Analysis of Proposed Cal-ITP Initiatives:

A Feasibility Study

Commissioned by Cal-ITP

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California Integrated Travel Project Goals

Cal-ITP was established to help California deliver on statewide goals of increasing transit ridership, reaching environmental targets, lowering transportation-related costs for public transit agencies and the traveling public, improving the customer experience of travel, and promoting equity throughout our state's vast transportation network:

- Improve the transit experience in California
- Reduce inequality
- Increase public agency buying power for technology and services
- Realize benefits for transit services
- Meet California climate change law

This study takes a business case approach to evaluating specific actions identified through prior research and stakeholder engagement, such as the Cal-ITP Market Sounding, that California could take to advance the project's goals.

Disclaimer

The purpose and scope of this analysis is to introduce the initiatives proposed on behalf of the California Integrated Travel Project, evaluate the economic and financial feasibility of these initiatives, and document the steps taken during the evaluation.

All of the information included in this study is based on data/information gathered from various secondary and primary sources and is based on certain assumptions. Although due care and diligence has been taken in compiling this document, there may be sources of information that we have not found whose inclusion would lead to different outcomes.

Neither the California Integrated Travel Project, nor its partners, nor the advisors who prepared this analysis assume any liability for any financial or other loss resulting from decisions made based on this report.

The prospective users of this document are encouraged to carry out their own due diligence and gather any information they consider necessary for making an informed decision.

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1 Introduction

Public transportation is foundational to making cities work and meeting California's environmental, economic and social goals. It is part of California's adopted climate policy to reduce vehicle miles traveled, to increase ridership, and to make it easier to access and to use transit. And California is embarking on a new social compact for California workers, based on an expansive vision for economic equity that takes access to work and jobs as the starting point.

Today, the long-term sustainability of the public transit system in California is in jeopardy, as transit agencies face rising costs, falling ridership, and a growing gap in the consumer experience between transit services and alternatives. Public transit struggles to meet the increasingly higher standards being demanded by customers in convenience, equity, trip planning, fare payment, quality of service, and multi-modal integration. Unless these core issues related to the demand for public transit services are addressed, future investments are unlikely to reverse the negative trends affecting the transit ecosystem.

To address these problems, a group of agencies and partners created the California Integrated Travel Project (Cal-ITP) to make public transit easier to use, easier to access, and more cost-effective statewide. Cal-ITP's vision is to improve the customer experience from end-to-end through a set of targeted and strategic actions.

The Cal-ITP partnership consists of the California State Transportation Agency (CalSTA), California Department of Transportation (Caltrans), and intercity and local transit partners. Together, this group is mapping out a transition to a simpler and more effective public transit ecosystem in California and engaging key stakeholders to help realize its vision.

In fall of 2019, Cal-ITP organized a market sounding event with companies and organizations in the payments and trip planning industry to identify barriers to achieving Cal-ITP's objectives and to gauge the feasibility of proposed solutions. As a result of this exercise, nine potential initiatives were identified that Cal-ITP could deploy to meet its goals. These nine initiatives have since been refined into three concrete and realistic initiatives, some of which have multiple components.

These three initiatives are:

1. Ensure access to reliable and accurate real time transit information;
2. Reduce friction in payments;
3. Create a statewide eligibility verification program.

While the potential benefits of implementing these initiatives have already been identified, a more thorough analysis was conducted to fully assess their financial and economic impact. The study concludes that all three initiatives are financially feasible and yield additional economic benefits under the conservative to moderate assumptions on project costs and ridership effects that are laid out in this report.

This feasibility study is being published at start of a severe economic downturn linked to the COVID-19 pandemic. The COVID-19 crisis had led to unprecedented declines in mobility and transit ridership for agencies across the United States and globally. An immediate effect of COVID-19 is a worldwide push towards contactless payments to limit virus transmission from the use of cash, and a push in the US to prevent payment-related interactions between a transit vehicle's driver and boarding customers. For agencies without an automated fare payment system, switching to free boarding is the only safe short-term solution, but unsustainable in the longer term especially considering decreasing local sales tax revenues that make up a considerable portion of agency revenues. We expect that some of this tendency towards contactless and automated payments will be *sticky* and lead to changes after the health and economic crisis. We believe that the initial impacts of the COVID-19 crisis on transit reinforce the need to improve the rail and transit system through the initiatives evaluated in this study.

Cal-ITP is responsible for conducting the analysis and mobilizing key stakeholders to carry out each initiative. To do so, Cal-IP will leverage any existing programs and entities that are best positioned to help implement the initiatives.

Section 2 of this report expands on the current state of public transit in California and the need for the proposed initiatives. Section 3 describes the proposed initiatives. Section 4 illustrates the results of the analysis. Finally, Section 5 outlines the main conclusions and recommendations generated from this exercise.

