includes data on the intended/desired EPK for all defined services.

- a Service Name:** In this column, the tool displays the name of each service type as defined in User Form 3.

These fields cannot be edited by the user and are only in this form for reference.

- b Current EPK:** In this column, the tool presents the current or base year 'EPK' (unit is currency, i.e. Indian Rupees) for each service type, as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.

- c Desired EPK:** Here, the user is required to enter the desired or targeted EPK individually for all defined services. The user must input numerical/ decimal values between 1 and 999.

It is important to note that changes (positive or negative) in EPK can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the

expected change in EPK to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.1 discusses the policy, financing, and planning interventions that could affect EPK, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

- d Years to Achieve Target:** In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in EPK to the desired/target EPK, for each defined service type. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for EPK transitions for all services.

- e Change Trajectory:** The trajectory of transition between the base year and targeted EPK can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in EPK).

2.8.2 USER FORM 5: PART B

Figure 80 presents the screenshot of the input fields in User Form 5 Part B. This form includes data on the intended/desired CPK for all defined services.

- a Current CPK:** In this column, the tool presents the current or base year 'CPK' (unit is currency, i.e. INR) for each service type, as entered by the user in User

Form 3. These fields cannot be edited by the user and are only in this form for reference.

- b Desired CPK:** Here, the user is required to enter the desired or targeted CPK individually for all defined services. The user must input numerical/ decimal values between 1 and 999.

It is important to note that changes (positive or negative) in CPK can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in CPK to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.6 discusses the policy, financing, and planning interventions that could affect CPK, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

A

Service Composition (Intracity)

Service Name	Current EPK (Rs)	Desired EPK (Rs)	Years to achieve target	Trajectory of Change
High Floor Standard	42.74	43	10	Linear
AC low floor	57.35	57	10	Linear
AC express Low floor	79.68	80	10	Linear
Electric	42.74	42.74	10	Linear

a **b** **c** **d** **e**

Figure 79 User Form 5 – Part A

B

Current CPK (Rs)	Desired CPK (Rs)	Years to achieve target	Trajectory of Change
58.45	58.48	10	Linear
78.7	78.7	10	Linear
78.7	78.7	10	Linear
85	70	10	Linear

a **b** **c** **d**

Figure 80 User Form 5 – Part B

The screenshot shows a table with four columns: 'Current staff to bus ratio', 'Desired staff to bus ratio', 'Years to achieve target', and 'Trajectory of Change'. There are four rows of data. A large orange circle with the letter 'C' is positioned above the table. Smaller orange circles with letters 'a', 'b', 'c', and 'd' are placed below the first, second, third, and fourth columns respectively.

Current staff to bus ratio	Desired staff to bus ratio	Years to achieve target	Trajectory of Change
5.32	5.32	10	Linear
4.25	4.25	10	Linear
4.25	4.25	10	Linear
5.32	5.29	10	Linear

Figure 81 User Form 5 – Part C

- c Years to Achieve Target:** In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in CPK to the desired/target CPK, for each defined service type. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for CPK transitions for all services.
- d Change Trajectory:** The trajectory of transition between the base year and targeted CPK can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in CPK).

2.8.3 USER FORM 5: PART C

Figure 81 presents the screenshot of the input fields in User Form 5 Part C. This form includes data on the intended/ desired operational routes for all defined services.

- a Current Staff to Bus Ratio:** In this column, the tool presents the current or base year 'staff to bus ratio' for each service type, as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.
- b Desired Staff to Bus Ratio:** Here, the user is required to enter the desired or targeted staff to bus ratio individually for all defined services. The user must input numerical/ decimal values between 1 and 10.

It is important to note that changes (positive or negative) in staff to bus ratio can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in staff to bus ratio to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.12 discusses the policy, financing, and planning interventions that could affect the staff to bus ratio, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

- c Years to Achieve Target:** In this column, the user is required to input the desired or targeted timeframe

(in number of years) to achieve the transition from the current/base year to achieve the transition in the staff to bus ratio to the desired/target ratio, for each defined service type. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for transitions in the staff to bus ratio for all services.

- d Change Trajectory:** The trajectory of transition between the base year and targeted staff to bus ratio can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in staff to bus ratio).

2.8.4 USER FORM 5: PART D

Figure 82 presents the screenshot of the input fields in User Form 5 Part D. This form includes data on the intended/desired operational routes for all defined services.

- a Current Operational Routes:** In this column, the tool presents the current or base year 'operational routes' for each service type as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.

Current Operational routes	Desired Operational routes	Years to achieve target	Trajectory of Change
2220	0	10	Linear
27	0	10	Linear
16	0	10	Linear
0	2264	10	Linear

Figure 82 User Form 5 – Part D

Current Avg. Route length	Desired Avg. Route length	Years to achieve target	Trajectory of Change
50.48	25	10	Linear
33.7	25	10	Linear
53.4	25	10	Linear
50.48	25	10	Linear

Figure 83 User Form 5 – Part E

- b** **Desired Operational Routes:** Here, the user is required to enter the desired or targeted number of operational routes individually for all defined services. The user must input numerical/ decimal values between 1 and 9999.

It is important to note that changes (positive or negative) in the number of operational routes can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in the number of operational routes to an expected change in

policy, financing, and planning related to future bus services and operations. Section 2.5 discusses the policy, financing and planning interventions that could affect the number of operational routes, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

- c** **Years to Achieve Target:** In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in the number of operational routes to the desired/targeted number of routes, for each defined service. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for transitions in the number of operational routes for all services.
- d** **Change Trajectory:** The trajectory of transition between the base year and targeted number of operational routes can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in the number of operational routes).

2.8.5 USER FORM 5: PART E

Figure 83 presents the screenshot of the input fields in User Form 5 Part E. This form includes data on the intended/desired average route length for all defined services.

- a** **Current Average Route Length:** In this column, the tool presents the current or base year 'average route length' for each service type as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.
- b** **Desired Average Route Length:** Here, the user is required to enter the desired or targeted average route length (in km) individually for all defined services. The user must input numerical/ decimal values between 1 and 999.

It is important to note that changes (positive or negative) in the average route length can be a result of policy, financing and planning interventions. Therefore, users should be able to relate the expected change in average route length to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.11 discusses the policy, financing, and planning interventions that could affect the average route length, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

c Years to Achieve Target: In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in average route length to the desired/target route length, for each defined service. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for transitions in the average route length for all services.

d Change Trajectory: The trajectory of transition between the base year and targeted average route length can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in average route length).

The screenshot shows a table with four columns: Current Cost, Expected Cost, Years to achieve target, and Trajectory of Change. There are four rows of data. A large orange circle with the letter 'F' is overlaid on the top right of the table. Below the table, there are four orange circles labeled 'a', 'b', 'c', and 'd' corresponding to the columns.

Current Cost	Expected Cost	Years to achieve target	Trajectory of Change
3273000	3273000	10	Linear
8574000	8574000	10	Linear
8574000	8574000	10	Linear
18000000	10000000	10	Linear

Figure 84 User Form 5 – Part F

2.8.6 USER FORM 5: PART F

Figure 84 presents the screenshot of the input fields in User Form 5 Part F. This form includes data on the intended/desired cost of the vehicle (bus) for all defined services.

a Current Cost: In this column, the tool presents the value of current or base year average current cost per bus for each service type as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.

b Desired Cost: Here, the user is required to enter the expected average bus cost (or purchase cost) in the horizon year (or in the defined time period). If a scenario specifies that the STU shall move to contracting an external/private operator and not investing in buses, the bus cost shall be zero. The user must input numerical, integer values between 0 and 99999999. Please note that all costs do not include adjusting for inflation or the current value of money, and the input unit is INR.

c Years to Achieve Target: In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in average bus cost to the desired/target cost, for each defined service. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for bus cost transitions for all services.

d Change Trajectory: The trajectory of transition between the base year and targeted average bus cost can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in average bus cost).

2.8.7 USER FORM 5: PART G

Figure 85 presents the screenshot of the input fields in User Form 5 Part G. This form includes data on the intended/desired average passenger trip length for all defined services.

a Current Average Passenger Trip Length: In this column, the tool presents the current or base year 'average passenger trip length' for each service type as entered by the user in User Form 3. These fields cannot be edited by the user and are only in this form for reference.

b Desired Average Passenger Trip Length: Here, the user is required to enter the desired or targeted average passenger trip length (in km) individually for all defined services. The user must input numerical/decimal values between 1 and 500.

It is important to note that changes (positive or negative) in the average passenger trip length can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in average passenger trip length to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.10 discusses the policy, financing, and planning interventions that could affect the average passenger trip length, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

c Years to Achieve Target: In this column, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in average passenger trip length to the desired/target length, for each defined service. The user must input numerical, integer values between 1 and 50. The target timeframe input is service-specific, and the tool applies individually defined timeframes for transitions in average passenger trip length for all services.

d Change Trajectory: The trajectory of transition between the base year and targeted average passenger trip length can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these

three transition types from the drop-down menu individually for each service (each service can have a different defined trajectory of change in average passenger trip length).

Note: In User Form 5, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages.

Current Pass. Trip Length	Expected Pass. Trip Length	Years to achieve target	Trajectory of Change
8.07	9.85	10	Linear
13.74	13.74	10	Linear
16.67	16.67	10	Linear
8.87	10.41	10	Linear

Figure 85 User Form 5 – Part G

2.9 DETAILED ESTIMATOR: USER FORM 6: VISION DATA FORM 3 (MODE SHARE)

Figure 86 presents the screenshot of User Form 6 – Vision Data Form 3. This is the last input form. In this form, the user is required to provide the targeted or envisioned intercity and intracity mode share data separately for STU buses, other buses, and intermediate public transport (IPT). This form consists of a total of 22 data fields (including intercity & intracity). However, if the STU's operational information, as provided by the user in User Form 1, is either intercity or intracity, then the form shall only display the data fields for the selected operational type. For example, Figure 87 shows the data fields visible to the user if the STU only operates intracity services.

For the STU mode share, the user can choose to insert the envisioned data in terms of mode share, daily trips, or fleet size. The user can select one of the provided choices and enter the desired input accordingly (see Figure 88).

⁷A good target for the bus share of intracity passenger trips would be 40–45 percent, including all bus and IPT trips, with 45–55% trips by non-motorised modes (including walking) and not more than 5–15% by private motorized modes. The share of all bus-based passenger trips should be 85–90% of all one-way passenger trips longer than 7 to 8 km in the city. For intercity or non-urban passenger trips, a good target would be 40–50% of total trips by buses and IPT, less than 5–10% by non-motorised modes, 35–45% by rail, air, and water transport, and less than 10–15% by private motorised modes.

Figure 86 Detailed estimator – User Form 6

Figure 87 User Form 6 – Data input display for STU with intracity operations

Figure 88 User Form 6 – Mode share data choices

The existing mode share, daily trips, and fleet size will appear prefilled, estimated by the tool based on the data inserted by the user in the previous forms (see Figure 89). The data fields under the choice selected by the user will remain active, whereas the other options will be invisible. Irrespective of the different choices and modes, the user must enter the number of years required to achieve the target and trajectory of the change.

For ease of understanding, the form has been divided into three parts: Parts A, B, and C (see Figure 90). Each part is discussed separately below, with labelled data fields in lowercase alphabetical order.

USER FORM 6 – PART A

Figure 91 presents the screenshot of the input fields in User Form 6 Part A. This part has a total of 16 data fields, out of which 8 must be filled out by the user, with the rest prefilled. For ease of understanding, the data fields are labelled in lowercase alphabetical order

In this part, the data on desired/envisioned STU bus mode share, daily trips, and fleet size are captured, along with inputs on the number of years to achieve the targets and trajectory of transition. The user must select one option from the 3 given options (mode share, daily trips, or fleet size). Please note that the sum of the mode shares of STU buses, all other buses, and IPT should not exceed 90 (i.e. 90 percent).

a Current STU Mode Share (Intracity): The tool estimates and presents the mode share of STU buses, i.e. the percentage of intracity passenger trips (by all travel modes, including walking) by STU buses in the region served by the STU. This is estimated from population

and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

b Desired STU Mode Share (Intracity): This data field will only appear if the user has selected the mode share option. In this field, the user is required to enter the desired/envisioned intracity STU mode share. The user must input a numerical/ decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

c Current STU Mode Share (Intercity): The tool estimates and presents the mode share of intercity STU buses, i.e. the percentage of intercity passenger trips (by all travel modes, including walking) by STU buses in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

d Desired STU Mode Share (Intercity): This data field will only appear if the user has selected the mode share option. In this field, the user is required to enter the desired/envisioned intercity STU mode share. The user must input a numerical/ decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

It is important to note that changes (positive or negative) in STU mode share can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in STU mode share to an expected change in policy, financing, and planning related

to future bus services and operations. Section 2.7 discusses the policy, financing, and planning interventions that could affect the STU mode share, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

e Current STU Daily Trips (Intracity): The tool estimates and presents the number of daily intracity STU passenger trips in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

f Desired STU Daily Trips (Intracity): This data field will only appear if the user has selected the daily intracity trips option. In this field, the user is required to enter the desired/envisioned number of daily intracity STU trips. The user must input a numerical value between 1 and 20,00,00,000.

g Current STU Daily Trips (Intercity): The tool estimates and presents the number of daily intercity STU passenger trips in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

h Desired STU Daily Trips (Intercity): This data field will only appear if the user has selected the daily intercity trips option. In this field, the user is required to enter the desired/envisioned number of daily intercity STU

trips. The user must input a numerical value between 1 and 20,00,00,000.

i Current STU Fleet Size (Intracity): The tool estimates and presents the intracity (urban) STU fleet size. This is estimated from STU and trip data captured in the previous forms. This value cannot be edited and only in this form for reference.

j Desired STU Fleet Size (Intracity): This data field will only appear if the user has selected the intracity fleet size option. In this field, the user is required to enter the desired/ envisioned intracity STU fleet size. The user must input a numerical value between 1 and 10,00,000.

k Current STU Fleet Size (Intercity): The tool estimates and presents the intercity (regional) STU fleet size. This is estimated from STU and trip data captured in the previous forms. This value cannot be edited and is only in this form for reference.

l Desired STU Fleet Size (Intercity): This data field will only appear if the user has selected the intercity fleet size option. In this field, the user is required to enter the desired/ envisioned intercity STU fleet size. The user must input a numerical value between 1 and 10,00,000.

m Years to Achieve Target (Intracity): In this field, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in the selected option—mode share, daily trips, or fleet size—to the target. The user must input a numerical, integer value between 1 and 50.

	Current	Desired	Current	Desired	Current	Desired	Years to achieve target	Trajectory of Change
Intracity	18.41%	28.08 %	3521000	5000000	6482	2000	10	Linear
Intercity	0.00%	0.00 %	0	0	0	0	10	Linear

Figure 89 User Form 6 – Prefilled data fields

	Current	Desired	Years to achieve target	Trajectory of Change
Mode Share By STU (including walk)				
Intracity	18.41%	28.08 %	10	Linear
Intercity	0.00%	0.00 %	10	Linear
Mode Share By Other Bus (including walk)				
Intracity	6.34%	6.10 %	10	Linear
Intercity	56.73%	56.73 %	10	Linear
Mode Share By IPT (including walk)				
Intracity	8.17%	8.23 %	10	Linear
Intercity	10.14%	10.14 %	10	Linear

Figure 90 User Form 6 – Parts A, B, & C

	Current	Desired	Current	Desired	Current	Desired	Years to achieve target	Trajectory of Change
Intracity	a 18.41%	b 28.08 %	e 3521000	f 5000000	i 6482	j 2000	m 10	n Linear
Intercity	c 0.00%	d 0.00 %	g 0	h 0	k 0	l 0	o 10	p Linear

Figure 91 User Form 6 – Part A – STU mode share

n Change Trajectory (Intracity): The trajectory of transition between the base year and targeted option—mode share/ daily trips/ fleet size—can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu.

o Years to Achieve Target (Intercity): In this field, the user is required to input the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in the selected options—mode share, daily trips, or fleet size—to the target. The user must input a numerical, integer value between 1 and 50.

p Change Trajectory (Intercity): The trajectory of transition between the base year and targeted option—mode share/ daily trips/ fleet size—can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu and explained below.

USER FORM 6 – PART B

Figure 92 presents the screenshot of the input fields in User Form 6 Part B. This part has a total of 8 data fields, out of which 4 must be filled out by the user, with the rest prefilled. For ease of understanding, the data fields are labelled in lowercase alphabetical order and explained below

In this form, data on the desired/envisioned mode share of other public transport buses is captured, along with inputs on the number of years to achieve the target and trajectory of transition.

q Current Other Public Transport Bus Mode Share (Intracity): The tool estimates and presents the mode share of all other public transport buses, i.e. the percentage of intracity passenger trips (by all travel modes, including walking) by other public transport buses in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

r Desired Other Public Transport Bus Mode Share (Intracity): In this field, the user is required to enter the desired/envisioned intracity other public transport bus mode share. The user must input a numerical/decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

s Current Other Public Transport Bus Mode Share (Intercity): The tool estimates and presents the mode share of all other public transport buses, i.e. the percentage of intercity passenger trips (by all travel

modes, including walking) by other public transport buses in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

t Desired Other Public Transport Bus Mode Share (Intercity): In this field, the user is required to enter the desired/envisioned intercity other public transport bus mode share in km. The user must input a numerical/ decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

It is important to note that changes (positive or negative) in other public transport bus mode share can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in other public transport bus mode share to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.8 discusses the policy, financing, and planning interventions that could affect the other public transport bus mode share, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

u Years to Achieve Target (Intracity): In this field, the user is required to enter the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in other public transport bus mode share to the desired/target share. The user

Figure 92 User Form 6 – Part B – Other public transport bus mode share

Figure 93 User Form 6 – Part C – IPT mode share

must input a numerical, integer value between 1 and 50.

- v Change Trajectory (Intracity):** The trajectory of transition between the base year and targeted other public transport bus mode share can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu.

- w Years to Achieve Target (Intercity):** In this field, the user is required to enter the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in other public transport bus mode share to the desired/target share. The user must input a numerical, integer value between 1 and 50.

- x Change Trajectory (Intercity):** The trajectory of transition between the base year and targeted other public transport bus mode share can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu.

USER FORM 6 – PART C

Figure 93 presents the screenshot of the input fields in User Form 6 Part C. This part has a total of 8 data fields, out of which 4 must be filled out by the user, with the rest prefilled. For ease of understanding, the data fields are labelled in lowercase alphabetical order and explained below.

In this form, data on the desired/envisioned IPT mode share is captured, along with inputs on the number of years to achieve the target and trajectory of transition.

- y Current IPT Mode Share (Intracity):** The tool estimates and presents the IPT mode share, i.e. the percentage of intracity passenger trips (by all travel modes, including walking) by IPT in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.
- z Desired IPT Mode Share (Intracity operations):** In this field, the user is required to enter the desired/envisioned intracity IPT mode share. The user must input a numerical/ decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

It is important to note that changes (positive or negative) in IPT mode share can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in IPT mode share to an expected change in policy, financing, and planning related to future bus services and operations. Section 2.9 discusses the policy, financing, and planning interventions that could affect intracity IPT mode share, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

aa Current IPT Mode Share (Intercity): The tool estimates and presents the IPT mode share, i.e. the percentage of intercity passenger trips (by all travel modes including walking) by IPT in the region served by the STU. This is estimated from population and trip data captured in User Form 2. This value cannot be edited and is only in this form for reference.

bb Desired IPT Mode Share (Intercity): In this field, the user is required to enter the desired/envisioned intercity IPT mode share. The user must input a numerical/ decimal value between 1 and 80. The user should enter the percent value without inserting the % sign, as 30 is interpreted as 30% by the tool.

