Introduction

This report analyzes a new transbay crossing to provide additional travel capacity between San Francisco and the East Bay, complementing the existing Bay Area Rapid Transit (BART) tube and the San Francisco-Oakland Bay Bridge. Several Bay Area organizations have published reports advocating for or contemplating the implications of a new crossing.[1] At the same time, public agencies, city officials, regional bodies, and state-level agencies have begun to evaluate the potential for such a project. Many expect the new crossing to constitute a new line within the BART system, and simply refer to the project as a "second tube."

However, we approach this project in a new and holistic way; as such, we consider an additional BART line to be just one of several alternatives. Working over the course of a semester, our team of 15 transportation planning and engineering graduate students at UC Berkeley has analyzed a comparison of alternatives—both in travel mode and alignment—as well the magnitude and distribution of potential benefits the project would yield. We have also turned to the historical context of Bay crossings and regional megaprojects in analyzing the governance, risk management, and funding and financing implications for a new crossing, providing recommendations in each case.

Given a multi-billion dollar project with widespread and long-lasting impacts, a thorough social equity analysis is imperative. To that end, this report carefully considers project benefits and involvement in the planning process across a range of communities. We provide a set of recommendations for how a new crossing can best serve the needs of the region and promote equitable outcomes.

A Megaproject in a Megaregion

There is a growing body of literature on megaprojects, which can most easily be thought of as multibillion-dollar infrastructure developments.[2] A new transbay crossing would definitely qualify as a megaproject, given early cost estimates between $8 billion and $12 billion.[3] (Such preliminary estimates usually mark the lower bound of eventual costs and do not include financing or operations and maintenance costs.) This project would be larger and more expensive than the combined scale of many other major Bay Area transportation projects of recent years, including the Bay Bridge Eastern Span replacement, the San Francisco Central Subway, Caltrain electrification, and BART extension projects in the East Bay and South Bay. The time scale for the project could also be immense—these same recent major projects in the Bay Area have taken between 15 to 28 years to complete from the start of planning.

Thus, a new transbay crossing would be significant not just for the nine-county Bay Area but also for a much larger *megaregion*. The megaregion concept is not new. A consolidated "Northern California Megaregion" including the Sacramento and Stockton metropolitan areas was first identified by the Regional Plan Association's *America 2050* project and expanded upon in a 2007 report from SPUR, *The Northern California Megaregion*. In 2016, the Bay Area Council published a report arguing that

[1] For a list reports that have informed this project, see Appendix A: Annotated Bibliography.
[2] Flyvbjerg, B. Buzelius, N. Rothengatter, W. *Megaprojects and Risk: An Anatomy of Ambition*. 2003.
[3] "The Case for a Second Transbay Transit Crossing." Bay Area Council. February 2014. http://www.bayareaeconomy.org/report/the-case-for-a-second-transbay-transit-crossing/

"challenges in housing, land use, jobs, transportation, and the environment have crossed regional boundaries," making planning at the megaregion scale necessary.[4] Indeed, this project would likely benefit from a planning process at the megaregion level.

In the Bay Area, the Metropolitan Transportation Commission (MTC) complements the traditional concentration of planning at the municipal and state levels, but this organization is still limited to a scale smaller than the megaregion. The U.S. Department of Transportation has recently funded research into the role and importance of megaregions in transportation planning, and it is likely there will be more institutional interest in addressing infrastructure investment at the megaregion scale in the near future.[5] A new transbay crossing could be a test case for such an effort.

Scope of Analysis

Our analysis of the potential new crossing is grounded in a consideration of social equity. Transportation infrastructure in the Bay Area has historically not been planned or executed with the needs of disadvantaged communities in mind. At the same time, these communities have frequently borne the costs of that infrastructure without sharing in the full benefits. This legacy informed an awareness of the need to not only avoid past mistakes, but also proactively orient a future project around improving social equity. Our primary geographic scale for this analysis is the five-county core of the region. However, we also take into consideration the traditional nine-county Bay Area, as well as the Northern California megaregion.