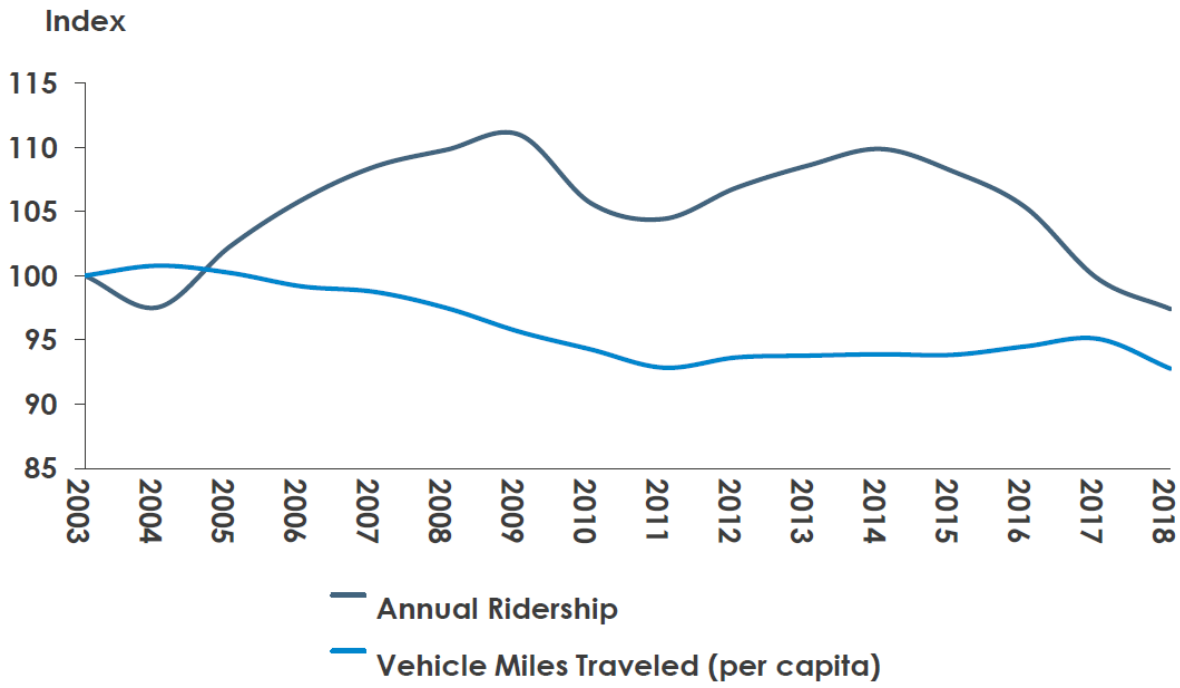
2 California Public Transit: Background

2.1 Overview

California has a large, disaggregated and complex public transit ecosystem. There are over 300 different public transit operators[1] including demand response and specialized services, dozens of different proprietary fare payment systems, scores of limited service area "apps", and various regional entities responsible for setting policies related to mass transit. As a result of this disaggregation, there is a lack of standardization across agencies, creating friction and hampering the customer experience in unnecessary and sometimes confusing ways.

Many of the problems facing public transit agencies are not unique to California, but rather reflect patterns seen in agencies across the United States: ridership is decreasing in many jurisdictions, less farebox revenue is being recovered by transit agencies, and operating costs are rising faster than inflation. These trends taken together create a vicious cycle, with underfunded systems leading to worse service, leading to lower ridership, which leads to more funding challenges.

Figure 1 – Annual Ridership and Vehicle Miles Traveled (per capita) in California



Source: National Transit Database and Eno Center for Transportation

The above figure shows a steep decline in transit ridership in recent years (dark blue line) and a recent decline in Vehicle Miles Traveled per Capita (light blue

[1] The number of agencies and operators depends on the source and definition, and ranges between 200 and 366.

line). According to California's Transportation System study[2], despite the decrease in miles driven per driver, the total miles driven statewide increased over the decade due to an increase in the number of drivers.

An important contributor to falling ridership has been the rapid expansion of transportation network companies (TNCs) such as Uber and Lyft, and other micro-mobility transportation options such as bike-sharing and scooter-sharing services. Additionally, most Californians still get around by driving their own personal vehicles. According to a UCLA study from 2018, rising personal vehicle ownership in Southern California contributes to a concerning trend of increasing vehicle miles and decreasing transit ridership. Recent research[3] shows that TNCs are substituting for transit during off-peak. Case studies have shown that a significant substitution effect may have been taking place[4], leading to an increasing number of car trips, especially in urban areas[5]. The competition from these alternatives, which offer superior customer experience features and easier trip planning and payment, poses a major challenge for transit agencies.

