Effective Bus-Only Lanes

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Abstract

This paper explores geometric design and institutional barriers to effective bus-only lanes in the United States. It highlights design features for effective bus lanes in those communities with bus-only lanes (US and abroad) and discusses institutional barriers, such as objections to remote enforcement and mixed-flow vehicle capacity reduction. It uses the City of San Francisco as an example of how a network of bus-only lanes could be implemented and what benefits could be derived.

Overview of Current Operations in San Francisco

San Francisco's Municipal Railway, known commonly as MUNI, operates a dense grid of bus and rail services across the 49 square miles of the City and County of San Francisco. Transit travel times in San Francisco have declined significantly in the last two decades, resulting in higher operating costs, necessitating service cuts and reducing ridership[i]. In an effort to reverse this trend, the City designated Transit Preferential Streets in its General Plan and installed bus-only lanes on many of these streets in the downtown core. The efficient operation of the bus-only lanes is often compromised by non-transit vehicles violating the exclusive lane. The City has not received many of the transit service benefits it anticipated when it installed the bus-only lanes.

San Francisco's bus-only lanes vary in type and hours of operation. Some are peak-hour curbside lanes; some are all-day or full-time curbside lanes; with the remainder as all-day or full-time dedicated lanes. Some allow taxis to operate in the lane with the buses. Where the lane is wide enough, joint bus and bike use is being investigated. The three types of lanes possess unique operating features.

Bus-only lanes in San Francisco's South of Market neighborhood
These lanes operate 24-7 and are shared with taxis and right-turners

The peak-hour curbside lanes prohibit parking during peak hours to enable the lane to convert to a bus-only lane. The lanes on Sacramento and Clay Streets through Chinatown and over Nob Hill are good examples of this type. The advantage of this type of lane is that street parking is possible when the lane is not in use. In residential areas, the availability of overnight parking for residents is a prime consideration.

All-day (7am-6 or 7pm) curbside lanes dedicate a traffic lane to bus-only use, but revert to mixed-flow operation in the evenings and at night. The lanes along Mission Street operate in this manner. It is unclear what advantage the provision of additional mixed-flow capacity at off-peak hours provides when the lane doesn't revert to parking.

Full-time dedicated bus lanes have been implemented where the street cross-section allows multiple mixed-flow lanes in addition to the bus-only lane and some on-street parking. Third Street from Townsend to Market Streets through the growing South of Market neighborhood is a good example of a full-time dedicated bus- (and taxi) only lane.

The placement of the bus-only lane affects the operation of the entire street. A curbside lane eliminates parking and requires other vehicles to enter the bus-only lane to make right turns. This can quickly lead to degradation of the bus-only lane, especially at intersections with heavy pedestrian crossing volumes that cause conflicts with the right turners.

If the lane runs next to the parking lane, a dedicated right-turn lane can be provided at intersections, allowing turning vehicles to cross the bus lane without blocking it. Combined with far-side bus bulbs, this arrangement provides an unobstructed pathway for buses.[ii] The bus-only lane on Third Street has some of these features.

Left and right hand lanes in downtown San Francisco
Some are peak hour, others are all day

Another option is for the bus-only lanes to operate in the left lane of the street. This arrangement is used where there is significant congestion caused by turning vehicles, where the lanes are shared by streetcars whose tracks are located in the middle lanes of the street or where the buses are looping to a terminal. This arrangement requires boarding islands in the middle of traffic lanes at stops, as all MUNI buses board from the right-hand side. Provision of islands requires a wider street cross section, as the islands must provide ample space to hold queuing passengers.

A survey of San Francisco's bus-only lanes shows a lack of consistency for operating hours of the lanes and uneven signage guidelines. The inclusion of taxi operation in the existing lanes is also not uniform across the City.

