

CALIFORNIA PATH PROGRAM  
INSTITUTE OF TRANSPORTATION STUDIES  
UNIVERSITY OF CALIFORNIA, BERKELEY

## **Development of Bus Rapid Transit Performance Assessment Guide Tool**

**Mark A. Miller, Aaron Golub**

**California PATH Research Report  
UCB-ITS-PRR-2010-37**

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation, and the United States Department of Transportation, Federal Highway Administration.

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## **ABSTRACT**

This report describes the development process of the Bus Rapid Transit Performance Assessment Guidebook (BRT PAG) Tool, which provides a decision support means for tool users to understand at a high level the benefits and costs associated with implementing bus rapid transit systems. The BRT PAG Tool is based on a conceptual framework consisting of BRT system strategies; stakeholder groupings; impacts of individual BRT system strategies; measurement methods used to analyze the impacts that BRT system strategies have on different stakeholders; and quantitative estimates of benefits and costs associated with these impacts. Prior to constructing the tool, research was performed on BRT information and data sources and the structure of the tool was developed. The current website for the BRT PAG Tool is <http://path.berkeley.edu/BRT-Performance-Assessment-Guidebook-Tool> and is best viewed using Microsoft's Internet Explorer web browser.

Key Words: bus rapid transit, deployment, impacts, decision support tool

## **EXECUTIVE SUMMARY**

This report constitutes the final report for PATH Project Technical Agreement TA-6AA0321-15378 — “Bus Rapid Transit Systems Performance Assessment Guidebook”. It describes the development process of the Bus Rapid Transit Performance Assessment Guidebook (BRT PAG) Tool, which provides a means of decision support for tools users to understand at a broad level the benefits and costs associated with implementing bus rapid transit systems. The BRT PAG Tool is based on a conceptual framework consisting of BRT system strategies; stakeholder groupings; impacts of individual BRT system strategies; measurement methods used to analyze the impacts that BRT system strategies have on different stakeholders; and quantitative estimates of benefits and costs associated with these impacts. The tool is best used in the early planning stages of the BRT project development process to familiarize planners – both at transit agencies and at Caltrans – with these elements of the conceptual framework.

Prior to constructing the tool, a review of BRT information and data sources was conducted and the structure of the tool was developed. Identifying the appropriate and relevant BRT information and data sources was based on the project team’s extensive knowledge of the public transit subject area in general and bus rapid transit systems and intelligent transportation systems areas in particular. The BRT PAG Tool was produced as a web-based instrument based on the *Visio 2007* platform, a diagramming program using graphics to represent images to create diagrams and flow charts.

Tool access is simple and best viewed via Microsoft’s Internet Explorer web browser. The BRT PAG Tool consists of the following three primary components: User Guide, Main Matrix, and Flowchart informational pages for each relevant BRT system strategy/stakeholder pair; each such flowchart page is composed of the following four components: BRT system strategy definition; impacts; measurement methods; and resource documentation

The current website for the BRT PAG Tool is

<http://path.berkeley.edu/BRT-Performance-Assessment-Guidebook-Tool>.

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## 1.0 PROJECT OVERVIEW

This report constitutes one of two final deliverables for PATH Project Technical Agreement TA-6AA0321-15378 — “Bus Rapid Transit Systems Performance Assessment Guidebook”. The project has developed a tool to assist users, e.g., Caltrans, in understanding high level impacts of bus rapid transit systems so as to help make more informed decisions about implementing these systems. The Bus Rapid Transit Performance Assessment Guidebook (BRT PAG) Tool has been developed by means of 1. examining BRT literature to identify and investigate BRT system strategies, BRT stakeholders and their perspectives, impacts of implementing BRT system strategies relative to specific measures of performance, methods of analysis in assessing implementation of such strategies, and quantitative findings of BRT benefits and costs; 2. determining the appropriate structure for the tool, and 3. carrying out the tool construction. The remainder of this section discusses the motivation for, objectives of, and a summary of the contents for the remainder of this report.