Overall public transportation ridership (absolute and per-capita), as well as inflation-adjusted fare revenue collection, has been decreasing for most California agencies. California transportation agencies collected around $1.8 billion in fares in 2018, with around 55% of fare revenues being collected by just three agencies: BART ($481 million), LA Metro ($315 million) and SFMTA ($203 million). Complementing this concentration of public transport in the metropolitan areas are a large group of small and very small operators. Around 90% of agencies are bringing in annual fare revenues of less than $10 million and two-thirds of transit agencies are bringing in less than $1 million. Among this smallest cohort, inflation-adjusted fare revenue collected has fallen 13% and ridership has declined 11% between 2012 and 2018. On a statewide level, transit ridership has dropped approximately 12% between 2014 and 2018, while inflation-adjusted fare revenues have dropped as well.[6]

California's large metropolitan areas also display regional differences regarding transit usage. For example, Northern California's Bay Area (San Jose-San Francisco-Oakland) has a higher share of public transportation usage compared to Southern California (Los Angeles-San Diego), with public transportation

[2] Source: California Legislative Analyst's Office

[3] Source: Blumenber, Evelyn; Garrett, Mark, King, Hannah; Paul, Julene, Ruvolo, Madeline; Schouten, Andrew; Taylor, Brian D.; Wasserman, Jacob (2020): What's behind Recent Transit Ridership Trends in the Bay Area? Volume I: Overview and Analysis of Underlying Factors. UCLA Institute of Transportation Studies. Text. https://doi.org/10.17610/T6PC7Q

[4] Source: Sturgeon, Lianne Renee, "The Impact of Transportation Network Companies on Public Transit: A Case Study at the San Francisco International Airport" (2019). Scripps Senior Theses. 1318. https://scholarship.claremont.edu/scripps_theses/1318

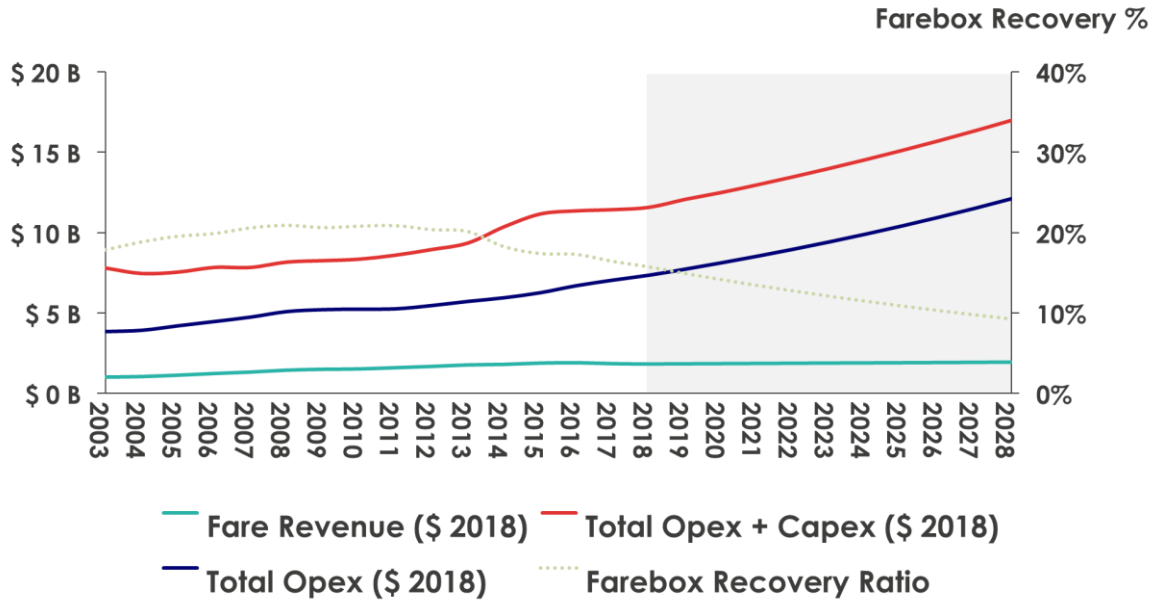
[5] Source: https://advances.sciencemag.org/content/5/5/eaau2670 (Access date: 26/02/2020)

[6] Source: National Transit Database (NTD)

accounting for 6% of all trips in the Bay Area as opposed to 5% in the Los Angeles region. However, given its larger size and population, the Los Angeles region accounts for 52% of all public transportation trips in California, compared to just 28% in the Bay Area. The San Diego region makes up for 8% of total public transportation trips in the state[7].

Total operating and capital expenses within the California public transportation system have been increasing steadily, outpacing the growth in ridership and revenues. In other words, it has become increasingly expensive to transport a passenger, and each passenger is – in real terms – paying a lower proportion of the costs of providing service for transit service. If these trends were to continue, the average fare recovery ratio of 15.7% in California in 2018 would fall to below 10% in 2030. Included in operating expenses, and of particular interest to Cal-ITP, is the rising cost of fare collection. While data on fare collection costs are not clearly reported and identifiable, the overall trend appears to be a concerning rise in the cost to collect each dollar of fare revenue.

