Enhancing Capacity and Managing Demand to Increase Short-Term Throughput on the San Francisco-Oakland Bay Bridge

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INTRODUCTION

As anyone from the San Francisco Bay Area can attest, trying to get to San Francisco from the East Bay can be a nightmare during the morning peak period. Currently, there are four main ways to cross the Bay between Oakland and San Francisco: by car or by bus on the San Francisco-Oakland Bay Bridge, by train through the Bay Area Rapid Transit's (BART's) Transbay Tube, or by ship on the San Francisco Bay Ferry (AKA "WETA"). However, all of these modes are at capacity and straining to cope with the increasing travel demands of the region.

To deal with this demand, there are proposals to expand or build new infrastructure. For example, public officials have begun discussions on building a second Transbay Tube to relieve crowding in the existing tube, and provide additional capacity [1]. However, this tube is at least 30 years off due to major financial and political challenges. Additionally, while a second Bay Bridge has never progressed beyond discussions, some proponents are advocating for its construction [2]. In light of recent experiences with challenges/delays these long-term infrastructure projects in California and elsewhere (e.g. high-speed rail) have faced, short-term solutions need to be explored to increase capacity across the bay while the long-term solutions (e.g. second Transbay Tube) are implemented. Sixteen different short-term solutions were determined based on research by the Metropolitan Transportation Commission (MTC), a literature review of existing research into urban congestion relief, and original research [3-9].

Figure 1 on the next page provides a comprehensive overview map of the San Francisco Bay Area and all relevant points to this research. It also includes markings for each of the strategies proposed later on that is bound to a physical location (some strategies are region-wide or otherwise not location-specific). These markings are color coded by priority order. The strategies and their order of priority are discussed after the brief data introduction below.

DATA OVERVIEW

In order to help assess these sixteen strategies and get a better feel for the transbay situation as a whole, ridership and capacity data was gathered for private vehicles and buses on the bridge, BART trains in the Transbay Tube, and WETA (the ferry) on the bay itself. Bus service was broken down by the three transit agencies utilizing the bridge: AC Transit with service to western Alameda and Contra Costa counties, WestCAT Lynx with service to Hercules in northwestern Contra Costa County, and Soltrans Route 200 with service to Vallejo in southwest Solano County.

Hourly vehicle data is the most discrete data available, and high-occupancy vehicle versus general purpose vehicle data was provided for the westbound direction (into San Francisco) at the bridge's toll plaza. The hourly vehicle data was simply quartered into 15 minute increments to best fit with the available transit data. For converting vehicles to people, it was assumed that the provided average ridership per vehicle into San Francisco (1.54 persons per vehicle) would equal the ridership per vehicle out of San Francisco.

In terms of transit, exact ridership, capacity, and timetable data was provided for each trip on WETA, WestCAT Lynx, and Soltrans Route 200. For AC Transit, ridership and load factor (which was converted to capacity) was provided for each trip. For BART, exits at each station in 15 minute bins was provided. Using station-to-station travel time, this was converted to the 15 minute bin at which each rider was in the Transbay Tube. A diagram of this ridership by mode for every 15 minutes is provided by Figure 2, split into the westbound (into San Francisco) and eastbound (out of San Francisco) directions.

