Sustainable Cities

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Equitable Access to Caltrain

Mapping and Scheduling Analysis

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Executive Summary

Project Purpose

In July 2019, the San Mateo County Civil Grand Jury released a report calling out the lack of coordination between Samtrans' "Caltrain Connector" and Caltrain's schedules, highlighting the overall disconnection of Bay Area transit agencies. Concurrently with the report, Caltrain began creating its yearly equity analysis and SamTrans started a revision of its bus routes through a Comprehensive Operations Analysis. These developments sparked the need for a review of equity concerns for disadvantaged communities as the question of "Who is public transit meant to serve?" arose in determining what the future of public transit would look like. In collaboration with Friends of Caltrain and Seamless Bay Area, our project identifies the adequacy of access to Caltrain routes via active mobility and SamTrans' "Caltrain Connector" routes in order to determine what infrastructure and policy changes should be made to improve access for disadvantaged communities, which are designated as "Communities of Concern" by the MTC. These Communities of Concern span across the Bay Area and would benefit the most from improved access to public transit.

Methodology

In order to determine physical accessibility to Caltrain stations for Communities of Concern, we compiled data layers in ArcGIS to visualize current infrastructure, including ADA accessibility and walking distances. From there, we generated transfer times between Caltrain Connector buses and Caltrain and categorized them into wait time buckets. We then cross referenced this data with the proximity of CoC's to SamTrans routes and determine where changes could be made to scheduling to allow for better access. Data on Caltrain fares from origin to San Francisco and Diridon Caltrain stations, average ridership per station, and mode share within CoCs were added to our GIS analysis. This gives users insight into commuter usage of public transportation in CoCs.

Results and Recommendations

- **Morning and evening transfer times are less variable than mid-day.** This is understandable as on-peak hours have higher service demand.
- 59% of all SamTrans to Caltrain transfer times are within the 5 to 15 minute optimal range.
- **81% of first SamTrans buses arriving at Caltrain station miss the first train of the day.** This may disincentivize early morning commuters from using public transportation.
- **Daly City Communities of Concern would benefit from Caltrain Connector service** to have direct access to Caltrain rather than transferring from BART.
- **Future Caltrain Connector service could give passengers more choice** in what Caltrain zone they are taken to to reduce fare burden of traveling through multiple zones.
- **Providing ADA accessibility at all Caltrain stations** (South San Francisco in particular) would reduce physical barriers to take the Caltrain, regardless of the mode of arrival.

Acknowledgements

This collaborative project could not have been done without the extensive help and guidance from our instructor, Deland Chan, and our community partners, Adina Levin and Ian Griffiths. Professor Chan's direction and help with communication with our community partners ensured that this project progressed smoothly. Ian, from Seamless Bay Area, and Adina, from both Seamless Bay Area and Friends of Caltrain, guided this project on a weekly basis throughout the quarter and provided invaluable feedback. We would also like to thank Evan Lyons, manager of the Spatial Analysis Center, for teaching us how to navigate the ArcGIS suite, and Michelle Louie with San Mateo County Transit District for providing us with samTrans ridership data used in our analysis. We are incredibly grateful for our mentors and collaborators, without which this project would not have been possible.

Project Purpose

In July 2019, the San Mateo County Civil Grand Jury released a report calling for the improved schedule coordination between Caltrain and other regional transportation agencies, hereafter referred to as the Grand Jury report. Specifically, the report found that 65% of people on SamTrans "Caltrain Connection" buses wait longer than 15 minutes for the train or have fewer than 5 to make their connection. Given this poor record, it is not surprising that only 3% of commuters use SamTrans buses. The report concludes that "despite the 'Caltrain Connection' designation expressed in the logo shown in samTrans schedules [on 16 bus lines], SamTrans makes no effort to coordinate these buses' Caltrain station arrival and departure times with the Caltrain train schedules." To assist with the San Mateo Civil Grand Jury inquiry and to highlight the broader implications of equitable access along the Caltrain corridor, Friends of Caltrain partners with Seamless Bay Area to analyze the existing barriers residents face in accessing Caltrain and the contributing factors.

Additionally, the Metropolitan Transportation Commission (MTC) has identified a number of tracts in the San Francisco Peninsula as Communities of Concern (CoC), which is a designation used by various local agencies as a factor to prioritize transportation projects and funding (San Francisco County Planning Authority). MTC 2018 Communities of Concern tract geography is based on eight ACS 2012-2016 tract-level variables (Metropolitan Transportation Commission, 2017).

Disadvantage Factor	Share of Regional Population 2009	Share of Regional Population 2014	Concentration Threshold*
Minority	**54%**	**59%**	**70%**
Low-Income	**23%**	**25%**	**30%**
Limited English Proficiency	9%	9%	20%
Zero-Vehicle Household	9%	10%	10%
Senior	6%	6%	10%
People with a Disability	18%	9%	25%
Single-Parent Family	14%	14%	20%
Cost-Burdened Renter	10%	11%	15%

Source: 2005-2009 and 2010-2014 American Community Survey 5-Year Average, MTC analysis.
** Concentration thresholds are higher than the regional mean (average) but below one standard deviation.*

Table 1. Communities of Concern Threshold (Plan Bay Area 2040, 2017)

If a tract exceeds both threshold values for Low-Income and Minority shares OR exceeds the threshold value for Low-Income AND also exceeds the threshold values for three or more variables, it is designated a CoC flag. These tracts cover a diverse cross-section of populations and communities that could be considered disadvantaged or vulnerable now and in the future (San Francisco County Transportation Authority).

The Grand Jury report focuses on the need to improve scheduling coordination between SamTrans and Caltrain timetables and they have presented a number of recommendations to optimize wait times, including an alternative schedule for a specific SamTrans Caltrain Connector

line. However, their analysis did not evaluate how the effects of uncoordinated schedules would be felt by residents of CoCs, nor did it address how access to Caltrain is fundamentally an equity issue beyond just accessible transfer times. This project attempts to bring together the Grand Jury's analysis and the MTC's framework on equity by evaluating barriers to Caltrain access specifically for CoCs via a spatial and temporal analysis of infrastructure inspired by the Grand Jury report.

The results of the San Mateo Civil Grand Jury report point to the poor coordination between SamTrans and Caltrain; for this reason, we have focused our project to San Mateo County, which is where these two transportation services overlap. Although this is the case, our work can be replicated to analyze the transit systems in other Bay Area counties, including Santa Clara County, the San Francisco Peninsula, and the East Bay.

Figure 1. Transportation agencies in the San Francisco Bay Area. (Source: Seamless Bay Area)

Essential Questions

- What barriers restrict access to public transportation for Communities of Concern in the San Francisco Peninsula?
- What infrastructure, schedule, and policy changes should be made to reduce these barriers?

Community Partners

Friends of Caltrain

Friends of Caltrain is a 501(c)(3) nonprofit organization with over 7,000 participating residents on the lower peninsula spanning from San Francisco to San Jose. Their goals include stable transit funding, a modern, connected transit network, and transit-supportive policies on the corridor to increase social and environmental sustainability in the Bay Area region. They have successfully organized to prevent drastic service cuts to Caltrain service and advocated for transit-supportive policies, improved capacity, and improved affordability of Caltrain and public transit for low-income users. Executive Director Adina Levin serves on the MTC Policy Advisory Council, the San Mateo County Congestion Management and Environmental Quality Committee, and Menlo Park's Complete Street's Commission.

Seamless Bay Area

Seamless Bay Area is a not-for-profit project whose mission is to transform the Bay Area's fragmented and inconvenient public transit into a world-class, unified, equitable, and widely-used system by building a diverse movement for change and promoting policy reforms. Some of their initiatives include raising public awareness, advancing legislative reforms, and conducting tactical advocacy. Ian Griffiths is the Co-Founder and Policy Director for Seamless Bay Area and has worked in urban and transportation planning for the past 12 years, including work with Metrolinx in Toronto and BART.

Project Goals

The overarching goal of our project is to understand the current state of public transportation use and access within Communities of Concern, thereby elucidating which tracts require the most immediate changes to public transit infrastructure. We accomplish this through two analysis paradigms. The first is a spatial survey of the barriers to Caltrain stations from these communities based on infrastructure availability and prevalence. We then make recommendations accordingly on improvements or changes following our mapping analysis, which may include expanding transit service, adding pedestrian and bike facilities, and other safety infrastructure in relation to spatial overlap with CoCs. The second is a scheduling analysis of the transfer times between SamTrans Caltrain Connector buses and Caltrain. We generate the set of transfer times between the two systems, which are spatially joined with CoC tracts in ArcMap to understand inter-tract variation in wait times. From there, we make recommendations for improvements or changes in scheduling which may include increased service at specific stations to better serve different tracts.