Figure 2 – Capital and Operating Expenses, Fare Revenues and Farebox Recovery Ratio

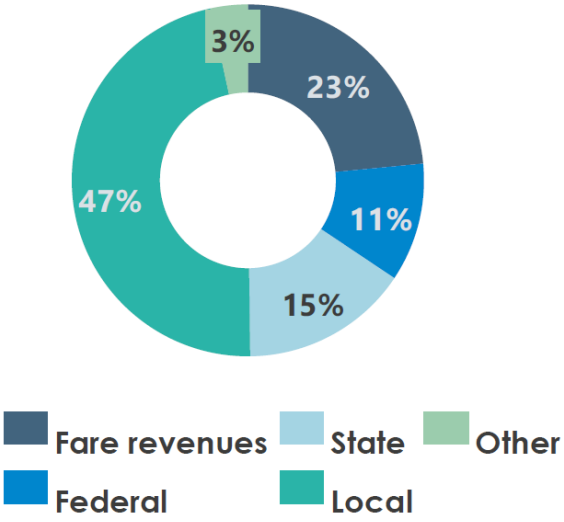


Source: National Transit Database and Cal-ITP projections

[7] Source: Caltrans (Ed.) (2013): 2010-2012 California Household Travel Survey, Final Report, retrieved from: http://www.dot.ca.gov/hq/tpp/offices/omsp/statewide_travel_analysis/Files/CHTS_Final_Report_June_2013.pdf (Access date: 26/02/2020)

California public transportation relies most heavily on subsidies from local sources (47%), and is also supplemented by state sources (15%), and federal sources (11%) for operational funding[8]. This implies that many California counties have made the policy decision to spread the cost of public transportation across their tax bases, and not to charge as much to users of the system directly.

Figure 3 – Transit Agency Revenue by Source (2018)



Source: National Transit Database

As ridership declines further, this dynamic may present a hurdle for securing funding increases for the transit system, since a greater portion of the population *not* using transit would be paying for system upgrades used by a shrinking share of the transit-using population. Local sales taxes continue to make up these deficits by funding service expansions and improvements. However, these improvements have not yet turned the tide of declining ridership. Facing exogenous economic shocks, many transportation services are faced with making painful cuts to service, from which it is difficult to recover.

2.2 Trip planning

An area in which the lack of standardization creates user experience problems for customers is in the realm of trip planning. Today, many customers expect that

[8] Source: California Department of Transportation (2017): California Statewide Transit Strategic Plan Baselines Report, retrieved from: http://www.dot.ca.gov/drmt/docs/spstsp/stsp2017baselinefinal.pdf (Access date: 07/30/2019)

agencies will provide tools to help them plan their trips, view maps of different routes and stations, and provide real-time information about the arrival times of buses and trains. Many agencies have their own custom mobile apps for transit information and route planning. In some cases, these apps also allow transit customers to purchase and use tickets. However, such tools are often not reliable, they require customers to know about and download each app, and they are not usable across different agencies, service areas or modes.

The backbone of providing customers with reliable transit information is publishing General Transit Feed Specification (GTFS) data. Static GTFS defines a common data format for transit agencies to share schedules and associated geographical information with mobile app developers. It is often used in trip planning applications to help users optimize a multi-modal journey and was originally designed for use with Google Maps. GTFS real-time data is used for live, current information regarding the location of a train or vehicle and to offer users valuable up-to-date information regarding arrival and departure times and service changes. GTFS real-time requires GPS or similar hardware to be installed on board the train or bus and data to be transmitted and converted into GTFS format, to be usable in mobile apps. These features are becoming more necessary in creating a compelling and attractive user experience. Unfortunately, GTFS real-time has yet to become a widely adopted standard among Californian transit agencies.

Table 1 – Implementation of GTFS in California

Type of information	Number of transit agencies	Share of ridership	Agencies share of total revenue
No GTFS	89	231 million	17%
Static GTFS	102	601 million	45%
Static and real-time GTFS	24	501 million	38%

Source: Rebel Analysis Database, data updated as of 02/25/2020

2.3 Fare payment

The disparate and disjointed fare payment structures across the State, in combination with the many different types of fare media accepted by transit agencies, creates a confusing and non-standardized environment for potential customers, discouraging transit usage.

Nearly all of the transit agencies in California set their own fare structure, including prices, discount groups, passes, and other payment options. Additionally, there is

a vast array of different fare collection technology and customized fare media deployed by the different agencies. On the one hand, there are more advanced smartcard payment systems such as the TAP and Clipper card programs, and on the other hand, services that only accept exact change in cash. While there are a few instances of integrated transit in which one type of fare media is accepted across different modes and agencies, such as LA Metro (TAP card), MTC in the Bay Area (Clipper card) and MTS in San Diego (Compass card), these and other fare payment systems in the State are not interoperable.

Regarding differences in fare structure, some agencies have flat fares, others have distance-based fares by miles (requiring customers to tap in and tap out), or by zones, and some agencies charge fares based on time-of-use (on-peak versus off-peak). Agencies usually offer discounted fares to different special groups, such as students, senior citizens, military veterans, low-income people or the disabled, yet do not follow a standard definition for each group (ie, senior citizens are defined as 60+, 62+, or 65+). Agencies also often offer different pass products such as daily, weekly and monthly unlimited passes and may offer free or discounted transfers from one mode to another. All of these rules differ greatly from agency to agency.