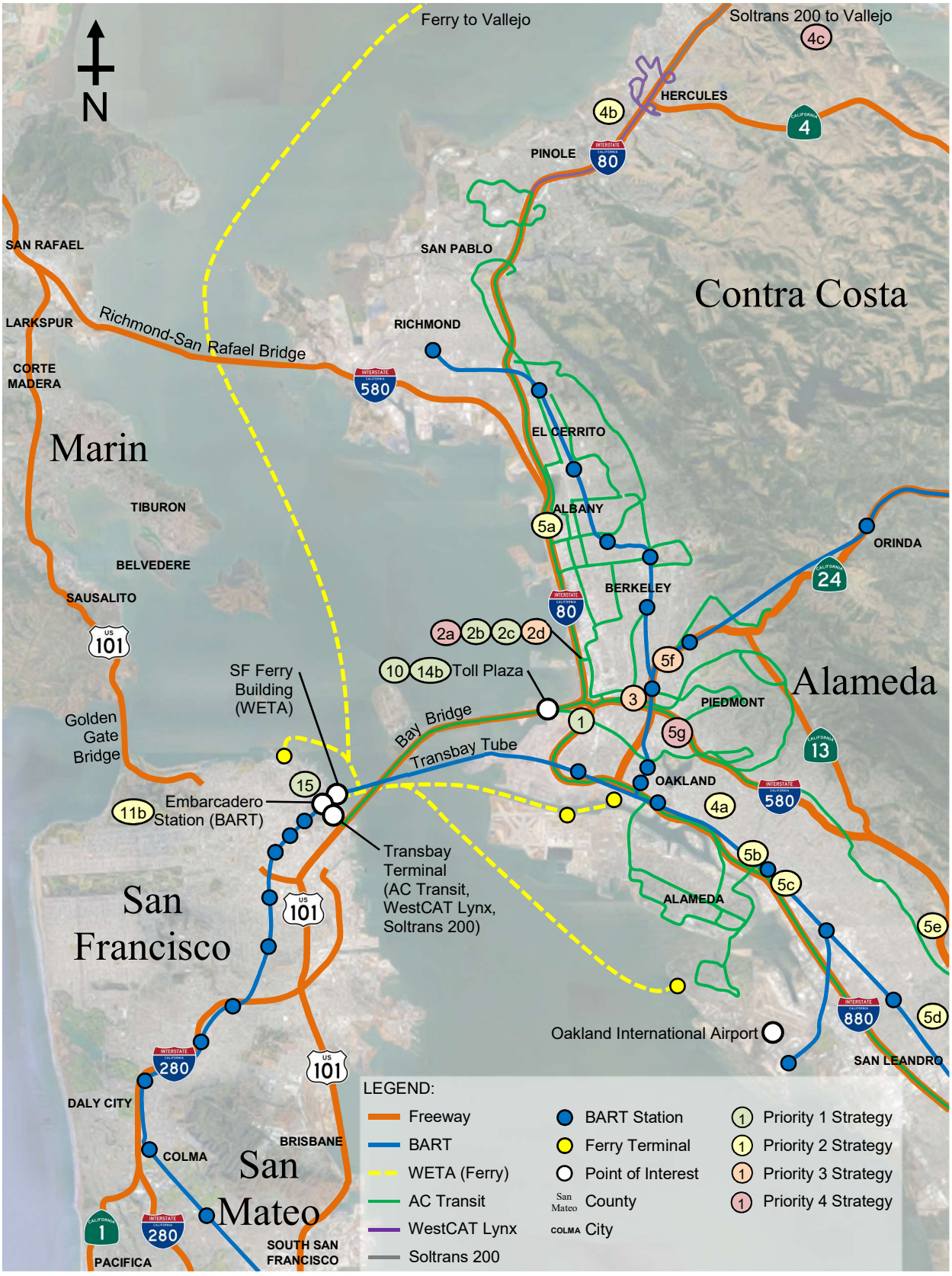
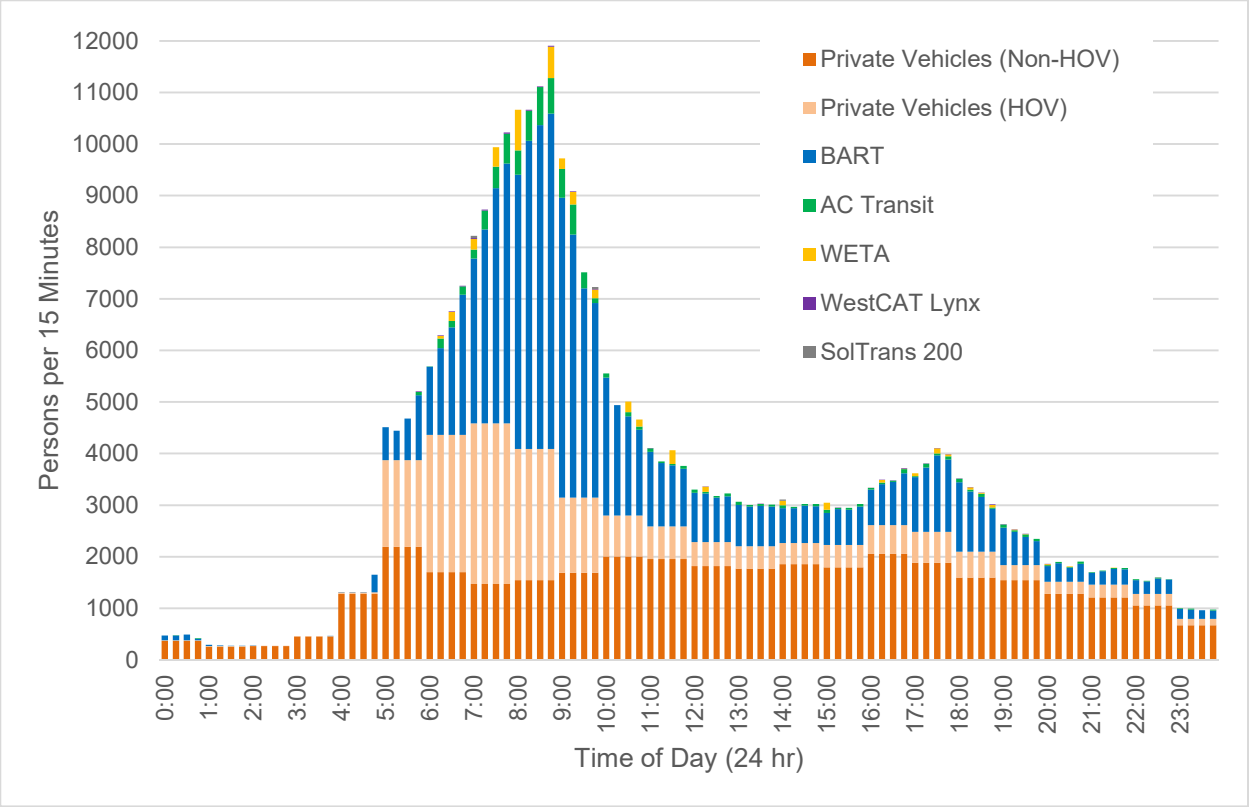