Significance and Policy Implications

Along the Caltrain corridor, initial analysis indicates that there are approximately 662,000 residents living in CoCs within the target 3-mile radius of Caltrain. This is a notable number of people, despite there being a larger number outside of that radius. The differentiating factor here is that there have been recent developments for system-wide changes in San Mateo County for Caltrain and SamTrans. The San Mateo Civil Grand Jury report was the main catalyst for this project, but also, concurrently, Caltrain has started conducting an equity analysis as part of its business plan and SamTrans has started conducting a Comprehensive Operations Analysis to review and improve its routes. SamTrans' analysis also includes requirements for addressing the inefficiencies of the Caltrain connector routes. Therefore, there are some open windows of opportunity in the decision processes of these agencies to influence their decisions.

Previous projects that have worked with Friends of Caltrain have made positive impacts on policy and program decisions, mainly because they were completed when timely decisions were in the works, as are now. In addition, because of the ongoing work by community partners, such as Friends of Caltrain and Seamless Bay Area, to educate and influence the community and decision-makers, it is more likely that our work will make an impact.

There is also the broader risk in the Bay Area that transit agencies are not as skilled as they should be in conducting the sort of observational, qualitative, culturally-informed research that would address problems of equitable access which we are working with in our project. With our focus on implementing solutions that address the four pillars of sustainability, we can start to think about solving these problems in a more holistic way which will better inform agencies on what types of changes they should be making.

On the ground level, as we are trying to push for these changes in policy and infrastructure, we must also make sure no one gets left behind, especially the most vulnerable and disadvantaged individuals in Communities of Concern who would benefit the most from increased access to public transit in the first place. Specifically for the San Francisco Peninsula, there is a large disparity between income levels of riders on Caltrain versus the local bus systems. Only 20% of Caltrain riders are low income, which is miniscule compared to the 73% and 77% on VTA and SamTrans, respectively (Metropolitan Transportation Commission, 2016). If we can make recommendations which help to address this inequity, we can help individuals in Communities of Concern have better access to Caltrain and public transit in general. This in turn will address all four pillars of sustainability which are necessary for truly sustainable changes.

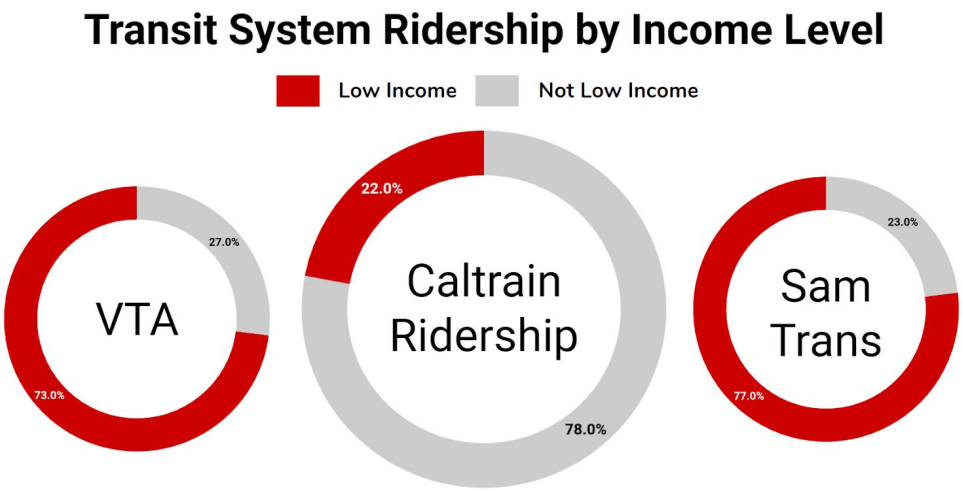


Figure 2. Transit System Ridership by Income Level
(Source: Metropolitan Transportation Commission, 2016)

Sustainability Implications

Our project is important for understanding what it means for a city to be sustainable. This is especially critical in the Bay Area, where many urban development projects need to be held accountable to address all aspects of urban sustainability. As a whole, sustainability can be divided into four pillars: environmental quality, social equity, economic vitality, cultural continuity. In relation to our project, our results have implications for all four areas.

Environmental Quality

In light of climate change acceleration, increased use of public transit and a decrease in single-rider car trips would help to decrease the overall carbon emissions of transportation use. In the bay area, about 40% of all greenhouse gas emissions come from the transportation sector, and 77% of that is from cars and light-duty trucks, so having better access to alternative modes of transportation could potentially reduce the Bay Area's impact on climate change (Bay Area Air Quality Management District, 2015).

Social Equity

To achieve equitable access to public transportation, it is critical that we understand and address the fact that people have unequal access to resources and opportunities by supporting those who need the most help. In our project, we aim to improve access to Caltrain, SamTrans, and other transit systems specifically for those underprivileged people in Communities of Concern. By doing our spatial analysis of access barriers and cross-referencing transit costs and schedules, we can then make informed recommendations regarding possible changes in fares, routes, and schedules at the system-wide level and also possible improvements in road and sidewalk infrastructure at the neighborhood level. The changes will allow for easier access to the Bay Area transit options for those in Communities of Concern by potentially lowering their costs of

transportation both in time and expenses and by removing physical barriers to accessing transit stations. This will make public transit a more viable option, so residents wouldn't have to resort to the costly purchase and maintenance of a personal vehicle.

Economic Vitality

As a result of increased access to public transit for people in Communities of Concern, there is also the effect of improved economic vitality. Better access to transit and more cohesive transit schedules will save people time by avoiding delays and allowing them to get to places of economic activity, such as stores and jobs, in a reasonable time. They therefore have increased opportunity to stimulate the economy. Even if people in the Communities of Concern don't make use of the improvements that our project results in, having more options open for them to move around in an affordable way other than personal vehicle use will allow them to make the best decision for themselves economically. Also, with less money spent on transit, they can then have more money to spend on other goods and services to stimulate the economy.

Cultural Continuity

The context of our project is that people in the MTC's Communities of Concern have barriers to accessing public transit in cost and physical accessibility. This limitation can be very costly to disadvantaged families, especially if they resort to bearing the expense of purchasing and maintaining a personal use vehicle. On average, the cost of owning and maintaining a personal vehicle for a year is about $9,000 (Bureau of Transportation Statistics, 2018). Considering that almost 50% of the population in CoCs are low income, a family of 3 could be spending more than 20% of their income on their vehicle (low income being <200% of the Federal Poverty Level for a family of 3 which is $21,330), and for many families, this cost could force them out of the communities they have lived in for years (Metropolitan Transportation Commission, 2017; US Department of Health and Human Services, 2019). This is not ideal for preserving the cultures that have evolved in their areas, not to mention that the time spent in Bay Area traffic is also a major cost for those families. With hours a day spent in traffic, this leaves individuals in these areas without time for civic engagement and spending their time in the community to foster its culture. Improving their access to affordable and efficient public transportation will give them the financially viable and time-effective means to travel to work, school, and other places, and allow them to stay where they are. Those affected communities can then hold on to their traditions and values, which are important for maintaining the identities of the individuals living there.

With the four pillars of sustainability in mind, our project aims to make recommendations for policy, schedule, and infrastructure changes that ensure all four are taken into account. Sustainability is important for the longevity of the communities of concern we are helping and for the Bay Area as a whole, so we need to set the bar for what holistic recommendations look like.

Literature Review

Historic patterns of land development inform the complexities of public transit in the Bay Area today - racial and socioeconomic walls constructed through land use and transportation policies explicitly were designed to inhibit the convenience of traveling around the Bay Area (Schafran, 2018). As such, there is a massive disparity in the availability of housing in areas concentrated with jobs. This disparity drives workers to commute long distances between their residential postings and their employment, exacerbating a congested highway system in the absence of a well integrated system of public transit (there exist over two dozen independent transit agencies in the Bay Area alone). The extent of this problem is clear: “29 percent of Bay Area commuters cross a county boundary to get to work each day” (Amin, 2015). As conditions for personal transit worsen in the Bay Area, expanding upon and optimizing the current public transit infrastructure becomes a relatively easy and increasingly important priority.