It is important to note that changes (positive or negative) in IPT mode share can be a result of policy, financing, and planning interventions. Therefore, users should be able to relate the expected change in IPT mode share to an expected change in policy, financing, and planning related

to future bus services and operations. Section 2.9 discusses the policy, financing, and planning interventions that could affect intercity IPT mode share, and users are encouraged to refer to the same before finalising an expected future value for this parameter in a defined scenario (for input in this field). Furthermore, it is recommended that users record and report these interventions (in relation to the input value) when reporting the outcomes of this tool.

cc Years to Achieve Target (Intracity): In this field, the user is required to enter the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in IPT mode share to the desired/target share. The user must input a numerical, integer value between 1 and 50.

dd Change Trajectory (Intracity): The trajectory of transition between the base year and targeted IPT mode share can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu.

ee Years to Achieve Target (Intercity): In this field, the user is required to enter the desired or targeted timeframe (in number of years) from the current/base year to achieve the transition in IPT mode share to the desired/target share. The user must input a numerical, integer value between 1 and 50.

ff Change Trajectory (Intercity): The trajectory of transition between the base year and targeted IPT mode share can be either linear (i.e. a constant rate of change throughout the defined time period of transition), logarithmic (i.e. the rate of change gradually decreases throughout the transitional period), or exponential (i.e. the rate of change gradually increases throughout the transitional period). The user must select one of these three transition types from the drop-down menu.

2.10 DETAILED ESTIMATOR: USER FORM 7: OUTPUT FORM

Figure 94 presents the screenshot of the User Form 7 output form.

After the user fills out the last user input form and clicks on 'Next', the tool displays User 7, the output form. This form includes 15 basic year-wise outputs, starting from the selected base year (in User Form 1), showing data for the next consecutive five years, and then presenting data for the following 3 decadal intervals (for example, if the base year is 2020, then the tool will display outputs for the years 2020, 2021, 2022, 2023, 2024, 2025, 2030, 2040, and 2050). These 15 outputs include parameters like the expected fleet, land requirement, budgetary details, etc. These outputs help the user assess and review the estimation. In case the user would like to make further modifications in the input forms, he/she can click on 'Previous', re-edit the relevant data fields in the previous forms, and return to the output form to view the new outputs. The mentioned 15 outputs (Figure 95) are coded in alphabetical order and detailed below:

Output

FEET[®]

User Form 1
STU Basic Information

User Form 2
Fleet Data Form

User Form 3
Service Data Form

User Form 4
Vision Data Form-1

User Form 5
Vision Data Form-2

User Form 6
Vision Data Mode Share

User Form 7
Output

Year	Annual operating cost (Crores)	Annual Revenue (Crores)	Annual Investment requirement (Infrastructure + Fleet) (Crores)	Annual profit/loss (viability gap) (Crores)	Total fleet size	Total cumulative land required for infrastructure (Hectares)	Total trips carried	Mode share %	Total staff strength required	Weighted average Occupancy (%)	Weighted average fleet utilization (%)	Weighted average vehicle utilization (%)	Weighted average Staff to bus ratio	Buses per 1000 population
2020	3,036	2,148	2,057	-2,945	7,610	175	3,990,226	19.38%	39,524	63.69%	87.92%	87.72%	5.19	0.71
2021	3,420	2,337	1,965	-3,049	8,424	194	4,266,416	20.34%	43,861	63.84%	88.08%	86.54%	5.21	0.76
2022	3,824	2,536	2,169	-3,457	9,306	214	4,555,110	21.30%	48,567	63.99%	88.25%	85.36%	5.22	0.82
2023	4,243	2,745	2,279	-3,777	10,260	236	4,857,123	22.27%	53,670	64.13%	88.40%	84.16%	5.23	0.88
2024	4,677	2,964	2,603	-4,316	11,293	260	5,173,302	23.23%	59,203	64.28%	88.56%	82.95%	5.24	0.94
2025	5,121	3,195	2,886	-4,813	12,412	285	5,504,533	24.19%	65,201	64.42%	88.70%	81.72%	5.25	1.01
2030	7,121	4,348	576	-3,349	18,375	423	7,187,238	28.04%	97,201	65.00%	89.23%	76.71%	5.29	1.31
2040	9,283	5,668	2,291	-5,906	23,953	551	9,369,137	28.00%	126,710	65.00%	89.23%	76.71%	5.29	1.30
2050	12,102	7,389	1,541	-6,254	31,226	718	12,214,134	27.96%	165,186	65.00%	89.23%	76.71%	5.29	1.30

Year	Annual operating cost (Crores)	Annual Revenue (Crores)	Annual Investment requirement (Infrastructure + Fleet) (Crores)	Annual profit/loss (viability gap) (Crores)	Total fleet size	Total cumulative land required for infrastructure (Hectares)	Total trips carried	Mode share %	Total staff strength required	Weighted average Occupancy (%)	Weighted average fleet utilization (%)	Weighted average vehicle utilization (%)	Weighted average Staff to bus ratio	Buses per 1000 population
2020	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2021	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2022	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2023	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2024	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2025	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2030	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2040	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00
2050	0	0	0	0	0	0	0	0.00%	0	0.00%	0.00%	0.00%	0.00	0.00

Default values Estimation Method
Exit Tool Infrastructure Details

Previous Save Output

SHAKTI SGAarchitects

Figure 94 Detailed Estimator – User Form 7 – Output form

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Output	Year	Annual operating cost (Crores)	Annual Revenue (Crores)	Annual Investment requirement (Infrastructure + Fleet) (Crores)	Annual profit/loss (viability gap) (Crores)	Total fleet size	Total cumulative land required for infrastructure (Hectares)	Total trips carried	Mode share %	Total staff strength required	Weighted average Occupancy (%)	Weighted average fleet utilization (%)	Weighted average vehicle utilization (%)	Weighted average Staff to bus ratio	Buses per 1000 population
Intracity	2020	3,036	2,148	2,057	-2,945	7,610	175	3,990,226	19.38%	39,524	63.69%	87.92%	87.72%	5.19	0.71
	2021	3,420	2,337	1,965	-3,049	8,424	194	4,266,416	20.34%	43,861	63.84%	88.08%	86.54%	5.21	0.76
	2022	3,824	2,536	2,169	-3,457	9,306	214	4,555,110	21.30%	48,567	63.99%	88.25%	85.36%	5.22	0.82
	2023	4,243	2,745	2,279	-3,777	10,260	236	4,857,123	22.27%	53,670	64.13%	88.40%	84.16%	5.23	0.88
	2024	4,677	2,964	2,603	-4,316	11,293	260	5,173,302	23.23%	59,203	64.28%	88.56%	82.95%	5.24	0.94
	2025	5,121	3,195	2,886	-4,813	12,412	285	5,504,533	24.19%	65,201	64.42%	88.70%	81.72%	5.25	1.01
	2030	7,121	4,348	576	-3,349	18,375	423	7,187,238	28.04%	97,201	65.00%	89.23%	76.71%	5.29	1.31
	2040	9,283	5,668	2,291	-5,906	23,953	551	9,369,137	28.00%	126,710	65.00%	89.23%	76.71%	5.29	1.30
	2050	12,102	7,389	1,541	-6,254	31,226	718	12,214,134	27.96%	165,186	65.00%	89.23%	76.71%	5.29	1.30

Figure 95 User Form 7 – Output form with labelled parts

- a Year:** This column displays the corresponding estimation years for which the outputs are derived— e.g. 2020, 2021, 2022, 2023, 2024, 2025, 2030, 2040, and 2050 in the above example.
- b Annual Operating Cost:** In this column, the expected annual STU operating cost is displayed for the corresponding estimation years.
- c Annual Revenue:** This column in the output form displays the expected annual STU revenue for the corresponding estimation years.
- d Annual Investment Requirement:** This column displays the expected annual investment required by the STU for the corresponding estimation years.
- e Annual Profit/Loss:** In this column, the expected annual STU profit/loss is displayed for the corresponding estimation years.
- f Total Fleet Size:** This column displays the expected total STU fleet size for the corresponding estimation years.
- g Total Land Required for Infrastructure:** In this column, the expected total cumulative land required by the STU is displayed for the corresponding estimation years.
- h Total Trips Covered:** This column displays the expected total trips carried out by the STU for the corresponding estimation years.

- i Mode Share:** In this column, the expected mode share attained by the STU is displayed for the corresponding estimation years.
- j Total Staff Strength:** This column displays the expected total staff strength required by the STU for the corresponding estimation years.
- k Weighted Average Occupancy:** In this column, the weighted average occupancy attained by the STU is displayed for the corresponding estimation years.
- l Weighted Average Fleet Utilisation:** This column displays the weighted average STU fleet utilisation for the corresponding estimation years.
- m Weighted Average Vehicle Utilisation:** In this column, the weighted average STU vehicle utilisation is displayed for the corresponding estimation years.
- n Weighted Average Staff to Bus Ratio:** This column displays the weighted average STU staff to bus ratio for the corresponding estimation years.
- o Buses per 1000 population:** In this column, the year-wise ratio of buses required per 1000 population is displayed.

Once the user is satisfied with the generated outputs, he/she must click on 'Save Output', (Figure 96) which is at the bottom centre of the form (in place of the 'Next' button).

Each output sheet displays a panel with the tab title, date of the saved output, name of the selected STU (e.g. BMTc, as shown in Figure 98), and a legend showing the

outputs generated. They are differently coloured to distinguish intracity, intercity, combined, and total outputs.

The 14 tabs provided in the output file and their respective outputs are explained below:

- 1. Input:** When the user clicks on this tab in the output file, a sheet will open with all the inputs inserted by the user in the forms during the estimation process. This file is included so that the user can view the inputs entered against the generated results, including any unedited values, such as values derived from census or default values.
- 2. Output Summary** - When the user clicks on this tab in the output file, a summary output sheet will open. This summary output sheet provides a comparative output table with separate outcomes for the following 10 intercity and intracity parameters for the base year, 5th year, and 10th year.
 1. Fleet Size
 2. Daily Passenger Trips
 3. STU Mode Share (share of total trips including walking) of all STU bus, other bus, and IPT passenger trips
 4. Average Daily Km Achieved
 5. Cumulative Buses to Purchase in the Given Period (up to the 5th and 10th years)
 6. Cumulative Land Requirement (up to the 5th and 10th years)
 7. Total Staff Strength (in that year)
 8. Total Required Cumulative Budget (up to the 5th and 10th years)
 9. Total Expected Revenue (up to the 5th and 10th years)

Output

User Form 1
STU Basic InformationUser Form 2
Fleet Data FormUser Form 3
Service Data FormUser Form 4
Vision Data Form-1User Form 5
Vision Data Form-2User Form 6
Vision Data Mode ShareUser Form 7
Output

Output

Year	Annual operating cost (Crores)	Annual Revenue (Crores)	Annual Investment requirement (Infrastructure + Fleet) (Crores)	Annual profit/loss (viability gap) (Crores)	Total fleet size	Total cumulative land required for infrastructure (Hectares)	Total trips carried	Mode share %	Total staff strength required	Weighted average Occupancy (%)
Intracity										
2020	2,528	2,303	1,274	-1,499	6,609	152	4,555,854	23.81%	36,396	68.06%
2021	2,613	2,381	431	-663	6,829	157	4,678,279	23.81%	37,449	68.06%
2022	2,701	2,461	438	-677	7,056	162	4,803,995	23.81%	38,531	68.06%
2023	2,791	2,544	445	-692	7,290	168	4,933,093	23.80%	39,642	68.06%
2024	2,885	2,630	453	-708	7,532	173	5,065,664	23.80%	40,783	68.06%
2025	2,981	2,718	461	-724	7,781	179	5,201,800	23.80%	41,955	68.06%
2030	3,491	3,185	703	-1,010	9,099	209	5,939,316	23.78%	48,223	68.06%
2040	4,551	4,152	975	-1,375	11,860	273	7,742,142	23.75%	62,860	68.06%
2050	5,933	5,413	1,018	-1,538	15,461	356	10,092,795	23.72%	81,946	68.06%

Default values

Estimation Method

Exit Tool

Infrastructure Details

Previous

Save
OutputSave
Output

SGArchitects



© 2017 SGArchitects

Figure 96 User Form 7 – Output form: Save Output button

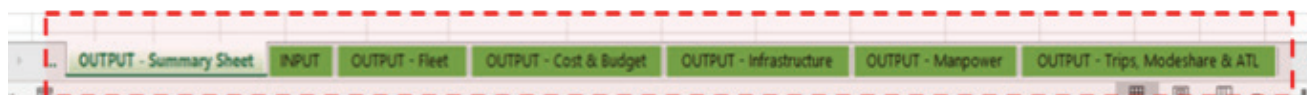


Figure 97 Output Tabs

OUTPUT- FLEET			
	Date	Legend	
	11 December 2020		Intra
	STU Name		Inter
	BMTC		Total
			Combined

Figure 98 Output Colour Coding

10. Total State Support Required (up to the 5th and 10th years)
3. **Output – Fleet (Intercity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to the intercity bus fleet will open. The sheet presents outputs over a period of 33 years for the following 8 parameters for intercity operations:
11. Year-wise Bus Fleet Procurement Requirement
 12. Year-wise Fleet Growth
 13. Fleet Composition
 14. Unutilised Fleet
 15. Number of Buses per 1000 Population (Combined)
 16. Daily Km Achieved (including dead km)
 17. Intercity Daily CO₂ Emissions (in metric tonnes)
 18. Intercity Daily per Capita CO₂ Emissions (in kg)
4. **Output – Fleet (Intracity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to the intracity bus fleet will open. The sheet presents outputs over a period of 33 years for the following 8 parameters for intracity operations:
19. Year-wise Bus Fleet Procurement Requirement
 20. Year-wise Fleet Growth
 21. Fleet Composition
 22. Unutilised Fleet
 23. Number of Buses per 1000 Population (Combined)
 24. Daily Km Achieved (including dead km)
 25. Intracity Daily CO₂ Emissions (in metric tonnes)
 26. Intracity Daily per Capita CO₂ Emissions (in kg)
5. **Output – Fleet Operations (Intercity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to intercity bus fleet operational parameters will open. The sheet presents outputs over a period of 33 years for the following 3 parameters for intercity operations:
27. Fleet Utilisation
 28. Vehicle Utilisation
 29. Average Occupancy
6. **Output – Fleet Operations (Intracity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to intracity bus fleet operational parameters will open. The sheet presents outputs over a period of 33 years for the following 3 parameters for intracity operations:
30. Fleet Utilisation
 31. Vehicle Utilisation
 32. Average Occupancy
7. **Output – Trips, Mode Share, & ATL (Intercity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to intercity trips, mode share, and average trip length (ATL) will open. The sheet presents outputs over a period of 33 years for the following 9 parameters for intercity operations:
33. Expected Year-wise Growth in Daily Intracity Public Transport (PT)
 34. Year-wise Intracity Bus Trips by Purpose
 35. Year-wise Intracity Trips by Distance
 36. Year-wise PT Mode Share (<=10 km)
 37. Year-wise PT Mode Share (>10 km)
 38. Average Passenger Trip Length
 39. Average Route Length
 40. Mode Share (including walking)
 41. Total Trips Covered

- 8. Output – Trips, Mode Share, & ATL (Intracity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to intracity trips, mode share, and ATL will open. The sheet presents outputs over a period of 33 years for the following 9 parameters for intracity operations:
- 42. Expected Year-wise Growth in Daily Intracity PT
 - 43. Year-wise Intracity Bus Trips by Purpose
 - 44. Year-wise Intracity Trips by Distance
 - 45. Year-wise PT Mode Share (≤ 10 km)
 - 46. Year-wise PT Mode Share (> 10 km)
 - 47. Average Passenger Trip Length
 - 48. Average Route Length
 - 49. Mode Share (including walking)
 - 50. Total Trips Covered
- 9. Output – Growth in Trips, Route, & Headway (Total):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to the total growth in trips, routes, and headway will open. The sheet presents outputs over a period of 33 years for the following 4 parameters for total operations:
- 51. Year-wise Expected Growth in Number of Trips
 - 52. Expected Year-wise Growth in Bus Trips
 - 53. Projected Number of Routes
 - 54. Projected Headway (minutes)
- 10. Output – EPK and CPK (Intercity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to intercity earnings per km (EPK) and cost per km (CPK) will open. The sheet presents outputs over a period of 33 years for the following 2 parameters for intercity operations:
- 55. CPK
 - 56. EPK
- 11. Output – EPK and CPK (Intracity):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs generated by the fleet tool related to intracity EPK and CPK will open. The sheet presents outputs over a period of 33 years for the following 2 parameters for intracity operations:
- 57. CPK
 - 58. EPK
- 12. Output – Cost and Budget:** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to cost and budgetary requirements will open. The sheet presents outputs over a period of 33 years for the following 7 parameters separately for intercity and intracity operations:
- 59. Year-wise Budgetary Requirement (Crores) for Fleet (Combined)
 - 60. Year-wise Budgetary Requirement for Intra- and Intercity Services (Total)
 - 61. Expected Daily Operating Cost for Intra- and Intercity Services (Total)
 - 62. Expected Annual Operating Cost, Earnings, & Total Profit (Intercity and Intracity)
 - 63. Expected Annual Operating Cost, Earnings, & Total Profit (Total)
 - 64. Annual Viability Gap (Intercity and Intracity)
 - 65. Annual Viability Gap (Total)
- 13. Output Infrastructure:** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to Infrastructure requirements will open. The sheet presents outputs over a period of 33 years for the following 5 parameters separately for intercity and intracity operations:
- 66. Expected Year-wise Land (Hectares) and Fleet Acquisition Requirement (Combined)
 - 67. Year-wise Annual Seats to Be Added for Intra -and Intercity Services (Total)
 - 68. Expected Year-wise Depot and Terminal Development for Intra- and Intercity Services (Total)
 - 69. Year-wise Cumulative Land Requirement (Intercity and Intracity)
 - 70. Expected Year-wise Cumulative Fleet and Land (Combined)
- 14. Output – Manpower (Total):** When the user clicks on this tab in the output file, a sheet displaying detailed outputs related to manpower requirements will open. The sheet presents outputs over a period of 33 years for the following 3 parameters for total operations:
- 71. Year-wise Annual Additional Staff Recruitment Requirement
 - 72. Year-wise Total Staff Strength
 - 73. Year-wise Expected Staff to Vehicle Ratio
- Any changes to these sheets are not recommended, but one can copy a sheet and then analyse the same against results for other STUs' outputs.
- Note: In the Output Form, wherever averages are mentioned, they shall be considered annual averages (unless stated otherwise). If daily data is required, any related averages shall be considered daily averages.

2

**FLEET TOOL
FUNCTIONALITY**

1 FLEET TOOL FUNCTIONALITY

The overall objective of the FLEET Tool is to provide STUs with an easy-to-use estimator of annual fleet, budgetary, and infrastructure requirements that factor in a variety of existing parameters in the bus service and operations environment. The tool determines the annual requirement for each consecutive year over a period of 33 years. The requirements are derived from the estimated or projected number of trips that need to be covered each year, which is, in turn, based on the operational environment and service requirements that have been projected for that year. Furthermore, these operational and service parameters are specific to different services as defined by the STU. Services may be defined by difference in both operational and vehicle characteristics.

Thus, the tool includes the functionality to project and estimate the operational and service requirements or parameters for each STU service type. It allows STUs to project the trajectory of change of operational and service requirements annually over a period of 33 years. The annual requirements for each defined service are estimated based on the values of these parameters (such as fleet utilisation, vehicle utilisation, load factor, EPK, CPK, etc.) estimated for each year (based on the defined trajectory). It is thus sensitive to all factors that influence the projections of long-term STU requirements. It allows the user to define multiple scenarios for these projections and compare the outputs across all scenarios.

The scenarios are defined by specifying operational and service requirements, which are expected to change over the course of the projection period, based on an intended policy and/or planning action (such as reduced/increased fares, provision of reserved bus lanes, disincentivising private transport modes through parking restrictions, congestion charges, etc.).

The tool also includes a simple aggregated calculator

(i.e., thumb rule estimator) for annual fleet requirements for urban and non-urban operations, using a rule of thumb regarding the population.

1.1 METHODOLOGY

The FLEET Tool has two distinct estimators. The users can choose either of these two estimators on the splash page. The primary estimator is a detailed estimator that enables scenario building based on variations in multiple parameters, such as service types, composition of different service types, specific operational and financial parameters for each service type, vision setting, etc. The detailed estimator is suitable for urban and non-urban (including mofussil services) bus operations. The secondary estimator is a thumb rule estimator that enables a quick assessment of the total fleet strength requirement. The thumb rule estimator is also applicable to both urban and non-urban operations and includes a built-in estimate of a factor relating the bus requirement in a city or region to its population.