There are also dramatic differences in fare payment technology and sales channels that are deployed. These include closed loop pre-paid smartcards, magnetic stripe fare media, paper tickets, mobile tickets with QR barcodes, and cash. Looking ahead, agencies will begin to accept contactless bank cards and mobile wallets (known as open-loop payments due to their interoperability, except when paying for transit). Sales channels include ticket vending machines, ticket sales offices, web and mobile based ticket sales and retail outlets where users can purchase new cards, tickets or load up prepaid transit dollars. Many smaller agencies in California are still limited to cash collection onboard buses and many require users to carry exact change.

Among the larger agencies, there is a trend toward investment in modern fare collection technology. This consists of onboard validators and faregates, which would in the future accept open-loop payment fare media including bank cards and mobile wallets, as well as agency-branded closed-loop smartcards which may be linked to a user's account and can be reloaded through the various channels mentioned above. Implementing these new automated fare collection systems has been identified by agency executives as a way to boost ridership, and in some cases, reduce operating costs by decreasing the need for cash collection. We estimate the costs associated with cash collection to be approximately 13% of the cash collected. While the use of cash in the United States is decreasing[9], even agencies actively providing alternatives to cash may still face the fixed cost of accepting cash.

[9] Source: https://www.frbsf.org/cash/publications/fed-notes/2019/june/2019-findings-from-the-diary-of-consumer-payment-choice/

Recent developments have brought more advanced fare payment collection technology called account-based fare payment[10]. These systems allow transit agencies to more easily implement fare capping – which simplifies the fare structure by eliminating the need for pre-paid passes. Under a fare capping program, the customer doesn't need to decide between some kind of pass and pay-as-you-go, as fares paid are automatically "capped" at the price of a daily, weekly or monthly pass, even if the customer is buying rides on a pay-as-you-go basis. This capability has significant advantages from an equity and inclusion perspective since it allows low-income customers to benefit from the volume discounts of passes that wealthier riders afford without needing to surrender the upfront cash.

2.4 Eligibility programs

Within the current public transit ecosystem, it can often be very difficult for low-income customers and other special groups to claim benefits that they are entitled to. It's likely that these hurdles and barriers have a negative impact on transit. Phrased more positively, a standardized, customer friendly solution for accessing benefits may help to improve the transit experience for this population.

Low-income customers are the population segment most likely to use transit because they lack the means to use alternatives. Around 13% of Californians fell below the poverty line of $24,900 per year for a family of four. Poverty was highest among children (19.3%) and lower among adults age 18–64 (17.1%) and those age 65 and older (18.5%)[11]. While the level of discount varies, a typical transit agency in California will have special programs for low-income riders, youth (or student) riders, seniors and persons with disabilities.

The processes to prove eligibility for these discounts are often onerous. The application processes for discounted fares differ between digital (e.g. transit smartcard) and non-digital (e.g. paper passes) fare collection systems. If an electronic system is in place, transit riders are required to apply for dedicated, discounted smart cards either via mail or in person. Seniors, youth and people with disabilities can prove their eligibility by showing their ID, student ID or Medicare card, or by documenting eligibility in some other way. Riders with temporary disabilities or special cases are sometimes required to obtain written proof from their physician. Some agencies – with digital or non-digital fare collection systems – require their riders to apply for a separate agency-branded card that documents the riders' eligibility for a discounted price. Some agencies that offer low-income rider programs require their customers to prove their eligibility by supplying verification of income once or twice a year to the agency. Some

[10] During the Cal-ITP market sounding, most fare collection vendors indicated that they support Account-Based Ticketing

[11] Source: Public Policy Institute of California, retrieved from: https://www.ppic.org/publication/poverty-in-california/ (Access date: 07/30/2019)

agencies require discounted passengers to have their photograph on the discount media.

Table 2 – Rides per Population Group

Population Group	Share of population	Share of riders
Senior (65+)	14%	7-10%
Youth (K-12)	16%	3%
Persons with Disabilities	13.4%	20%
Low-income	17.6%	Depends on the low-income thresholds and household size

Source: Rebel Analysis Database

2.5 Identified issues

Public transportation in California faces serious challenges: as mobility preferences and options shift to personal cars, shared rides, TNCs and new micro-mobility services, transit ridership and fare revenue are decreasing. Meanwhile, operating costs and capital expenditures in public transportation are steadily increasing.

The constantly optimized, rigorously tested customer experience provided by TNCs and new mobility services are setting new standards in mobility and customer expectations: Dense networks, real-time information, multimodal offerings, and seamless payments (at least for those participating in the banking system) have become the norm. Hundreds of public transit operators in California are struggling to introduce similar features and are failing to keep up with the rate of mobility innovation found in the private sector. This implies that the downward pressure on public transportation demand may well get stronger over time.