Research Design

To inform our key considerations, we first reviewed recently published reports from advocacy and nonprofit organizations as well as public agency documents.[6] We supplemented our review with formal and informal interviews of representatives from transportation agencies; planning organizations; transit providers; advocacy organizations focused on social equity and disadvantaged communities; and municipalities from the Bay Area, California and across the country.

To analyze the impact of different travel modes and crossing alignments, we began with alignments proposed in published reports and in our interviews. We added stations and alignments that appeared promising for the group's equity goals, subject to engineering feasibility. We then ran the proposed alignments through both MTC's regional travel model and land use model to provide projected future land use and travel data for the various alternatives.

In addition to the modeling outputs, we utilized existing data on the transbay corridor and region to inform public health, economic development, and resiliency analysis. We conducted a supplementary

[4] "The Northern California Megaregion: Innovative, Connected, and Growing." Bay Area Council. June 2016. http://www.bayareaeconomy.org/files/pdf/The_Northern_California_Megaregion_2016c.pdf.
[5] Ross, Catherine L. "Megaregions: Literature Review of Organizational Structures and Finance of Multijurisdictional Initiatives and the Implications for Megaregion Transportation Planning in the U.S." U.S. Department of Transportation, Federal Highway Administration. October 2011. https://www.fhwa.dot.gov/planning/publications/megaregions_report_2012/megaregions2012.pdf.
[6] Refer to Appendix A: Annotated Bibliography for a list of reports and for summaries of each.

literature review and case study analysis to inform research on risk analysis, governance structures, resiliency, finance and funding, and social equity.

This report is organized into the following topics:

- **Key Considerations:** A presentation and justification of overarching purpose and need statements for a new crossing. The five key considerations guiding our analysis are: social equity; accessibility and connectivity; land use planning coordination; climate change mitigation; and resilience and adaptation.
- **Policy Context and Current Conditions:** This section gives context for the existing and future transportation and social equity issues facing the region. Includes a presentation of the existing travel and land use patterns, economic conditions, and socio-demographic makeup of the Bay Area. A discussion follows of the relevant state, regional, and local policies that directly affect and inform the potential construction of a new crossing, as well as a description of the key agencies likely to be involved.
- **Historical Context:** Discussion of a new crossing must grapple with the history of San Francisco Bay crossings and regional megaprojects. Major infrastructure projects in the Bay Area have often experienced controversy stemming from cost overruns and negative impacts to low-income neighborhoods. This section first assesses that history, then offers a series of case studies that explore how social equity is incorporated in megaprojects across the country.
- **Social Equity Opportunities:** The process by which a new crossing is designed, built, funded, and operated will determine the extent to which it benefits disadvantaged communities. These communities historically have suffered in the planning and construction of major infrastructure projects, and this section analyzes what opportunities exist at all stages of the process to maximize equitable outcomes.
- **Governance and Risk Management:** This section explores the potential benefits and drawbacks of different governance structures for the project delivery and operation of a new crossing. Risk management is a particularly important aspect of this analysis given the massive scale a new crossing represents. Case studies from across the country offer insight into the potential risks and rewards of these governance structures.
- **Performance Metrics and Alternatives Development:** Using the goals established in the key considerations, a set of performance metrics to judge potential crossings is proposed, defined, and justified. Four alternatives to be studied are then described. They include two BART-only alternatives, one standard rail alternative, and a no-build alternative with dynamic pricing and improved bus service on the Bay Bridge.
- **Alternative Analysis:** This section assesses the performance of each alternative compared to baseline and each other. Estimates for quantitative metrics are derived existing regional datasets, as well as from running each alternative through MTC's

UrbanSim land use model and Travel Model One. The potential for further extension and refinement of the models is also analyzed.

- **Funding and Financing:** The funding & financing section outlines key recommendations for appropriate cost estimating and incorporation of equity concerns in transportation fundraising. Two funding scenarios are presented: an ideal and constrained, with assumptions explained by funding source. Innovative funding tools used in Sao Paulo and Denver are analyzed with discussion on applicability and adaptation for a third crossing.