The detailed estimator has three broad components:

- Data input interface
- Calculation engine
- Outputs

There are two input data sources in the tool. The data

in the first source – the overall number of current trips in the region served by the STU – are derived from the tool's database. This database, which can be edited by the user, has been created for 56 STUs in India using census data, tourist data reports, CMPs, etc. The tool presents the data, along with the year in which the data is collected, in the first form, when an STU is selected (from the drop-down menu). The growth factors for the population and tourist trips are also presented on this page. Trips in the region are divided into work, education, non-work, and tourist trips, each further broken down into trips less than 10 km and greater than 10 km in length. The tool estimates the current annual trips, population, etc. by applying the growth factor from the data year to the current year. The second source covers the current STU operational, fleet, and service-related data (such as the load factor, fleet distribution by service type and age, vehicle utilisation, CPK, EPK, etc.). This needs to be entered by the user in multiple forms. The data required from the user is presented in data collection forms in this manual (see Annexure 1). Users are also required to input the desired or envisioned value of all parameters to be achieved in the future (in different forms in the tool), the number of years to achieve the change, and the trajectory of change (linear, logarithmic, or exponential).

The tool estimates fleet size requirements (overall or for a given service) using the following equation:

$$\text{Total Fleet} = \frac{\text{Trips In the Region per day} \times \text{Mode share by STU} \times \text{Average passenger trip length}}{\text{Fleet Utilization} \times \text{Average kilometer per bus per day} \times \text{Average Occupancy}} \quad 1$$

fleet. The average km covered (including dead mileage) is also reported by the STUs and used to derive the average vehicle utilisation (per service or overall) as the actual average operated km per bus per day divided by the average scheduled km per bus per day. Both factors are reported by the STU and include dead mileage. The average occupancy is determined by multiplying the average number of seats (for each service or the overall weighted average) by the percentage load factor reported by the STUs.

Here, the average route length and occupancy (or percentage load factor) are reported by STUs and need to be converted into passengers by multiplying the percentage load factor with the average number of seats per bus. The average number of daily per bus passenger trips is calculated with the following equation: Total daily passenger trips (including pass holder trips and day tickets)/ (total fleet held multiplied by the percent fleet utilisation). A detailed flow chart presenting the working of the FLEET Tool is presented in Figure 99.

The average passenger trip length is not recorded by most STUs but can be estimated based on other collected data through the following equation:

Average passenger trip length

=

Average Route Length

Average daily per bus passenger trip

÷

Average Occupancy

2

FLEET TOOL ESTIMATION MODULES – BROAD FLOW & LOGIC

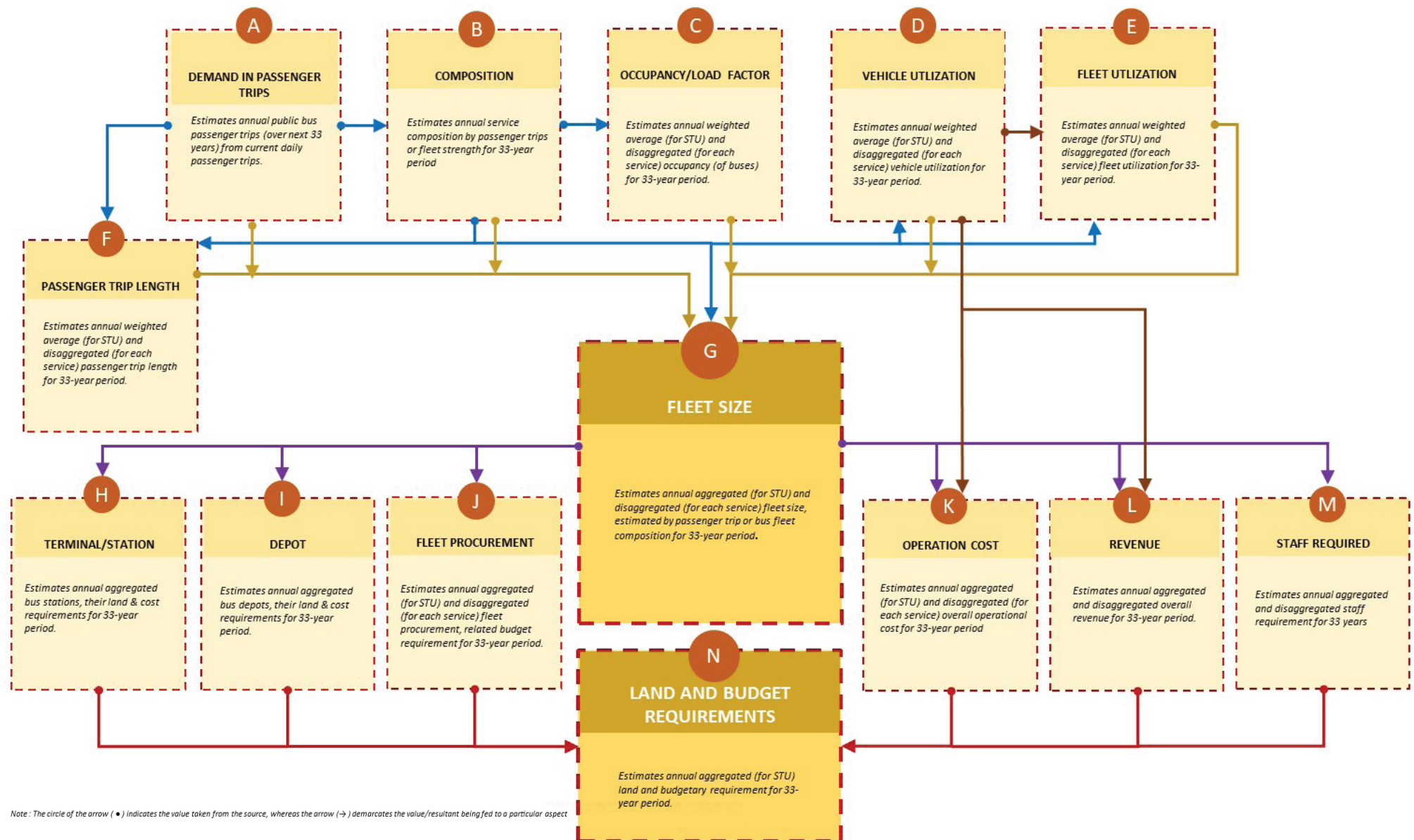


Figure 99 FLEET tool flowchart

Each of the factors included in Equation [1] are projected for each year over a period of 33 years from the current/base year, using the vision data provided by the user (as discussed above), and these projected values for each year are used in Equations [1] and [2] for each respective year.

Based on the estimate of the overall and disaggregated (service-wise) fleet estimates for each of the 33 years, annual financial requirements (such as the overall operational cost, revenue, state support required, etc.), infrastructure requirements (such as the number of depots and terminals to be built, total land required, investment required for depot and terminal development, etc.), and staffing requirement (total staff required) are estimated. These estimates are based on the default values, such as the vehicle cost, CPK, and EPK for each service type, per bus land (in sqm) requirement for a depot and a terminal, per bus development cost of the depot and terminal, etc. The per bus land and cost requirements for depot and terminal development have been derived from ASRTU Bus Terminal and Depot Design Guidelines (SGArchitects, 2015) (SGArchitects, 2017), but can be edited in the default form. Values such as bus cost need to be provided by the user, whereas the bus's scrap value is included in the default values and can be edited in the default form. Additionally, the parameters that affect the financial requirements can have defined future values (to be specified by the user). Hence, the EPK, CPK, purchase price of different bus types, etc. can be defined in the future, along with the years to achieve the target and expected trajectory of change.

Based on the annual projected fleet requirement, the additional number of buses that need to be purchased for each service type is generated based on the difference from the fleet held in the previous year, after excluding the number of buses that will reach their end of life or

retirement age during that year. For example, if 1) the estimated required number of buses for a particular service in 2020 is 1000, based on Equation [1]; 2) the fleet strength in 2019 (either based on STU data or Equation [1]) is 900; and 3) the number of buses that will reach retirement age at the beginning of 2020 is 100, then the number of buses that need to be purchased/acquired is $1000 - (900 - 100) = 200$. To estimate the number of buses reaching retirement age each year, users are required to input the operational age of the vehicles and current fleet strength disaggregated age-wise for each service type. The tool uses this information to estimate the number of buses that will be scrapped in a given year and thus may need to be replaced.

The tool takes in service-specific inputs and provides outputs disaggregated by service type. The service characteristics are defined apart from other factors, based on the number of buses (operated under each service) and passengers carried. These two factors may not necessarily be correlated between services, because different services can have different occupancy or load factors (for example, more expensive services such as AC or limited stop services usually have a lower load factor). The tool allows users to specify different compositions of services (in the total volume for the STU) in the future, as well as the number of years for the change in composition to be achieved and trajectory of change. For example, an STU is currently running 2 services – a diesel regular service with 50% fleet strength and 60% of all passenger trips (for the entire STU) and a diesel AC service with 50% fleet strength and 40% of all passenger trips, and it plans to replace all these buses in next 10 years with 40% electric AC buses covering 30% passenger trips and 60% regular electric buses covering 70% passenger trips. This transition can be plotted by the tool as the change in the percentage of

passengers carried (of the total passengers carried) or change in percentage of buses under each service. Thus, if the change in percentage of passengers carried is selected as the method of estimation (in the tool), and the trajectory selected is logarithmic, the tool will estimate the fleet strength per year so that the diesel bus passenger trips go down to 0 in the next 10 years, and the electric bus passenger trips increase to 30% and 70% for AC and non-AC services, respectively, as a logarithmic curve. The composition calculated for each year is used to estimate the number of trips by each service, which is used, in turn, to estimate the fleet requirement for that service (Equation [1]). If the method of estimation selected is 'composition by buses under each service,' the tool will estimate all parameters (for Equation [1]) per each year as weighted averages, use these estimates to determine the total fleet requirement, and then divide the total buses as per the composition plotted each year by the target period of 10 years.

In the above example, there are two additional approaches to estimation. One can choose to retain existing buses in the STU fleet until their end of life, even if it means postponing the complete transition to a different technology or service type, or discard the buses prematurely in order to achieve the transition to a new technology and service type in a predetermined fixed time period. When the former approach is selected, the tool only estimates the fleet strength of all services after accounting for the current strength, while matching the overall requirement (of vehicles to be operated or passenger trips to be served) of the STU in a given year as per the trajectory and vision inputs. If the latter is selected, the tool estimates the requirement for each service type based on the composition that needs to be

achieved each year (as per the vision composition and trajectory of change inputs), leading to a possible premature retirement of the fleet. The number of buses that will be retired prematurely each year is presented as a separate chart in the output sheets. The four possible cases based on these two estimation methodologies are presented in Figure 100.

The thumb rule estimator either generates a value for 'buses/1000 population' or allows the user to define the same. It estimates the total annual fleet strength requirement for a city using this factor over a 33-year period. The project team has used secondary data from 35 Indian cities to develop a relationship between the city population and bus fleet size required to serve that population. Two methods were used. One of the methods targeted a service level of one bus every 10 minutes on all major arterial and sub-arterial roads in the city. For this, the total major road length in the case study cities was estimated. The second method was based on the understanding that the average trip length of bus commuters in most cities is in the range of 10 km and that the majority of bus trips are in the range of 7–15 km (CENSUS, 2011) in Indian cities. The second method assumes a bus fleet strength requirement to cater to 100% of trips in the city with a length of 7–15 km (see Figure 102). Using these two methods, the number of buses required in a city has been estimated for a 12 m long urban bus, midi bus, and minibus. Based on this, a relationship between the parameter of buses per 1000 population and the city population has been derived (see Figure 103). The graphs suggest that cities with a population of less than 25,00,000 require 0.32 buses per 1000 population, while cities with more than 25,00,000 people may require 0.38 buses per 1000 population. This value increases to about 1 bus per 1000 population for cities with a population of

1,35,00,000 (Figure 101). Users can use an estimate of buses per 1000 population based on the bell curve graph in Figure 101 or enter a custom value.

Case 1

Composition is estimated by percent of service/fleet type and not passenger – service transition sticks to planned projections even if existing fleet is rendered unutilized

Case 2

Composition is estimated by percent of passengers carried by different services and not vehicle type in fleet – service transition sticks to planned projections even if existing fleet is rendered unutilized

Case 3

Composition is estimated by percent of service/fleet type and not passenger – service transition ensures that existing fleet is utilized till end of life

Case 4

Composition is estimated by percent of passengers carried by different services and not vehicle type in fleet – service transition ensures that existing fleet is utilized till end of life

Estimation methodology can be selected between forms 5 & 6

Figure 100 Four Cases under 2 Estimation Methodologies

⁸ Based on an estimate of 1000 passenger trips per day per bus for 12 m urban buses, 625 passenger trips per day per bus for midi buses, and 350 passenger trips per day per bus for minibuses

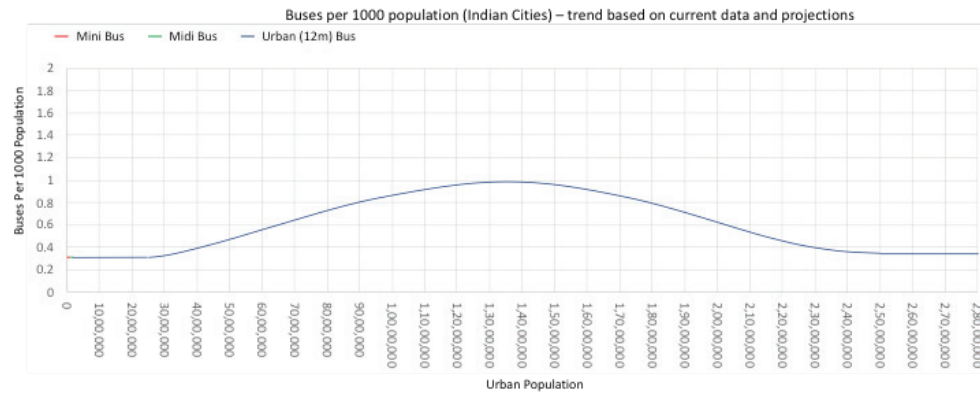


Figure 101 Buses per 1000 population in Indian cities (Trend based on current data and projections)

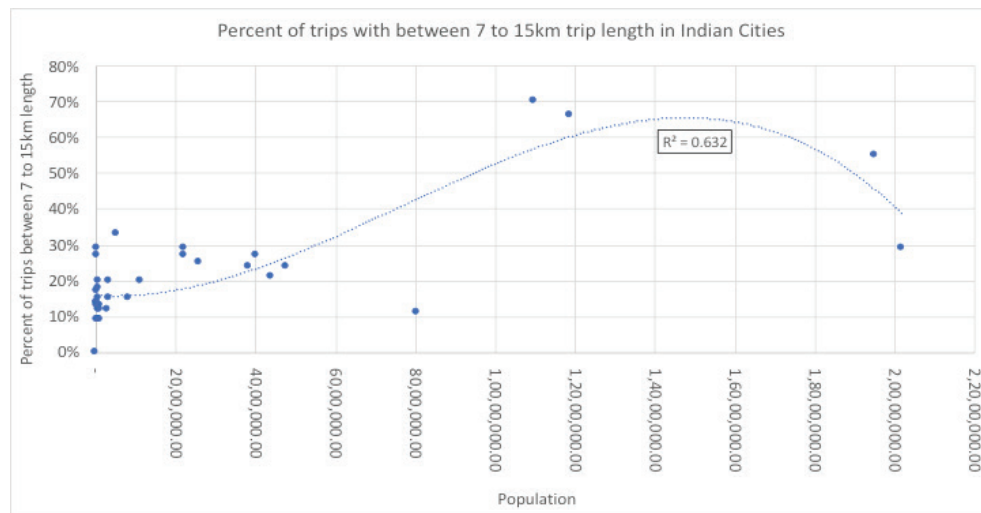


Figure 102 % trips of 7-15 km in Indian cities

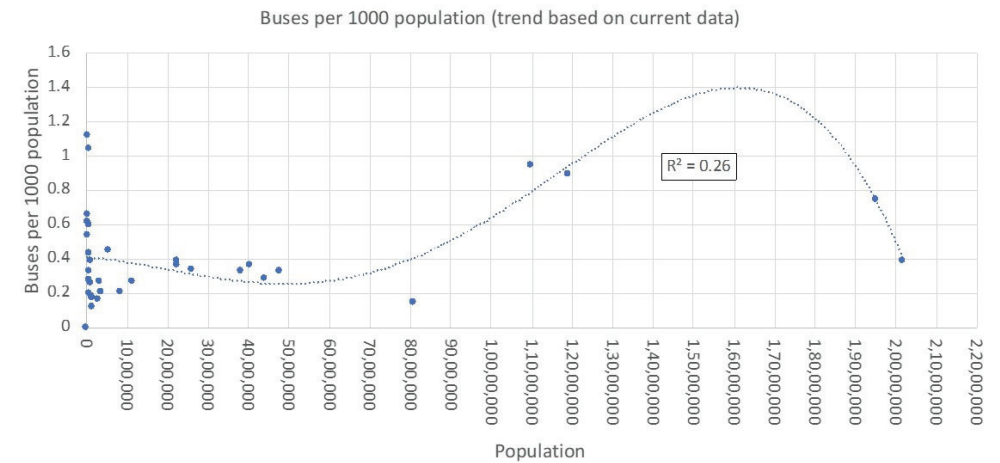


Figure 103 Estimated bus requirement per 1000 people (Trend based on current data)

2 GUIDELINES FOR USE OF FLEET OUTPUTS BY CITY OFFICIALS

A significant number of the buses are operated by state transport undertakings (STUs), i.e. public bus companies, which are amongst the largest bus companies in India. However, most of these organisations are unprofitable, in terms of both operational cost recovery and the capacity to maintain and expand services, fleets, and infrastructure. The combined net loss of STUs in 2015–16 was INR 11,349 crore, 7.2% higher than in 2014–15 (Hindustan Times, 2017). However, there are signs that the STUs have initiated steps to improve efficiency and remain competitive in the evolving scenario – where both state and central governments are emphasising strengthening public mobility in the country. Not only are we observing an increase in the number of STUs registering reduced losses, but also an overall improvement in staff productivity, average occupancy ratio, and overall vehicle productivity (Business-standard, 2016). For example, Bengaluru Metropolitan Transport Corporation (BMTTC) became one of the few public transport agencies to operate at a profit. It is evident from the outputs generated by the FLEET Tool (for different STUs, in this study) that factors like fleet utilisation, vehicle utilisation, occupancy, and staff to bus ratio contribute to a bus service's efficiency which, in turn, affects STU profitability.

Loss reduction strategies for STUs have been identified based on a comprehensive review of literature, case studies, and best practices. These strategies are based on two broad approaches – improved optimisation and increased ridership. The possible strategies and approaches that could be adopted by the STUs to improve efficiency, reduce annual losses, and improve profitability are presented in Annexure 1. This includes action plans based on these strategies, with detailed actionable points (including the scope of each action) in terms of planning, financing, and implementation of identified interventions.

