

AS-A04

THRESHOLDS FOR RAPID TRANSIT MODE SELECTION



This Knowledge Product is intended to be used as an interactive Excel spreadsheet. These tools are available online on the GPSC's TOD website and the World Bank's TOD COP website. The reader should first review the summary presented below before using the spreadsheet tool.

Type: Checklist + User Guide



INTRODUCTION

As urban economic growth in World Bank client countries outstrips rural economies, cities continue to see a rapid influx of population and jobs. These new jobs require accessibility through public transit means that are faster and more reliable. Public transit demands have necessitated a change from unregulated and local bus systems to more robust and high-quality rapid mass transit systems. Several cities have launched new rapid transit systems in the last 2 decades including cities in Tanzania (Dar-es-Salaam), Brazil (20+ cities) and South Africa (6 cities) to China (40+ cities), India (15+ cities) and Indonesia (10+ cities). Most cities face difficulties in timing transit investments and changes in land use regulations for more integrated TOD outcomes. Rapid transit investments are more appropriately located along corridors with high population densities and employment access. However, a city may choose to proactively invest in rapid transit systems at the same time as land use regulations are relaxed. This will increase choices for the non-driving population in terms of real estate and mobility.

The increasing choices in rapid transit modes in recent years offer developing countries the option of selecting a transit mode that best addresses mobility needs and economic constraints. While rail rapid transit systems have been around longer, they are more expensive to build and offer little flexibility in adjusting for demand variations. Bus rapid transit systems, on the other hand, offer more flexibility in adjusting to varying demand, but the “Rapid” version is comparatively new and is difficult to enforce in many cities with poor traffic behavior.

Transit planners in World Bank client countries, are often ill-equipped to make the decision without considerable data collection and modeling studies. Furthermore, access to data is often a daunting task and restricts informed decision-making. The Rapid Transit Mode Selection Tool helps cities conduct a rapid selection for bus or rail rapid transit modes with relatively accessible data points that are often available at local levels.

Disclaimer: *The Transit-Oriented Development Implementation Resources & Tools knowledge product is designed to provide a high-level framework for the implementation of TOD and offer direction to cities in addressing barriers at all stages. As the context in low and middle-income cities varies, the application of the knowledge product must be adapted to local needs and priorities, and customized on a case-by-case basis.*

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PURPOSE

This Rapid Transit Mode Selection Tool is intended to provide assistance on rapid transit mode selection to cities who are either (1) considering the introduction of a new rapid transit mode for an intended network at the city scale; or (2) in the process of evaluating rapid transit modes for operations along a corridor:

➔ **Initial Assessment:** This tab is intended to help cities make an initial assessment among a set of modes that should be considered for the Alternative Analysis. The tool is designed to use data that are readily available to assess potential rapid transit modes that differ by technology and right-of-way.

The Initial Assessment may be used to inform the Assess Rapid Transit Tool (AS-H02)

➔ **Detailed Evaluation:** This tab is intended to help cities determine the most appropriate mode alternatives for a specific corridor. The tool is designed to use data that represent an informed opinion as to the extent of demand in the corridor with rapid transit in place. Please copy the tab for use for every different corridor. The final selection of Mode Alternative should be based on context-specific criteria, which can be more important than a small numerical difference in the Evaluation Score.

ASSUMPTIONS AND LIMITATIONS



BRT Rapid: E.g: Harmoni Central Busway Transjakarta

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BRT Semi-Rapid 1: E.g: Lanzhou BRT

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BRT Semi-Rapid 2: E.g: Ahmedabad BRT

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1. The tool classifies the modes broadly under rail and bus and further classifies them based on the achievable speed and person-capacity. The classification based on speed is broadly defined by the degree of “separateness” from other traffic movement and conflict points. This degree is classified as ROW (right-of-way) Class A, B, or C, where ROW Class A denotes full separation either through grade separation or continuous barriers; Class B denotes partial separation either through discontinuous lane or grade separation, and Class C denotes mixed traffic movement (Vuchic 1981). Several physical and technological mechanisms can be used to achieve the ROW variations, including actual physical separation, but also including technological measures such as signal priority.
2. The rapid transit modes considered in this selection Tool include:
 - a. Bus Rapid Transit (BRT) - is a high-quality bus-based rapid transit system, characterized by better quality and fuel-efficient buses, dedicated right-of-ways, and pre-boarding fare collection. Three types of BRT choices are available in this tool, differentiated mainly by the mode capacity and operating conditions:
 - » BRT Rapid – is a BRT system using standard, articulated or double-articulated buses, designed to operate on a fully segregated corridor; either on an elevated or isolated busway or along physically separated bus lanes with continuous passing lanes delivering highly reliable, fast and comfortable services equivalent to Metro systems.
 - » BRT Semi-Rapid 1 – is a BRT system using standard, articulated or double-articulated buses, designed to operate with high speeds and reliability on a dedicated bus lane with passing lanes at stations and physical segregation or signal prioritization techniques at junctions for faster movement of buses.
 - » BRT Semi-Rapid 2 – is a BRT system using standard or articulated buses and designed to operate at higher than average speeds along a dedicated bus lane with general traffic turns allowed at signals.