### 1.1 Motivation

The California Department of Transportation (Caltrans) has recently adopted a policy supporting implementation of bus rapid transit systems on the California State Highway System (Caltrans, 2007). In particular, this policy begins with the following strong statement:

*The California Department of Transportation (Department) recognizes and supports the concept and implementation of Bus Rapid Transit (BRT) as a potentially cost-effective strategy to maximize people throughput (emphasizing the movement of people, not just vehicles), reduce traveler delay, increase capacity, and foster energy savings on the California State Highway System (SHS), as well as on conventional highways. The Department will work closely with local jurisdictions, regional transportation planning agencies, transit operators, and other stakeholders to plan, develop, implement, and advocate for BRT systems.*

Associated with this policy, Caltrans has also had a concern over the impacts resulting from implementing bus rapid transit system strategies yet the department has lacked a decision support tool to enable it to understand the potential benefits and costs of proposed BRT projects that must be considered when deciding whether a BRT project will be implemented or discontinued. There is a need to understand these BRT implementation issues using a systems approach.

## **1.2 Objectives**

The overall objective of this project is to develop a decision support tool that uses a systems and integrated approach to bus rapid transit systems deployment-related research; provides an initial assessment of impacts of implementing BRT strategies that need to be used toward that end; and will enable Caltrans to determine conditions under which a BRT project may be implemented or discontinued. No single tool can evaluate all impacts of a BRT project as they are highly specific to the actual conditions of the existing street and traffic patterns and then any modifications made under the BRT scenario. Because no single tool can evaluate all of the costs and benefits of the BRT implementation with various stakeholders, this performance assessment guidebook is really a tool of tools that is best used in the early planning stages of the BRT project development process. It compiles a wide array of discussions, and links to tools and methods into a single structured environment that helps enable BRT implementers such as transit agencies and Caltrans to understand the various impacts to be expected from a BRT project to be implemented or discontinued. From there, an agency could embark on a more specific and detailed evaluation along one or several of the cost and benefit impact threads, which are discussed in the guide. Furthermore, the tool can assist agency staff to understand the required elements of an impact study, thereby allowing them to develop detailed scopes of work for consultant teams to follow.

## **1.3 Contents of the Report**

This is the first of four sections. Section 2 provides a discussion of the methodological approach used in developing the BRT PAG Tool; a description of the tool is provided in Section 3 along with the means to access the tool, followed by conclusions in Section 4.

## **2.0 METHODOLOGY**

In this section the set of steps used in the development of the Bus Rapid Transit Performance Assessment Guidebook tool is described.

### **2.1 Develop Conceptual Framework**

When assessing the implementability of a bus rapid transit system various factors come into play that should be considered. Firstly, a BRT system may be implemented incrementally and with flexibility over time relative to numerous individual elements or strategies. Such BRT system strategies including the following:

- Station and Lane Access Control
  - Queue jumps
  - Adding a bus lane
  - Converting a (travel or parking) lane to a bus lane
  - Time of Day bus lane
- Intelligent Transportation Systems
  - Transit signal priority (passive, active, adaptive)
  - Collision warning and avoidance
  - Lane Assist (vehicle guidance)
  - Precision docking
  - Fare payment (off-board and on-board)
  - Automatic vehicle location
  - Passenger information (stop/station and in-vehicle)

Secondly, numerous stakeholders abound with their own perspectives, priorities, and agendas that should be considered. Different stakeholders include the following:

- Bus riders
- Bus operators
- Cities (local departments of transportation and revenue or finance)
- Businesses
- Pedestrians
- Cyclists
- Caltrans
- Drivers (local and through BRT corridor area)

- Societal/general population/environment

The next factor focuses on the impacts that individual BRT system strategies have with respect to individual stakeholders. The impacts of BRT system strategies may be assessed according to specific measures of effectiveness including the following key measures relative to BRT system impacts: travel time and service reliability.

The fourth factor deals with measurement methods and approaches (and the collection of data) used to analyze – quantitatively and/or qualitatively – the impacts that BRT system strategies have on different stakeholders. Examples of such measurement methods include the following:

- Before-and-after travel time studies using on-board field surveys
- Analytical models
- Micro-simulation modeling of before-and-after traffic conditions
- Before-and-after surveys
- Analogy (an estimate based on a synthesis and analysis of actual operating experience)

The fifth and final factor focuses on quantitative estimates of benefits and costs associated with the impacts that BRT system strategies have on their respective stakeholders.

The five-part conceptual framework just outlined provides the basis for the content of the BRT PAG Tool.

## **2.2 Research Bus Rapid Transit Information and Data Sources**

Based on our knowledge of the public transit subject area in general and bus rapid transit systems and intelligent transportation systems areas in particular, we readily compiled and subsequently examined a multitude of reports and associated documentation from these fields. A subset of these information sources – the top priority reports – are listed and briefly described in Table 1. The complete listing is provided in the Bibliography at the end of this report.