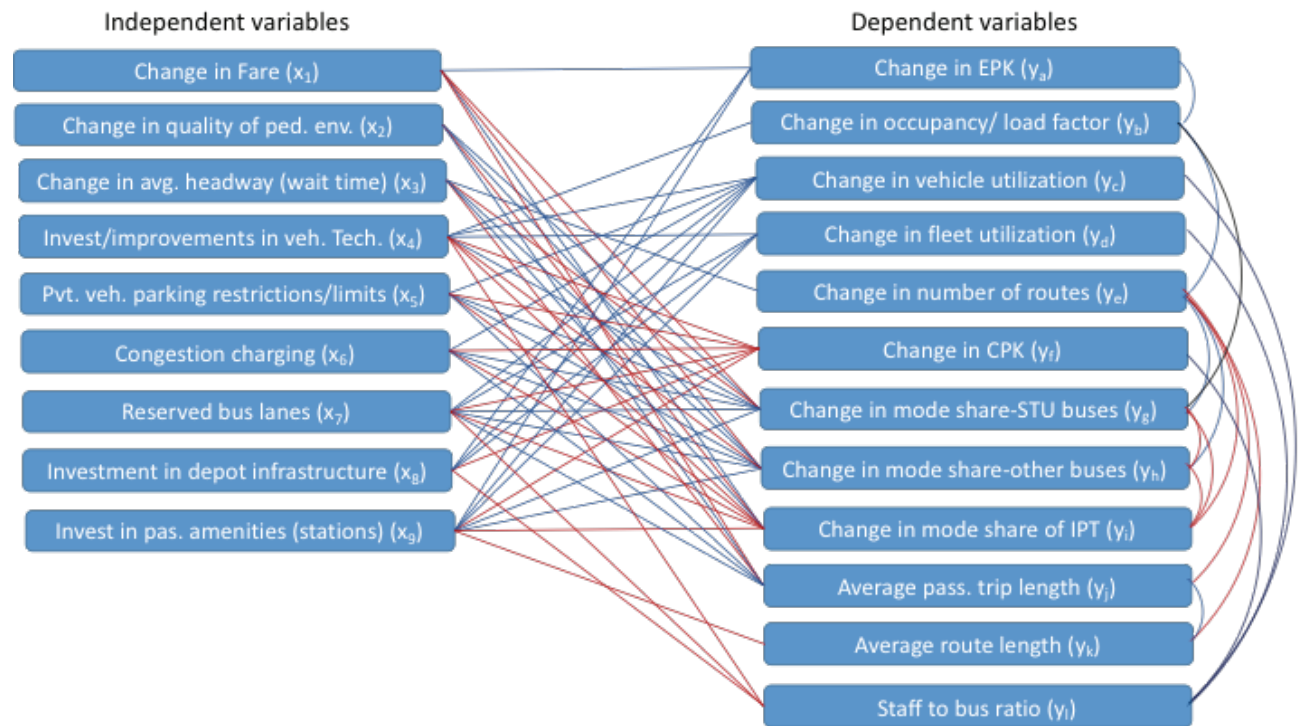


Figure 104 Relationship between policy factors and STU operational characteristics

STU officers can use the FLEET outputs from the detailed estimator to plan their operational and service strategies for achieving higher efficiency and profitability. They can also use the outputs to estimate long-term budgetary requirements (based on revenue gaps), land requirements, etc. This data can be used to advance applications for state financial support, additional land acquisition, participation in central or bank (such as the World Bank, ADB, etc.) sponsored funding programmes, etc. The tool outputs that can be of use to STU officials in decision-making and long-term planning are:

- Annual operational cost and revenue (including operational losses/profit)
- Annual land requirement for depot and terminal development
- Annual number of depot and terminals that need to be developed and associated cost
- Annual operational characteristics of each service – load factor, vehicle utilisation, and fleet utilisation
- Annual financial characteristics of each service – EPK, CPK, and Bus Cost
- Annual estimate of overall viability gap based on composition of fleet or passenger trips by service.

To generate these outputs, the tool requires the users to define the current and future scenarios. The current scenario is established through the available STU data, including operational, economic, infrastructural, and fleet characteristics. The future scenario is defined as the vision and includes expected operational, fleet, and economic characteristics for the STU. The desired/envisioned values for a number of factors (such as CPK, EPK, vehicle utilisation, fleet utilisation, mode share, etc.) can only be achieved as an outcome of certain planning, policy, and financing actions. In other words, the vision that can be achieved can be determined through an assessment of expected policy, planning, and financial interventions, which, in turn, provides an estimate of the STU's operational, financial, service, and infrastructural requirements over a period of 33 years. A total of 11 factors are defined as an outcome of such policy & planning actions. These factors (dependent variables), which require inputs from the user in the vision forms, are:

- Expected EPK (ya)
- Expected occupancy/load factor (yb)
- Expected vehicle utilisation (yc)
- Expected fleet utilisation (yd)
- Expected number of routes (ye)
- Expected CPK (yf)
- Expected STU mode share (yg)
- Expected other bus mode share (yh)
- Expected IPT mode share (yi)
- Expected average passenger trip length (yj)

- Expected average route length (yk)

A total of nine factors (or independent variables) that influence one or more of the above dependent variables have been identified. These factors are:

- Change in STU bus fare (x1)
- Change in quality of pedestrian environment in stop catchment area (x2)
- Change in average headway or passenger wait time at bus stop (x3)
- Level of investment in bus/vehicle technology and service planning improvements (x4)
- Parking policy that includes paid parking and restrictions on private vehicle parking (x5)
- Congestion charges or other monetary disincentives for private vehicle use (x6)
- Provision of reserved bus lanes (x7)
- Investment in depot infrastructure (x8)
- Investment in bus terminal/station infrastructure (x9)

In addition to the dependent variables being affected by independent variables, many are also influenced by other dependent variables. For example, an increased load factor (yb) will contribute to increasing the EPK (ya). The effects of the independent and dependent variables on dependent variables are presented in Figure 104.

In the above figure, blue lines represent direct effects (i.e. when x increases, y will also increase), and red lines represent inverse effects (i.e. when x increases, y will decrease).

The following sections explain the effects of different variables on the dependent variables. Decision-makers can use this information to finalise the expected or projected values of the operational characteristics of the STU in the future. **Furthermore, decision-makers can use this to finalise policy and planning actions, to facilitate improved STU performance.**

2.1 EXPECTED EPK (YA)

The expected EPK of an STU consists of fare box and non-fare box revenues. However, it is observed that nearly 90–95% of all STU earnings are through fare box revenues, and the contribution of other sources of revenue (such as advertisement, rentals, parking, freight, etc.) is not very significant. Furthermore, these non-fare box revenue sources can mostly only be tapped through the development of bus depot and terminal infrastructure. Most advertisement, rentals, and other non-fare box earning opportunities are tied to the development of bus infrastructure. Investing in such infrastructure can therefore contribute to increasing the non-fare box revenue, thereby increasing the EPK by up to 3 percent.

Increased fares have a more direct impact on EPK; between 85% to 95% of the increase in EPK can be attributed to increased fares. However, the fallout is that increasing the EPK will decrease the total number of bus trips (or load factor), thus significantly reducing the current EPK. In contrast, if the load factor of current buses were to increase without making any other changes, it is expected that 85–95% of the increase in the load factor would translate to an increase in EPK.

The relationship of these factors with the dependent variable, i.e. EPK, can be defined through the following equation:

$$y_a = \beta_{a1}x_1 + \beta_{a8}x_8 + \beta_{a9}x_9 + \beta_{aby}b_y$$

Here, β represents the parameter value of the indicators. This parameter value defines the contribution of changes in each of the independent variables to the overall change in the dependent variables. Below is the list of factors,

included in the equation above, that can help improve the EPK. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the EPK.

Change in fare $\uparrow$

Investment in depot infrastructure $\uparrow$

Investment in passenger amenities (stations) $\uparrow$

Change in load factor $\uparrow$

2.2 EXPECTED OCCUPANCY/LOAD FACTOR (YB)

The bus load or occupancy factor is a measure of how full the STU buses (or a particular STU service) are throughout the day. It is calculated by dividing the average number of passengers in a bus during the day by the total seats in the bus. Bus services are designed to cater to all passengers travelling during peak hours, even at a very low level of service (overcrowding), especially for urban services. However, during non-peak hours, many services run at much lower demand than their seating capacity. Furthermore, even during peak hours, the entire route of each service may not witness high demand, and services cannot always be flexible to this kind of demand variation. This inevitable variation throughout the day and along the route implies that even for high demand services, the average load factor for most services cannot be higher than 65–75 percent. However, where STUs deploy modern techniques to ensure higher degrees of demand-responsiveness, and decision-makers ensure additional policy and planning measures, the average load factor may be increased to 80–95 percent.

Clearly, the load/occupancy factor is expected to increase (given all other factors, including the number of buses, are constant) when more trips are covered by STU buses. This implies that the use of STU buses should become more attractive, while the use of other travel modes (primarily private transport and competing public transport modes such as private operators) should become less attractive. This is represented by a dependent variable, i.e. the increase in STU mode share (y_g). When the mode share increases, but the total number of buses does not increase proportionately, this will result in an increase in load factor.

Investment in vehicle technology improvements will indirectly increase the load factor by attracting more passengers, thereby improving mode share. Furthermore, it can directly affect the load factor by improving bus capacity (revised seating layout). Additionally, investment in service planning improvements can result in more efficient service and operational planning, which will result in a higher average load factor. At the same time, an increased load factor on already overcrowded buses (e.g. during peak hours or on high-demand routes) may lead to the reduced attractiveness of buses and thus a reduced mode share. This requires a fine balance between demand, fleet size (supply), and density (load factor).

The relationship of these factors with the dependent variable, i.e. the load factor, can be defined through the following equation:

$$Y_b = \beta_{b4}x_4 + \beta_{bg}y_g$$

Below is the list of factors, included in the equation above, that can help improve the load factor. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the STU load factor.

Investment in improvement of vehicle technology and service planning ↑

Change in STU bus mode share ↑

2.3 EXPECTED VEHICLE UTILISATION (YC)

Vehicle utilisation is defined as the ratio of average daily actual km covered (including dead miles) to the average daily scheduled km per bus for a service (including dead miles). This factor represents the level of inefficiency in bus operations, due to both internal and external factors. Internal factors could include staff unavailability or missed schedules, while the most common external factor is vehicular congestion. Therefore, planning or policy decisions that reduce the risk of buses being stuck in traffic contribute to increasing vehicle utilisation. One of the most promising solutions for congestion is the development of reserved bus lanes on congested corridors (applicable to urban STUs). Moreover, congestion caused by friction from parked vehicles can be addressed through the notification of a parking policy or parking rules and increasing parking charges. Congestion can also be checked through private vehicle disincentives that penalise their use. This may include congestion pricing or other financial or physical disincentives.

Investment in bus infrastructure, in conjunction with route rationalisation and service planning, can contribute to improving vehicle utilisation, by minimising dead mileage and thus increasing the effective km covered per bus per day. Dead mileage can be reduced through the coordinated planning of new depots and terminals to minimise the distance between them, as terminals are the

actual starting point of the bus routes, and buses have to travel empty from depots to terminals. In India, the actual km covered by urban buses is in the range of 190–230 km. This figure is higher on rural or other non-urban routes. Modern e-buses currently may fall short of this range, due to technological limitations related to battery capacity. Even where this range is achievable, it comes at a cost – both the bus price and axle load are high. As electric vehicle technology is still evolving, additional investment in this industry will result in more efficient technology, which will ensure longer vehicle ranges without additional cost and/or weight. A longer range can have a direct impact on vehicle utilisation in the case of e-buses. A very low staff to bus ratio (e.g. lower than 4–4.5) can be indicative of a lack of crew to operate the buses for, say average, 16 hours per day. This can result in lower vehicle utilisation. However, a very high staff to bus ratio, e.g. above 5.2–5.5, may not necessarily improve vehicle utilisation.

The relationship of these factors with the dependent variable, i.e. vehicle utilisation, can be defined through the following equation:

$$Y_c = \beta_{c4}x_4 + \beta_{c5}x_5 + \beta_{c6}x_6 + \beta_{c7}x_7 + \beta_{c8}x_8 + \beta_{c9}x_9 + \beta_{c10}y_l$$

Below is the list of factors, included in the equation above, that can help improve vehicle utilisation. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase STU vehicle utilisation.

Investment in improvement of vehicle technology and service planning ↑

Parking policy that includes paid parking and restrictions on private vehicle parking ↑

Congestion charges or other financial disincentives for private vehicle use ↑

Provision of reserved bus lanes ↑

Investment in depot infrastructure ↑

Investment in passenger amenities (stations) ↑

Change in staff to bus ratio ↑

2.4 EXPECTED FLEET UTILISATION (YD)

Fleet utilisation refers to the ratio of the average on-road fleet (in active use) to the total fleet held. Most STUs, especially urban STUs, keep a reserve bus fleet for replacement purposes in the case of a breakdown. The fleet is also used when buses are out-of-service for scheduled maintenance. The reserve fleet is usually around 5% of an STU's fleet size (depending on the average age and maintenance level of the fleet, etc.). Therefore, most STUs manage to maintain a fleet utilisation of 93–95 percent, while, for some STUs (especially non-urban STUs), it can be as high as 97–99% (where they decide to maintain a lower reserve fleet, as the overall fleet is large, and bus replacement is not always possible due to long route lengths).

An increase in fleet utilisation can lead to reduced fleet size requirements, resulting in lower capital investment requirements in procurement and bus replacement. The fleet utilisation can increase due to technological improvement (which ensures fewer breakdowns),

investment in reserved bus lanes (for urban STUs) to ensure a lower crash rate, investment in bus depot infrastructure to ensure better bus maintenance, and investment in (larger) bus terminals/stations to establish mini bus maintenance yards (which can take care of minor breakdown issues faster, without the need for a depot visit). A very low staff to bus ratio (<4–4.5) can be indicative of a lack of staff to maintain the buses, leading to increased bus downtime. This can result in lower fleet utilisation. However, a very high staff to bus ratio (>5.2–5.5) may not necessarily improve fleet utilisation, and optimum staff levels need to be maintained.

The relationship of these factors with the dependent variable, i.e. fleet utilisation, can be defined through the following equation:

$$Y_d = \beta_{d4}x_4 + \beta_{d7}x_7 + \beta_{d8}x_8 + \beta_{d9}x_9 + \beta_{dly}|$$

Below is the list of factors, included in the equation above, that can help improve fleet utilisation. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase STU fleet utilisation. Investment in improvement of vehicle technology and service planning ↑

Provision of reserved bus lanes ↑

Investment in depot infrastructure ↑

Investment in passenger amenities (stations) ↑

Change in staff to bus ratio ↑

2.5 EXPECTED NUMBER OF ROUTES (YE)

STUs need to cater to changes in demand in the city by revising and adding routes on a regular basis. Fleet size usually increases in response to a growing number of trips (in the city or region served by the STU). An increase in the number of routes, when other factors such as number of buses per route remain constant, usually results in greater accessibility and thus increased STU ridership. It also ensures that more passengers get direct services from their origin to their destination, thereby leading to reduced journey time and increased ridership.

To increase the number of routes, additional buses are required in the system (so that they can be deployed on additional routes). This can be achieved either through fleet expansion or redeployment of the existing fleet on additional routes by reducing the number of buses deployed on existing routes. Thus, increasing STU mode share will result in larger fleet size (to cater to the increased number of trips), while a reduction in the current average headway (with constant mode share) will make additional buses available for deployment on new routes. Similarly, increased vehicle and fleet utilisation will make additional buses available in the system (with constant mode share and headway) for deployment on new routes.

The relationship of these factors with the dependent variable, i.e. the number of routes, can be defined through the following equation:

$$Y_e = \beta_{e3}x_3 + \beta_{ecyc} + \beta_{edyd} + \beta_{egygy}$$

Below is the list of factors, included in the equation above, that can help increase the number of STU routes. The

arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the number of STU routes.

- Change in average passenger wait time at bus stop ↑
- Expected vehicle utilisation ↑
- Expected fleet utilisation ↑
- Change in STU mode share ↑

2.6 EXPECTED CPK (YF)

The average cost per km (CPK) for operating a service depends on the fuel/energy cost, manpower (crew, maintenance staff, and other STU staff), spare parts for buses, depot and other infrastructural maintenance costs, etc. A reduced CPK ensures higher STU profitability and reflects the STU's level of financial efficiency. Since better and more planned maintenance results in lower fuel consumption, required part replacement, staff requirements, etc., it results in a lower CPK. To enable improved fleet maintenance, a well-planned, efficient depot/workshop facility is required. Thus, greater investment in depots will lead to lower CPK. Similarly, investment in bus terminals, i.e. existing ones planned with minimum depots and new ones developed along with depots, should result in both better maintenance and fewer dead miles (thereby leading to lower per km fuel cost). Parking restrictions and financial disincentives (such as congestion charging) on private modes, along with provision of reserved bus lanes (for urban STUs), should lead to improved average fuel efficiency and, thus, a lower CPK. Furthermore, investment in bus technology improvement should also result in reduced energy charges, and, again, a lower CPK. Another way to reduce

the CPK is to decrease the staff to bus ratio.

The relationship of these factors with the dependent variable, i.e. expected CPK, can be defined through the following equation:

$$Y_f = \beta f_4 x_4 + \beta f_5 x_5 + \beta f_6 x_6 + \beta f_7 x_7 + \beta f_8 x_8 + \beta f_9 x_9 + \beta f_{lyl}$$

Below is the list of factors, included in the equation above, that can help reduce the CPK for STUs. The arrows next to the factors indicate whether these factors need to increase or decrease in order to reduce the CPK for an STU.

- Investment in improvement of vehicle technology and service planning ↑
- Parking policy that includes paid parking and restrictions on private vehicle parking ↑
- Congestion charges or other financial disincentives for private vehicle use ↑
- Provision of reserved bus lanes ↑
- Investment in depot infrastructure ↑
- Investment in passenger amenities (stations) ↑
- Changes in staff to bus ratio ↓

2.7 EXPECTED STU MODE SHARE (YG)

The percentage of all passenger trips (including walking) in the region served by the STU that are covered by STU buses is referred to as the STU mode share. The observed STU mode share is currently 0.5–20% for non-urban services and up to 28% for urban services. However, it is estimated that this mode share can be increased up to 24–30% for non-urban services and 40–42% for urban services. The expected change or improvement in STU

mode share (assuming other variables such as the load factor remain constant) can be an outcome of changes in mode share by other modes. For example, in the case of deterioration in the service level of other buses or IPT, some of the trips by these modes may shift to STU buses, thereby leading to increase in STU mode share and decrease in the mode share of other buses and/or IPT. Another key dependent variable that affects the attractiveness of STU bus use is the load factor. An average increase in load factor suggests an increase in crowding (on parts of the routes throughout the service or during the peak time). This will lead to reduced attractiveness, a decrease in the number of trips, and, ultimately, a decreased mode share. Similarly, an increase in fare is likely to discourage the use of STU buses, thereby resulting in a decreased mode share.

In terms of measures to increase the mode share, an improved pedestrian environment in the vicinity of bus stops/stations (especially in the case of urban services), reduced wait time, investment in vehicle/bus improvement, and provision of reserved bus lanes, leading to reduced passenger journey time and improved passenger amenities (at stations), will improve bus service accessibility and attractiveness. This, in turn, will result in increased ridership and, thus, increased mode share. Furthermore, private vehicle use disincentives, such as parking restrictions and congestion charging, will shift private vehicle passenger trips to public transport modes, leading to increased STU mode share.

The relationship of these factors with the dependent variable, i.e. the STU mode share, can be defined through the following equation:

$$Y_g = \beta g_1 x_1 + \beta g_2 x_2 + \beta g_3 x_3 + \beta g_4 x_4 + \beta g_5 x_5 + \beta g_6 x_6 + \beta g_7 x_7 + \beta g_9 x_9 + \beta g_{byb} + \beta g_{hyh} + \beta g_{iyi}$$

Below is the list of factors, presented in the equation above, that can help increase STU mode share. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase STU mode share.

- Change in STU bus fare ↓
- Change in quality of pedestrian environment in stop catchment area ↑
- Change in average passenger wait time at bus stop ↓
- Level of investment in bus/vehicle technology and service planning improvements ↑
- Parking policy that includes paid parking and restrictions on private vehicle parking ↑
- Congestion charges or other financial disincentives for private vehicle use ↑
- Provision of reserved bus lanes ↑
- Investment in bus terminal/station infrastructure ↑
- Change in load factor ↓
- Change in other bus mode share ↓
- Change in IPT mode share ↓

2.8 EXPECTED OTHER BUS MODE SHARE (YH)

The percentage of all passenger trips (including walking) in the region served by the STU that are covered by other (non-STU, other STU, or private) buses is referred to as other bus mode share. These other buses are considered competition for STU buses, and, thus, a higher mode share of other buses is a reflection of poor STU operations. However, both IPT and other/private bus services contribute to strengthening public transport, along with STU bus services. Hence, while reduction in the mode share of other buses and IPT may contribute to an increase in STU mode

share, not all passenger trips are likely to shift from one green/energy-efficient mode to another, and a significant portion of this reduced share may contribute to increasing private transport-based passenger trips. A reduction in other bus and IPT mode shares may therefore be in the interest of the STU, but not necessarily in the interest of the passengers and/or city/region served by the STU.