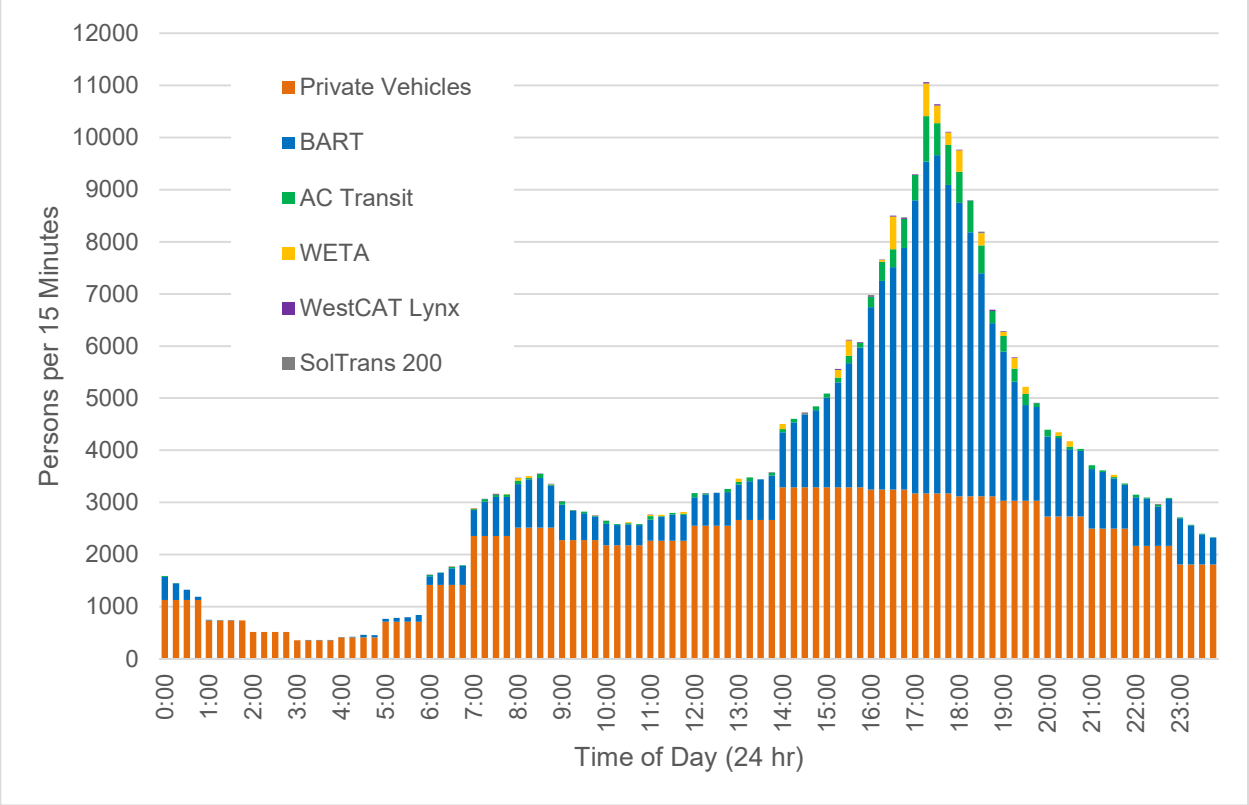