Enforcement of the bus-only lanes is handled by a detail of the San Francisco Police Department assigned to MUNI. As of 2004, there were 13 officers assigned to the detail, which covers all MUNI enforcement, including fare evasion and transit lane violation. According to the San Francisco Transportation Authority, along the transit lanes in the Civic Center area on Market Street, over one-quarter of the vehicles on the street are violating the bus-only lane during the day, with over 60% of the vehicles violating the outbound bus-only lane in the pm peak hour. While the report notes that boarding time for the buses is the most significant cause for delay, the violation of the bus-only lanes keeps buses from accessing the boarding islands, causing them to wait more than one cycle at many signals to cross each intersection.[iii]

As congestion grows on a street, violations of the bus-only lane increase. In the left photo, three vehicles are violating the bus-only lane. None are in the right photo.

San Francisco has established a strong network of bus-only lanes, but their operation is hampered by spotty enforcement, resulting in violation of many of the lanes by mixed-flow traffic or illegally stopped vehicles. Additionally, lack of consistent operating times and signage / street markings can lead to confusion conditions for drivers not familiar with the concept of bus-only lanes. (The lanes are marked with a diamond and “Bus Only” text. The diamond is recognized throughout California as a carpool lane, not a transit only lane.) All these problems can be overcome, leading to efficient bus-only lanes, speeding the MUNI’s service in the City.

Survey of Bus-Only Lane Technology in London

Around the world, bus-only lanes have been created in response to congestion delaying transit operations in dense settings. One of the most extensive applications of bus-only lanes is London, England, where there are over 860 kilometers (537 miles) of bus priority streets that include bus priority at intersections and 24-hour enforced bus-only lanes. The London Bus Initiative (LBI) (Phase 1) was implemented between 2000 and 2003 “to deliver a step change enhancement of the actual and perceived quality of London’s bus service” with the aim of making travel by bus more attractive and getting more people to use buses.[iv]

Bus-only lane in central London
Red pavement clearly marks the bus-only lane

The LBI covered 27 high frequency bus routes. The goals of the program were to change travel habits and get more people onto buses, make improvements benefiting the whole route and make buses the first choice of mode on the LBI routes. The project spent $105 million over three years, with $19 million spent on enforcement activities, $50 million on traffic engineering, $6 million on bus operations, $16 million on program support and $15 million on major projects. This investment significantly reduced waiting times and minimally reduced travel times while congestion on the roadway network increased. Overall, patronage on the routes using the LBI increased 21.9%.

The strong results of the LBI plan are not centered on effective bus-only lanes, but the suite of engineering, enforcement and technology brought together for the project comprise an excellent toolbox from which to draw.

London recognized that manual enforcement of bus-only lanes is costly and only partially effective, as it would be prohibitively expensive to employ the number of enforcement officers necessary to patrol the extensive bus-only lane network. Instead, the London turned to video enforcement.

The initial video enforcement technology utilizes bus cameras and cameras mounted along bus-only lanes. The buses have twin video cameras. One records general roadway conditions, to establish circumstances relating to an offense. A second clearly records the license plates of the cars in the lane. Each image is recorded to a single VHS tape where time and date are added, along with vehicle location. In addition to the bus mounted cameras, there are more than 110 cameras along the bus-only network.

London is in the process of converting its analog video system to a wireless digital system. The benefits of the conversion to digital technology is discussed below. London has implemented the new technology along routes in South London to enforce violations of the bus-only lanes, with plans to bring the technology to the entire network over time. [v]

Besides enforcement technologies, London has invested in engineering and design to improve the operation of its bus-only lanes. The lanes are paved or painted entirely red and clearly marked.

Photo Enforcement Technology

Photo enforcement technologies have matured over the past 10 years. Advances in digital photography and wireless communication have reduced installation and operating costs, while image recognition software can automate much of the violation assessment process.

Initial technological solutions to video enforcement of traffic violations used either traditional photography or video tape. Each of these technologies has significant drawbacks. Conventional film cameras are expensive to operate. Maintenance of the system requires someone to regularly change the film in the camera. The film must be developed, and then the photographs analyzed manually. Additionally, there is an on-going cost to continually purchase new film and materials. Video technology has some of the same drawbacks as film. Tapes must be collected from the cameras and manually analyzed. Depending on the archive process, the tapes may be reused, reducing, but not eliminating, the on-going replacement costs.