The factors that affect STU mode share also impact the change in mode share of other buses, although the direction of the impact may not be the same. For example, while an investment in STU bus technology may help increase the STU mode share, it may simultaneously reduce the mode share of other buses, as these buses may be less comfortable and attractive to passengers. Similarly, an increase in STU fares may increase the mode share of other buses, as passengers may shift from STU buses to other/private buses. On the other hand, private transport disincentives, such as parking restrictions and congestion charging, can contribute to increasing the mode share of both STU and other/private buses. Similarly, an improved pedestrian environment and provision of reserved bus lanes (which are used by all bus services) will also contribute to increasing the bus mode shares. However, investment in STU bus stations and reduction in the STU bus service load factor will increase the STU's attractiveness over other/private buses, and, thus, the other/private bus mode share may see a decline. An increase in STU and IPT mode share will also lead to such a decline for other/private buses.

The relationship of these factors with the dependent variable, i.e. other bus mode share, can be defined through the following equation:

$$Y_h = \beta_{h1}x_1 + \beta_{h2}x_2 + \beta_{h3}x_3 + \beta_{h4}x_4 + \beta_{h5}x_5 + \beta_{h6}x_6 + \beta_{h7}x_7 + \beta_{h9}x_9 + \beta_{hbyb} + \beta_{hgyh} + \beta_{hiyi}$$

Below is the list of factors, included in the equation above, that can help increase the other bus mode share (some at the cost of STU mode share). The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the other bus mode share. Red coloured arrows indicate changes that will lead to a reduction in STU mode share.

- Change in STU bus fare ↑
- Change in quality of pedestrian environment in stop catchment area ↑
- Change in average passenger wait time at bus stop (for STU buses) ↑
- Level of investment in (STU) bus technology and service planning improvements ↓
- Parking policy that includes paid parking and restrictions on private vehicle parking ↑
- Congestion charges or other financial disincentives for private vehicle use ↑
- Provision of reserved bus lanes ↑
- Investment in bus terminal/station infrastructure ↓
- Change in load factor ↑
- Change in STU bus mode share ↓
- Change in IPT mode share ↓

2.9 EXPECTED IPT MODE SHARE (YI)

The percentage of all passenger trips (including walking) in the region served by the STU that are covered by IPT buses is referred to as the IPT mode share. IPT is considered competition for STU buses, and, thus, a higher IPT mode is a reflection of poor STU operations. However, both IPT and other/private bus services contribute to

strengthening public transport, along with STU bus services. Hence, while a reduction in the mode share of other buses and IPT may contribute to an increase in STU mode share, not all passenger trips are likely to shift from one green/energy-efficient mode to another, and a significant portion of this reduced share may contribute to increasing private transport-based passenger trips. A reduction in other bus and IPT mode shares may therefore be in the interest of the STU, but not necessarily in the interest of the passengers and/or city/region served by the STU.

The factors that affect STU mode share also impact the change in IPT mode share, although the direction of the impact may not be the same. For example, while an investment in STU bus technology improvements may help increase the STU mode share, it may simultaneously reduce the IPT mode share, as the IPT buses may be less comfortable and attractive to passengers. Similarly, an increase in STU fares may increase the IPT mode share, as passengers may shift from STU buses to IPT. On the other hand, private transport disincentives, such as parking restrictions and congestion charging, can contribute to increasing the mode share of both STU and IPT buses. Similarly, an improved pedestrian environment will also contribute to increasing the bus mode shares. However, provision of reserved bus lanes (which are generally not used by IPT), investment in STU bus stations, and a reduction in the STU load factor will increase the attractiveness of STU services over IPT, and, thus, the IPT mode share may see a decline. An increase in STU and other bus mode share will also lead to such a decline for IPT.

The relationship of these factors with the dependent variable, i.e. IPT mode share, can be defined through the

following equation:

$$Y_i = \beta_{i1}x_1 + \beta_{i2}x_2 + \beta_{i3}x_3 + \beta_{i4}x_4 + \beta_{i5}x_5 + \beta_{i6}x_6 + \beta_{i7}x_7 + \beta_{i9}x_9 + \beta_{i10}y_b + \beta_{i11}y_h + \beta_{i12}y_i$$

Below is the list of factors, included in the equation above, that can help increase IPT mode share (some at the cost of STU mode share). The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the IPT mode share. Red coloured arrows indicate changes that will lead to a reduction in STU mode share.

- Change in STU bus fare ↑
- Change in quality of pedestrian environment in stop catchment area ↑
- Change in average passenger wait time at bus stop (for STU buses) ↑
- Level of investment in (STU) bus/vehicle technology and service planning improvements ↓
- Parking policy that includes paid parking and restrictions on private vehicle parking ↑
- Congestion charges or other financial disincentives for private vehicle use ↑
- Provision of reserved bus lanes ↑
- Investment in bus terminal/station infrastructure ↓
- Change in load factor ↑
- Change in STU bus mode share ↓
- Change in IPT mode share ↓

2.10 EXPECTED AVERAGE PASSENGER TRIP LENGTH (Y_j)

The current average passenger trip length is calculated for each service type based on the data collected by the STU. It is a factor related to the average route length, average number of passengers per bus trip, and load factor (or average occupancy) for each service and is derived using the following formula:

$$r_i / [p_i / (l_i \times s_i)]$$

Here, j denotes each service type, while r is average route length, p is number of passengers per bus trip, l is the average load factor, and s is the average seating capacity of the fleet (operated under service i). p is defined by the following equation:

$$p = x / y,$$

where x is the average km operated by each bus/vehicle under a service (vehicle utilisation $\times$ scheduled km per day per service), and y is the average number of passengers carried per bus per service (total passenger trips (including pass holder trips) / total operational buses per day).

Current data shows that the average passenger trip length for non-urban services can vary between 25 and 40 km, while urban trips can vary between 8 and 13 km. This is expected to increase by a maximum of 20 percent, based on increased vehicle speeds increase and an increase in average household income levels.

Since average trip length is governed by both budget and time limitations (as both travel time and travel cost are directly related to travel distance), changes in journey speed or cost can cause a change in average passenger

trip length. For example, a reduction in bus fare will allow commuters to travel longer distances on the same budget, thereby increasing average passenger trip length.

Similarly, an improved pedestrian environment contributes to increased journey speed, because walking speeds in such an environment increase from 1 m/s up to 1.4m/s, leading to 20% time savings in a 10-km trip (Gandhi, 2013). This will allow commuters to travel further in the same amount of time, hence contributing to an increase in average passenger trip length.

Similarly, parking restrictions and congestion pricing can free up road space, allowing buses to move faster in traffic. Reserved bus lanes can also facilitate faster bus movement. Both these measures increase the distance that can be travelled in a given amount of time. Although there is no desirable average passenger trip length, generally a shorter trip length indicates a lower carbon footprint, while a longer trip length indicates that people are able to travel further to avail employment and educational opportunities. In any case, an understanding of the factors that influence changes in trip length allows decision-makers to be aware of the potential side effects (such as changes in average trip length) of measures taken to influence other dependent factors.

The relationship of these factors with the dependent variable, i.e. the average passenger trip length, can be defined through the following equation:

$$Y_j = \beta_{j1}x_1 + \beta_{j2}x_2 + \beta_{j3}x_3 + \beta_{j5}x_5 + \beta_{j6}x_6 + \beta_{j7}x_7$$

Below is the list of factors, included in the equation above, that can lead to an increase in the average passenger trip length. The arrows next to the factors indicate whether these factors need to increase or decrease in order to increase the average passenger trip length.

- Change in STU bus fare ↓
- Change in quality of pedestrian environment in stop catchment area ↑
- Change in average passenger wait time at bus stop (for STU buses) ↓
- Parking policy that includes paid parking and restrictions on private vehicle parking ↑
- Congestion charges or other financial disincentives for private vehicle use ↑
- Provision of reserved bus lanes ↑

2.11 EXPECTED AVERAGE ROUTE LENGTH (YK)

The average of all different route lengths operated under each service is referred to as the average route length of that service. Services running on shorter route lengths are generally more reliable, while longer route lengths help reduce journey time, as they provide more direct options, with less connecting time (between routes). The current observed average route lengths for urban services range from 12 to 50km, while the range for non-urban services is 30–600 km.

Since routes terminate at a station or bus terminal at both ends, the average lengths of bus routes tend to be longer, with fewer bus terminals. If the number of routes increase, while other factors, including fleet size and average headway, remain constant, the average route length will tend to decrease. However, since route length is also a function of demand, it is unlikely that these changes will contribute to a change in average route length in excess of 10–30 percent.

The relationship of independent factors with the dependent variable, i.e. the average route length, can be defined through the following equation:

$$Y_k = \beta_{k9}x_9 + \beta_{key}$$

Below is the list of factors, included in the equation above, that can lead to a reduction in the average route length (for a service). The arrows next to the factors indicate whether these factors need to increase or decrease in order to decrease a service's average route length.

- Investment in passenger amenities/stations ↑
- Change in number of routes ↑

2.12 STAFF TO BUS RATIO (YL)

The ratio of the overall staff requirement for a service, including both on-roll and contractual (or private operator) staff (including all crew, maintenance, admin, management staff, etc. working for the service or STU), to the total buses under a service (or the STU) is referred to as the staff to bus ratio. This dependent variable is a reflection of a service's (or STU's) financial and operational efficiency, and a lower staff to bus ratio (i.e. indicated lower staff requirement per bus) suggests higher efficiency and, thus, a lower operating cost. However, a very low staff to bus ratio can be an indicator of a lack of staff to adequately service the bus (which leads to lower fleet and vehicle utilisation). The typical staff to bus ratio in India ranges from 2.5 to 6.5, with a value around 5–5.2 being desirable.

²²The number of terminals will increase, due to a natural increase in trips, even if the mode share is constant.

Investment in newer buses, as well as better bus technology, service planning, staff training, etc., is likely to reduce the maintenance staff and bus crew required per bus. Another way to reduce the maintenance staff requirement is to invest in existing depot infrastructure to improve depot operational efficiency and reduce bus downtime. Moreover, better operational planning, investment in staff training, etc. may increase the efficiency of the administrative and management staff, thereby reducing the per bus requirement. And, finally, the development of reserved bus lanes significantly reduces bus crashes and improves the driving cycle (especially in urban operations), thus reducing engine wear-and-tear and its maintenance (staff) requirement and staff to bus ratio.

The relationship of independent factors with the dependent variable, i.e. the staff to bus ratio, can be defined through the following equation:

$$Y_l = \beta_{l4}x_4 + \beta_{l7}x_7 + \beta_{l8}x_8$$

Below is the list of factors, included in the equation above, that can lead to a reduction in the staff to bus ratio (for a service). The arrows next to the factors indicate whether these factors need to increase or decrease in order to reduce a service's staff to bus ratio.

- Level of investment in (STU) bus technology and service planning improvements ↑
- Provision of reserved bus lanes ↑
- Investment in depot infrastructure ↑

3 STRATEGIES

The strategies identified for STU loss reduction are based on a review of literature, case studies, and best practices. They are based on two broad approaches – improved optimisation and increased ridership – and are explained in detail below.

1. STATE SUPPORT THROUGH REDUCED TAXATION

The overall cost breakup for most STUs shows that interest on government loans constitutes the highest share of their expenses, followed by operational and staff costs (Anumita Roychowdhury, 2017). These loans make it difficult for STUs to have good balance sheets. State and city governments regularly write off these loans, blaming the same on the STU and often labelling them unviable. However, it has been found that a significant factor in STU losses is the high tax rates applicable to them. There is no one-size-fits-all answer for road and transport taxes in India, as tax rates vary highly by state. The implication of high taxation on STUs can be seen in the case of the Bangalore Metropolitan Transport Corporation (BMTC). In 2014–15, the operator reported a loss of INR 649 million, with a total liability of INR 3.096 billion from motor vehicle and fuel tax alone. Without these taxes, BMTC would have had a surplus of INR 2.447 billion. Every 1% tax reduction translates to 6.99 extra buses BMTC could have bought, improving bus frequency and reducing overcrowding on its peak-hour services (Mukherjee, 2017).

A 2002 World Bank study revealed that, despite buses being a public transport service, the total tax burden per vehicle km is 2.6 times higher for public buses than cars in India. Buses have to pay tax according to the seating formula under the Central Motor Vehicle Act, which is 33

seated plus 20 standing. This is a major disadvantage, as taxes on buses are charged annually, whereas car tax is only levied once and is significantly lower than bus tax. Furthermore, bus agencies pay property tax, excise, customs, road tax, value added tax (VAT), motor vehicle tax, and advertisement tax, among others. If such tax obligations were reduced or waived, it could help improve bus operators' overall economic efficiency (Anumita Roychowdhury, 2017).

Taxing public buses at high rates is, in many ways, a low-hanging fruit for the government to increase fiscal revenue. From a commuter's point of view, however, taxes contribute to both higher fares and declining service quality – hardly an incentive to use the service. In the long run, this is likely to encourage the use of private vehicles over public transport, resulting in recurring losses for public transport (PT) operators and increasing problems related to private transport, such as accidents and congestion. In the long term, public transport companies'/ STUs' poor performance results in unavailability of the only affordable means of mobility for millions of people. Thus, it is imperative that the high tax rates applied to STUs be rationalised, in order to maintain public transport. This does not have to result in a loss of fiscal revenue for the government. Reduction in per bus taxes allows a much-required expansion in the fleet size, which offsets reduced per bus fiscal revenue through an increased tax base.

2. REDUCING OVERALL OPERATIONAL COSTS

The costs incurred by STUs in running bus services include fixed (infrastructure) and variable (operating) costs. Operating costs are the direct costs involved in vehicle operations, such as fuel, spare parts, labor, etc. and should have a direct influence on fare structure. Furthermore, factors such as traffic volumes, weather conditions, geographical settings, and topographical features also influence the operational cost. A broad operational cost breakup is presented in Figure 106.

Presently, STUs face an imbalance between operating costs and revenue generated through fare box and non-fare box sources (BUS KARO 2.0 – Case studies from India, 2014). Because fare increases have an adverse impact on both ridership and access to mobility, reduction in operational costs may be the only viable solution to address this imbalance. Many techniques to reduce the operational cost have been successfully applied by different STUs and can serve as a source of learning for other STUs.

The fuel cost is one of the most significant components of the operational cost, accounting for 35–50% of the total operational cost (Embarq-WRI, India, 2014). The main reason for the increased profitability of STUs such as Karnataka State Road Transport Corporation (KSRTC) is the vast improvement achieved in bus fuel efficiency. KSRTC's fuel efficiency has increased from 4.70 km per litre (L) of diesel in 1999–2000 to 5.28 km/L in 2005 (The Hindu, 2005). Nevertheless, questions remain on methods for improving fuel efficiency. Due to the complexity of the variables that impact fuel efficiency, such as vehicle technology and fuel type, vehicle age, etc., it is difficult to set any benchmarks and prescribe generalised solutions.

Findings from the literature review suggest better driver training and offering efficiency improvement-linked incentives (to drivers) helps enhance fuel efficiency. Better training not only improves the vehicle driving cycle, thereby increasing its mileage, but also equips the vehicle crew with certain behavior that contributes to enhanced passenger comfort. For example, KSRTC employees have been trained to be more courteous to passengers, resulting in increased ridership and fare box revenue (BUS KARO 2.0 – Case studies from India , 2014). Revenue is a clear measure of passenger acceptance of the service; hence, a fixed percentage of the revenue should be shared with drivers and conductors. This reduces the tendency to pilfer and improves efficiency, as well as customer service. For example, Andhra Pradesh State Road Corporation (APSRTC), which was one of the largest bus operators in the world (before the bifurcation of the state), is considered a pioneer for having successfully implemented a staff incentive scheme to improve fuel efficiency. The STU pays a 4% incentive (2% for both the driver and conductor) for earnings beyond the fare box benchmark (Andhra Pradesh State Road Transport Corporation 2014) to ensure drivers and conductors maximise the number of passengers picked up at all designated pick up points. Cost savings due to improved fuel efficiency can also be shared with the maintenance staff in predetermined percentages. An indirect benefit is also expected in terms of discouraging the tendency to make unscheduled stops.

3. REDUCING STAFF COSTS

On average, the staff cost constitutes 40% of the total STU operational cost. Most STUs have more than 20% overhead (non-operational) staff (cleaners, security, (excess) administrative assistants, etc.), which adds to the operational cost without increasing revenue. This has resulted in high levels of redundancy, with up to seven employees per bus on an average, leading to an increase in the per vehicle km operational cost (World Bank , 2005). For some STUs, the high staff cost is due to state government salary and pension norms, which are beyond the STU's control. In many cases, government norms result in very high staff salaries, without adding much value in terms of productivity (Kearney, 2017). For example, senior vehicle crew salaries are very high, and this often has no or little relation to better performance. These inefficiencies also significantly contribute to loss accumulation. Yet another reason for a high staff to bus ratio and, thus, high staff costs can be the deterioration of the operational fleet, without any replacement of the staff required to manage/operate it. In November 2016, Delhi Transport Corporation (DTC) had a staff of 28,816 to manage a fleet of 4,128 buses, but since only about 3,537 buses were usually on the road, the staff to bus ratio was close to 6.98. One-third of DTC's total expenditure is on staff salaries. This enormous labor cost skews the STU's balance sheet (Anumita Roychowdhury, 2017).

Thus, a significant reduction in operational costs can be achieved by rationalising the staff remuneration and numbers. Some studies suggest that the greatest scope for reducing per km operational cost lies in reduction of staff earnings or remuneration (World Bank , 2005). However, this may not be a practice that is socially accepted or agreeable to the employees' union, meaning

that innovative improvements may be required in the STUs' human resource (HR) policies. This can be achieved by comparing private and public operators' HR policies and cost breakup. One can improve staff utilisation without affecting their earnings through redeployment of excess staff to other more suitable (i.e. suited to their experience and payoffs, as per government norms) forms of employment, either within or outside the STU. Rationalising staff deployment gradually reduces the need to hire additional staff for an expanding fleet, until the point of desired equilibrium. This can be a step towards reducing the staff to bus ratio to the recommended value of 5.2 and will also contribute to gradually optimising individual staff costs based on the value provided to the organisation. Staff outsourcing for functions like vehicle crew, maintenance, etc. can be another means of reducing high staff payoffs. However, these measures may also need to be weighed against any potential loss of the employees' social and economic well-being.

4. REDUCING MAINTENANCE COSTS

Maintenance and repairs are often overlooked as a possible source of savings for STUs. Lack of maintenance not only leads to low vehicle utilisation, but also reduced attractiveness and reliability of the service, adversely affecting ridership. Many STUs do not effectively implement preventive maintenance strategies, as seen from observed poor correlation of maintenance expenditure to vehicle productivity (Kearney, 2017). Improving maintenance effectiveness can potentially translate to cost savings. APSRTC is a clear example of this, as it has been able to achieve 99.5% fleet availability by undertaking in-house vehicle maintenance through a vigorous system of checks

and monitoring that involves multiple levels of management. Furthermore, BMTC and KSRTC have reduced the cancellation rate of services from 6.2% to 1% through improved vehicle maintenance and better crew management. In contrast, in Assam State Transport Corporation (ASTC), 39% of the fleet is non-operational, largely due to poor maintenance practices (Kearney, 2017).

For cost savings, STUs often tend towards bad maintenance strategies, which usually proves counterproductive in the long run. These strategies frequently include letting buses run to the point of failure, using substandard parts and materials. Thus, it is recommended that the STU employ staff with specialised knowledge gained through constant training. The STU should incorporate the use of sophisticated technology that involves detailed analysis of various aspects of the vehicles. This will aid the STU in immediately detecting any possible flaw or inconsistency in regular patterns. STUs should also adopt stringent practices for daily inspections, weekly check-ups, minor monthly maintenance interventions, major quarterly interventions, and comprehensive annual vehicle servicing. Offloading maintenance activities through the outsourcing of part or all of the maintenance can also be considered, based on a detailed cost benefit analysis. A good service provider with the right expertise/experience may be able to troubleshoot problems early on or provide more effective preventative measures at a lower cost. The reduced cost and high expertise can be attained by the outsourced organisation through improved utilisation of depot infrastructure and staff. Outsourcing is usually done by servicing buses from different operators in multiple shifts. STUs may be limited by their organisational policies in exploring such innovative optimisation techniques – which, in turn, may only be possible through outsourcing.