This fragmentation of the Bay Area affects the public transit sector, where decentralization and disconnection of transit operators presents a large challenge. The Bay Area is “the only large region without an operator that carries more than half of the transit market”, inhibiting the amalgamation of and cooperation between transit providers who would otherwise be able to have more influence over transit in the area as a whole (Amin, 2015). While this fragmentation may seem discouraging, regions around the United States and abroad which also feature multiple transit providers provide examples of how these systems can be successfully integrated. Looking to areas such as Seattle, Phoenix, and Zurich inform us of common patterns between successful integrated transit systems: there is a strong focus on the consumer experience, leadership, trust, and collaboration between all actors in these systems (Amin, 2015).

Bay Area commuters who do choose to ride on public transportation are also faced with a number of difficulties: ridership of some systems, such as BART, CalTrain, and MUNI, are facing problems of over-congestion in ridership during peak hours, often surpassing the maximum occupancies that these transit types were designed for. However, other transit agencies, such as the Valley Transportation Agency (VTA) are experiencing drops in ridership (Plan Bay Area 2040, 2017). In an attempt to address discrepancies in ridership across different counties, most counties in the Bay Area (8 of 9) adopted a “self-help” approach: finding funding for transit agencies through individual transportation sales taxes. This method has generated over $2.5 billion for transit agencies in 2016 alone (Plan Bay Area 2040, 2017). As a whole, the Plan Bay Area program is expected to funnel $292 billion for transportation development, housing, and general Bay Area affordability through 2040 (Frick, 2014).

In this period of expansion, there are targeted areas that can benefit greatly from renovations to public transit. One area in particular, which our project attempts to cover, is the serviced areas of SamTrans and Caltrain, and is informed through the published Grand Jury Report. The Report established that although SamTrans provides a fixed-route, bus transit network for San Mateo

County of which 16 routes connect or terminate at Caltrain stations, these routes are not well-coordinated with the scheduled train arrival and departure times. Additionally, only 3% of all Caltrain commuters utilize SamTrans in conjunction, not surprising considering the lack of coordination between the “Caltrain Connector” route on SamTrans and the scheduling of Caltrain (San Mateo County Civil Grand Jury, 2018). Moving towards an integrated schedule by manipulating existing services will optimize connections between these two systems. This investment in the public transit sector is important and suggests an increasing focus by policymakers on expanding upon alternatives to private transportation, an opportunity that these recommendations hope to capitalize upon.

Methodology

In this section, we discuss our methodology for completing our spatial and scheduling analysis, as well as the process of evaluating our results to generate recommendations. ArcMap and Tableau were used for data visualization. Python 3 and the Pandas library were used with Jupyter to generate transfer times en masse between SamTrans and Caltrain, as well as for preprocessing this and other data for use with ArcGIS tools.

The following data was downloaded from online databases or requested from transit agencies:

a. City, county, tract layers (DataSF, 2019)
b. MTC Communities of Concern attribute data (Bay Area Metro, 2018) and joined to Census tract geospatial data
c. Census tract data (TIGER Census data)
d. Mass transit routes (stops, routing)
    i. Caltrain stations, centerline (San Mateo County GIS, 2015)
    ii. SamTrans, route and stop features (SamTrans website)
e. Roads (North America street network data obtained from Evan Lyons, Stanford)
f. Bike routes, infrastructure, and locations (MTC)
g. ADA accessibility at Caltrain stations (Caltrain, 2019)
h. GTFS (schedule) data from Caltrain and Samtrans Caltrain Connector buses (Caltrain, 2019; Samtrans, 2019)
i. SamTrans ridership data from SamTrans (Ons and Offs at each stop from August 2018 through July 2019) (Provided by Michelle Louie, SamTrans)

Spatial Analysis

After compiling data sources, spatial data were input into ArcMap. ArcMap is part of the ArcGIS suite and is used to view, edit, create and analyze geospatial data through layering data layers to create maps. ArcMap was first used to determine the spatial distribution of existing barriers to Caltrain for Communities of Concern. After narrowing the spatial extent of our analysis to San Mateo County and creating a data layer specifically for Community of Concern tracts within SMC, we began to add additional layers of infrastructure data. This included the Caltrain centerline,

Caltrain stations (northbound and southbound), SamTrans bus routes, and filtering for SamTrans Caltrain Connector bus routes. From here, additional attribute data was added to strengthen the spatial distribution of factors that influence access. A marker for ADA accessibility was added to the existing Caltrain station points, showing which stations were accessible to those using wheelchairs. A ¼-mile buffer was generated around each SamTrans stop serviced by a Caltrain Connector route (Morphocode). These buffers were dissolved into one layer, which was intersected with the set of CoC tracts such that the percentage of overlap was calculated for each CoC to generate a pedestrian “walk-shed” statistic for Caltrain Connector access.

Generation of Transfer Times

To gain more insight into the results of the Grand Jury report, transfer times for SamTrans Caltrain Connector buses arriving at Caltrain stations and Caltrain departures were generated for each possible connection (ie, every time a Caltrain Connector arrived at a station). Connections were defined by their unique combination of bus route, bus direction (inbound, outbound), destination Caltrain station, and desired Caltrain heading (northbound, southbound) -- an additional layer of complexity not analyzed in the Grand Jury Report. A scripted data analysis using Pandas was conducted to calculate transfer times, or the time an individual must wait between arriving at a Caltrain station and boarding the next departing train. Freely-available SamTrans and Caltrain schedule data were downloaded from each operator in the standard GTFS format and processed with the script. Due to the widespread use of the GTFS format, this analysis could be replicated for a different set of bus-train transfers with little overhead (or, for example, other bus operators along the SamTrans route). After generating transfer times for all connections, times were sorted into four buckets: under 5 minutes, between 5 and 15 minutes (deemed an ideal wait time), between 16 and 30 minutes, and over 30 minutes.

Scheduling Analysis in ArcMap

Transfer times were aggregated by their boarding station, and matched to the CoC tract connected to that station by a Caltrain Connector bus. A series of spatial joins in ArcMap were performed to join transfer times to their respective CoC tracts of origin. This showed what wait times one might face if boarding a SamTrans Caltrain Connector in a specific tract. Summary statistics of median, mean, maximum, and minimum wait times for each tract were calculated and visualized via choropleth mapping. These were also grouped by on-peak (morning and afternoon commute times) and all-day transfer times. This helps us better understand the spatial distribution of wait times across San Mateo County CoCs. We can now see disparities between CoCs and determine which are disproportionately impacted by long waits, which indicates that more samTrans service is needed.

Discussion of Methodology

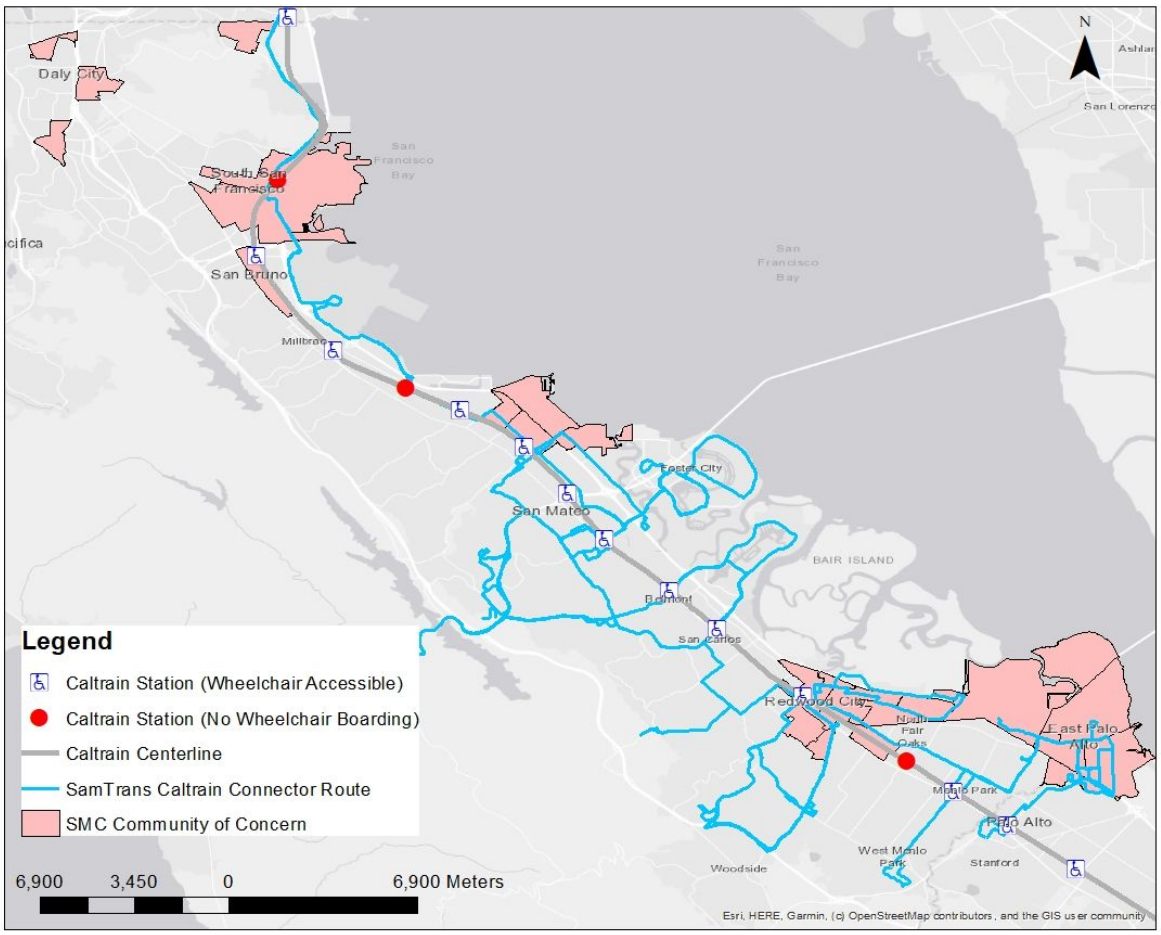
While mapping existing infrastructure can give us an idea of physical access to public transportation, we felt as though it was not sufficient to determine access. For example, a ¼ mile buffer around Caltrain stations shows the pedestrian shed of the infrastructure and that it is