With the maturation of digital imaging technologies and wireless data transmission, the costs of video enforcement have dropped significantly. Digital cameras require no film or development process. The image data can be sent electronically to a central computer for analysis, archiving and storage. The transmission of the data can be done wirelessly, eliminating significant capital costs to wire each camera into a network. Data analysis of the enforcement images can be automated, as well, with software culling the images of infractions to reduce the number of images that must be reviewed manually. To allay privacy concerns, software can be programmed to obscure the images of surrounding vehicles' license plates and occupants.

Beyond the analysis of single images, image recognition software can now identify the same vehicle in multiple photos taken by multiple cameras or by the same camera over some period of time. There are legitimate reasons for cars to enter and drive in bus-only lanes for short distances, and software can be programmed to identify different situations. The most common situation for an allowed violation is to merge to make a right turn at an upcoming intersection or driveway. A second situation is to avoid an obstacle in another lane. Also, a car might be pulling to the curb to pick up or deposit a passenger, or to pull into an on-street parking place.

Comparing images from multiple cameras, software can analyze if the car in the bus-only lane is merging to turn, or if it is violating the bus-only lane. The software can be programmed to ignore recurring images of the same vehicle passing the cameras leading to an intersection, recording the trip a car makes to merge across the lane to turn at an intersection, but then recognizing the action as a car legally merging to make a turn. The same software can trigger a violation if the same car stays in the bus-only lane through the intersection without turning.

Using multiple images taken from the same camera, software can determine what period of time a vehicle is stopped in the bus-only lane. If conditions permit, it might be allowable for vehicles to stop at the curb to pick up or deposit passengers. Software can analyze multiple images from the same camera to determine if the vehicle is stopped for too long, or is obstructing a bus. Additionally, if it is determined that taxis may share the bus-only lane, the software can identify taxis by the protruding signs on the roof of the vehicle and not record a violation. [vi]

Photo Enforcement in California

Legal and technical issues surrounding the use of camera enforcement for red light violations in California has been well researched. The California Auditor General issued *Red Light Camera Programs: Although They Have Contributed to a Reduction in Accidents, Operational Weaknesses Exist at the Local Level* in 2002. It outlined the features of the various red light camera enforcement programs in California. It examined the design, implementation and operation of seven cities' programs, as well as legal challenges to the programs. The framework for photo enforcement of bus-only lanes is much the same as for the red light programs. Therefore, the challenges encountered initially by California's red light programs can inform the potential challenges to establish photo enforcement of bus-only lanes.

The State Auditor General's report identified a number of legal and technical issues that dogged early photo enforcement programs. The report noted that to ensure the local law enforcement agencies remain in charge of the operation of the program, governments must maintain a high level of oversight over the operations of the private contractors who operate the cameras and generate the data that leads to the issuance of citations. It was also suggested that municipalities periodically inspect the cameras to ensure that they are operating according to the initial specifications; and to make sure they have not been adjusted to record and flag violations that are easy to challenge. Policy issues over using the images for law enforcement purposes beyond red light enforcement, such as providing the images for evidence of auto theft, are unresolved. Some cities lacked engineering and safety criteria for camera locations and others avoided placing cameras at intersections where multiple jurisdictions would be involved in their approval and operation. Finally, many cities didn't pursue engineering solutions to increase intersection safety before turning to the photo enforcement solution.

The report listed seven elements of oversight necessary to ensure significant involvement by local authorities. These are:

- conducting periodical visits to the vendor's operations facility
- providing clear business rules to the vendor
- auditing the issuance of unauthorized or unapproved citations
- making misuse of images a breach of contract
- making sure records are kept confidential
- limiting the time images are kept before being destroyed
- periodically conducting technical inspections of cameras[vii]

Selection criteria for intersections were discussed, with some applicable to bus-only lanes, including traffic volumes, safety of enforcement officers, technical suitability for camera enforcement, recent or planned improvements, community and law enforcement input and funding sources.[viii] Engineering measures were also discussed, with signage and lane marking improvements applicable to bus-only lanes.