**Table 1 Bus Rapid Transit Information and Data Sources**

Title	Description
TCRP Report 90: <i>Bus Rapid Transit – Implementation Guidelines</i>	This report presents planning and implementation guidelines for bus rapid transit (BRT), which are based on a literature review and an analysis of 26 case study cities in and outside the United States. The guidelines cover the main components of BRT—running ways, stations, traffic controls, vehicles, intelligent transportation systems (ITSs), bus operations, fare collection and marketing, and implementation.
TCRP Report 118: <i>Bus Rapid Transit Practitioner’s Guide</i>	A report providing information on the costs, impacts, and effectiveness of implementing bus rapid transit (BRT) components. It includes practical information that can be readily used by transit professionals and policy makers in planning and decision making related to implementing different components of BRT systems.
FTA Report FTA-FL-26-7109.2009.1: <i>Characteristics of Bus Rapid Transit for Decision Making 2009 Update</i>	A reference tool intended for transportation planners and decision makers and provides information on BRT systems including the seven major elements of BRT together with their respective features and attributes; BRT system performance; and benefits of BRT systems.
NCHRP Research Results Digest 336: <i>Benefit/Cost Analysis of Converting a Lane for Bus Rapid Transit</i>	This report presents the results of a study of the cost benefit of converting a mixed flow travel lane to exclusive bus rapid transit (BRT) use; including a literature review of BRT projects in operation in the United States and several other countries, identification of potential locations where BRT implementation involved taking or converting an existing mixed-flow traffic lane for exclusive BRT use and interviews with representatives of these projects.
TCRP Synthesis 48 <i>Real-Time Bus Arrival Information Systems</i>	This synthesis describes the state of the practice in real-time bus arrival information systems, including both U.S. and international experience. This report also includes a review of the relevant literature, in addition to the results of a survey that was conducted as part of this project. The survey covered technical capabilities of the systems, agency experience, cost, and bus rider reactions to these information systems. This synthesis also contains the results of interviews with key personnel at agencies that have implemented or are in the process of implementing these systems.
TCRP Synthesis 73 <i>AVL Systems for Bus Transit: Update</i>	A report documenting the state of practice of AVL systems and changes in agency practices related to the use of AVL systems with a literature review, results of a survey effort, and the findings from case study interviews. Also, information is presented on how transit agencies implement and use AVL systems as well as on benefits and costs.
Transit Signal Priority (TSP): A Planning and Implementation Handbook	This report outlines a process for planning and implementing TSP, based on a systems engineering approach that identifies many of the issues that may need to be addressed in a TSP project; It provides information on the current state of the practice of TSP in North America; it documents TSP implementation case studies to highlight issues that arise and solutions that have been developed.
TCRP Report 100: <i>Transit Capacity and Quality of Service Manual</i>	A report for public transit practitioners and policy makers documenting background, statistics, and graphics on various types of public transportation; providing a framework for measuring transit availability and quality of service from the perspective of the passenger; contains quantitative techniques for calculating the capacity of bus transit services as well as bus stops, stations, and terminals.

### 2.3 Develop Tool Structure

The BRT PAG Tool is web-based using a *Visio 2007*<sup>1</sup> platform. Access to the tool is simple and best viewed via Microsoft's Internet Explorer (IE) browser<sup>2</sup>. The tool structure is based on a matrix of impacts of BRT elements on stakeholders. Hyperlinks are used to connect from this matrix to related content within the tool and access additional informational sources external to the tool.

The BRT PAG Tool consists of the following three components, each of which is individually described in Section 3:

- User Guide
- Main Matrix
- Flowchart pages for each relevant BRT system strategy/stakeholder pair composed of the following components:
  - BRT system strategy definition
  - Impacts
  - Measurement methods
  - Resource documentation

### 2.4 Construct Tool

Constructing the tool was an iterative process based on repeated applications of the 'production-review-revise' cycle. Reviews were conducted by the project advisory panel with whom the research team met regularly and frequently to discuss project progress. The bulk of the work in making the tool was in producing each flowchart page because there are 71 of them. Producing each flow chart page together with the User Guide and Main Matrix pages consisted of the following sub-tasks:

- Design graphics for User Guide, Main Matrix, and Flowchart Pages
- Insert informational content in Flowchart Pages
- Add hyperlinks as necessary to User Guide, Main Matrix, and Flowchart Pages

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<sup>1</sup> The Visio platform is a diagramming program that uses vector graphics (geometrical objects such as lines, curves, and various shapes) to represent images to create diagrams and flow charts.