physically accessible by walking for the overlapping geographies. Further, the ADA marcation shows that those with physical disabilities can access rail transit at specific stations. However, these inferences fail to incorporate other factors influencing access such as convenience, time, and demand. Even if a Caltrain station is within walking distance or ADA accessible, long wait times may deter an individual from using the service. This demonstrates why an insight on non-physical barriers in addition to the physical accessibility of infrastructure is essential to understanding where improvements are best directed. Our methodology aims to bridge this gap, in response to the Grand Jury report's methodology which only looked at wait times resulting from asynchronous SamTrans and Caltrain schedules. By showing the spatial distribution of access barriers, we can extrapolate which areas demand the most attention from transit agencies engaging in planning and schedule upgrades.

Quantitative data can also only tell us so much. While a ¼ mile buffer is the rule of thumb for estimating the pedestrian shed of a station, it does not consider the availability or quality of the surrounding street network. Each person's demand for public transportation and access issues they face are unique, so it would have been beneficial to to out into the field and collect qualitative data through interviews and stories about what barriers people face daily. Many times, the desire to drive versus use public transit is a matter of convenience or lack of trust in the reliability of the existing public transportation infrastructure, and this can be difficult to measure quantitatively without gathering survey data.

While we know that public transportation is inefficient overall in the Bay Area, this analysis allows us to focus in on specific communities and how they might be impacted by asynchronous scheduling systems and direct efforts to reform transit more effectively.

Results



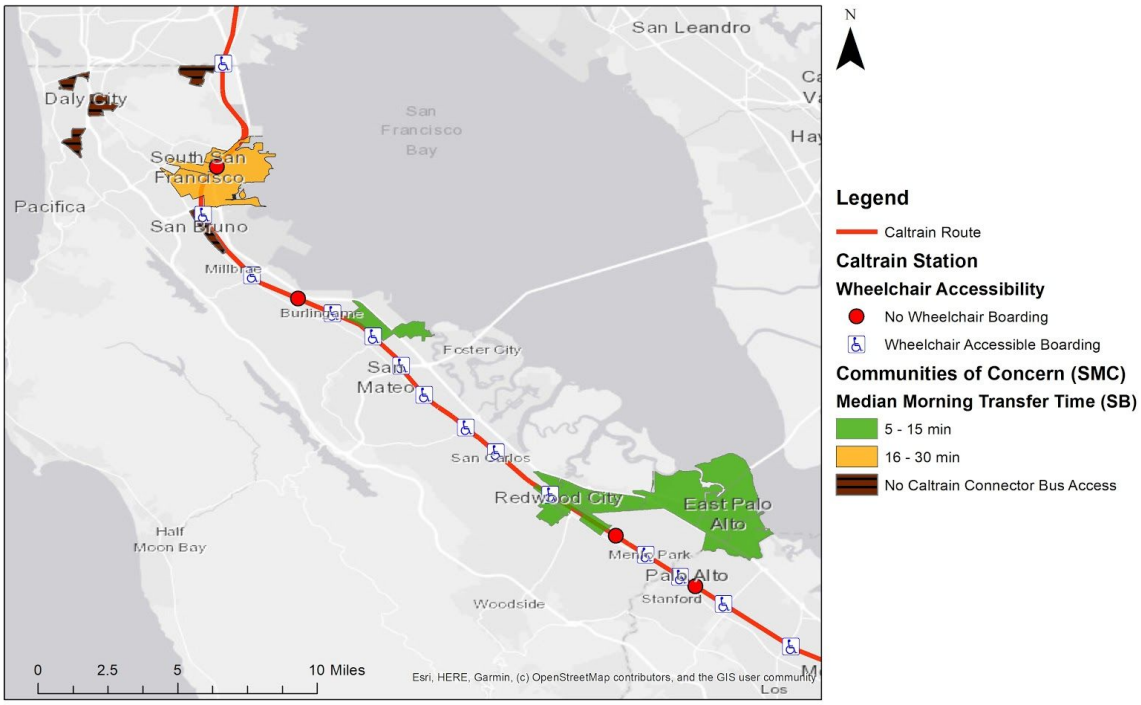
SamTrans and Caltrain Transit Infrastructure with Communities of Concern Reference Map

This map shows San Mateo County overlaid with the Communities of Concern (coral polygons), Caltrain Connector routes (blue), the Caltrain Route (grey line), and Caltrain station denoted by ADA wheelchair symbols.

SamTrans to Caltrain Transfer Times (dataset available for download)

Example output, grouped by SamTrans Caltrain Connector route and Caltrain station:

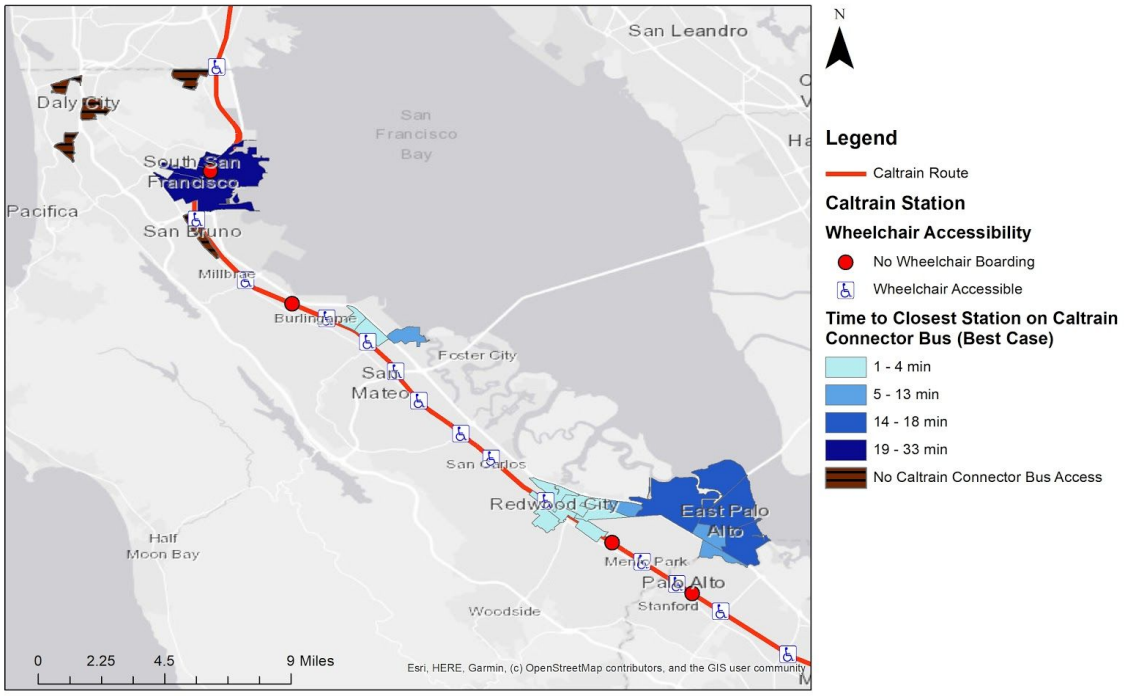
SamTrans Route	Caltrain Stop	Caltrain Direction	SamTrans Direction	Median Transfer Time (min)
250	Hillsdale Caltrain	0	0	20
250	Hillsdale Caltrain	0	1	12.5
250	Hillsdale Caltrain	1	0	17
250	Hillsdale Caltrain	1	1	13
250	San Mateo Caltrain	0	0	13.5
250	San Mateo Caltrain	0	1	13
250	San Mateo Caltrain	1	0	22
250	San Mateo Caltrain	1	1	15
251	Hillsdale Caltrain	0	0	12
251	Hillsdale Caltrain	0	1	7
251	Hillsdale Caltrain	1	0	19
251	Hillsdale Caltrain	1	1	24
256	Hillsdale Caltrain	0	0	10.5
256	Hillsdale Caltrain	0	1	5
256	Hillsdale Caltrain	1	0	25.5
256	Hillsdale Caltrain	1	1	21
260	Belmont Caltrain	0	0	13.5
260	Belmont Caltrain	0	1	14
260	Belmont Caltrain	1	0	25



