SII – Sustainability Innovation Inventory

Authors: Abby Spinak, Dave Chiu, Federico Casalegno,
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Intermittent Bus Lane System (Lisbon)

Executive Summary

The Intermittent Bus Lane System is a traffic management system that improves the efficiency of public transportation without significantly curtailing available road space for other vehicles.

Buses are often considered less reliable than other forms of public transportation, because they are affected by traffic congestion and other public roadway delays. While designated bus lanes can address these delays, restricting access to bus lanes results in an inefficient use of road space for other vehicles during high traffic conditions. However, low frequency bus routes (fewer than 20 buses/hour) can be managed electronically to allow buses unhindered travel while keeping the bus lane open to other traffic in between buses. This traffic management strategy, called the Intermittent Bus Lane (IBL) System, uses GPS information on bus locations and visual cues on the roadway to designate a bus lane as open or closed based on expected bus arrival times.

Preliminary data from a Universidade de Lisboa IBL project implemented in Lisbon, Portugal for six months in 2005-2006 demonstrated an average increase in speed of public buses on the IBL-enabled route of 20-25%. At times of peak traffic congestion, bus speed showed gains of up to 50%. Effects of the IBL on non-bus traffic were shown to be insignificant in this study.

The 2005-2006 Lisbon study additionally showed that drivers tended to accept the IBL and willingly comply with IBL traffic signals without the need for strict enforcement.

Why Implement the IBL System?

IBL systems can improve the sustainability of a city's transportation network by reducing emissions associated with traffic congestion and encouraging people to use public transportation by increasing the dependability and speed of public buses. They contribute to social sustainability by allowing cities to improve the functionality of public transportation inexpensively through traffic management, with minor infrastructure costs.

The IBL system would be most appropriate for cities without an extensive subway, light-rail, or commuter rail system or for cities interested in extending their public transportation services in areas beyond a train network. Existent bus systems with a high-frequency arrival rate or bus systems that use routes with consistently heavy traffic may want to consider a more standard fully-exclusive bus lane. Bus routes with many intersections, lane merges, traffic lights, or other traffic flow disturbances may consider using the IBL system as one part of a more comprehensive traffic management strategy.

Current Technology

The IBL system consists of variable visual indicators both on the road surface and in the form of traffic signs. These indicators respond to alerts of oncoming buses and notify drivers in other vehicles on the roadway when a lane changes from a "regular lane" to a "bus lane." IBL explanatory signs on the roadway tell drivers what signals to look for while using the IBL System. (See Figure 1, below.)

Buses on an IBL-enabled route use GPS to determine their locations and communicate their GPS coordinates to control boxes located near the roadway via radio or cellular transmission. The control boxes then compute the estimated time of bus entry into their particular IBL segment and, as needed, signal LED indicators on the roadway and vertical sign indicators above the roadway to light up. The Lisbon IBL project used signaling procedures designed in collaboration with the Portuguese National Road Authority.

When IBL indicators signal the arrival of a bus, cars already in the bus lane are allowed to continue, but all other traffic is prohibited from entering the lane. Because this system allows traffic to remain in the bus lane, traffic flow observation is necessary to determine the required lag time between designating an IBL an active "bus lane" and the arrival of the bus; otherwise, the bus will continue to be delayed by traffic. The Lisbon case study experimented with three types of knowledge communicated to the IBL control boxes:

- Individual bus location only
- Individual bus location plus traffic conditions (flow, speed, and queue length) measured by loop detectors
- Long-range bus locations, including the oncoming bus location, plus traffic conditions

The study concluded that the third condition – long-range bus and traffic data – produces the most effective IBL system in heavy traffic, but all three systems were at least moderately effective at establishing right-of-way for buses under light traffic conditions.

After the bus passes, the IBL indicator signals switch to indicate a "normal lane," and traffic is free to enter the IBL as they wish.

The IBL indicators used in the 2005-2006 Lisbon test are shown below:

Figure 1: Signs Used in the Lisbon IBL. *An explanatory sign (top right) tells drivers to look for signs indicating a change from a "regular lane" to a "bus lane." When a bus is approaching in an IBL, the vertical traffic sign (top left) indicates that the lane has changed to a bus lane, while lights between the IBL and other traffic lanes (bottom) turn on to signal to cars that entering the IBL is not permitted.*

Technology & Experience Roadmap

IBL systems can be configured in a number of different ways to maximize efficiency and reliability. Because they rely on GPS data and electronic signals, IBL systems can be combined with other available technology to effectively manage traffic flow in traffic-prone areas and encourage use of public transportation.

Transit Signal Priority (TSP) for Buses

Transit Signal Priority (TSP) is a low-cost method of establishing right-of-way for buses – it enables buses to extend green traffic signals to pass quickly through intersections. IBL studies indicate that giving buses right-of-way through intersections offers the potential for significant time savings on bus routes (Viegas and Lu, 2004). Combining IBL signals with TSP could therefore improve the efficiency of public buses.

TSP for Non-bus Traffic in Intermittent Bus Lanes

TSP can also be used in an IBL system to "flush the queues" of traffic ahead of the bus (Eichler, 2005). This traffic, which is allowed to stay in an IBL after an oncoming bus has been indicated, can create delays during peak traffic conditions. Additional management strategies for this traffic could make IBL systems more reliable.

In-Car Telematic Navigation Systems

IBL systems could also be used in coordination with other time-saving traffic technology, such as in-car navigation systems. As many navigation systems also rely on GPS technology, these systems could be coordinated with the IBL system to update drivers on IBL-enabled roadways about the locations and expected arrival times of nearby buses. On-board navigation systems could also help direct traffic to non-IBL roadways during times of extreme or unexpected traffic congestion.

Public Transit Web Services

Knowledge of bus locations and average speeds can help online trip planning sites more accurately determine best routes for travelers during different traffic conditions. Connecting the real-time bus information available through an IBL system to these online services could increase public confidence in municipal transportation systems.

Future Directions

As the Universidade de Lisboa study added an IBL to a previously mixed-use roadway, future research is needed to determine the impact of opening currently exclusive bus lanes to all traffic in between bus arrivals.

The Intermittent Bus Lane concept is also part of a larger trend in using embedded technology in city infrastructure to adapt the functions of urban space as needed in response to changing user behavior patterns. Continued research on the coordination of data, sensors, and space around the city will make future cities more responsive to the demands of residents and visitors.

Works Cited and Sources for Additional Information:

Eichler, Michael and Carlos F. Daganzo. "Bus Lanes with Intermittent Priority: Assessment and Design." *Transportation Research Part B* 40 (2006): 731-744.

Viegas, José and Baichuan Lu, "The Intermittent Bus Lane signals setting within an area." *Science Direct*. 2004. Accessed on 5 June 2008. http://www.sciencedirect.com

Viegas, José Manuel, Ricardo Roque, Baichun Lu, and João Vieira. *The Intermittent Bus Lane System: Demonstration in Lisbon*. 2007. http://www.civil.ist.utl.pt/nispt/en/index.htm

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MIT Mobile Experience Lab, Massachusetts Institute of Technology

Design Laboratory

School of Architecture and Planning

http://mobile.mit.edu

Federico Casalegno

Dave Chiu

Abby Spinak

Cisco Systems, Inc.

Internet Business Solutions Group

http://www.connectedurbandevelopment.org/

James Macaulay

Nicola Villa

Shane Mitchell

CONNECTED URBANDEVELOPMENT