ASSUMPTIONS AND LIMITATIONS



LRT-Semi-Rapid: E.g. Manila LRT

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Metro: E.g. Delhi Metro

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- b. Light Rail Transit (LRT) - Light Rail Transit is an electric powered rail based transit system which is lighter than the conventional heavy rail system and characterized by its ability to operate short trains along dedicated lanes. LRTs exist in many forms, including streetcars, trams, and the more modern LRT systems. This tool only includes the option of the modern LRT with dedicated ROW features as described:
 - » LRT Semi-Rapid – is an LRT system using up to 4 train cars, with a physically segregated right-of-way and dedicated tracks at grade, allowing occasional traffic turns at junctions.
 - c. Metro /Rail Rapid Transit – Metro / Rail Rapid Transit is an electric powered rail-based transit system which is designed to operate in fully grade-separated corridors with closer station spacing than heavy commuter rail.
3. The following transit modes are not included in this tool
- a. Local Bus – because it serves a local connector and feeder connection only and cannot be classified as “rapid”;
 - b. Streetcar or Mixed Traffic LRT – because it operates in mixed traffic more often and cannot be classified as “rapid”;
 - c. Commuter Rail – because it serves the regional transit function, not urban ‘rapid’; and
 - d. Monorail / Skytrain (suspension rail) / gondola cars – because it does not adapt itself to forming a network, an essential requirement for urban transit, but could be used as feeder lines in atypical topographies as deemed necessary.
4. The tool uses a higher and lower case assumption for computing potential travel demand for the given conditions. These higher and lower cases represent density variations within a city or along a city corridor. For a city or corridor where both extreme conditions are observed, a mode must be favorable under both conditions to be viable.
- a. **THE HIGHER CASE** may be interpreted as the computed conditions for the denser core of the city.
 - b. **THE LOWER CASE** may be interpreted as the computed conditions for the sparsely developed suburban areas in the city.

ASSUMPTIONS AND LIMITATIONS

5. The tool assumes capacities based on vehicle dimensions per TCQSM methods, using 6 persons per m² of standee space and load diversity factors depending on train length. (Reilly and Levinson 2011). A load diversity factor is applied to derive optimum capacities, where peak capacities are defined as the maximum number of people that can be carried past a given location during a given time period under specified operating conditions, without unacceptable delay, hazard, or restriction, and with reasonable certainty. It is assumed that a system that operates at peak capacities at all times is over capacity. Typical frequencies for BRT are based on observed actual frequencies. (Global BRT Data n.d.)
6. The tool uses a cost per passenger-km unit to determine cost efficiencies as explained in the optimization model for technology selection developed by L. Moccia. (Moccia, Allen and Bruun 2018). The model uses a synthetic representation of the temporal and spatial variability of demand, and of several operational and design aspects.

The model is adjusted to show that planning for a faster technology can be more important than the choice between bus and rail per se, except at very low demand density, and that cost differences between technologies are small in a wide demand range. The social discount rate assumed in running this model is 7%.

7. The tool does not consider contextual parameters such as political preferences, costs of land acquisition and construction of supporting infrastructure.
8. The tool is applicable in multiple contexts- greenfield, urban infill, suburban and redevelopment.
9. The tool is not intended to compare different corridor alignment alternatives, or service planning alternatives. It only provides guidance on the rapid transit mode based on modal characteristics.
10. This tool is applicable for municipalities, development agencies, transit agencies, private developers or any agency interested in proposing a transit system for the city.