<sup>2</sup>The current version of Internet Explorer is IE 8. Older versions of IE work fine with the BRT PAG Tool.

- Format content in Flowchart Pages
- Enable a new window to be opened when linking to documents external to the tool
- Publish Visio tool-content file as web document, which also generates accessory web files
- Upload all web-related Visio files to web site that houses the tool
- Upload external documentation to web site that houses the tool

### **3.0 THE BUS RAPID TRANSIT PERFORMANCE ASSESSMENT GUIDEBOOK TOOL**

In this section the User Guide, Main Matrix, and Flowchart Pages are discussed. The current website for the BRT PAG Tool is

<http://path.berkeley.edu/BRT-Performance-Assessment-Guidebook-Tool> and is best viewed using Microsoft's Internet Explorer web browser.

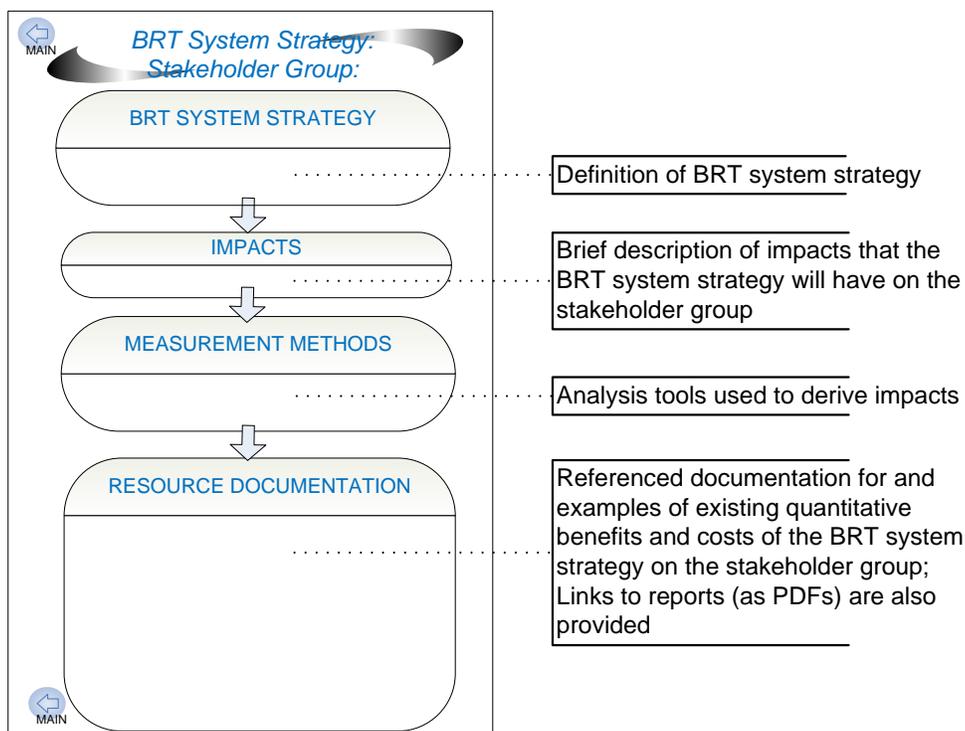
#### **3.1 User Guide**

The User Guide explains how to navigate the tool and is immediately accessible from the website's Home Page, the first page the user sees when the tool is launched by clicking on the website's URL. Figure 1 shows the 1-page User Guide. As is explained on this page, everything is steered from the Main Matrix and from there the various impacts of BRT elements can be investigated.

## USER GUIDE FOR THE BRT PAG TOOL

**Where to begin?** The “Main Matrix” page shows BRT system strategies (the rows) and stakeholder categories (the columns). The tool is structured around designated BRT system strategy/ stakeholder pairs, shown with a  in the cell entry corresponding to a particular BRT system strategy impacting a particular stakeholder group. Clicking on any such button will take you to the informational flowchart page for that pair. (See below for the Flowchart Page Template). From any flowchart page, clicking on the  at the top or bottom left-hand corner returns you to the Main Matrix page from which you can access any other flowchart page. Alternatively, you can use the “Go To Page” feature on the left-hand side in the tool’s navigation frame to access any page. The “Pan and Zoom” feature is also available to help you view the details of any page. At the bottom of the Main Matrix is a listing of Secondary or Co-Benefits including Emissions, Ridership, and Land Use & Development and links () to their individual informational pages. [Click here](#) to go to the Main Matrix.