Figure 1: San Francisco Bay Area and Relevant Regional Features



(a)



(b)

Figure 2: Person Throughput Westbound (a) and Eastbound (b) across the Transbay Corridor by Mode

ALTERNATIVE ANALYSIS

Now that it has been shown how the transbay services are straining to keep up with demand during peak commute hours, solutions can be explored. As mentioned in the introduction, a second bridge or tube is many decades away at best. Therefore, the focus here is on solutions that are more short-term. Sixteen strategies have been proposed in two broad categories: capacity enhancement and demand management.

Capacity Enhancement

The first category, capacity enhancement, contains twelve strategies that focus on improving the capacity of the transbay corridor. These include tactics focusing on adding onramp HOV queue jumps, incentivizing carpooling, and increasing transit capacity.

Strategy 1 is to create an HOV/transit queue jump on West Grand Avenue in West Oakland. Currently, there is a wide shoulder on the West Grand Avenue onramp onto I-80 that is unused except by occasional buses or HOVs illegally jumping the queue of cars waiting for the toll plaza. This tactic would legitimize this queue jump by improving the hardscape to bus lane standards, including restriping, signage, upgrading drainage inlets, and enforcement. This incentive was first proposed by MTC [3].

Strategy 2 proposes several changes to the Powell Street and I-80 interchange in Emeryville, as well as to I-80 through Emeryville, to improve the attractiveness of HOV and transit. These changes include adding a right-side HOV lane on I-80 from the southbound Powell off-ramp to the existing right-side HOV lane before the toll plaza, converting the existing southbound Powell onramp to HOV and adding movements from the Powell Street intersection to allow more approaches to access the ramp, and building a new park-and-ride lot under the I-80 overpass.

Strategy 3, much like Strategy 1, focuses on adding an HOV lane, this time from MacArthur Boulevard to I-580 towards the Bay Bridge in Oakland. Currently, there is no movement from MacArthur Boulevard to San Francisco. The original proposal comes from the Bay Area Toll Authority (BATA) [4].

Strategy 4 takes a look at expanding transbay bus service. BATA originally proposed expanding AC Transit service with two new lines, and improved capacity on existing lines [4]. To expand on these recommendations, perhaps WestCAT could expand Lynx service to Contra Costa County cities that are unserved by BART other than Hercules, such as San Pablo, Pinole, and Martinez. As well, perhaps SolTrans could expand their Vallejo-San Francisco (Route 200) service to Fairfield and possibly Vacaville.

Strategy 5 looks at expanding park-and-ride capacity in the East Bay. Currently, there are four lots with 503 stalls of capacity in northwest Alameda County. MTC proposes adding 700 more stalls in three lots, and this research suggests another 569 stalls in four lots, for 1,772 stalls and eleven lots total. Other elements of this strategy include expanding BART parking capacity, and partnering with rideshare mobile applications as an alternative to additional parking capacity.

Strategy 6 has two components, both related to partnering with ridesharing mobile applications. The first component includes vanpool/minibus apps like RidePal, Bridj, MagicBus, and Chariot, that could complement existing transit services. The second component includes casual carpool apps like Via, Scoop, uberPOOL, and Waze Carpool, that could increase HOV rates.

Speaking of casual carpooling, Strategy 7 involves enhanced casual carpooling. This is a high-tech method of increasing car occupancy beyond the minimum to qualify for HOV, using incentives such as toll discounts or VMT tax rebates. This strategy is based on Kalon Kelley's research [8].