DATA SOURCES

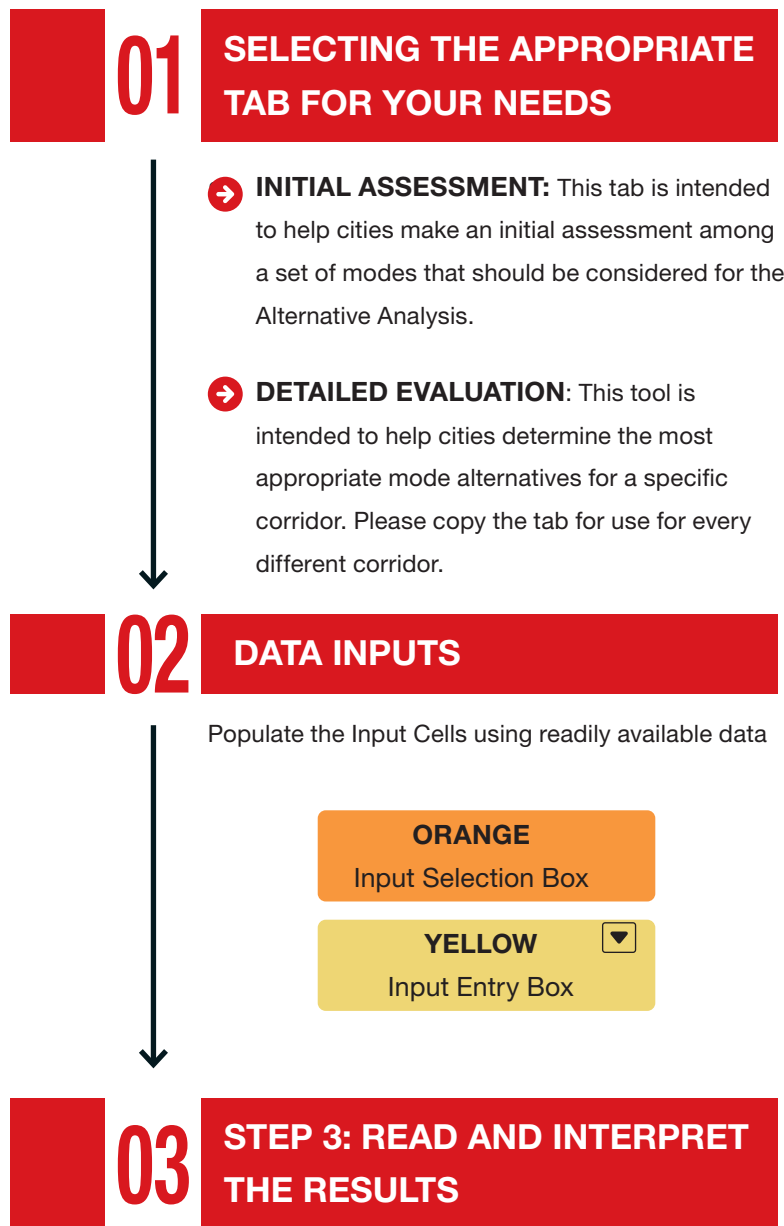
- For Initial Assessment
 - Census information – area and population
 - Local bus usage data – in annual terms (multiple daily numbers by 300) and in spatial terms to identify the highest ridership observed at the peak hour at the peak loading point.
- For Detailed Assessment
 - Census information – population
 - Planned Corridor details – corridor length, projected ridership
- Use or add data to the Urban Transport Data Analysis Tool (Agarwal, et al. 2014)

HOW TO USE THE RAPID TRANSIT MODE SELECTION TOOL?

First, the user should read the User Guide Tab before using the spreadsheet. The application of the Rapid Transit Mode Selection tool consists of three basic steps:

THE TOOL INCLUDES:

- ➔ USER GUIDE
- ➔ INITIAL ASSESSMENT
- ➔ DETAILED EVALUATION
- ➔ ASSUMPTIONS & THRESHOLDS
- ➔ GLOSSARY



HOW TO INTERPRET THE RESULTS?

➔ **Initial Assessment:** In this tool, the results are expressed as the degree to which a mode is favorable or competitive or unfavorable in terms of (1) the ability of the mode to manage peak passenger demand at higher and lower ranges of demand; and (2) the cost efficiency of the mode technology at higher and lower ranges of demand.

A city that is home to a high variation of population and employment densities, would need to consider the results for both higher and lower cases. On the other hand, a city that is characteristically closer to either the higher or lower end of the density range may use the results from the most applicable scenario. The results of the tool should be used not as direct recommendations but as preliminary guidance on appropriate mode(s) for the city, given prevailing conditions of population density and travel habits. For instance, if the INITIAL ASSESSMENT tool suggests that rail is COMPETITIVE for the whole network whereas bus is FAVORABLE, it may well be that part of the network would be better off as rail. Mixed results could be interpreted in some instances to indicate a mixed-mode solution warranting at least DETAILED consideration by corridor.

➔ **Detailed Evaluation:** If passenger is known by segment/corridor, the DETAILED EVALUATION tool could be used to explore the particular segment that works better as rail. In effect, both tools together could be used to assign segments of a large notional network to either rapid (BRT or Metro) or semirapid (BRT or LRT).