The report also contains the following appendices:

- **Appendix A**: An annotated bibliography of reports and resources that discuss a third crossing.
- **Appendix B**: Communities of Concern Definitions from the Metropolitan Transportation Commission
- **Appendix C**: Transbay Travel Patterns
- **Appendix D**: Performance Metric Sources & Methodology
- **Appendix E**: Land Use Scenario Outputs for Various Model Runs

Key Considerations

Approach

Drawing from existing reports on the potential next transbay crossing and adding our own concerns, we developed a set of considerations in five topic areas. These considerations guide our analysis of a new transbay crossing. We modeled the development of these considerations after the problem statement formation process used to guide major infrastructure reports. Our performance metrics for evaluating alternatives are based on these considerations.

The five key considerations are:

- Social Equity
- Accessibility and Connectivity
- Land Use Planning Coordination
- Climate Change Mitigation
- Resilience and Adaptation

It may seem counterintuitive that we have not included system capacity explicitly in this list. However, system capacity constraints are embedded in all of these concerns as a means of addressing the larger goal. For example, the social equity discussion explains how crowded transit vehicles create spatially uneven impacts. Similarly, land use planning coordination aims to allocate system capacity efficiently with coordinated development to encourage alternatives to driving. So although we do not list capacity as a concern per se, it is ubiquitous throughout the considerations.

Social Equity

Summary Statement

Low-income communities and communities of color are disproportionately burdened by the shortcomings of the existing transbay transportation system, adding to the historical harm large infrastructure projects have brought. In these communities, unreliable transit service can inhibit access to economic opportunities. At the same time, many low-income residents are exposed to air pollution from heavily traveled freeways and are more vulnerable to displacement pressures associated with new investment. Transportation projects like a new transbay crossing have the opportunity and obligation to provide social equity benefits that combat these challenges.

Consideration Description

An equity analysis of a transportation project, plan, or policy typically involves grouping individuals to demonstrate benefits received or costs borne. Such analysis may show that a project privileges people of a certain geography, socioeconomic status, age or generation, or travel mode (Transportation Research

Board, 2011).[7] In the Bay Area, large transportation investments have historically created inequitable burdens to two groups: low-income communities and communities of color.

For example, in the 1960s the construction of BART, new freeways (see Figure 1), and urban renewal projects destroyed over 5,100 housing units in the predominantly black neighborhood of West Oakland. The disruptions forced a net outmigration of over 14,000 residents—almost 4% of the Oakland population at the time (Rhomberg, 2004, Metropolitan Transportation Commission & Association of Bay Area Governments, n.d.).[8, 9]

Figure 1: Demolition for the cypress freeway in West Oakland

Source: "The Changing Face of Oakland," n.d.[10]

More recently, BART's Oakland Airport Connector project was found to have violated Title VI of the Civil Rights Act of 1964 by planning and designing the rail extension without properly considering the project's impact on low-income communities and communities of color, many of whom work in and around the Oakland Airport (Lekach, 2014).[11] Although the project proceeded and has achieved its ridership goals, transportation advocates have argued that bolstering the existing bus service would have been less expensive and enabled more investment in the overall BART system, benefitting a larger

[7] Transportation Research Board. (2011). *TRB Special Report 303: Equity of Evolving Transportation Finance Mechanisms*. Washington, D.C.: Transportation Research Board. Retrieved from http://www.nap.edu/catalog/13240

[8] Rhomberg, C. (2004). *No There There: Race, Class, and Political Community in Oakland*. University of California Press.

[9] Metropolitan Transportation Commission, & Association of Bay Area Governments. (n.d.). City of Oakland -- 1950 to 1960 Census data. Retrieved December 5, 2016, from http://www.bayareacensus.ca.gov/cities/Oakland50.htm

[10] The Changing Face of Oakland. (n.d.). Retrieved December 1, 2016, from http://oaklandplanninghistory.weebly.com/the-changing-face-of-oakland.html

[11] Lekach, S. (2014, November 20). "BART to OAK" airport connector to open after years of planning. Retrieved December 1, 2016, from https://oaklandnorth.net/2014/11/20/bart-to-oak-airport-connector-to-open-after-years-of-planning/

portion of the BART ridership population. (Baldassari, 2016[12], Cabanatuan, 2014).[13] The connector example illustrates the importance of properly analyzing the magnitude of the benefits of a transportation project in relation to the project cost, and analyzing who receives the benefits.