On a more cultural level, Strategy 8 seeks to shift attitudes on carpooling to be more attractive. Wang and Chen show that awareness programs can have a massive benefit at an economical cost [9].

If increasing carpooling appeal does not work, Strategy 9 is to increase HOV enforcement, which has been shown to be highly effective in Los Angeles [10]. Another idea comes from WSDOT, who sends educational materials to offenders, as reported by other road users [11]. This either persuades or guilts offenders into compliance, without punishing victims of false reports.

Back to hardscape improvements, Strategy 10 proposes upgrading the Bay Bridge Toll Plaza to electronic tolling to expedite the toll process, similar to the Golden Gate Bridge's successful program.

Underneath the bay, Strategy 11 is to increase BART capacity, either through improving train capacity by adding cars so that all peak-hour trains are at the ten car maximum, or improving station capacity at the most impacted stations.

Speaking of BART, Strategy 12 is to alter BART service. This can be done either through skip-stop "metro" service that increases frequency along the core of the system and speed along the suburban fringes, or through offering express service that drops stations from certain trips to increase track capacity.

Demand Management

The second category of strategies for improving operations across the transbay corridor, demand management, contains four strategies that focus on shifting demand away from peak periods.

Strategy 13 implements congestion pricing, either to offset demand or increase occupancy. Demand can be offset simply by charging more during peak hours and less during off-peak hours. Occupancy can be increase by expanding the current binary HOV/non-HOV tolling scheme to offer further discounts at higher occupancies.

Speaking of tolling, Strategy 14 is to reimplement eastbound tolling on the Bay Bridge to add the carpooling and off-peak incentives of the westbound direction to the eastbound direction. Utilizing Strategy 10's electronic tolling would minimize the real estate needed to avoid reducing capacity.

Like Strategy 8, Strategy 15 seeks to change corporate cultures to promote telecommuting or reduce workplace car demands. San Francisco has a large office workforce, many of whom could partially work from home, taking cars off of the road and riders off strained transit assets.

Lastly, Strategy 16 takes a look at changing land-use planning to add more housing to San Francisco and workplaces to the East Bay. While this is certainly a longer term strategy, it is included with the rest as it needs to be undertaken starting today to have much effect in the future.

RECOMMENDATIONS

While it would be excellent to implement all sixteen proposed strategies for tackling congestion across the transbay corridor, limited funding and other constraints restrict what can be done. To that end, each strategy has been evaluated for merit below, ranked in order of priority in Table 1 on page 6, and plotted in terms of cost versus benefits in Figure 3 on page 7.

For strategies with multiple components, the components have been denoted alphabetically under the number of their parent strategy. Each of these parts has been assessed for cost and effectiveness, either in terms of capacity increase or demand offset. Some elements are able to be directly quantified. However, most require some level of estimation. To this end, a series of bins has been devised to help sort the strategies while keeping estimates at an appropriately high level. For cost, seven bins have been created, ranging from "less than $500,000," to "greater than $100,000,000." There is also a "net gain" bin for the select few projects that will directly pay for themselves, either through increased revenues or decreased costs. Specific benefits differ based on each strategy, but for comparison are binned from "no benefit," to "extensive benefit." Of note, Strategy 4c (expanding SolTrans Route 200 bus service), has been dropped from the analysis due to the planned abandonment of Route 200.

Table 1 lists the strategies by priority group, in decreasing order of priority. Priority 4 is for strategies that should not be implemented. It is important to note that the contents of each group are not ranked by priority, but rather the arbitrary order in which they are listed in this research.

Figure 3 maps these strategies visually, using smaller circles with more defined borders to denote more exact cost estimates. Of note, while left-to-right positioning within each column roughly approximates cost, top-to-bottom positioning within each row is simply numerical rank. E.g. all of the strategies listed in the "Some Benefit" row have approximately the same benefit no matter their vertical positioning, but strategies on the right of the $1m-$5m cost column are anticipated to be more expensive than those on the left. Lastly, the graph has a background shading from green to yellow to orange to red, to denote decreasing priority optimization.