This choropleth map shows the median morning transfer time for southbound Caltrains for passengers from each CoC connecting with samTrans Caltrain Connectors. For example, someone living in a CoC in South San Francisco would have to wait 16-30 minutes (median) at the train station before the next train toward San Jose departed.

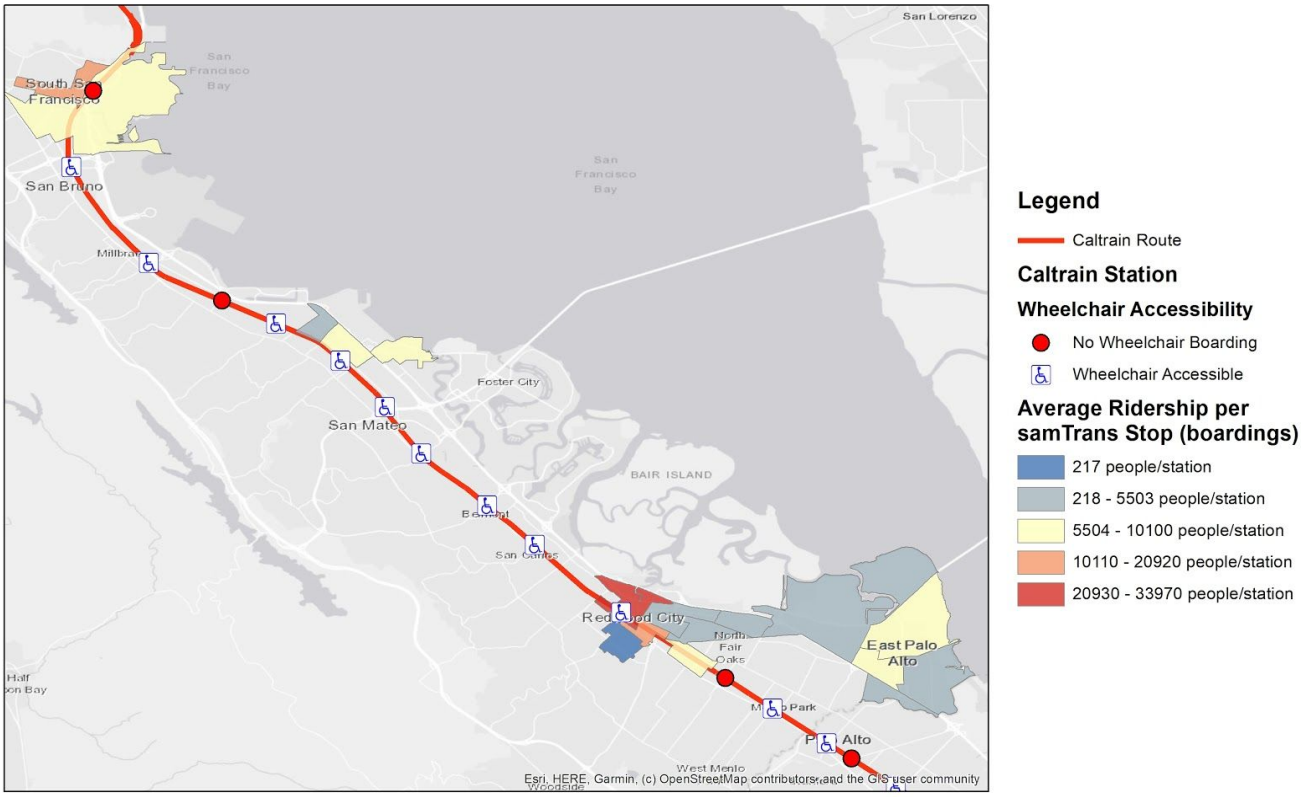
See Appendix 1 for additional maps showing median transfer times by CoC tract. (Visit southbound web map here and northbound web map here)

Time to Nearest Caltrain Station via Caltrain Connector



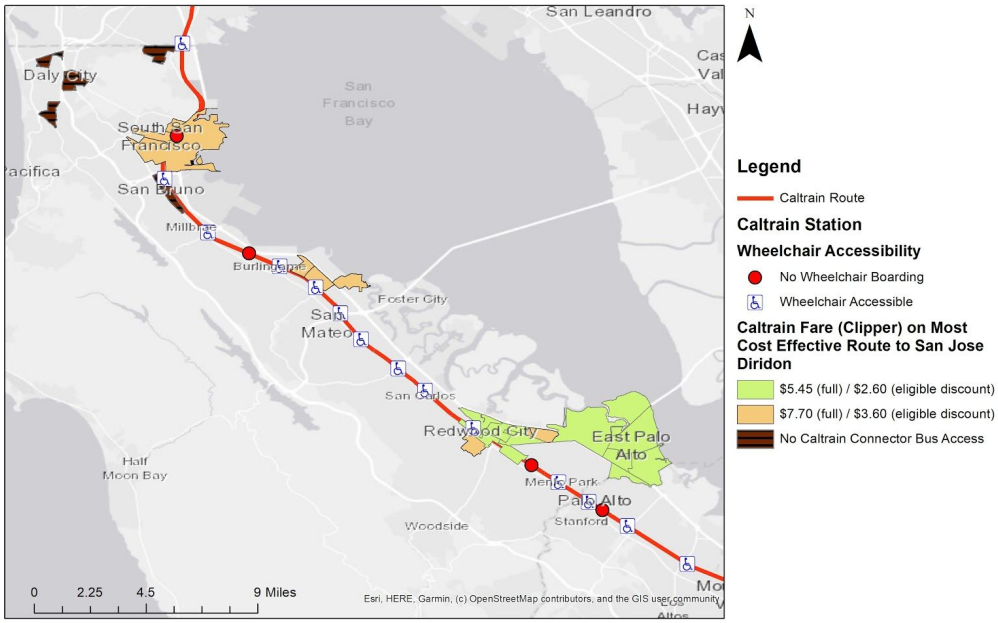
This choropleth map shows the minimum amount of time someone traveling from a CoC would have to spend on a Caltrain Connector to the closest Caltrain Station. For example, someone living in a CoC in South San Francisco would have to ride a Caltrain Connector for 19-33 minutes before arriving at the first Caltrain station along that bus route. (Visit web map here)