### ***Flowchart Page Template***



**Figure 1 BRT PAG Tool User Guide**

### **3.2 Main Matrix**

The Main Matrix, shown in Figure 2, highlights with a “button” icon each BRT system strategy/stakeholder category pair that has a corresponding Flowchart Page.

BRT SYSTEM STRATEGIES	STAKEHOLDER CATEGORIES								
	Bus Riders	Bus Operators	Cities	Businesses	Pedestrians	Cyclists	Caltrans	Drivers (Local)	Drivers (Through)
<b>STATION AND LANE ACCESS CONTROL</b>									
Queue Jumps	☐	☐	☐	☐		☐	☐	☐	☐
Add Busway	☐	☐	☐				☐	☐	☐
Convert Parking Lane to Bus Lane	☐	☐	☐	☐		☐	☐	☐	
Convert Travel Lane to Bus Lane	☐	☐	☐			☐	☐	☐	☐
<b>INTELLIGENT TRANSPORTATION SYSTEMS</b>									
Signal Priority: Passive	☐	☐	☐				☐	☐	☐
Signal Priority: Active/Adaptive	☐	☐	☐				☐	☐	☐
Collision Warning/Avoidance	☐	☐	☐		☐	☐	☐	☐	☐
Lane Assist (Vehicle Guidance)	☐	☐	☐				☐		
Precision Docking	☐	☐	☐				☐		
Fare Payment (Off-Board)	☐	☐							
Fare Payment (On-Board)	☐	☐							
Automatic Vehicle Location	☐	☐							
Passenger Information (Stop/Station)	☐	☐	☐						
Passenger Information (In-Vehicle)	☐	☐							
<b>SECONDARY OR CO-BENEFITS</b>									
Emissions (local mobile-source and greenhouse gas pollutants)			☐						
Ridership			☐						
Land Use and Development			☐						

Figure 2 BRT PAG Tool Main Matrix

### **3.3 Flowchart Pages**

The Flowchart Pages comprise the core of the tool's content. A general template for these pages is shown in Figure 3 and depicts the internal structure of each flowchart page. The name of the page is at the top indicating the BRT system strategy/stakeholder category pair that is the page's focus. From the top to bottom, the first component, "BRT System Strategy", defines the individual BRT system strategy. The "Impacts" component provides a brief description of impacts that the BRT system strategy will have on the corresponding stakeholder group. Next, "Measurement Methods" outlines commonly used analysis tools to derive the impacts. Finally, the "Resource Documentation" component provides a description of documentation for and examples of existing quantitative benefits and costs of the impacts of the corresponding BRT system strategy on the stakeholder group.