Public transportation in California urgently needs to consider fundamentally rethinking its service propositions, its pricing propositions and the way it engages with its existing and potential customers. To inform this assessment, our team conducted in-depth market research and gathered feedback from market parties and transportation providers between September 2019 and January 2020. In this research, three main, underlying issues were emphasized:

Issue #1: Lack of reliable information decreases ridership: Due to low adoption of GTFS real-time or equivalent transit information standards, (existing and potential)

transit users are not provided with the reliable transit information in real time that is expected today. Lack of real-time service information (e.g. vehicle arrival time, platform changes, crowding, important notices) decreases the trust of frequent transit riders in the public transportation system, and discourages new users. Currently, using transit in California requires planning ahead and collecting information from different sources. Infrequent riders and visitors of California will not choose transit as their preferred travel option as long as additional effort is necessary to obtain basic information such as trip price and payment options. The landscape is further complicated since there is no statewide alignment in available service information, tariff structure or discounts – each agency and service area have different rules.

Issue #2: Frictions in payment create unnecessary hurdles for users: Outside of the four larger smartcard systems (TAP, Clipper, Compass and Connect), digital fare payment solutions are rare. Large numbers of small agencies only accept (exact) cash payments or use paper passes. The digital solutions that are introduced by some of the agencies are rarely interoperable with each other. Traveling from one region to another in California means purchasing multiple types of fare media. This creates a hurdle for infrequent riders and visitors that do not have the required fare media (e.g. a smartcard) and therefore discourages or prevents them from using transit. To provide a modern solution for their users while avoiding large up-front infrastructure investments, some transportation services are procuring mobile ticketing applications. However, these applications are limited to a particular service area and do not provide interoperability between transportation agencies. Mobile apps seem to be a successful tool to satisfy the short-term need for innovation, but in the long-term, they can cause lock-in problems and very high switching costs for transit operators and agencies.

Issue #3: Complex processes for transit riders eligible for discounts hamper inclusivity: Our team identified several groups of transit riders with complicated onboarding experiences: Youth, elderly, commuters receiving employee benefits, veterans, persons with disabilities and low-income riders. In short, all users that have part or all of their fares paid by someone else, and users eligible for discount programs. All these users, and the transit agencies serving them, could benefit from seamless eligibility verification for their customers.

Our root cause analysis shows that lack of standards, standards-based solutions and lack of coordination among transportation providers are the most significant barriers for introducing seamless, innovative solutions for information and payments in transit. Without an organized, statewide effort the chance for providing integrated solutions and adopting innovative new ideas, while leveraging California's buying power, is very low.

Cal-ITP aims to tackle the above highlighted issues through providing a recognizable and seamless customer experience for obtaining information about transit and paying for transit, optimized for mobile technology. The three Cal-ITP initiatives are:

1. Ensure access to reliable and accurate transit information;

2. Reduce friction in payments;
3. Create a statewide eligibility verification program.

While the proposed initiatives may not address some of the more fundamental issues in public transportation – such as quality of service and frequency of service – we offer that the implementation of these measures will alleviate the downward pressure that comes from increasing customer expectations and competing offerings. The initiatives aim to provide a way forward by organizing providers to offer integrated services.

3 Proposed Cal-ITP Initiatives

3.1 Overview

Regarding transit information and fare payments in California, three main issues were identified: (1) lack of reliable information, (2) frictions in payment and (3) complex process for transit riders to verify their eligibility for discounted fares. Cal-ITP aims to tackle these issues with three groups of initiatives:

1. Ensure standardized statewide access to reliable transit information

To provide reliable and valuable information for transit riders, Cal-ITP suggests implementing GTFS real-time, a transit information standard used worldwide, for all fixed route bus and rail transportation services in the state, as well as GTFS extensions as they are adopted.

2. Create a standardized statewide fare payment system

To create a standardized fare payment system, Cal-ITP proposes the following four interrelated projects:

A. Outside of the larger smartcard systems, acceptance of digital payment solutions is rare and different card systems are not interoperable which results in a payment experience full of obstacles. To improve the payment experience, at least one single payment method must be accepted across the whole state complementing existing payment options. *Cal-ITP proposes that this alignment takes place on contactless EMV payment technology*. This can take the form of a contactless (bank-issued) payment card, a closed loop (transit agency-issued) payment card, or a mobile wallet.

B. Additionally, to be able to provide everyone the same payment method, *Cal-ITP proposes issuing closed loop transit cards state-wide, based on the EMV standard, for the unbanked, underbanked and customers whose transit fares are funded by a third party*.