The California Vehicle Code 21455.5 governs the implementation and operation of red light camera enforcement programs. The legal requirements require the placement of warning signs at either each intersection or city or county entrances, issuance of public notices before the start of the program, issuance of warning citations for the first 30 days of the program, approval of all citations by sworn officers or qualified personnel and a city or county public meeting before approval of an installation and operation contract.[ix]

The Auditor's report found that the introduction of red light enforcement cameras reduced the number of collisions at intersections from 11 to 55%. The accident reductions were greatest for jurisdictions that had the longest operating programs. San Francisco experienced a 33% reduction in collisions at intersections with cameras.[x]

Camera enforcement is effective, but is either revenue neutral or operates at a slight loss. Poor accounting practices were highlighted in the State Auditor's report. Many jurisdictions initially paid their vendors on a per-citation basis, but did not reconcile the vendor's invoices against the tickets that were actually paid in court. Some cities are moving away from per-citation payments to a flat fee. A flat fee arrangement requires larger periodic payments for the system's operation, but eliminates the possibility and perception that the vendor is tweaking the system to maximize the number of citations issued. [xi]

Potential Improvements for San Francisco

The focus of this paper is to make the operations of San Francisco's bus-only lanes more efficient. Issues surrounding the expansion and addition of new bus-only lanes is left uninvestigated.

Improvements to San Francisco's bus-only lanes can be grouped into four phases:

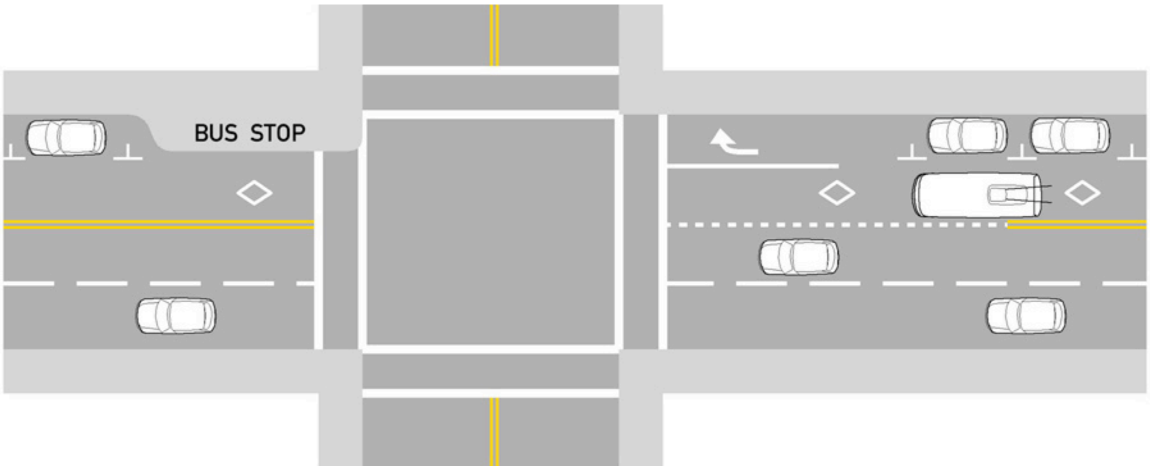
- Standardize operating hours, signage and markings
- Improve enforcement
- Traffic operation improvements
- Civil and streetscape improvements

Investigation of San Francisco's existing bus-only lanes uncovered a myriad of operating times, described at the beginning of this paper. Motorists driving through the City encounter the same markings for lanes that may or may not be in operation at any given time. Signage varies with the hours of operation and permitted vehicles, buses only or buses and taxis. (There is also the potential for bicycle usage where the lane is wide enough.)