5. FLEET UTILISATION AND EXPANSION

The fleet strength, including its composition and growth, indicates the rate of STU growth, as well as its efficiency. Maintenance or growth in the share of STU passenger trips is only possible with a fleet of adequate strength. Increasing fleet strength requirements can be met through the purchase of additional buses and by increasing the availability of existing fleet by maximising utilisation. Fleet utilisation indicates the share of revenue earning vehicles out of the total fleet and reflects the efficiency of the STU maintenance department. This utilisation depends on the provision of adequate spares to meet foreseen contingencies (periodic maintenance) and unforeseen contingencies (vehicle breakdowns).

The impact of limited fleet growth is reflected in the form of a trend of falling ridership and STU mode share – indicating that STUs have not been able to match the growth requirement of the public bus transportation system. Thus, to ensure high ridership, it is essential for any STU to expand its fleet based on the current and expected demand. An expanding fleet not only ensures that potential passenger trips are captured, but also attracts more trips by effectively increasing accessibility and reducing wait time. BMTC, one of the profitable STUs, doubled its ridership from 2.5 to 5 million passengers, with a fleet expansion from 3,500 to 6,500, over the past decade. The fleet expansion was based on a long-term strategy and vision with a planning horizon of around 10 years, which helped the agency predict the transport requirements in conjunction with the city expansion and expected increase in passenger trips.

6. FLEET UPGRADATION

Catering to the increasing transportation demand only through fleet expansion, without increased utilisation, leads to increased inefficiencies and losses. The majority of STUs are unable to sustain planned growth due to mounting financial losses, largely caused by the continued use of an aging bus fleet. Fleet utilisation depends mainly on the availability of vehicles fit for use. Even if fleet utilisation with an old fleet is very high, vehicle utilisation and occupancy ratios remain poor, leading to loss of revenue (Kearney, 2017). An older fleet has a poor utilisation level due to the longer downtime required for maintenance activities. Moreover, this impacts vehicle productivity, as older buses have more frequent breakdowns. Today, with income levels increasing among many passenger categories, there is a demand for improved services (even at a higher price). This is where private players have been able to capture a greater share from STUs, contributing to STU losses. This signifies that STUs need fleet expansion with an upgraded fleet to sustain their businesses and be competitive in the market. To this end, KSRTC has introduced more than 100 AC buses over the past year for long-distance travelers. In the case of BMTC, there is already a plan to introduce AC Volvo services on selected routes in Bangalore. These progressive corporations are also adopting new technologies to make their operations more efficient and remunerative (Embarq-WRI ,India , 2014).

7. FARE REVISION

There is a need for STUs to adopt a scientific approach to determining the fare structure, considering changes in operational costs, such as fluctuations in fuel cost and inflation rates. This can be an effective way of maintaining the operator's service quality and financial sustainability (Embarq-WRI, India, 2014). For example, BMTC operates all public bus services in the city of Bangalore, and fares are based on a stage system, with a telescopic structure (BMTC 2014). In other words, fares increase as distances increase, with the cost per marginal unit of distance decreasing as the trip length increases. Each stage is approximately equal to 2 km, although they can be shorter on certain routes. BMTC operates several differentiated services, each with its own fare structure. The historical changes in BMTC fare rates (price per km) indicate that prices increased by about 75% over the past decade. During that period, BMTC fares changed 11 times, roughly once a year, on average. With respect to fare setting, BMTC services may be categorised as follows: ordinary services (roughly 85% of all services) and other differentiated services (15% of all services). In both cases, BMTC utilises a formula to determine the fare hike (per passenger km) to neutralise the burden of increases in diesel prices and STU employee dearness allowance (DA). In other words, the formula is dependent on two factors, fuel prices and staff costs. BMTC conducts a review twice a year to determine whether a change in the fare structure is necessary. It is expected that, as a public service, STUs will need to maintain their fare levels to ensure affordability and public access. Therefore, for BMTC fare revision for ordinary services, state government approval is required. However, fare revision for other value added and premium services does not require such approval, and

these services often prove to be profitable. This can be used to cross-subsidise any operational losses (caused by delays in fare revision) from ordinary services.

8. SERVICE AND OPERATIONAL PLAN

With the expansion of bus transport services, there is an increasing need to allocate/plan space for bus infrastructure such as depots and terminals. Strategic distribution of infrastructure spaces across the city, region, or state can significantly improve STU efficiency (Kearney, 2017). Service provision and operations based on a planned distribution and arrangement of STUs' infrastructural assets will lead to improved efficiency and cost savings, resulting in overall loss reduction. For example, to reduce dead mileage, DTC has initiated the practice of re-fueling buses at the closest depots to the terminating point, instead of always at the mother depot (Bhasin 2011). Such efforts require a review of the operational and service plans. Software solutions for asset management can be useful in this case and help improve service consistency by predicting future demand, using data analytics to inform real-time asset deployment and service modifications, monitoring asset management and maintenance and highlighting issues, etc. (World Bank, 2005). In another example, 38 depots and 50 bus terminals for BMTC were developed through a long-term land banking strategy, discussed in detail in the following section (Bangalore Metropolitan Transport Corporation 2014).

9. LAND BANKING

Normally, public transport corporations earn revenue from the sale of tickets and passenger passes, i.e. traffic revenue (Anumita Roychowdhury, 2017). Another revenue stream comes from commercial revenue. Generation of this commercial revenue can help STUs minimise their recurring losses. Recently, STUs have realised that their civil infrastructure and land holdings can be used to as a sustainable source of commercial revenue. This is typically done by letting out the building space owned by the STUs. In addition to this, STUs also need to revamp their existing assets – terminals, depots, and workshops – through better planning (Mukherjee, 2017). The current approach to planning bus infrastructure such as depots and terminals focuses on fulfilling basic requirements such as docking bays in terminals and parking space in depots. Most bus infrastructure is not planned for functional and space use efficiencies.

Better bus infrastructure planning can significantly contribute to increasing overall ridership (due to improved passenger experience at the terminal) and vehicle utilisation (due to improved maintenance facilities). Better planning also enables better space utilisation and, thus, accommodation of more buses and/or passengers or release of space for potential monetisation.

The Bangalore case is a good example of improved bus infrastructure planning through leveraged land holdings. The Bangalore Development Control Regulations (Revised Master Plan 2015 – Bangalore Volume III 2007) specified transportation zones, considering bus stands, bus shelters, transport depots, etc. This gave birth to the innovative concept of Traffic and Transit Management Centres (TTMCs). TTMCs are huge, empty areas with a cumulative site area of 1,43,248 square metres (m²) and parking for

2800 two wheelers and 3715 four wheelers. The space allows people to park their two-wheelers and four-wheelers and switch to public transport for commuting. Apart from facilitating increased ridership, TTMCs have been a significant source of non-fare box revenue for BMTC. The total expected revenue from these sites is more than INR 48 crore per annum, helping BMTC recover part of its losses. Based on this, BMTC decided to leverage its land holdings in strategic locations throughout the city, combining the development of passenger terminals with the creation of commercial real estate space. This enables BMTC to utilise rental revenue to cross-subsidise the construction and operational cost of the terminals and similar amenities (Embarq-WRI ,India , 2014). This model provides an example of how to leverage land holdings to simultaneously provide bus infrastructure and generate non-fare box revenue. Innovative contracting options such as public-private partnerships (PPPs) can increase the viability of such projects.

10. OTHER PPP STRATEGIES

PPP strategies can be used by STUs to counter the competitive edge of private operators. For example, under the PPP model implemented by ASTC, private vehicle owners operate their vehicles under the ASTC brand. ASTC undertakes vehicle management, including scheduling and dispatch, and allows vehicle owners to utilise its stations, where they are also provided support for ticket issuance. ASTC receives 10% of the gross income as a commission, and the bus owner keeps the remaining 90 percent. The programme was initiated with 559 buses in 2001-02 and grew to 1,790 buses in 2005-06. During this period, annual ASTC earnings increased from INR 2 crore to 14 crore

(Embarq-WRI ,India , 2014). While this approach enabled ASTC to increase its revenue, it also helped improve its operational efficiency.

In addition to this, ASTC has also found innovative ways to generate commercial revenue. Several ASTC properties—depots, terminals, interchanges, etc.—are in prime locations. ASTC management has decided to commercially utilise them through redevelopment by integrating multi-level parking lots, cinemas, shops, hotels, petrol pumps, etc. at these locations. These initiatives have helped the agency to open up an alternative revenue stream to cross-subsidise operational and non-operational costs. These efforts have allowed ASTC to reduce its annual losses to Rs. 1.35 crore. ASTC has also explored additional methods to diversify its revenue streams, such as provision of courier services and commercial operation of tyre retreading plants and a printing press, in order to cross-subsidise losses, and achieve overall profitability (Embarq-WRI ,India , 2014).

3.1 ACTION PLAN

For one or more of the abovementioned strategies to be executed, a planned STU approach to seeking alternate revenue streams, in order to achieve profitability and financial sustainability, is required. A review of the existing literature revealed that multiple STUs have successfully achieved, or demonstrate strong potential to achieve, loss reduction through selected strategies, interventions, and/or actions based on an integrated long-term action plan. This action plan has three main components – planning, funding, and implementation.

Each of these components is detailed below.



3.2 PLANNING

The first step towards attaining and sustaining STU profitability entails planning different strategies critical to achieving this objective. This planning phase also includes proposing budgetary requirements and an action plan for implementation (of each strategy). The studies required for this planning may be conducted in-house or through a qualified consultant/expert and may need to be cross-referenced with one another. These studies should include the following:

1. Long-Range Demand Assessment and Service Planning – STUs stand to benefit from long-range, division-wise, and service-specific planning for operations in both current and future scenarios. Such long-range plans should have annual projections for the next 30–50 years. These plans can be developed through a mixed use of existing tools or customised approaches. The plans should cover the following:
 - a. The plans should be responsive to or factor in parameters to account for expected changes in demography, infrastructure expansion (such as road network improvement), and other scenarios.
 - b. The plans should include service, division, origin-destination, and trip length specific demand

- projections in different scenarios. These scenarios should be based on fare and developmental factors, apart from other parameters.
- c. Based on the demand estimates, the plan should recommend (today and in the future) potential routes (or origin-destinations to be served) and estimates of fleet requirements for different services (such as AC, standard, luxury).
 - d. The plan should also recommend the required capacity for each division and depot/terminal in the division to cater to demand over the next 20–50 years. Based on this, the plan should specify the additional land requirement, or excess land available for other uses (for a defined time period), at each depot and terminal site. This may include recommendation of new sites or the shifting of existing sites in order to improve passenger accessibility and operational efficiency (including reduction of dead miles).
 - e. The plan should recommend a desirable fare structure (for different services) based on passengers' ability to pay, willingness to pay, and service valuation. This should be provided on an annual basis over the study period (30–50 years).
 - f. The divisional and service-wise study findings should conform to the aggregated STU and/or state level projections. The aggregated findings should be used to recommend revisions in current STU taxes. The study should provide recommendations on tax rates in line with STU profit-loss estimates in all defined scenarios (accounting for potential technological and planning interventions to improve profitability), on an annual basis, over the study period (30–50 years). The recommendations should be based on this analysis, highlighting the optimal tax levels required to improve the STUs' financial health without significantly affecting state tax revenue earned (e.g. by offsetting individual tax reduction through tax base expansion).
 - g. The plan should define annual budgetary requirements for both fixed and variable costs in all defined scenarios. These budgetary requirements should be both divisional and aggregated for the STU, based on the estimated fleet and infrastructure development, maintenance, and operational requirements (in all defined scenarios over the study time period).
 - h. The long-range plan should define annual achievable benefits in terms of profitability, optimisation, increased ridership, etc. It should also include an economic analysis of these identified benefits, along with a detailed cost benefit analysis (accounting for the budgetary requirements to achieve the benefits).
 - i. The plan should detail a road map for rolling out the recommendations on suggested interventions in a phased manner, taking into account the practical implementation issues, budgetary limits, etc.
2. Digitisation and IT Integration Plan – To achieve sustained optimisation, a high level of automation and digitisation is required in fleet, operations, and service management. This is especially true for large STUs such as MSRTC. To achieve this, planning and scoping for digitisation is required. This can be achieved by developing a detailed digitisation and information technology (IT) integration plan, with the following components:
 - a. Audit the current level of digitisation and generate a gap assessment based on the future required level of digitisation and IT integration. Using this, establish the scope of digitisation and IT integration based on a paperless approach.
 - b. The digitisation and IT integration scope should include, but may not be limited to, fleet management, scheduling, and planning, as well as bus and driver performance monitoring cum evaluation.
 - c. The scope should detail the following abilities of one or multiple pieces of equipment/software to be procured or developed:
 - i. Automation in depot management (and management information systems (MIS)), including the collection, assimilation, analysis, and sharing of data on the fleet, staff, spare parts, fuel, maintenance scheduling, etc.
 - ii. Identification and alerts regarding specific maintenance requirements for the fleet based on (defined benchmarks of) the input data, through the digitisation of depot management and MIS.
 - iii. Automation and digitisation of the collection, assimilation, analysis, and sharing of real-time bus location, bus performance, and ticketing data.

-
- iv. Real-time bus scheduling based on real-time bus location data, demand parameters (also gathered from real-time ticketing data), and other predefined temporal and spatial factors.
 - v. Integration of Global Positioning System (GPS) and Integrated Task Management Systems (ITMS) software to capture real-time bus and crew performance data. This data should be analysed to evaluate crew and bus performance against defined benchmarks (and highlight shortcomings, as part of the software dashboard).
 - d. The plan should include a detailed road map, action plan, and budgetary requirements for the development, procurement, and deployment of identified digitisation, automation, and IT tools. It should estimate and detail the level of optimisation expected to be achieved through the defined interventions, based on the expected increase in staff/ vehicle/ fleet utilisation, operational efficiency, occupancy, etc. It should also provide an assessment of the expected positive impact on ridership and additional attracted trips. Based on these details, the plan should provide a cost-benefit analysis of the investment proposed for the defined interventions.
 - e. The plan should include a list of software, equipment, or tools required as part of this plan, along with recommendations for an off-the-shelf procurement or in-house development approach for the same. Where development is recommended, the plan should explore the possibility of integrating a royalty model with the software developers, when the developed software is licensed to other STUs/operators. This recommendation should be based on a detailed cost-benefit analysis.
- 3. Staff Training Plan – A review of case studies and other literature suggests that the training of staff, especially the crew, plays a critical role in achieving significant reductions in operational and/or other costs. This training is not limited to induction training but should also include regular training focused on refreshing the crew's skills, as per the prevailing requirements and technological and operational developments. This means that recurring annual training programmes with fixed targets will need to be built into the administrative structure and annual organisational budget. This study should detail these requirements, including the following:
 - a. It should identify the gaps in skill levels of different staff categories and the optimisation and ridership improvement parameters that will be positively affected by addressing these gaps.
 - b. It should identify the required training programmes and define the staff strength or percentage of staff (for different staff categories) that need to receive specific training. It should also specify the frequency of these training programmes for each staff category. The following are examples of training programmes that may be included:
 - i. Driver training to improve fuel efficiency. Such training is conducted by the Government of India undertaking Petroleum Conservation Research Authority (PCRA).
 - ii. Skill development programmes, such as those conducted under the National Skill Development Mission.
 - iii. Trainings to improve the behavior of staff who interact with passengers (such as bus crew).
- iv. Specialised equipment training for workshop maintenance staff. This may be conducted with bus or equipment manufacturers.
 - v. Specialised equipment and software training for other staff, such as the planning, traffic, and statistical department staff.
 - vi. Specialised leadership training for senior management and administrative staff.
 - vii. Generalised safety and other training for all staff.
- c. It should highlight how the proposed training plan will improve staff productivity and operational efficiency, apart from improving staff's skill levels and general employability. It should also detail the contribution of the proposed training in optimising existing staff utilisation, e.g. through reassignment of excess staff or overhead staff (in a phased manner over the study period).
 - d. The plan should define a road map to roll out this training plan, along with the fixed and variable budgetary requirements.
 - e. The study should include an economic analysis of the expected benefits of the proposed interventions, as listed in the training programme. It should also evaluate these benefits against the expected expenditure (over the study time period, i.e. 30–50 years) through a detailed cost-benefit analysis.
- 4. HR Policy and Administrative Restructuring Plan – It is understood that most STUs' administrative structure and HR policies are old and may need revision/ rewriting to incorporate new knowledge,

technological advances, policy changes, etc. Furthermore, the proposed digitisation and training plans are also likely to necessitate changes in these policies/structures. These changes are likely to contribute to improving the organisational efficiency, potentially resulting in reduced costs and increased revenue. In order to achieve this, an HR policy and administrative restructuring plan should be developed. This plan should cover the following:

- a. Evaluate the current HR practices and administrative structure against the current and projected (over the study period of 30–50 years) organisational requirements (division- and department-wise). This should also take into consideration best practices from both private and public operators and other organisations.
- b. Propose a revised administrative structure and HR policies based on the gap assessment. These should incorporate the following:
 - i. Incorporate an incentive mechanism into HR policies, especially for staff whose performance have a direct impact on STU profitability, e.g. the crew and maintenance staff.
 - ii. Build in/revise/review staff category-specific increment/promotion norms.
 - iii. Incorporate measures, norms, and administrative structures to enable re-assignment or rehabilitation of excess staff (including overhead staff, where required).
 - iv. Identify divisions/departments that may need be merged or newly formed. Propose a revised administrative and management structure in line with these changes.

v. Identify and propose functions, responsibilities, etc. that may be outsourced.

- c. The plan should quantify the economic and other benefits to the STU (over the study period) that may be achieved by undertaking the proposed interventions proposed. It should also highlight any expected adverse and/or positive impacts on the staff's well-being (social, psychological, or economic) as a result of the proposed changes.
- d. The plan should estimate the budgetary requirements for implementing the proposed administrative and HR policy changes. Such budget estimates should account for any loss of revenue (or other losses) due to disruptions in administrative and HR processes expected as a result of this transition.
- e. The plan should include a cost-benefit analysis to justify the proposed interventions (listed in the plan) over the short and long term.
- f. The plan should also propose a detailed action plan and timeline for rolling out the proposed changes.
5. Business Plan – Based on the four plans listed above, a detailed business plan can be developed for the STU. This plan should be based on the budgetary, economic, and action plan details included in each of the plans, resulting in an overall organisational business plan that demonstrates clear economic and financial business viability. The plan should highlight the investment requirement and expected profit and loss forecasts over a long term – 30–50 years. This

plan can be used to seek investment from government or private entities and/or obtain short- or long-term loans from financial institutions. The business plan should cover the following:

- a. The plan should include the current worth of the STU, highlighting fixed and movable assets, past and current expansion and growth, staff strength, expertise, business (service) highlights, etc.
- b. The plan should detail the expected and future market share, current and future plans for growth, current and future plans for operational and service improvement, etc. It should clearly highlight growth trends in cost, revenue, and expected revenue in different scenarios, showing the expected break-even point (year).
- c. It should highlight potential fare box and non-fare box revenue sources to be tapped (or planned to be tapped). This should include details of identified land parcels for potential land banking. These details should be accompanied by the expected valuation of the same.
- d. The plan should also include any identified potential opportunities for PPPs in different aspects of STU functioning, such as depot operations, fleet operations, etc.
- e. It should identify all potential threats and opportunities, such as taxation norms and government policies.

3.3 FUNDING AND FINANCING

The business plan should form the basis of the funding approach to cover investment requirements estimated as a part of the planning process. The business plan should be used in generating confidence in the organisation's current or potential financial health, which will aid the STU in seeking investment from various sources, including the following:

- Government funding through state budgetary support (the current funding route)
- Private investment through different PPP arrangements
- Short- and long-term loans from financial institutions such as national banks, the Asian Development Bank (ADB), World Bank, etc.

Funding should be sought in line with an integrated implementation road map.

3.4 IMPLEMENTATION

After the planning stage is completed and financing/funding for identified interventions is secured, the implementation phase begins. This stage begins with the pre-implementation stage, which entails identification of critical landmarks or milestones in the implementation process. At this stage, the departments/organisations concerned with the implementation of the identified actions should be obligated to adhere to the timeline for the achievement of identified milestones.