Average Ridership per Station by CoC Tract

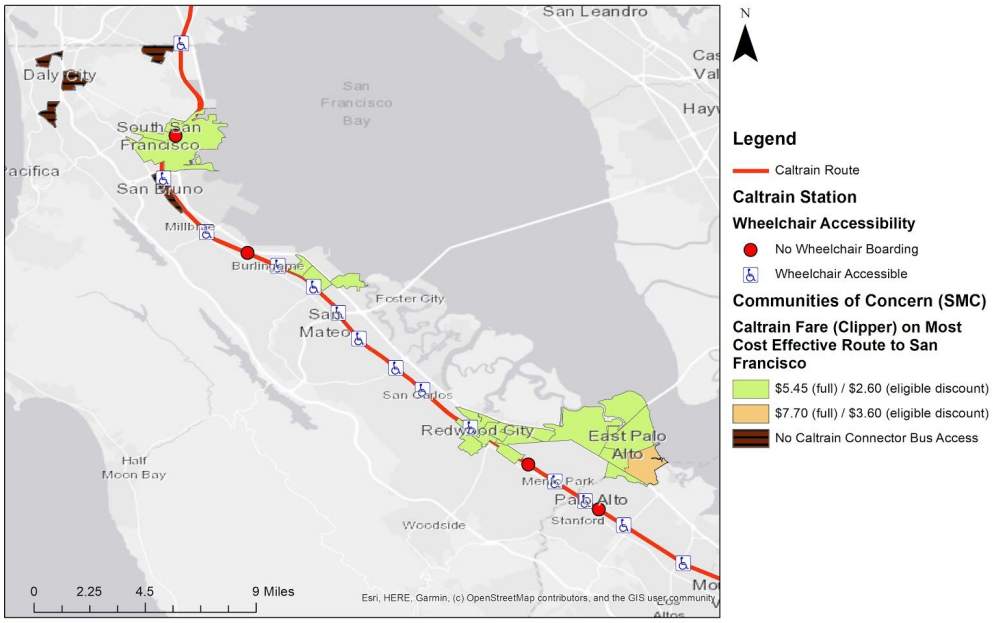


The above map shows the average samTrans riders per bus stop in each CoC that appears. It offers a look into which geographies presently with the most demand. Intersecting routes should be acknowledged as important/reliable means of commute.

Caltrain Fares with regard to Origin Station per CoC

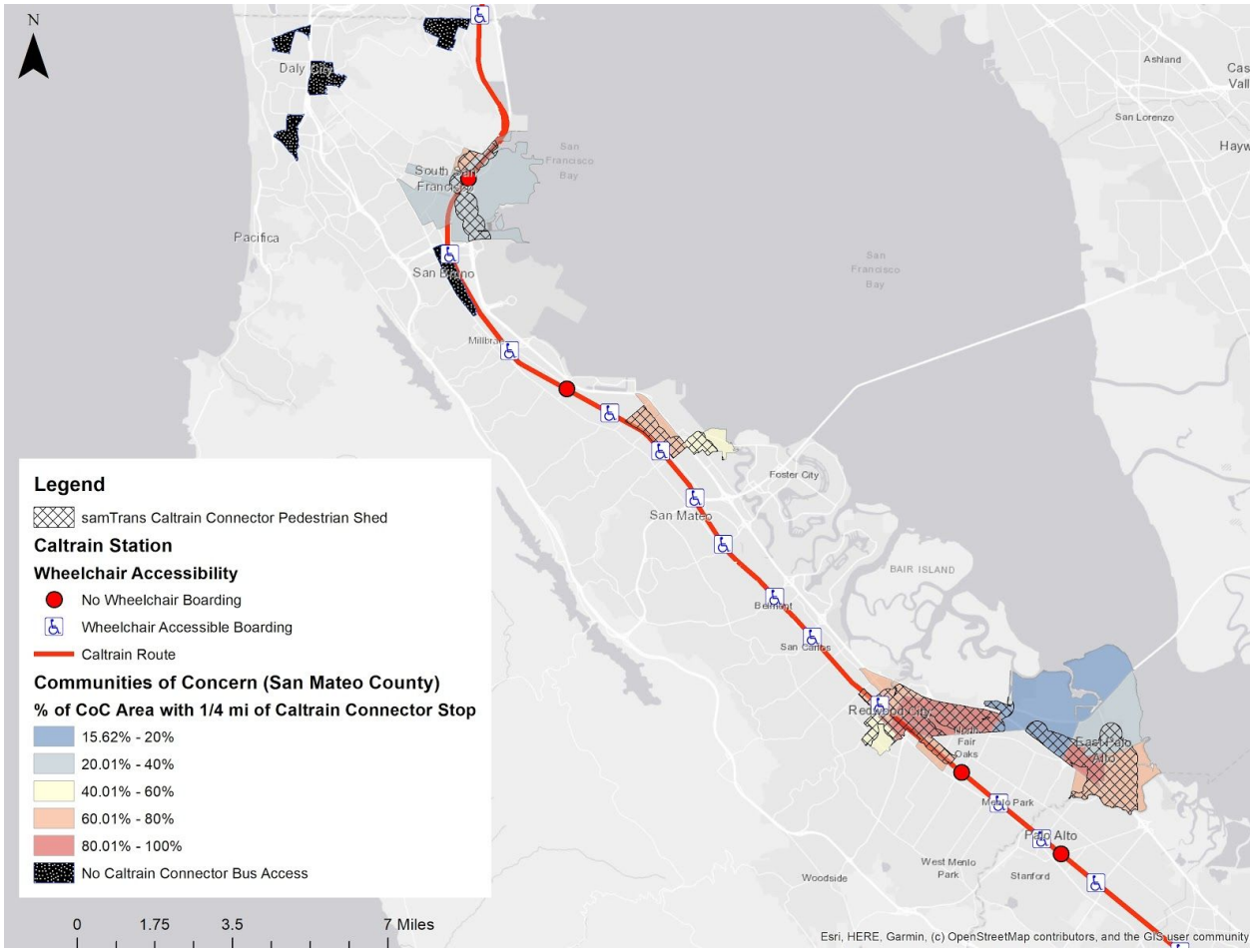


For each CoC, the above map shows the cost of cheapest Caltrain ticket to San Jose from a station connected via a Caltrain Connector Route. Because of the zone boundary that falls mid-Peninsula, residents of more northern CoCs face higher daily costs to accessing southern job centers like San Jose. (Visit web map here)



For each CoC, the above map shows the cost of cheapest Caltrain ticket to San Francisco from a station connected via a Caltrain Connector Route. Surprisingly, every CoC except for one in East Palo Alto has access the lower fare by because a Caltrain Connector connects them to a closer zone. This lone CoC is only connected to Palo Alto Station, which means a more costly to ride to SF. (Visit web map here)

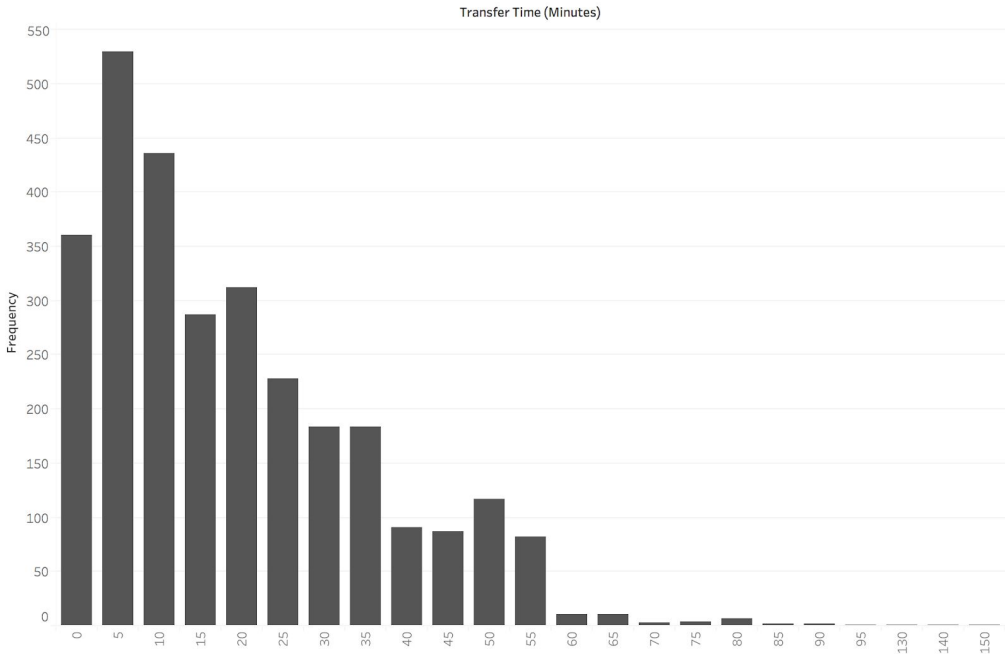
Pedestrian Walk Shed: Portion of CoC within Walking Distance to SamTrans Station along SamTrans Caltrain Connector Route (Visit web map here)



The above choropleth map shows the percentage of CoC area that fall within the "pedestrian shed", or ¼ mile radius, of SamTrans bus stations. The crosshatched area represents the pedestrian shed. CoC tracts with lower percentages would benefit from more extensive SamTrans bus coverage via increasing the number of stops throughout the geography of the tract.