Standardization of bus-only lanes throughout the City should be a top priority. Operating hours should be divided between daytime lanes and fulltime lanes. The daytime lanes should be standardized where the bus-only lane requires a restriction on parking in a residential neighborhood. By abandoning the bus-only restriction overnight (7pm-7am) and enforcing the bus-only lane during the day (7am-7pm), the neighborhood retains parking overnight and the buses have priority during the day. Lanes elsewhere should be enforced 24 hours. The practice of letting the bus-only lane revert to mixed use operation in off-peak hours adds mixed-use capacity when it is not needed, so it serves no functional need. By enforcing lanes 24 hours, the permanence of the lane is reinforced. This also makes lane marking schemes clearer.

Signage should be standardized to the two types of lanes. The midday lanes which replace curb parking should be marked with a sign that combines the bus-only restriction with the parking restrictions. The 24 hour lanes should be signed more than once a block.

Street markings should be enhanced, especially along the 24 hour lanes. London marks its bus-only lanes with red pavement. The placement of the bus-only lane should also be identified to determine if a double yellow line should separate the bus-only lane from the mixed use lanes. This would be done in locations where there is no reason for autos to enter the bus-only lane, and should be marked with attention given to traffic conditions at intersections. For example, if traffic is allowed to merge into the bus-only lane to make right turns, the length of marking allowing passage into the bus-only lane should reflect queuing conditions at the intersection. If a stronger approach is favored, the bus-only lanes could be painted or paved completely in an identifying color, as in London. The current practice of marking the lane with a diamond confuses many drivers, as the diamond symbol is recognized as the "carpool lane" on freeways and expressways in California.[xii]

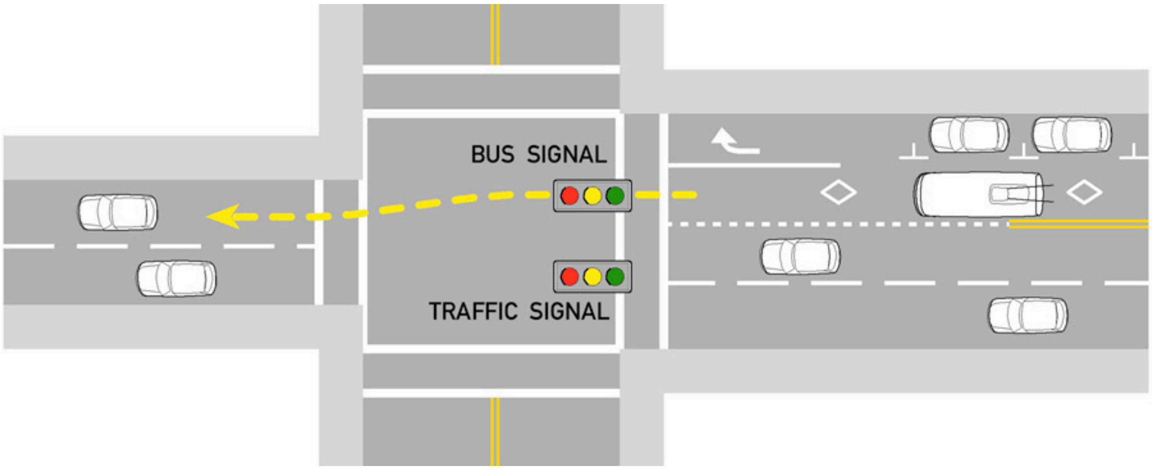


Striping should reflect the locations where it is permissible to enter the bus-only lane

Enforcement should be increased where buses are regularly hampered by congestion caused by other vehicles violating the bus-only lane. A pilot program adopting digital photo enforcement in the most congested areas should be initiated. Bus operations before and after the enforcement should be studied to clearly quantify the benefits of the program. The pilot program should investigate the locations where bus operation is most delayed by bus-only lane violations and where the lane carries a high number of buses. Potential pilot locations need not cover a long corridor, keeping the initial capital investment for cameras and related equipment to a minimum. Establishing remote photo enforcement of bus-only lanes would require an addition to the California Vehicle Code, just as the establishment of red light camera programs did.