For this, there are people who need to be recruited, trained, and managed. Tasks need to be assigned, completed work needs to be signed off on, and incomplete work needs to be rescheduled, and perhaps rebudgeted. Solutions for developing problems need to be found quickly. This requires professional management of the implementation process. Project management is a topical area of professional application to achieve the planned objectives rapidly and professionally (Hauc and Kovac, 2000). Professional management of the implementation process should help the STU frame an approach encompassing the entire organisation. Thus, the methodology for implementation of planned action should span multiple levels and departments. The proposed implementation arrangements should follow established procedures and practices as much as possible to enable speedy and efficient implementation. These include:

1. A dedicated project management unit (PMU) should be established in the executing agency, consisting of managerial staff (from different departments) and technical experts, assisted by appointed professional consultants. These may be project management and transaction advisory consultants, among others (Project Administration Manual, 2015).
2. To provide strategic direction and oversight, a Project Steering Committee (PSC) should be constituted with the concerned officials from different departments such as HR, finance, operations, administration, etc. Each department should also have its own Project Coordination Committee (PCC) headed by the respective supervisors or managers. The PCC should identify, initiate, review, and approve sub-projects (Project Administration Manual, 2015).
3. A dedicated project implementation unit (PIU), headed by a Project Implementation Director, should be established in the STU. The PIU should be supported by secondary implementation units embedded in terminals and depots to supervise and implement the approved activities (Project Administration Manual, 2015).
4. Apart from decentralisation of the administrative machinery and provision of adequate coordinating mechanisms at the local level, it will also be necessary to ensure that there is the full participation and involvement of other stakeholders at every stage of planning and implementation. The selection of the specific tasks, however, is governed by local conditions, and in assigning priorities, it may be necessary to involve both the local administration and representatives of the public, particularly beneficiary groups. This entails formulation and implementation of a detailed communication strategy. This strategy should help address any doubts about the objectives of the exercise and thus control resistance to the implementation process.

IMPLEMENTATION ACTIONS:

The implementation phase involves putting the project plan into action. Thus, implementation should consider the development of a precise action plan as an integral process. To ensure the realisation of action plan results, the following points regarding implementation must be taken into consideration:

1. The comprehensive action plan should be drawn up after very careful consideration and exhaustive consultations with the state governments, central ministries, and other various organisations concerned with the plan formulation and implementation strategies (Planning Commission, 2017). This plan should include the identification of projects, tasks, and sub tasks (as identified in the planning stage) for implementation in an integrated and a time-bound manner.
2. Consultations should also be held with a wide variety of professional organisations, as well as individual experts, communications specialists, and trade union representatives.
3. The current schemes'/projects' existing plans should be taken into consideration. This will ensure that ongoing schemes/projects are completed expeditiously and that the resources earmarked for them are not spread over many other schemes, resulting in neither the ongoing schemes being productive, nor the new ones progressing satisfactorily, due to underinvestment.
4. It is essential to draw up a firm timeline specifying the date on which the project report will be firmed up, considering various parameters specified in the plan. This will include the dates on which the sanctioning authority, whether it is the state or central government, will be ready with the formal sanction. Furthermore, the specific dates on which contracts for various schemes falling under the formulation plan are finalised and the contract documents signed should be given.
5. To ensure that the abovementioned timeline is strictly adhered to, the delegation of authority for investment decisions, clearance of contracts, etc. should be considerably enhanced, and those directly responsible for implementing the strategies should receive adequate training and capacity building to carry out their duties independently.
6. Subsequently, a Programme Evaluation and Review Technique (PERT) network should be drawn up for each strategy, with an attached deadline. There should be no backwards revision of the deadline, and all performance should be judged against the final targets (Planning Commission, 2017).

3.5 EXPECTED OUTCOMES

By undertaking the above-mentioned actions, STUs can improve their optimisation and ridership, which will directly help in increasing their operational and overall (i.e. break-even) profitability to the target level, i.e. complete financial independence from the state.

ANNEXURES

ANNEXURE 1: GENERAL DATA FORM

STU Data Collection Checklist -1																	
General Information Form																	
A. Basic Info:																	
Name of STU _____		Data year _____		Operation Type		Urban or Non Urban or Both											
Service type		in Nos		Fleet Size		in Nos											
For city bus estimation																	
Population _____		Bus/thousand Population _____		Estimation year _____													
B. Infrastructure Info :																	
Number of bus terminals _____		Total area _____ Ha		Total land area allocated including developed and Undeveloped bus terminals in Ha													
Number of bus depots _____		Total area _____ Ha		Total land area allocated including developed and Undeveloped bus depots in Ha													
C. Fleet Details :																	
Number of Buses by age :																	
1yr		2yr		3yr		4yr		5yr		6yr		7yr		8yr		Fleet	
9yr		10yr		11yr		12yr		13yr		14yr		15yr		> 15yr			
Fleet Utilization _____ %				% Load Factor _____ %				Daily Passenger trips _____									
Daily Scheduled Km _____ Km				Avg.Daily Km Achived _____ km				Operational Routes _____									
EPK _____ Rs				CPK _____ Rs				Staff to Bus ratio _____									
Total Operational Hours _____ Hrs				Share of Pass holders _____ %				Avg Dead Kilometers _____									
D. Vision Data :																	
Estimation Year _____ Fleet Growth _____																	
Tick one Linear or Exponential or Logarithmic																	
STU Mode share _____ %		Fleet Composition _____ %		Cost of vehicle _____ Rs													
Fleet Utilization _____ %		Load Factor _____ %		Vehicle Utilization _____ %													
Avg Passenger Trip Length _____ Km		Avg.Route Length _____ km		Operational Routes _____ No.s													
EPK _____ Rs		CPK _____ Rs		Staff to Bus ratio _____													

ANNEXURE 2: SERVICE-SPECIFIC DATA FORM

STU Data Collection Checklist -2 : Service Specific																	
A. Basic Info:																	
Name of STU _____			Data year _____		Operation Type ☐ Urban or ☐ Non Urban or ☐ Both												
Service Name _____				Service Fleet Size _____ in Nos													
B. Infrastructure Info :																	
Number of bus terminals _____			Total area _____ Ha		Total land area allocated including developed and Undeveloped bus terminals in Ha Total land area allocated including developed and Undeveloped bus depots in Ha												
Number of bus depots _____			Total area _____ Ha														
C. Service Info:																	
Cost of bus _____ in Rs		Type of Bus _____		Age limit _____ year		Seating Capacity _____ %											
Number of Buses by age :																	
1yr		2yr		3yr		4yr		5yr		6yr		7yr		8yr		Total Fleet 	
9yr		10yr		11yr		12yr		13yr		14yr		15yr		> 15 year			
Fleet Utilization _____ %				% Load Factor _____ %				Daily Passenger trips _____									
Daily Scheduled Km _____ Km				Avg. Daily Km Achieved _____ km				Operational Routes _____									
EPK _____ Rs				CPK _____ Rs				Staff to Bus ratio _____									
Total Operational Hours _____ Hrs				Share of Pass holders _____ %				Avg Dead Kilometers _____									
D. Vision Data (Service Specific):																	
Estimation Year _____		Fleet Growth _____		☐ Linear or ☐ Exponential or ☐ Logarithmic													
STU Mode share _____ %		Fleet Composition _____ %		Cost of vehicle _____ Rs													
Fleet Utilization _____ %		Load Factor _____ %		Vehicle Utilization _____ %													
Avg Passenger Trip Length _____ Km		Avg. Route Length _____ km		Operational Routes _____ Nos													
EPK _____ Rs		CPK _____ Rs		Staff to Bus ratio _____													

ANNEXURE 3: MODEL BASE VALUES AND ASSUMPTIONS

The values used for estimation of outputs in the long-range bus resource requirement model can be categorized as those for demand, cost and revenue, operations, and infrastructure. As a default, the model outputs are based on capital cost values for buses in an outright purchase + operational cost method, and not a GCC method. For users to work on the GCC method, the default value of the capital cost will need to be set to 0, and the per kilometer operational cost will need to be modified to account for the principal and interest amount on the capital cost.

1. DEMAND

The demand estimates for bus transport in the model (for both urban and non-urban) operations is derived from 2011 census data (GoI, 2011). Since the census data covers only work trips, the share of work trip in the total trips have been derived from literature (Geetam tiwari, Nishant, 2018; Dr.Sanjay Gupta, Sandhya Dhameniya, 2016; Dr. Anvita Arora et al, 2014). This allows an estimation of number of urban and non-urban trips per day. This data has been computed for 56 regions (primary geographic area of operations for 56 STUs) and the same has been compiled in FLEET Tool version 1.96 (Gandhi, 2021). Using this information, per capita trip rate for each of these regions has been estimated. Based on this data we know that the average per capita trip rate for urban areas is 1.5, for non-urban areas in plains is 0.82 and for hilly and island areas it is 0.7. The non-urban trips from union territories and City States are mainly intercity trips. We know based on data available from Delhi (The Economic Times, 2020;

Wikipedia, 2020; Northern Railways, Indian Railways, 2019) that trip rates for such intercity trips cannot exceed 0.15 and 0.20. Weighted average of current mode share of non-urban bus trips of the total non-urban work trips for India is 17.2% (Census, 2011). However, it is important to note that the mode share for buses derived from census when extrapolated on other trips such as education and non-work trips, will cover not just public transport or stage carriage buses but also school buses and other contract carriage bus operations. If only work trips are considered, then the mode share of bus based non-urban work trips out of total trips (including work, education, and non-work trips) will be 6.7% . The current number of buses registered as stage carriage buses in India is approximately 4.5 lakh (MORTH, 2019). Out of these approximately 50,000 buses are operating on city intra-city routes (Annexure 4). This translates to about 6 crore daily non-urban bus trips (based on 60km average passenger trip length – see discussion below) and 3 crore daily urban bus trips in India (based on 600 passenger trips per bus per day – see discussion below). This amounts to 8.3% mode share by public transport buses in all non-urban trips in India (based on an average per capita trip rate of 0.8 for non-urban trips).

2. COST AND REVENUE

The expected service life for an ICE bus operating approximately 200+ km per day is 12 years (Anders Nordelöf et al, 2019) and (Christian Krelling & Madhav G. Badami, 2019) while the expected service life for an electric bus is often considered as high as 15 years (Anal Sheth, Debasis Sarkar, 2019). Therefore, these values are used for ICE and electric bus service life in the model. The

on-road capital cost of a 12m ICE urban bus varies significantly for standard floor and low floor buses and also between CNG and Diesel buses. The price for these buses varies with bus technology and fuel type. It is approximately 35 lakh for Diesel standard floor non-AC bus, about 45 lakh for CNG standard floor non-AC bus, about 76 lakh for diesel low floor non-AC urban bus, about 92 lakh for CNG low floor non-AC urban bus and about 109 lakh for AC-CNG low floor urban bus (Christian Krelling & Madhav G. Badami, 2019). Assuming an average fleet composition of 50% standard floor non-AC diesel bus, 40% low floor CNG non-AC bus and 10% low CNG AC-bus, the average cost of an ICE fleet is estimated at Rs. 65 lakh per bus.

The capital cost of a Diesel or a CNG 9m, 30 to 32-seater midi bus is estimated at Rs 26 Lakh (TrucksBuses AutoWeb Pvt. Ltd., 2021). This cost for a 7m, 15 to 18-seater minibus is expected to be Rs 15Lakh (Quikr, 2021). The capital cost of a similar 9m electric bus currently in operation in cities like Lucknow, Kolkata and Indore is Rs 75 Lakh (Department of Heavy Industry, 2018). 7m electric minibuses are not known to be commercially available in India. However, Tata motors is currently developing this model. We expect the cost of such a bus to be between Rs 21 Lakh and Rs. 47 Lakh (Alibaba, 2021). These prices are considered the same for both urban and non-urban buses.

The estimated capital cost of a 12m electric urban bus (non-AC, standard floor) varies between 73 lakh to 110 lakh for a 100 km range non-AC electric bus and between 90 to 130 lakh for 200km range non-AC urban bus – with different floor heights (standard, semi-low and low floor) (Mr. Gerald Ollivier et al, 2020; Rakhi Basu et al, 2021). An AC bus is expected to cost between 15 to 20 lakh more

than a non-AC bus (Sandeep Gandhi, 2021). Assuming 50% standard floor non-AC electric bus with 200km range, 40% low floor non-AC electric bus with 200km range and 10% AC low floor electric bus with 200km range, is expected to be about 112 lakh (excluding any subsidies). We understand the cost of batteries (in India) for electric bus is expected to fall by at least USD 100 over the next 10 to 15 years (Debjoy Sengupta, 2020), from the current price of about USD 200. This translates to a price reduction of about Rs. 26 lakh per bus (with a range of 200km). Thus, an average price of an electric bus over the next 15 years can be considered lower about Rs. 13 lakh, or approximately Rs. 100 lakh. Therefore, an average capital cost of an electric bus in the fleet can be considered as 1.5 times the capital cost of an ICE bus over the next 10 to 15 years.

The residual value recoverable at the time of scrapping of the bus (at the end of its service life) is considered between 13.4% and 14.9% (Christian Krelling & Madhav G. Badami, 2019). We have considered 14% as the average residual value at the end of the service life of a bus. This amounts to Rs. 9 lakh on an average cost of Rs. 65 lakh for an ICE urban bus. Electric buses are expected yield a lower value because of higher service life and lower cost recoverable components except for the battery. The end of the life residual value of the battery for a 120Kwh battery pack of the bus is estimated at approximately Rs. 2 to 3 lakh (Dipti Kamath et al, 2020).

Amounting for this, the end of the life residual value for an electric bus including the battery pack can be assumed to be the same as that of an ICE bus. Similarly, the end-of-life residual value for both ICE and electric midi and minibuses is estimated at Rs. 5 lakh and Rs 3 Lakh, respectively.

Due to easy availability of Diesel (as against CNG), non-urban bus routes are currently almost entirely operated by diesel buses. The on-road capital cost of a 12m standard diesel bus for non-urban services is expected to be same as the urban bus, i.e., approximately Rs. 35 lakh. The price of an AC diesel bus is expected to be Rs. 15 lakh higher than a non-AC diesel bus (Christian Krelling & Madhav G. Badami, 2019). The on-road cost of a luxury inter-city bus such as the Volvo 9400 XL is expected to be approximately Rs. 90 lakh (Kitty Writer, 2021). We understand that the majority of non-urban bus services are focused on regional and rural routes, with a few services catering to intercity routes. We therefore assume that nearly 2/3rd of the buses to be standard non-AC 12m diesel buses, 5% as luxury coaches and the rest as standard AC diesel buses. Based on this the average on-road capital cost of a bus in a fleet of buses operating non-urban services is taken as Rs. 42 lakh. We understand that over the next 10 to 15 years, the average capital cost of an electric bus is expected to be 1.5 times the cost of an ICE bus. Using this, the average cost of electric buses with a 350 KWh battery pack (a range of 200 to 250km) can be expected to be Rs. 65 lakh. The capital cost of midi and minibus is not likely to be different for ICE or electric buses operating urban and non-urban services.

The model considers an average utilization of between 180 to 190 km per day for urban buses. This requires a one battery replacement during the lifetime of the bus. This is based on 2600 charging cycles (Yuliya Preger et al, 2020). The operational cost of a 12m electric bus should account for the battery replacement capital cost and related interest component (assumed at 12% per annum for 6 years). The cost of the battery more than 7 years from today is estimated at USD 75/KhH (Debjoy Sengupta,

2020). The sum total of other operational cost (excluding fuel cost) including crew cost, maintenance cost, taxes, insurance, etc. are expected to be similar. These are estimated at approximately Rs. 40.0 per km from literature (Christian Krelling & Madhav G. Badami, 2019; CIRT, 2020). The energizing cost of urban electric buses is expected at approximately Rs. 7 to 8 per km (Mr. Gerald Ollivier et al, 2020) while the expected cost of battery replacement (average over the next 10 to 15 years) including interest component is estimated to be approximately Rs. 2 per km (Debjoy Sengupta, 2020). This makes the total operational cost of operating a 12m electric bus (excluding the capital cost as explained above) for an operator to Rs. 50 per km. The total operational cost (TCO) of 12m electric urban buses is estimated to be 9% higher than that of 9m electric midi buses (Ravi Gadepalli et al, 2020). Accordingly, the operational cost of 9m electric bus is assumed to be 9% higher than the operational cost of 7m electric minibus. This is used to estimate the operational cost of 9m electric midi bus and 7m electric minibus at Rs. 46 per km and Rs. 42 per km, respectively.

The per kilometer fuel cost for a CNG standard floor 12m city bus is estimated at approximately Rs. 20 per km (Christian Krelling & Madhav G. Badami, 2019; Drivespark, 2021; Goodö eturns, 2021). This brings the total per km cost of operations for a 12m standard floor CNG city bus to about Rs. 62 per km. We know from literature that the cost per km of operations of 12m standard floor bus varies from Rs 54 to Rs. 66 (SGA, 2018; CIRT, 2020). This supports the figure of Rs. 62 per km for ICE standard floor urban buses. Similarly, the per km operations cost for midi buses in Rajkot city was Rs. 33 per km in 2018. It can be expected to be anywhere between Rs. 36 to 38 today based on an average annual increase of 4% to 6% annually.

Therefore, the cost of operations for ICE urban midi buses is taken as Rs. 40 per km. Similarly, the cost of operations of ICE min urban bus is assumed at Rs. 30 per km.

Average EPK (including non-fare box revenue sources) for urban operations is estimated at more than Rs. 35 per kilometer for all urban STUs (CIRT, 2020). EPK values reported in CIRT annual report are for different size of buses, however majority operations are by 12m bus. Based on this the average EPK for 12m buses is assumed to be Rs. 40 today, assuming 4% per annum increase in fare price or other non-fare box revenue sources. The fare box revenue is directly related to occupancy per bus which is related to its seating capacity. The seating capacity of a midi bus is twice that of a minibus while that of an urban bus is 30% more than that of the midi bus (Sanjay Bhatia, 2019). This relationship is used to estimate the average EPK for midi and minibuses specified in the tool default values. These are Rs. 31 per km for midi buses and 16 per km for minibuses.

These values are used as default values in the model and can be edited by users where required.

Average EPK (including non-fare box revenue sources) for non-urban bus services in India, in 2017, was Rs. 38 per kilometer while the average CPK for the same was Rs. 64 per kilometer (CIRT, 2020). However, the mean EPK and CPK in that year for more progressive operators such as MSRTC, KSRTC, GSRTC, UPSRTC and APSRTC was Rs. 32 and Rs. 37 per km respectively (CIRT, 2020). Considering average inflation of 4% annually, the average CPK for non-urban service in 2020 can be considered as Rs. 42 per km (based on current mix of bus types). Long range planning for STU's like MSRTC and APSRTC suggests that non-urban bus operations can be profitable including generating revenue to finance capital expenditure (SGArchitects, 2018; SGArchitects, 2018). This implies that

in a best-case scenario the average EPK for non-urban services in India can exceed Rs. 60 per km. However, in a business as usual (BAU) scenario (in 2020) the EPK is considered as Rs. 36 per km, while that in a progressive scenario the services are expected to be operationally profitable with an average EPK of Rs. 45 per km. These values are average for a fleet with a majority of standard size (12m length) buses.

We understand (from observations and from interactions with different STU officials) that majority of buses operated by STUs are standard size buses, with a few operating a fleet of 9m length midi buses – especially on regional services (these also include private operators running regional services). We assume that the average EPK and CPK for these buses to be different. We thus assume an average CPK of standard size (12m buses) including 65% non-AC buses, 30% AC buses and 5% luxury buses to be approximately Rs. 45 per km, while the EPK of these services in each of the scenario can be Rs. 41 in a BAU scenario, Rs. 50 in a progressive scenario and Rs. 65 in a best-case scenario. As discussed above, we assume the CPK to be lower by 9% for midi and mini-buses respectively and similarly, the earning per km to be reduced in proportion to the seating capacity. This suggests CPK of Rs. 41 per km for midi non-urban bus services and Rs. 38 per km for any mini non-urban bus services. Similarly, EPK in a BAU scenario for non-urban midi bus services can be Rs. 28 per km Rs. 14 per km for mini non-urban bus services. This will be Rs. 39 per km and 19 per km respectively in a progressive scenario and Rs 50 and Rs. 24 per km respectively in a best-case scenario.