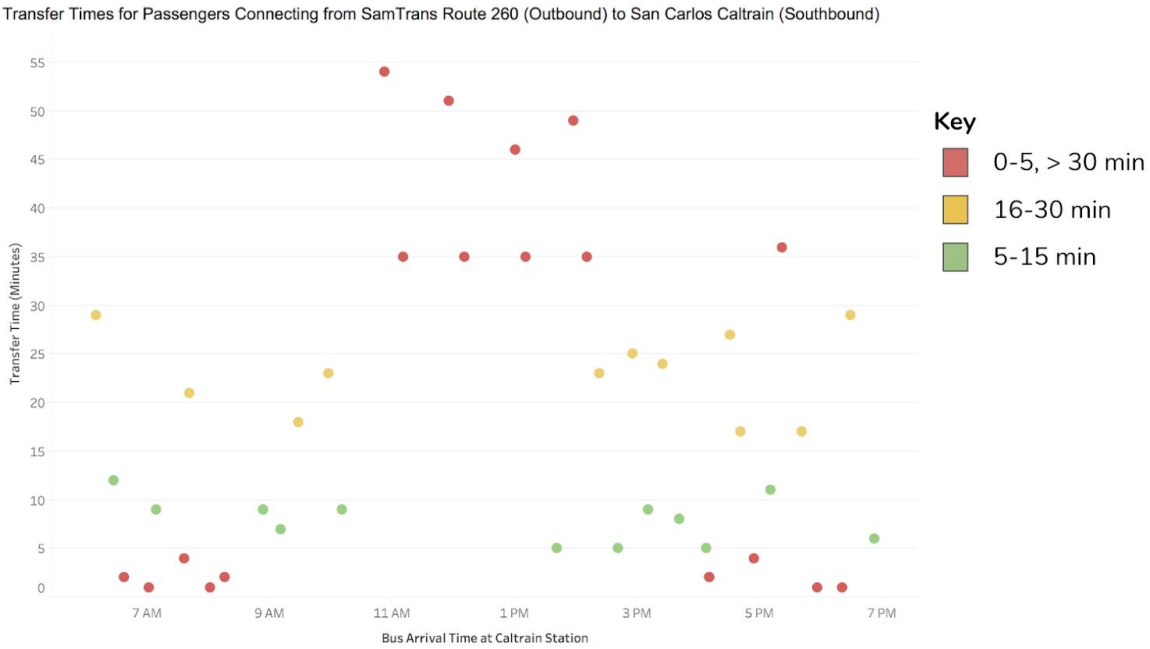
Key Findings

1. **Summary statistics of all connection transfer times:** median = 17 minutes, mean = 21.04, standard deviation = 16.7. In looking at a histogram of our transfer times, it is clear that there are more transfer times toward the shorter end of the spectrum. This is positive, as it indicates that fewer people have lengthy waits for Caltrains. However, there is still a significant amount of transfers under 5 minutes which are more likely to result in a missed connection.



2. **81% of first SamTrans Caltrain Connector bus arrivals miss the first Caltrain departure of the day.** Our analysis defines these missed connections as the train having departed in the last 10 minutes before the first SamTrans bus arrives at the Caltrain station. The Grand Jury Report notes that their “connections to not include bus/train interactions where there is currently no bus scheduled early enough to meet the train (Table B1, San Mateo County Civil Grand Jury, 2018). However, we believe that these early missed connections are a prime example of lacking coordination between SamTrans and Caltrain during commute hours and thus wasted resources that could be allocated to reduce wait times during later on-peak hours.

3. **Transfers during on-peak times (during morning and afternoon commutes) have lower variability and shorter weight times.** Higher frequency service during on-peak hours is expected, as service demand his higher when people are commuting to or from work.



The graph above visualizes the disparity in wait times between SamTrans "Caltrain Connector" buses and Caltrain. As apparent above, the greatest variation in wait times occurs in the mid-day.

4. **41% of all connections are shorter than 5 minutes or longer than 15 minutes.** The Grand Jury Report found that 35% of *morning* commute time connections are within the 5 to 15 minute optimal range. Our analysis reports that of *all* connections, this proportion is higher. This is reasonable, as off-peak (mid-day) transfer times are often higher as service demand is lower. All-day connections are included in our figure.

Policy Recommendations

Our policy recommendations are split into two main groups: short-term and long-term recommendations.

Short-term recommendations

The following steps should be taken as soon as possible:

- **Implementing ADA access to all stations along the Caltrain route:** Communities of Concern around South San Francisco Station do not have access to an ADA-designated Caltrain Station. Commuters with disabilities are forced to take a SamTrans Caltrain Connector to a ADA-designated Caltrain Station.
- **Assess demand and determine the feasibility of new SamTrans bus service to underserved Communities of Concern:** Extend Caltrain Connection Service to Daly City Communities of Concern. Daly City Communities of Concern have access to BART via local SamTrans service. However, users will first need to ride local SamTrans to BART, take BART to Millbrae, and transfer to Caltrain in order to have access to Caltrain service. This could be avoided by having direct SamTrans Caltrain Connector service from Daly City Communities of Concern to Bayshore or South San Francisco Caltrains.
- **Investigate improving ECR/ECR Rapid bus service** along El Camino Real to become an efficient, high-frequency, reliable trunk line that can supplement Caltrain during the off-peak and weekend hours when Caltrain frequency is low. This will better serve populations living along the arterial and lessen the impact of a missed Caltrain. Improvements could include queue jump lanes/BRT, transit signal priority, and overnight service.
- **Investigate demand for earlier SamTrans services** since many of the “Caltrain Connector” routes miss the first Caltrains in the morning. This will help encourage the adoption of public transit for early commuters, if needed, who otherwise are not serviced in that timeframe.
- **Assess impact of potential outliers** like cost, overall travel times, attractiveness of transit alternatives, and others, acting as barriers against adopting public transit outside of purely scheduling difficulties.
- **Implementing attractive, clean alternatives for local transit** such as shared bike services as an additional method of incentivizing public transit. This will increase accessibility of clean, local transportation as well as increasing access to local transit providers.

Long-term recommendations

The following steps should be taken in coordination with Caltrain Electrification--which will result in increased train frequency throughout the day--and Reimagine Samtrans.

- **Develop a new SamTrans route network that prioritizes frequency and Caltrain connection:** A new “Frequent” network of bus routes--which can be based off existing “Caltrain Connectors” and by consolidating circuitous, confusing, or underperforming routes--should be developed to ensure frequent connections from communities to

Caltrain. Service should operate every 15 minutes or better and meet the first Caltrain trip(s) of the day. **FLEX service complementing this high-frequency service can be implemented to maximize transit access throughout San Mateo County.**

- **Evaluate destinations of Caltrain Connectors with consideration of Caltrain payment zones.** Some CoCs are only connected to one Caltrain zone, meaning higher fares in one direction, while other CoCs have flat-rate samTrans access to a variety of Caltrain zones which gives more flexibility in Caltrain station choice and thus an opportunity for lower fares.
- **Alter fare structure for equity and accessibility:**
    - **A means-based fare policy** lessens the burden of transportation costs on disadvantaged populations. This increases their accessibility throughout the Peninsula and incentivize leaving cars behind.
    - **Zone-based maximum fares to encourage regional travel:** One major difficulty of transit travel along the Peninsula is the cost of transferring between numerous agencies. By limiting fares to certain amounts based on distance traveled instead of agencies utilized, it decreases cost and makes public transit more accessible in the region.