West Oakland still provides an example of inequitable outcomes today. The overcrowding on westbound BART trains during the morning peak hour impacts passengers boarding in downtown and West Oakland more severely than those who board BART in the suburbs. Passengers boarding in West Oakland are less likely to find a seat and more likely to be passed up by a full train. This reduction in travel reliability has a greater impact on people working hourly jobs with rigid schedules, and increased transit commute times have been linked to more frequent stress and anxiety. (Alameda County Public Health Department, 2013).[14] At the same time, proximity to transportation investments may exacerbate displacement pressures on West Oakland residents, further removing disadvantaged communities from the transportation access that is so critical.

Social equity is both the lens through which we frame our entire analysis and an explicit consideration. We focus on the topic because of our appreciation for the structural discrimination and inequities that impact lives on a daily basis. We draw inspiration from the City of Richmond's 2014 "Health in All Policies" ordinance, which explicitly encouraged all city staff to incorporate health outcomes in their decisions (Corburn, 2014).[15] A similarly holistic approach to social equity is necessary in studying a potential transbay crossing project to meaningfully address the social equity concerns with a project of this financial and geographic scale.

Accessibility and Connectivity

Summary Statement

The existing transbay transportation system currently provides inadequate and inequitable accessibility to the regional economy. To ensure that all Bay Area residents can easily and efficiently get to where they want to go, the transportation system must be connected, abundant, and reliable, with sufficient capacity in its links to significant job centers.

Consideration Description

All communities benefit from easy accessibility to both essential and leisure activities like jobs, schools, social services, and family and community spaces. Disadvantaged communities face particular constraints in this area, as low-income individuals are less likely to have access to a car and are more

[12] Baldassari, E. (2016, November 27). BART's Oakland Airport Connector losing money; Uber, Lyft to blame? Retrieved from http://www.eastbaytimes.com/2016/11/27/barts-oakland-airport-connector-losing-money-uber-lyft-to-blame/

[13] Cabanatuan, M. (2014, April 25). Sky-high cost of BART Oakland Airport link - SFGate. Retrieved December 1, 2016, from http://www.sfgate.com/bayarea/article/Sky-high-cost-of-BART-Oakland-Airport-link-5428538.php

[14] Alameda County Public Health Department. (2013). *Getting on Board for Health - A Health Impact Assessment of Bus Funding and Access*. Alameda County Public Health Department. Retrieved from http://www.acphd.org/media/308854/transithia.pdf

[15] Corburn, J., Curl, S., Arredondo, G., & Malagon, J. (2014). Health in all urban policy: city services through the prism of health. *Journal of Urban Health*, *91*(4), 623–636.

dependent on public transit services.[16] Seniors and those with disabilities are also more reliant on alternatives to driving. Transit that is unreliable, infrequent, inaccessible, or otherwise inadequately provided can therefore cause significant economic and quality of life hardships for members of these communities.

In a Bay Area context, transit system users face fragmented operations without fare or schedule integration, train overcrowding during peak hours, a lack of overnight rail service, relatively high fares, and low station densities. Each of these factors affects real and perceived access to the regional economy and general movement throughout the region. The crossings between Oakland and San Francisco together represent the most significant transportation bottleneck in the region due to the extreme travel demand between the East Bay and San Francisco. Improvements to the transbay transit system are therefore likely to produce substantial benefits in this area.

While other Bay Area transit issues are more technical in nature, addressing intermodal connectivity requires additional political considerations. It is also one of the most pressing issues facing the region, as the integration of fares, schedules, and routes can significantly increase or decrease accessibility without major changes to the larger transit network. Transit operators and municipalities must also coordinate to provide safe walk and bike paths for the "last-mile" connectivity that allows people to easily access the transit network.

Land Use Planning Coordination

Summary Statement

Future major transportation infrastructure investments must be coordinated with land use changes in order to fully realize potential benefits. If land use policies are not adjusted to concentrate employment centers and key destinations near transit project nodes, the current transbay transportation system will continue to degrade, and the efficiency of improvements to the system will be reduced.