3. OPERATIONS

The values used for bus operations are calculated using known characteristics of urban bus operations in India. It is known from Literature that more than 80% of urban bus operators operate at an average daily occupancy of between 70% (operators like BMTC) and 120% (Metropolitan Transport Corporation (MTC) Chennai) (CIRT, 2020; SUTP). We also know that average length of urban bus trips is around 10km in India while on an average a bus can do 200km in urban operations (Rahul Goel et al, 2014; SGA, 2020). Based on this, the estimated number of passenger trips per city bus per day is expected to be between 600 to 1000 passengers. This number at 70 to 120% average occupancy for 30 to 32-seater urban midi buses will be between 460 and 800 passenger and that for 15 to 18-seater urban minibuses will be between 320 to 540. The model uses an upper value of 120% average daily occupancy because the peak achievable mode share for buses is estimated at 66% based on the number of trips in a city with population in the range of 1.5 crore that will have a trip length between 6 to 15km. A high occupancy can be expected in cities with that high patronage for buses. Additionally, this ensures that estimates of bus requirements are not exaggerated (high occupancy reduces fleet size requirement). Therefore, same number of buses can cater to a 66% mode share at 120% occupancy and 38% mode share at 70% occupancy.

For estimation of fleet size for non-urban services a region-based classification is developed. These are plains, hilly/islands, or union territories. and the average passenger trips per bus have been estimated using current mean vehicle utilization and passenger trip length from literature (CIRT, 2020). We estimate the current average daily bus utilization for non-urban services is

300km. For urban services, the vehicle utilization is currently observed to be in the range of 190 km (CIRT, 2020). A lower limit of 169km per day is assumed for small cities with scant bus operations. This is because, services are expected to be less regulated in these conditions and it may be possible that crew functions in single but smaller shift instead of two 8-hour shifts. The mean passenger trip length for non-urban (including regional) services in plains is estimated at 39km (CIRT, 2020). This distance is expected to reduce with increasing patronage of bus service as an outcome of improved road network. Accounting for this the model assumes a 30km average passenger trip length for non-urban services. The average occupancy in 2016–17 for non-urban public bus companies in India was 72. This translates to 30 passenger per bus for a 42-seater bus. Since most buses in regional and non-urban services are more than 40-seater, we assume average occupancy of 30 passengers per bus for the estimates. This translates to approximately 300 passenger trips per non-urban bus per day.

Based on the standard accepted operational practice of holding 5% buses as standby in case of breakdown and other eventuality, the average fleet utilization for both urban and non-urban services is assumed as 95% in the model. Similarly, we understand that the staff to bus ratio based on 16-hour bus operations and a crew which includes conductors and including all contractual and non-contractual staff for an operator, cannot be less than 5.2. This is also based on current staff data and documentation of best practices (CIRT, 2020; ASRTU, 2017). Per km emissions for buses have been considered for a 12m bus urban bus. These are based on documented values for 12m diesel buses (Embarq-WRI, 2014). These values are assumed to be same for both urban and non-urban operations.

4. INFRASTRUCTURE

Bus infrastructure characteristics and requirements have been estimated based on literature (SGArchitects, 2015; SGArchitects, 2017) and also based on interactions with Indian operators such as BMTC, MSRTC, APSRTC, JKSRTC, HSRTC and OSRTC. Based on this we know that the upper limit of bus depot capacity requirements (especially for electric buses due to regulatory requirements of peak power demand at a site) is about 120 buses, while the lower limit for the same can be 80 buses. 80 to 100 bus capacity bus depots are also considered the most efficient in terms of operations as well space and equipment utilization (SGArchitects, 2015). Therefore, a range of 80 to 120 bus capacity depots is used for the model (both for urban and non-urban operations). The per bus area requirement for an 80-bus capacity depot is approximately 163 sq.m., while that for a 120-capacity depot is approximately 155 sq.m. Therefore, an area requirement of 160 sq.m. per bus (both for urban and non-urban operations) is used in the model. The development cost for a bus depot and bus terminal are derived from current rule of thumb construction rates. These have been adjusted for a significant open versus built up areas for bus infrastructure (especially bus depots) and expected cost of the equipment. The average construction cost for bus depot is taken as Rs. 12,500 per sq.m., while that for a bus terminal is taken as an average of Rs. 14,500 per sq.m. (of site area) for at grade bus parking, at grade car parking and maximum 2 level structures for bus terminal and semi-pucca structures (workshop shed) for bus depot. This amounts to approximately Rs. 20 lakh per bus for depot development and Rs. 10 lakh per bus for bus terminal development.

We know based on literature (SGArchitects, 2015) that for urban services a 10-minute layover time with a peak hour flow of 100 buses per hour (or a flow of 1,000 buses per day), requires a bus terminal site measuring approximately 15,000 sq.m. If we assume an average route length of 18 to 20 km, a visit to a bus terminal every 1.5 hours by a city bus can be expected. This would mean on an average 4.5 visits per day (4 round trips) for each of the two bus terminals at either end of the route. Thus approximately 222 urban buses use each bus terminal site designed to cater to peak hour flow of 100 buses per hour, or approximately 70 sq.m. per bus. For non-urban services, an average layover time per bus is assumed as 20 minutes. And two round trips are assumed with an average route length of 60 to 70km. This will require approximately 2.5 visits per bus per terminal a bus terminal site measuring approximately 28,000 sq.m. is required for a peak hour bus flow of 100 buses per hour (or 1,000 buses per day) with average layover time of 20 minutes (SGArchitects, 2015). Thus, approximately 400 buses will use each bus terminal site (1000/2.5), which amounts to 70 sq.m. per bus (28,000/400). Therefore, both urban and non-urban bus terminals area requirement is estimated @70 sq.m. per bus in the fleet. Number of bus terminal sites for both urban and non-urban services are expected to be in the small category (SGArchitects, 2015) with peak flow not exceeding 4 to 12 buses per hour for non-urban services and 7 to 20 buses for urban services.

ANNEXURE 4: TOTAL NUMBER OF FLEET SIZE IN EACH STATE AND UNION TERRITORY OF INDIA

S. No	States	Total Reg. Buses	Stage Carriage	Urban Buses	Current no. of primary tech bus	Current no. of alternate tech bus
1	Andaman & Nicobar Islands UT	1089	396	110	96	14
2	Andhra Pradesh	41187	14245	1782	1782	0
3	Arunachal Pradesh	5192	471	4	4	0
4	Assam	18459	1943	772	727	45
5	Bihar	33751	12273	198	198	0
6	Chandigarh UT	2932	567	240	240	0
7	Chhattisgarh	15484	5811	398	398	0
8	Dadra and Nagar Haveli UT	594	72	13	9	4
9	Daman and Diu UT	0	13	13	13	0
10	Delhi	41682	6867	6767	6867	0
11	Goa	11888	4323	175	125	50
12	Gujarat	74855	30673	1899	1859	0
13	Haryana	57696	14551	206	206	0
14	Himachal Pradesh	9633	5875	262	165	97
15	Jammu & Kashmir	29079	17861	190	150	40
16	Jharkhand	10398	1220	260	260	
17	Karnataka	93690	41431	9499	9499	
18	Kerala	117720	44157	3243	3243	
19	Lakshadweep UT	0	0	0	0	0
20	Madhya Pradesh	53468	29020	790	686	104
21	Maharashtra	141289	36673	6715	6575	140
22	Manipur	2583	329	25	25	
23	Meghalaya	5518	2006	286	286	
24	Mizoram	1268	1268	150	150	
25	Nagaland	5926	1960	33	33	
26	Orissa	27621	16025	687	637	50
27	Puducherry UT	3834	1699	40	40	
28	Punjab	45378	2732	515	515	
29	Rajasthan	108680	39520	555	455	100
30	Sikkim	363	263	41	41	
31	Tamil Nadu	187073	64482	7409	7409	
32	Tripura	2953	1370	16	16	
33	Uttar Pradesh	75309	18250	1195	1105	90
34	Uttarakhand	12031	4627	303	253	50
35	West Bengal	46963	17078	822	782	40
36	Telangana	51580	16530	5580	5540	40
	Total	13,37,166	4,49,402	51,293	50,389	904

Alibaba. (2021, 02 22). <https://www.alibaba.com/>. Retrieved from alibaba.com: <https://www.alibaba.com/showroom/7m-electric-bus.html>

Anal Sheth, Debasis Sarkar. (2019, 01 25). Life Cycle Cost Analysis for Electric vs. Diesel Bus Transit in an Indian Scenario. *International Journal of Technology (IJTech)* , Vol 10, No 1 (2019), 105–115. doi:<https://doi.org/10.14716/ijtech.v10i1.1958>

Anders Nordelöf et al. (2019, 10). Life cycle assessment of city buses powered by electricity, hydrogenated vegetable oil or diesel. *Science Direct, Transportation Research Part D: Transport and Environment, Volume 75*, 211–222. doi:<https://doi.org/10.1016/j.trd.2019.08.019>

Anumita Roychowdhury, G. D. (2017). *Waiting for a bus: Strategies to improve Delhi's Bus system*. New Delhi: Center for Science and Environment (CSE).

ASRTU. (2017). Retrieved 02 15, 2021, from <http://www.asrtu.org/wp-content/uploads/2017/10/Best-Practice.pdf>

Business-standard. (2016, March 16). State road transport undertakings on revival mode. New Delhi, New Delhi, India.

Census. (2011). B-28 'Other Workers' By Distance From Residence To Place Of Work And Mode Of Travel To Place Of Work - 2011. Office of the Registrar General & Census Commissioner, India. GOI. Retrieved from https://censusindia.gov.in/2011census/B-series/B_28.html

CENSUS. (2011). B-28 'Other Workers' By Distance From Residence To Place Of Work And Mode Of Travel To Place Of Work - 2011. Office of the Registrar General & Census

Commissioner, India. GOI. Retrieved from https://censusindia.gov.in/2011census/B-series/B_28.html

Census. (2011). *Census Population 2011*. Retrieved 09 23, 2020, from www.census2011.co.in: <https://www.census2011.co.in/>

CENSUS. (2011). *Census Population 2011*. Retrieved 09 23, 2020, from www.census2011.co.in: <https://www.census2011.co.in/>

Census. (2011). Census2011. Retrieved from censusindia.gov.in: https://censusindia.gov.in/2011census/B-series/B_28.html

Census 2011, GOI. (2011). CENSUS 2011. Retrieved from censusindia.gov.in: https://censusindia.gov.in/2011census/B-series/B_28.html

Christian Krelling & Madhav G. Badami. (2019, 04 25). CNG and diesel urban buses in India: A life-cycle cost comparison. *International Journal of Sustainable Transportation*, 591–605. doi:10.1080/15568318.2019.1594468

CIRT. (2017–18). *STATE TRANSPORT UNDERTAKINGS PROFILE AND PERFORMANCE*. PUNE: CENTRAL INSTITUTE OF ROAD TRANSPORT. Retrieved from <http://www.cirtindia.com/>

CIRT. (2020). *State Transport Undertakings Profile and Performance*. Pune: Central Institute of Road Transport. Retrieved from <http://www.cirtindia.com/>

Debjoy Sengupta. (2020, 09 25). mercomindia.com.

Retrieved from <https://mercomindia.com/average-cost-lithium-ion-battery/>

Department of Heavy Industry. (2018, 03 15). Retrieved 02 16, 2021, from <https://dhi.nic.in>: <https://dhi.nic.in/writereaddata/UploadFile/Benchmark%20price%20for%20Electric%20Buses636662995963975616.pdf>

Dipti Kamath et al. (2020, 04 28). Retrieved 02 15, 2021, from <https://pubs.acs.org/doi/pdf/10.1021/acs.est.9b05883>

Dr. Anvita Arora et al. (2014). *Low Carbon Comprehensive Mobility Plan – Visakhapatnam*. UNEP DTU Partnership, Technical University, Denmark ISBN: 978–87–93130–25–8. Retrieved 02 17, 2021, from https://www.researchgate.net/publication/281267267_Low_Carbon_Comprehensive_Mobility_Plan_-_Visakhapatnam

Dr.Sanjay Gupta, Sandhya Dhameniya. (2016). *Base Year Travel Demand Model – Delhi*. New Delhi: School of Planning and Architecture, New Delhi. Retrieved 02 17, 2021, from https://www.toi.no/getfile.php/1348327-1530707770/Publikasjoner/DELHI_%20Base%20Year%20Travel%20Demand%20Model.pdf

Drivespark. (2021, 02 15). Retrieved from www.drivespark.com: <https://www.drivespark.com/diesel-price-in-delhi/>

Embarq-WRI ,India . (2014). *BUS KARO 2.0 – Case studies from India* . New Delhi : Embarq-WRI ,India .
Embarq-WRI. (2014). *Bus Karo 2.0 – Case studies from India*. New Delhi: Embarq-WRI, India.

Gandhi, D. S. (2021). Retrieved 02 17, 2021

- Geetam Tiwari, Nishant. (2018). *Travel to Work in India: Current Patterns and Future*. Indian Institute of Technology Delhi, Transportation Research and Injury Prevention Programme, New Delhi. Retrieved 02 16, 2021, from <http://tripp.iitd.ac.in/>: <http://tripp.iitd.ac.in/assets/publication/WorkTravelReport.pdf>
- Gol. (2011). *Census*. Office of the Registrar General & Census Commissioner, India. Retrieved from https://censusindia.gov.in/2011census/population_enumeration.html
- GOI. (2011). *Census*. Office of the Registrar General & Census Commissioner, India. Retrieved from https://censusindia.gov.in/2011census/population_enumeration.html
- Goodö eturns. (2021, 02 15). Retrieved from www.goodreturns.in: <https://www.goodreturns.in/cng-price-in-delhi-s10.html>
- Hindustan Times, . (2017 , October 27). How poor operational efficiency bleeds India's public bus transport undertakings. New Delhi, India .
- Kearney, A. (2017). *Ministry of Road Transport and Highways – Final Recommendations*. New Delhi: Government Of India.
- Kitty Writer. (2021, 01). Retrieved 02 15, 2021, from <https://tractorsinfo.com/volvo-bus-940oxl-intercity-coach-price-specifications-images-review/amp/>
- MORTH. (2019, 09). Retrieved 02 16, 2021, from morth.nic.in: <https://morth.nic.in/sites/default/files/Road%20Transport%20Year%20Book%202016-17.pdf>
- Mr. Gerald Ollivier et al. (2020, 07 16). www.busworldacademy.org. Retrieved from BUSWORLD ACADEMY INDIA WEBINAR: <https://www.busworldacademy.org/presentation/outlook-on-electric-buses-in-india>
- Mr. Gerald Ollivier et al. (2020, 07 16). www.busworldacademy.org. Retrieved from Busworld Academy India Webinar: <https://www.busworldacademy.org/presentation/outlook-on-electric-buses-in-india>
- Mukherjee, A. (2017, March 6th). *WRI – India* . Retrieved from wri-india.org: <http://wri-india.org>
- Northern Railways, Indian Railways. (2019, 07 30). Retrieved from https://nr.indianrailways.gov.in/view_section.
- STEELBLUE&lang=o&id=0,1,263,314,315,567#:~:text=At%20the%20end%20of%20February,registering%20a%20decline%20of%201.0%25.
- Quikr. (2021, 02 17). Quikr. Retrieved from <https://delhi.quikr.com/>: <https://www.quikr.com/cars-bikes/used-commercial-vehicles+mahindra-18-seater-bus-price-list-in-delhi-ncr+lucknow+x16222205003>
- Rahul Goel et al. (2014, 10 27). Benchmarking vehicle and passenger travel characteristics in Delhi for on-road emissions analysis. *Travel Behaviour and Society*. doi:<http://dx.doi.org/10.1016/j.tbs.2014.10.001>
- Rakhi Basu et al. (2021, 02 15). Retrieved from <https://iea.blob.core.windows.net/assets/db408b53-276c-47d6-8b05-52e53b1208e1/e-bus-case-study-Kolkata-Clarifications.pdf>
- Ravi Gadepalli et al. (2020, 07). Retrieved 02 15, 2021, from www.uitp.org: https://drive.google.com/file/d/1O1bovhTVc-SBb1z_mzeXOawOKlZEWNWX/view
- Sandeep Gandhi. (2021, 02 15). <http://urbanmobilityindia.in/>. Retrieved 02 15, 2021, from <http://urbanmobilityindia.in/Upload/Conference/16cf89aa-ef62-484a-9b71-74bcb5c84af.pdf>
- Sanjay Bhatia. (2019, 09 23). Tata Motors. Retrieved 02 15, 2021, from <https://drive.google.com/file/d/1lCoJaJ9xA-j72oY4WupU2ZuiwlphoFh7/view>
- Sanjay Bhatia. (2019, 09 23). TATA MOTORS. Retrieved 02 15, 2021, from <https://drive.google.com/file/d/1lCoJaJ9xA-j72oY4WupU2ZuiwlphoFh7/view>
- SGA. (2018, 09 13). Technical Study of the existing BRTS corridor for the last mile connectivity and pre-feasibility of potential electrification of the corridor. New Delhi: Shakti Sustainable Energy Foundation. Retrieved 02 15, 2021
- SGA. (2020). Road Map for Bus Fleet Infrastructure and development for Bengaluru Metropolitan Transport (BMTc). New Delhi: Shakti Sustainable Energy Foundation. Retrieved from <http://www.sgarchitects.in/images/projects/public-transport/BMTc%20REPORT-2020%20for%20Print%20.pdf>
- SGA. (2021). FLEET TOOL VERSION 1.96. DELHI: SSEF.
- SGArchitects. (2015). Bus Terminal Design Guidelines . Delhi : SGArchitects.
- SGArchitects. (2017). Bus Depot Guidelines. Delhi: SGArchitects.

SGArchitects. (2018). APSRTC – Roadmap for Bus Fleet and Infrastructure Development Report. New Delhi. Retrieved 02 17, 2021, from https://shaktifoundation.in/wp-content/uploads/2019/07/APSRTC_Road-Map-for-Bus-Fleet-and-Infrastructure-Development-Report.pdf

SGArchitects. (2018). MSRTC – Roadmap for Bus Fleet and Infrastructure Development Report. New Delhi: Shakti. Retrieved 02 17, 2021, from https://shaktifoundation.in/wp-content/uploads/2018/07/3.MSRTC-REPORT-_SGA.pdf

SGArchitects. (2020). Road- Map for Bus Fleet and Infrastructure Development for Bengaluru Metropolitan Transport. New Delhi: Shakti Sustainable Energy Foundation. Retrieved from <http://sgarchitects.in/images/projects/public-transport/BMTC%20REPORT-2020%20for%20Print%20.pdf>

SUTP. (n.d.).

The Economic Times. (2020, 01 20). Domestic air passenger traffic grows by just 3.74% in 2019 compared to 18.6% in 2018: DGCA. Domestic air passenger traffic grows by just 3.74% in 2019 compared to 18.6% in 2018: DGCA. New Delhi. Retrieved 02 15, 2021, from <https://economictimes.indiatimes.com/industry/transportation/airlines/-aviation/domestic-air-passenger-traffic-grows-by-just-3-74-in-2019-compared-to-18-6-in-2018-dgca/articleshow/73436058.cms>

The Hindu. (2005, July 16). 'Operational efficiency helped make profits'- Issue 15. Retrieved from www.frontline.in

TrucksBuses AutoWeb Pvt. Ltd. (2021, 02 16). TrucksBuses.

com . Retrieved from <https://www.trucksbuses.com/>: <https://www.trucksbuses.com/buses/fully-built-buses/staff-tourist/tata-lp-712-starbus-marcopolo-32-seater>

Wikipedia. (2020, 12 22). Retrieved 02 15, 2021, from https://en.wikipedia.org/wiki/Highways_passing_from_Delhi

World Bank . (2005). ROAD TRANSPORT SERVICE EFFICIENCY STUDY. World Bank.

World Bank. (2005). Road Transport Service Efficiency Study. World Bank.

Yuliya Preger et al. (2020, 09 02). Retrieved 02 15, 2021, from <https://iopscience.iop.org/article/10.1149/1945-7111/abae37/pdf>



Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the areas of clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance.



SGArchitects was established in 2006 and provides consultancy services in the field of sustainable urban transport including public and non-motorized transport. We provide expertise in research, planning and implementation for all forms of sustainable urban transport projects, including developing toolkits, guidelines and other resource material.