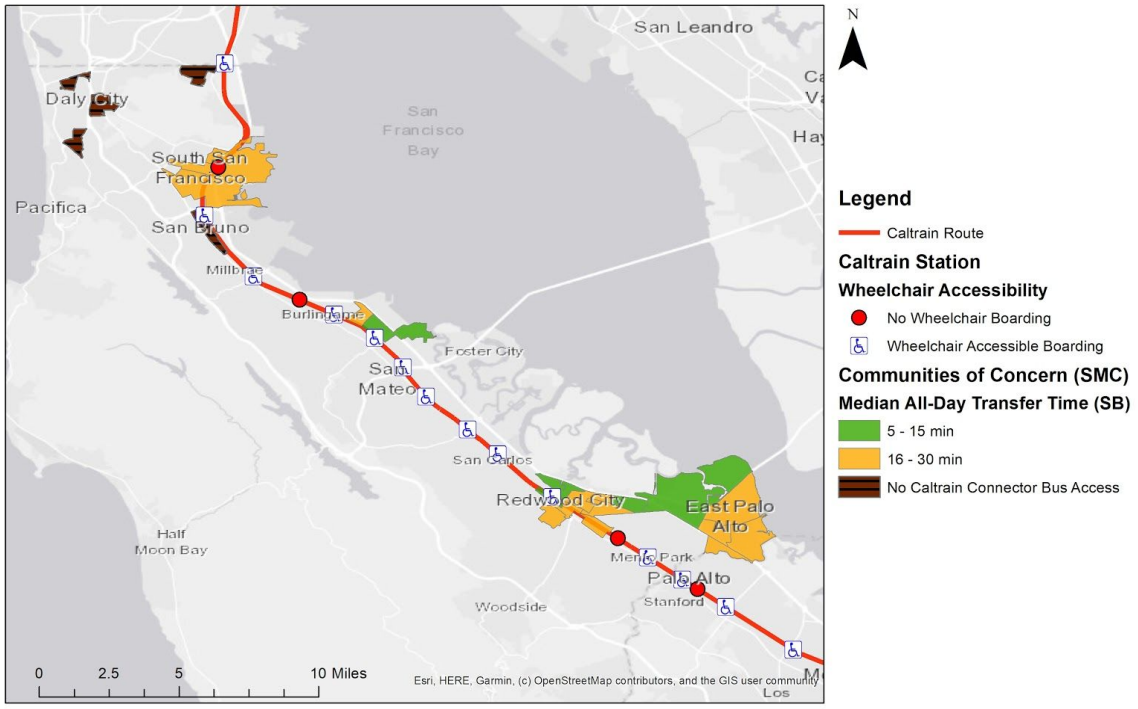
Conclusion

A sustainable, integrated, and equitable public transportation system in the Bay Area may one day be achieved through significant structural and policy change. While this goal seems far off, existing transit authorities can begin to implement small changes to schedules and service areas to improve transportation access. Most importantly, they should undertake these developments without leaving any communities behind -- especially those that are most vulnerable and disadvantaged. Our project aims to contribute to such a utopian vision by providing preliminary recommendations for integrating public transit in San Mateo County between SamTrans bus and Caltrain rail service. We specifically hoped to highlight barriers to access faced by Communities of Concern, some of whom may benefit the most from increased public transportation service. Transit agencies are constantly adjusting schedules and preparing for expansion, and we hope that our paradigm for understanding key areas to focus improvements might be considered in future planning. We recognize that this analysis can be completed with other transit agencies around the Bay Area, such as between Caltrain and VTA in Santa Clara County. An expansion on this project could greatly increase the integration and efficiency of systems throughout the entire San Francisco Peninsula.

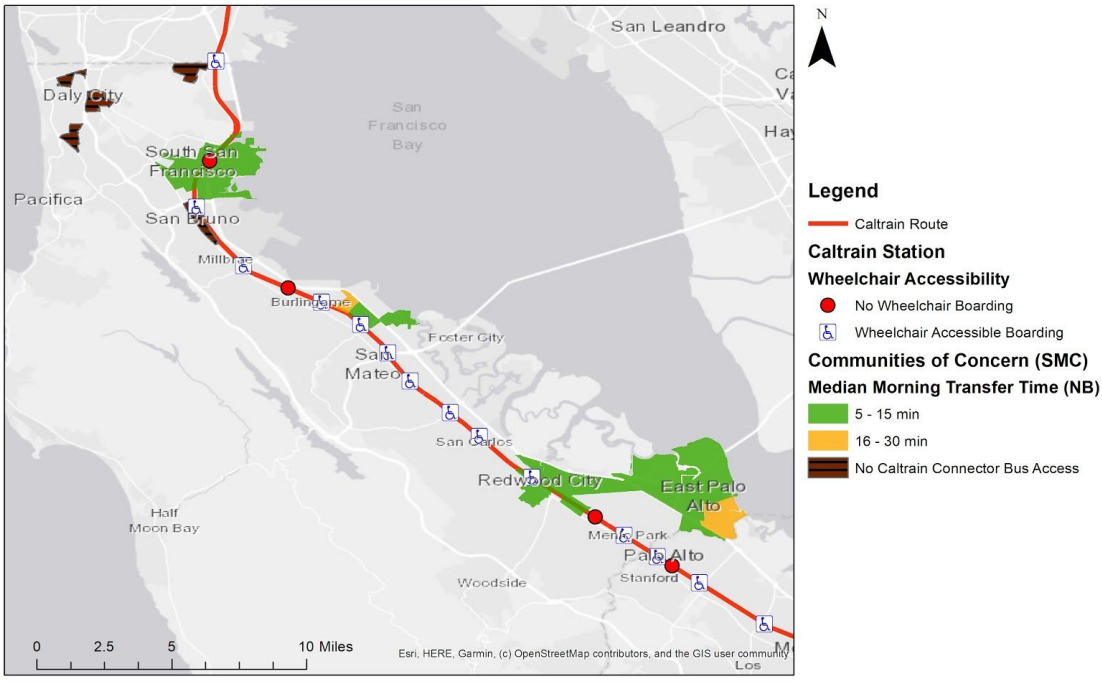
More broadly, we want to acknowledge that ‘access’ in this context is an elusive term. While we’ve analyzed the potential impacts of variable transfer times and available infrastructure on physical access, there exist other barriers to the adoption of public transit that are less easily conveyed through our mapping and quantitative data. As improvements in scheduling progress, the total travel time for commuters is still unclear and often makes public transit much more inconvenient and slower than other forms of transit. Additionally, the cost of adopting public transit can be prohibitive due to the compounded pricing from bus providers and Caltrain. A more holistic definition of access should be adopted in future analyses, including qualitative data and surveys that better elucidate personal barriers that are often overlooked.

Appendix 1: Additional Maps

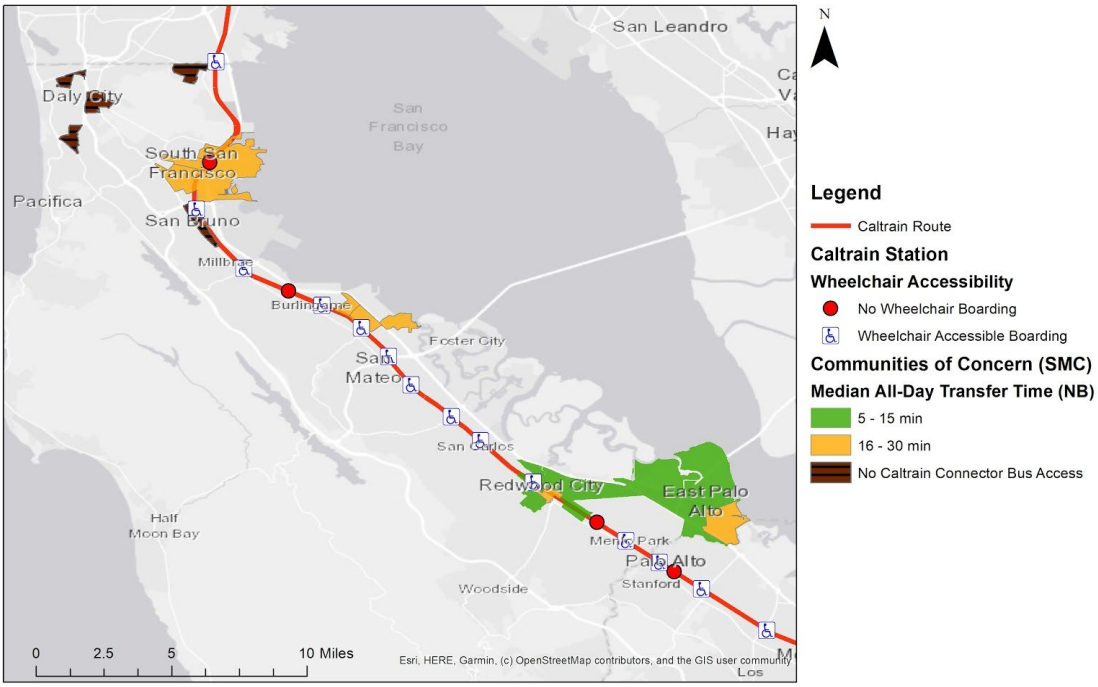
Map 1. Median Southbound All-Day Transfer Times



Map 2. Median Northbound Morning Transfer Times



Map 3. Median Northbound All-day Transfer Times



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