Consideration Description

The low-density development predominant in the Bay Area since the 1950s has led to a region where most people are dependent on automobiles.[17] In addition to residential development in outlying areas, most office space since the 1970s has been built in suburban locations where low-density, auto-oriented development prevails.[18] Despite major investments in transit infrastructure, transit ridership in the Bay Area decreased by 14% between 1991 and 2012,[19] while ridership in comparable U.S. regions like Los Angeles, New York, and Miami experienced substantial increases.

[16] http://nhts.ornl.gov/briefs/PovertyBrief.pdf
[17] "Bay Area Regional Form and Population Growth." SPUR Urbanist. 1 February, 2010. http://www.spur.org/publications/urbanist-article/2010-02-01/bay-area-regional-form-and-population-growth. Accessed 6 December, 2016.
[18] "The Future of Downtown San Francisco." SPUR. March 2009. https://www.spur.org/sites/default/files/publications_pdfs/SPUR_The_Future_of_Downtown_SF.pdf.
[19] "Seamless Transit." SPUR Urbanist. 11 May 2015. http://www.spur.org/publications/urbanist-article/2015-05-11/seamless-transit. Accessed 6 December 2016.

Rail transit is typically built to both serve existing areas of land use activity and encourage denser and more sustainable development,[20] and current policies have not been sufficient to fully achieve these outcomes along BART and Caltrain lines. The development of BART did not include a planning process to require or otherwise lead to land use intensification near stations. Over forty years after BART began service, certain station areas are still not designated as regional Priority Development Areas nor have their municipal zoning regulations been altered to allow any increase in development intensity. As a result of this lack of land use response, the transportation benefit provided by BART access is available to a much smaller number of people than it otherwise would be. This reduces not only its overall impact, but also its equity benefits, as housing near a BART station can command an even higher premium. Furthermore, BART's orientation towards the suburbs rather than the core means that a car is required in order to easily access the transit network in many cases.

The inability to produce large amount of office and residential development near stations has resulted in cities across the state of California failing to reduce driving despite significant investments in transit infrastructure.[21] Barriers to growth include zoning and approvals processes that preclude multifamily housing and other dense infill development, organizational and agreement issues between development and transit agencies, and managing parking and local traffic. Existing policies have not been sufficient to overcome these challenges, and dealing with this issue must be a priority in order to maximize benefits from a potential new crossing.

Climate Change Mitigation

Summary Statement

Car travel in the Bay Area is a significant contributor to greenhouse gas (GHG) emissions, and the transportation system must shift towards greater transit use if the region hopes to meet its greenhouse gas reduction goals. The transbay corridor contains the highest travel demand, employment density, and capacity for growth in the region, and encouraging greater utilization of this corridor via improved transit is essential to this cause.

Consideration Description

The long-range regional transportation plan currently under development by MTC and ABAG aims to reduce the region's GHG emissions to 15% of 2005 levels by 2035.[22] These efforts place a high priority on shifting Bay Area residents towards transit and active modes and away from solo vehicle travel, as the transportation sector is responsible for around 40% of the region's total emissions.[23]

---

[20] Njus, Elliot. "MAX Orange Line riders aren't showing up as predicted." The Oregonian. 13 October 2016. http://www.oregonlive.com/commuting/index.ssf/2016/10/max_orange_line_riders_arent_s.html.
[21] Kolko, Jed. "Making the Most of Transit: Density, Employment Growth, and Ridership around New Stations." Public Policy Institute of California. February 2011. http://www.ppic.org/content/pubs/report/R_211JKR.pdf.
[22] Metropolitan Transportation Commission. (2016, May 16). Metropolitan Transportation Commission San Francisco Bay Area Regional Transportation Plan / Sustainable Communities Strategy Environmental Impact Report. Notice of Preparation. Retrieved from http://mtc.ca.gov/sites/default/files/PBA2040_NOP-EIR_LegalNotice.pdf
[23] Bay Area Air Quality Management District. (2015). *Bay Area Emissions Inventory Summary Report: Greenhouse Gases Base Year 2011*. San Francisco: Bay Area Air Quality Management District. Retrieved from