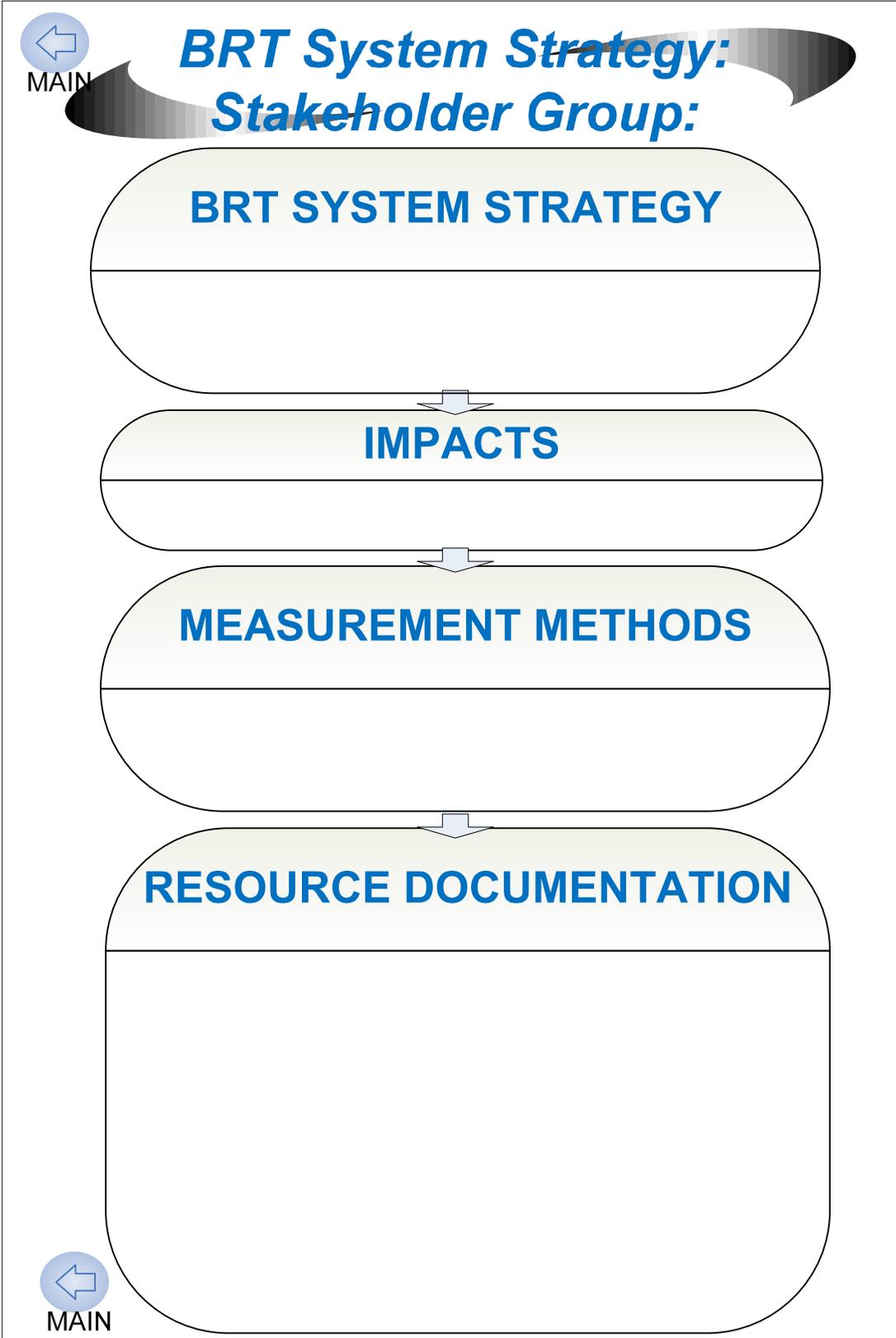


Figure 3 BRT PAG Tool Flowchart Page Template

#### **4.0 CONCLUSIONS AND FUTURE DIRECTIONS**

A tool to assist in decision making regarding bus rapid transit systems deployment was formulated and developed here. Using a systems approach, the tool helps fill a gap in the understanding of the impacts – both benefits and costs – of proposed BRT projects that must be considered when deciding whether a BRT project will be implemented or discontinued as well as the methodological approaches undertaken in the process of ascertaining these impacts.

Enhancements and/or updates to the BRT PAG Tool would make it much more powerful. At this stage in the tool's development, we can envision two ways the tool could be improved upon to assist Caltrans more effectively.

The first way is to recognize that there are gaps in the amount of information and data within the “Resource and Documentation” component of the Flowchart Page for some of the BRT system strategies, namely, Intelligent Transportation Systems (ITS), e.g., collision warning/avoidance, lane assist (vehicle guidance), and precision docking. Once such ITS strategies progress toward and achieve actual BRT revenue service operation, tangible and quantitative impacts will be able to be measured and such information can then be inserted into the BRT PAG Tool and fill these informational and data gaps. For example, currently there is an ongoing federally-funded pilot program to demonstrate the benefits of vehicle-assist and automation (VAA) applications – lane assist and precision docking – for full-size public transit buses in revenue operation. It is expected that upon completion in early 2011 quantitative impacts of VAA will be documented at which time the BRT PAG Tool may be updated and subsequently assist users more effectively overall and more specifically in the area of ITS elements.

The second way is to conduct follow-on case studies in which the BRT PAG Tool is applied to specific corridors that are being considered by Caltrans and local area transit agencies for the implementation of bus rapid transit systems. The feedback on tool

effectiveness and lessons learned from such case studies can then be used to enhance the tool.

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