Table 1: Roster of Strategies by Priority

Priority 1: Implement Now	
1a	Upgrade West Grand Avenue Onramp to Bus Lane Standards – Base Proposal
1b	Upgrade West Grand Avenue Onramp to Bus Lane Standards – I-580 Eastbound Onramp to Maritime Avenue Intersection Extension
1c	Upgrade West Grand Avenue Onramp to Bus Lane Standards – Extension Past Maritime Avenue Intersection
2b	HOV Improvements at Powell Street and I-80 in Emeryville – Powell Street Onramp Conversion to HOV and Adding More Movements to Access the Onramp
2c	HOV Improvements at Powell Street and I-80 in Emeryville – Convert Right Lane of I-80 to HOV from Powell Street Onramp to Existing HOV
5i	Commuter Parking – Partner with Ridesharing Apps for Station Access
6a	Partner with Developers of Ridesharing Mobile Applications – Vanpools/Minibuses
9b	Increased Enforcement – Citizen Reporting System
10	Electronic Tolling at the Bay Bridge Toll Plaza
14b	Eastbound Tolling – Convert the Bay Bridge Toll Plaza into a Bidirectional Facility
15	Changing Corporate Cultures
16	Land-Use Planning Changes
Priority 2: Implement Soon	
4a	Expand Bus Service – AC Transit
4b	Expand Bus Service – WestCAT
5a	Commuter Parking – I-80 and Buchanan Street
5b	Commuter Parking – I-880 and Fruitvale Avenue
5c	Commuter Parking – I-880 and High Street
5d	Commuter Parking – I-580 and Fairmont Drive/Foothill Boulevard
5e	Commuter Parking – I-580 and Golf Links Road/98th
7	Enhanced Casual Carpooling
8	Shifting Attitudes on Carpooling
11a	BART Capacity Increases – Improving Train Capacity
11b	BART Capacity Increases – Improving Station Capacity
12a	Altered BART Service – Skip-Stop “Metro” Service
12b	Altered BART Service – Express Service
Priority 3: Implement When Feasible	
2d	HOV Improvements at Powell Street and I-80 in Emeryville – Park-and-Ride Lot
3	MacArthur Onramp Bus Lane
5f	Commuter Parking – SR-24 and Telegraph Avenue/56th Street
5h	Commuter Parking – BART Parking Capacity Increases
6b	Partner with Developers of Ridesharing Mobile Applications – Casual Carpools
9a	Increased Enforcement – Adding HOV Facility Patrols
13	Congestion Pricing
14a	Eastbound Tolling – Downtown San Francisco Cordon
Priority 4: Recommend Against Implementation	
2a	HOV Improvements at Powell Street and I-80 in Emeryville – Convert Right Lane of I-80 to HOV from Before West Frontage Road Onramp to Powell Street Onramp
4c	Expand Bus Service - SolTrans
5g	Commuter Parking – I-580 and Broadway/Piedmont Avenue