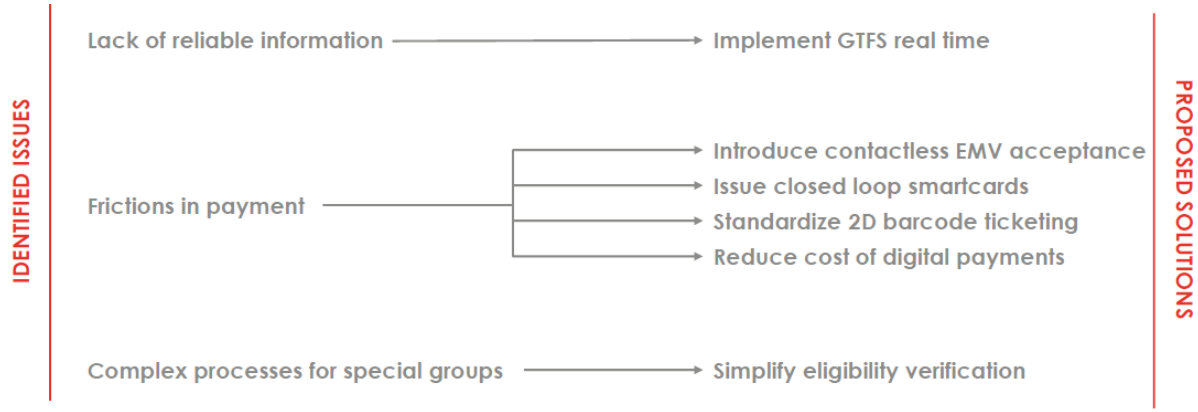
C. Although more and more companies are offering 2D barcode-based payment solutions for transit operators, standards are not yet in place. *Cal-ITP aims to take steps towards standardizing the layout of barcodes used in transit and developing open ticket sales and fare payment application programming interfaces (APIs)*. We expect this standardization effort to prevent more customer experience issues for riders and technology lock-ins for transit operators and allow smaller agencies with limited access to capital to introduce mobile ticketing.

D. We anticipate that the above efforts will lead to an increase in digital payments. Since the fees paid by transit agencies can be lower with greater overall transaction volume, *Cal-ITP aims to reduce the costs borne by transit agencies through a state-wide master service agreement with a payment acquirer-processor*.

3. **<u>Create a statewide eligibility verification program for transit riders with discounted fares</u>**

Digitalization often leads to higher customer satisfaction, but it may simultaneously create new hurdles for some riders. Digital payment solutions usually require digital verification of transit riders' eligibility for discounts, which is not inclusive for riders without access to digital technology. Many of the current processes in place are time-consuming and costly for both transit operators and riders. *<u>Cal-ITP suggests introducing a centralized eligibility verification system that can accommodate the benefits of all special groups and discounts.</u>*

Figure 4 – Summary of Identified Issues and Proposed Solutions



In this chapter, we introduce the proposed initiatives in detail, describe the suggested steps to carry out the initiatives, and assess the expected costs and benefits of the initiatives. Interdependencies between the initiatives are highlighted at the end of this chapter, which explain any combinatory effects in costs and benefits. A more complete description of the methodology used in the analysis can be found in Appendix 2. Appendix 2 also explains the sources behind the key cost and benefit assumptions presented in this chapter.

3.2 Ensure access to reliable and accurate transit information (Initiative #1)

Cal-ITP aims to ensure that transit operators publish accurate and constantly up-to-date route planning and wayfinding information for use in mobile apps and other computer aided programs. This information should include:

1. Transit schedules, routes, stations and stops
2. Trip costs for every route, starting with the standard/base fare
3. Real-time vehicle location and arrival information, and any deviations from schedule

GTFS (General Transit Feed Specification) and its real-time extension GTFS-rt are globally recognized specifications for transit information. Cal-ITP recognizes that the GTFS specification has some limitations, including no accuracy requirements or guidelines that can help agencies to establish accurate GTFS data while adhering to existing statewide reporting requirements. In order to aid agencies in implementing GTFS throughout their network and vehicles, Cal-ITP proposes to:

- Officiate GTFS as the statewide standard for transit data
- Expand GTFS to serve more use cases
- Develop a common GTFS infrastructure
- Initiate and support the creation of California Implementation Guidelines for GTFS
- Create and maintain a program to establish, incentivize and maintain compliance with the statewide standard including the development of California Implementation Guidelines
- Provide a way for local agencies to source GTFS implementation support
- Provide an ongoing way for local agencies to source equipment (such as Automated Vehicle Location equipment) to be able to publish and communicate real-time information and other aspects of mobility data standards as they are developed
- Provide a way for local agencies to source passenger-facing equipment (such as information displays)

Several agencies are publishing transit information based on GTFS and GTFS-rt in California already, however most agencies are currently not doing so. These agencies may be invited to opt-in to this program and leverage the buying power of the State of California to receive implementation support, to procure AVL equipment and, potentially, passenger facing information displays.

In assessing the impacts of this initiative, we assume that all agencies that currently do not support GTFS-rt (except demand response services) will implement it in 3 years, starting in 2021.[12]

Expected Benefits of Implementing GTFS-rt

- Incremental fare revenue from increased transit ridership
- Decreased passenger waiting times
- Higher passenger satisfaction (not quantified in this study)
- Transit operators can better harvest data and operational patterns (not quantified in this study)

[12] A more complete overview and explanation of assumptions is found in 0

Expected Costs of Implementing GTFS-rt

- Implementation cost of $250 per transit route where GTFS static is not available
- Implementation cost, borne by the State, of $500,000 to procure a framework contract for a simple automatic computer aided dispatch or vehicle location system (CAD/AVL) with GTFS-rt
- Implementation cost of $150 per vehicle for Android devices and mountings
- Yearly operating cost of $366 per vehicle for mobile data and Software-as-a-Service subscription to a CAD/AVL service with GTFS-rt

3.3 Reduce friction in payments (Initiative #2)

Cal-ITP aims to create a public transportation environment in California in which all transit agencies will accept at least one standardized fare payment method. This entails Cal-ITP promoting one payment method – contactless EMV technology – as a basis for statewide standardization of fare payments in California. The increased penetration of digital (i.e. non-cash) payments is an undeniable trend. The latest developments in consumer payment in the retail environment (such as e-wallets, contactless bankcards, 2D barcode such as QR-codes), have boosted transit riders' expectations for ease of payment. In addition, the seamless onboarding and payment experience provided by (private) mobility service providers have further lifted user expectations and increased the pressure on public transportation operators to implement new payment solutions.