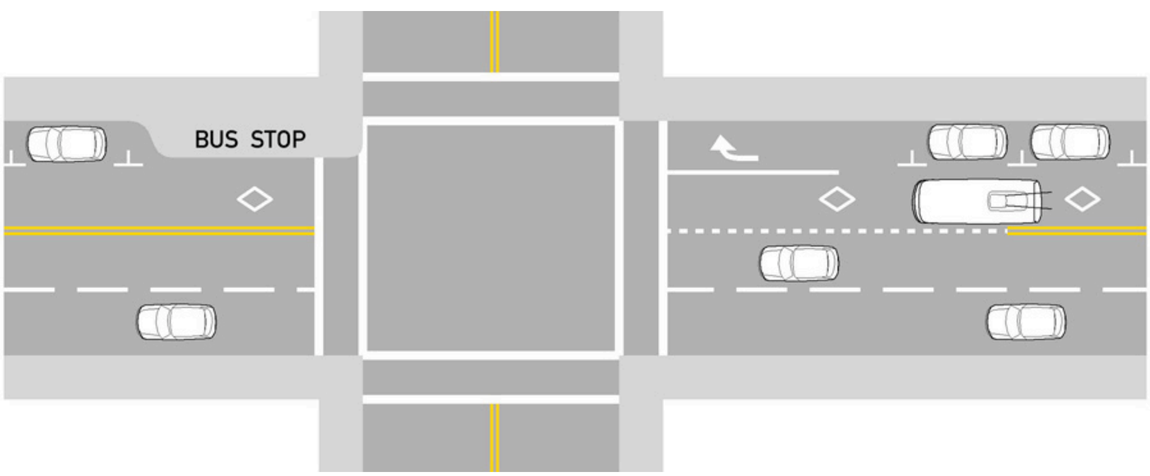
In locations where bus-only lane operations are compromised by congestion from traffic legally merging across the bus-only lane to make right turns, modifications to traffic signal operations should be undertaken. Introduction of right turn phases and changes to pedestrian crossing phases can help clear congestion. Provision of right turn pockets of an adequate length is also a crucial component to clearing queued traffic from the bus-only lane.

Queue-jump lanes provide a bypass lane for transit vehicles at signalized intersections to pass stopped mixed flow traffic queued at the intersection. The signal phasing provides a special phase for the transit vehicle to cross the intersection, moving it past the other vehicles stopped at the intersection. This can allow buses to make a curbside stop on the right side of the street and then make a left turn across lanes at the intersection. At locations where the bus-only lanes end, queue-jump phases should be added to traffic signals to allow buses to enter mixed-flow lanes prior to the release of the remaining traffic.



Queue-jump signal allows bus to cross intersection prior to mixed traffic when bus-only lane ends

Streetscape improvements should be considered to improve the efficiency of bus-only lane operations. The addition of bus bulbs along streets where the bus-only lane is next to a parking lane utilizes redundant bus lane width to provide an easily identified stop location without reducing parking. In some cases, it might be possible to gain a parking space, as the length of the bus bulb only needs to accommodate the stopped bus, and not the additional distance for the bus to pull out from the curb. The bulb eliminates the need for the bus to pull in to the curb. Moving the bus stop to the far-side of the intersection can be combined with traffic signal modifications that extend the green for approaching buses. This also frees the near-side curb for an exclusive right turn lane for autos.



Far-side stop allows near-side space for right turn lane for autos.

Other streetscape improvements could include physical barriers, such as curbs or medians to separate the bus-only lane from the traffic lanes.

Conclusions

The engineering and technology exist to improve the efficiency of bus-only lanes. San Francisco should standardize the hours of operation, signage and markings for its bus-only lanes to improve bus service while decreasing operating costs. California has carefully studied the implementation of photo-enforcement of red lights; the use of photo enforcement for bus-only lanes is a natural extension of the technology. Traffic and civil engineering solutions can further improve the efficiency of bus-only lanes.

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Endnotes

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[viii] ibid

[ix] CaliforniaVehicle Code (CVC) Section 21455.5, Traffic Signal Automated Enforcement

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[xi] ibid

[xii] Market Street Study Technical Report – San Francisco County Transportation Authority, 2004 (http://www.sfcta.org/documents/ExistingConditionsReport.pdf)