In this tool, the results are expressed in terms of an Evaluation Score. The evaluation considers the following parameters:

- a. Provides Adequate Capacity (Scored out of 3)
- b. ROW Availability (Need vs. availability of dedicated corridors) (Scored out of 3)
- c. Potential to Integrate Pedestrian Needs (Such as safe crossings) (Scored out of 2)
- d. Potential to Improve Living Conditions in surrounding Development (Scored out of 2)
- e. High Estimate of TAC per PKT (High Cost = Low Score) (Scored out of 3)
- f. Low Estimate of TAC per PKT (High Cost = Low Score) (Scored out of 3)
- g. Ease of Implementation with respect to: Familiarity with Technology (Scored out of 2)

REFERENCES

- Agarwal, O. P., Gouthami Padam, Aroha Bahuguna, and Salvador Pena. 2014. Urban Transport Data Analysis Tool (UT-DAT) : user's manual (English). Energy Sector Management Assistance Program (ESMAP). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/395261468147569317/Urban-Transport-Data-Analysis-Tool-UT-DAT-users-manual>.
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- Moccia, Luigi, Duncan W Allen, and Eric C Bruun. 2018. "A Technology Selection and Design Model of a Semi-Rapid Transit Line." Researchgate .
- Reilly, Jack, and Herbert Levinson. 2011. Public Transport Capacity Analysis Procedures for Developing Cities. Washington DC: The International Bank for Reconstruction and Development / The World Bank.
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GLOSSARY

CAPACITY

The maximum number of people that can be carried past a given location during a given time period under specified operating conditions, without unacceptable delay, hazard, or restriction, and with reasonable certainty.

HISTORICAL DAILY PEAK HOUR FACTOR

The ratio of Peak Hour Peak Direction Passenger Demand for a typical route (i.e. representative of the system as a whole) to its total daily boardings in both directions. This factor helps to convert daily passenger flows into peak hour passenger flows. It should be ideally be determined by looking at historical data. Please note that this factor is usually higher for public transport as compared to total traffic.

LOCAL TRANSIT

Public transport operating on fixed routes with frequent stops (100-400 m apart), generally in mixed traffic on surface roadways, relying heavily on walk access and egress.

LOCAL TRANSIT BOARDINGS

The annual number of passengers boarding local transit vehicles, counting separately each boarding made in the course of single journey or trip between origin and destination. Also known as unlinked passenger trips (UPT). Boardings on regional services should not be included in city totals when using this tool.

LOCAL TRANSIT SERVICE AREA

The reasonably contiguous area served by the local transit network, not including regional services. Indicative extent would be the area within 1 km of regularly served

local stops. This area does not include portions of the metropolis connected to the local service area solely by regional services.

MEAN LOCAL TRANSIT TRIP LENGTH

The average distance traveled by one public transit boarding passenger, calculated by dividing total local transit person-km by total local transit boardings.

NETWORK EXTENT

The number of kilometers of a route in a public transport network, without double-counting kilometers where routes share the same path.

PASSENGER TRAFFIC DENSITY (PTD)

The total number annual transit passengers passing the average point along a system or route in both directions combined, formed by dividing system PKT by network extent (for a system) or route PKT by route length (for a single route).

PASSENGER-KILOMETERS TRAVELLED (PKT)

The total distance traveled by passengers on transit vehicles (for a single route or a system), which may be determined by multiplying the number of unlinked passenger trips by the average length of such trips.

PEAK HOUR PEAK DIRECTION PASSENGER DEMAND (PHPD)

The number of transit passengers carried in the peak hour in the peak direction. This occurs almost universally on weekdays and is measured for a single route at its maximum load point.

PROJECTED ANNUAL RAPID TRANSIT PASSENGER BOARDINGS IN A CORRIDOR/ ANNUAL CORRIDOR RIDERSHIP

The estimated or projected annual passenger boardings for a specific rapid transit corridor of known length.

The estimate should be consistent with operating characteristics (such as average speed) for the available ROW

RAPID TRANSIT

Public transport operating on fixed routes at a significantly higher average speed than local service, usually in exclusive rights-of-way and/or completely separated from surface traffic. Access depends on both walking and local public transport service. Stations are typically 800m-2km apart.

REGIONAL TRANSIT

Public transport operating on fixed routes within and outside the local service area, offering higher average speeds than even rapid transit, with average station spacings usually longer than 2 km. A large share of access may be by motorized transport.

RIGHT-OF-WAY

Land that is used for moving vehicles carrying passengers or goods, such as railways or highways. Rights-of-way may be identified, purchased, or reserved in advance for future transportation use, and may be required to construct elevated or underground rapid transit.

ROW CLASS

Classification of the type of operating environment of the RoW. ROW Class A = fully grade-separated ROW, Class B = at-grade lane separation, Class C = mixed traffic.

TOTAL ANNUALIZED COST

Total annualized cost is the annualized value of the total net present cost expressed in per PKT.

VEHICLE CAPACITY

The average number of people that a vehicle can be scheduled to carry at capacity (as defined herein).



Indore, India