Roughly 125,000 vehicles travel west on the Bay Bridge each day, and BART and AC Transit transport an additional 128,500 daily riders westward across the Bay.[24] While daily flows are evenly distributed between cars and transit, around 75% of the morning peak's 39,000 hourly westbound travelers use transit, with BART carrying 64% of the load, AC Transit and WestCAT buses combining for 7%, and the Water Emergency Transportation Authority (WETA) transporting 3%.[25] However, BART is already at 110% of capacity during this time period, and planned increases in transit capacity will only raise corridor capacity to 46,000 people per hour, insufficient to meet a projected demand of 53,000 in 2040.[26] How this corridor and the rest of the transportation network accommodate this demand will in large part determine the success of the region's climate change mitigation efforts.

While climate change is a global issue, its impacts will be felt locally. Climate change is likely to exacerbate already-poor environmental conditions in disadvantaged communities, saddling them with a disproportionate share of the negative impacts. Additionally, efforts to reduce GHG emissions frequently include benefits that may not be easily accessed by disadvantaged communities. Recognizing and reversing these mismatched burdens and benefits is essential to ensuring that these communities receive equitable treatment in climate change mitigation strategies.

Resilience and Adaptation

Summary Statement

Transbay travel relies almost exclusively on the San Francisco-Oakland Bay Bridge and the BART tube. Reliance on a single crossing each for automotive travel and transit make the corridor vulnerable to disruptions from disasters or maintenance needs. To ensure resilience, the region must protect critical infrastructure and use this project to mitigate risk through redundancy.

Consideration Description

The planning for a new transbay crossing must address long-term travel demand while also promoting resilience in the Bay Area's transportation system. Resilience is best understood as insurance of critical infrastructure against vulnerability from risks like natural disasters and maintenance failure.[27] In addressing resilience, we consider critical assets and the network as a whole to be important. The system is resilient if travelers have a robust set of choices—both travel mode and route—and if service can continue after unexpected disruptions.

Early planning for BART presented the system as providing congestion relief between suburban communities and the commercial core at peak commute periods. The promotion of a commute alternative, rather than a robust network, yielded a system ill-equipped for a major hazard or service

http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Emission%20Inventory/BY2011_GHGSummary.ashx?la=en

[24] Arup. Memorandum. 2016. May 23. Same as above.

[25] Arup. Memorandum. 2016. May 23. Same as above.

[26] Arup. Memorandum. 2016. May 23. Same as above.

[27] See discussion of definitions of resilience in section three: Mattsson, L.-G., & Jenelius, E. (2015). Vulnerability and resilience of transport systems – A discussion of recent research. *Transportation Research Part A: Policy and Practice*, *81*, 16–34. https://doi.org/10.1016/j.tra.2015.06.002

disruption.[28] The BART Transbay Tube, for example, is a critical piece of the Bay Area's daily travel patterns with no alternative in the case of a disaster or maintenance issue.

The Bay Area's high earthquake risk makes vulnerability to seismic activity a key concern. Quick restoration of BART and ferry service was critical for the region's economic vitality following the Loma Prieta earthquake in 1989.[29] However, the Transbay Tube also is also vulnerable to seismic activity and could take months to restore service in the event of an earthquake.[30] Many other critical BART assets are vulnerable to sea level rise and flooding in the coming years. This is particularly true in the East Bay where tracks and stations leading to the transbay corridor are built in low-lying coastal areas. A future transbay crossing project must create an opportunity to ensure a resilient corridor and system now and into the future.

[28] See BART's history on early concepts for the system.
[29] See pg. 12 for findings from the Loma Prieta earthquake on travel behavior: Deakin, E. (1991). Transportation Impacts of the 1989 Loma Prieta Earthquake: The Bay Bridge Closure. *University of California Transportation Center*. Retrieved from http://escholarship.org/uc/item/6rb2j9pf
[30] See Section Two: Element One in BART's Climate Change Adaptation Pilot