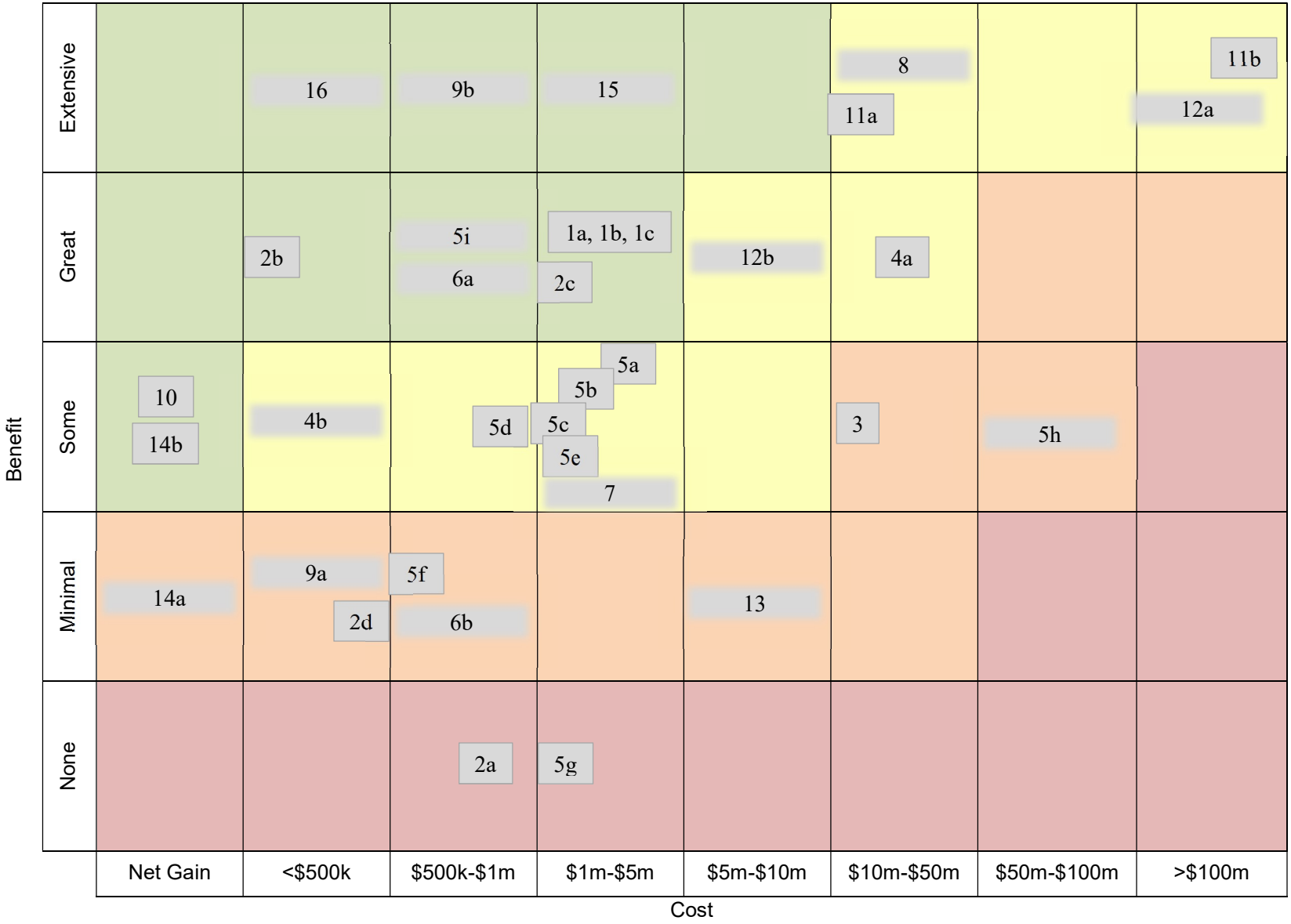


Figure 3: Strategy Cost versus Benefit Map

CONCLUSIONS

Congestion is a major issue on the transbay corridor across all modes of transportation. This severe congestion was quantitatively assessed for demand, capacity, and occupancy, in order to glean potential opportunities for improvement. Sixteen strategies were compiled, combining existing proposals and plans relevant to the transbay corridor with several new proposals, both original to this thesis and building upon past experiences and suggestions of others. These strategies were detailed and evaluated in terms of costs and benefits, and ranked in priority order. While it would be fantastic to implement every component of all sixteen strategies here and now, budget shortfalls, political will, bureaucratic inertia, and other constraints prevent this idealism.

There are several limitations to this research. Perhaps most notably is that while the data provided is mostly complete, there are some assumptions that had to be made, mostly regarding the exact times transit passengers were on the transbay corridor. Another major limitation of this research is that while some costs and benefits were quantified, many were estimated. This is due to limitations of the nature of this research, in that a full complement of technical experts is not available to accurately assess the time savings, ridership growth, or other metrics of success and their costs for each of the strategies. For the purviews of this research, estimates based on similar examples will have to do.

An overarching goal of future research should be to continue to brainstorm new ideas as well as adopt the best practices from elsewhere. This will ensure that no fresh opportunities are missed because the researchers are set in old ways. Some opportunities include improved methods of implementing dynamic tolling and even seemingly unlikely ideas such as reversible lanes or HOV lanes on the bridge itself. After all, the Bay Bridge itself was once deemed impossible.

One last goal is to continue to monitor the evolving transbay commute conditions. With each transbay mode at capacity during peak hours, the projected 30% growth in Bay Area population will have a difficult time traveling between Oakland and San Francisco without capacity enhancements or demand management. A keen eye will be needed to adapt to shifting demographics and emerging technologies. This will become especially important once connected and autonomous vehicles start to enter the mainstream.

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