Cal-ITP recognizes that the complexity and cost for agencies to install and operate contactless validation technologies may be prohibitive for many agencies. Cal-ITP also understands that many agencies have implemented or are considering implementing mobile tickets with QR or visual validation, which may complicate the movement toward a unified payment approach Cal-ITP wishes to lower the cost for these agencies to implement mobile ticketing while at the same time promoting standardization and preventing the proliferation of different proprietary platforms that hinder a smooth user experience.

3.3.1 Accepting contactless EMV-media as payment method (Initiative #2, Project #1)

Bank cards and contactless mobile wallets (e.g. Apple Pay or Google Pay) that adhere to EMV specifications should be accepted for both identification and fare payment across all transit agencies. EMV acceptance would be in accordance

with the UK Contactless Transit Models 2 and 3[13], respectively the Aggregate Pay as You Go and the Pre-Purchase models. This means that customers can tap and pay with any contactless bank card or mobile phone that adheres to the contactless EMV specifications of the major global payment networks (VISA, Mastercard, American Express, Discover) and that all base fares and pre-paid passes are supported. Improved and more equitable products such as fare capping could technically be adopted by participating transit operators over time.

Cal-ITP recognizes that the implementation of contactless payment technology requires a substantial effort from transit agencies. In order to aid these agencies in implementing this, Cal-ITP will need to undertake the following actions:

- Provide a method for local agencies to source their EMV front-end payment acceptance and inspection devices
- Provide a central fare calculation and fare aggregation service and a method for agencies to source the same
- Provide a method for agencies to source payment processing services
- Provide a path forward for agencies to source EMV implementation support

In assessing the impacts of this initiative, we will assume the following:

- The penetration of contactless payment methods is increasing in the coming years in California. We assume that half of the riders that buy single journey tickets or use stored value in a transit card system will shift to using either contactless payment cards or their mobile phones to pay their fares. In addition, we evaluate separately the impact of linking passes to contactless payment cards. In this case, we assume that half of riders that now buy passes will shift to contactless EMV payment media over the project lifetime.
- We assume that starting in 2021, agencies will gradually implement the acceptance of bank cards until all agencies in California support this standard by the end of 2025.

[13] Source: http://www.theukcardsassociation.org.uk/wm_documents/Contactless%20transit%20models%20-%20further%20information.pdf

Expected benefits of accepting contactless EMV-media as payment method

- Incremental fare revenue from increased transit ridership
- Lower costs of fare media for passengers
- Lower fare collection costs for transit agencies (dependent on agencies switching off other methods)
- Decreased passenger time spent on purchasing tickets or transit card top-ups
- Higher passenger satisfaction (not quantified in this study)
- Decreased vehicle dwell times (not quantified in this study)

Expected costs of accepting contactless EMV-media as payment method

- For all agencies except Clipper and TAP: capital costs of $1,500 per vehicle, and $15,000 per station for refitting with EMV-compatible devices, and $50,000 configuration costs.
- For Clipper $8 million to activate and for TAP $30 million to implement EMV acceptance and $2 million configuration costs
- Operating costs of 20% of the capital expenditures
- Operating costs from digital payment processing fees

3.3.2 Centralized closed loop media issuance (Initiative #2, Project #2)

Understanding that bank card- and smartphone-based payment solutions are not available to everyone in California, Cal-ITP aims to introduce closed loop fare media through which eligible customers and the unbanked can get a contactless card or mobile token that is accepted throughout California.

A transition to newer, more advanced fare collections systems does not itself guarantee that the issues highlighted in this report will also get addressed for low-income customers. In fact, a fare collection system that emphasizes non-cash payments tends to create new barriers for many low-income customers, as some of them may not have bank accounts, or pay high fees, and therefore don't have debit or credit cards to use in the transit system. Twenty percent of Californians are underbanked, meaning that the household had a checking or savings account but also obtained financial products and services outside of the banking system. Seven percent of Californians are unbanked and don't make use of any banking services whatsoever. It is important for transit agencies and Cal-ITP to

remain focused on this segment in the design of new fare payment solutions and benefit programs.

While this problem can be addressed in many ways, the core of the issue is that the transit system must allow these customers to still use cash to pay for transit, even if it is trying to remove cash from the transit system itself. One way to accomplish this is with closed loop pre-paid cards and extensive retail networks where customers can use cash to load value onto their transit cards. This way, even an agency moving toward open-loop payments can retain the closed loop card option, and all types of customers can tap their cards at the faregates or onboard buses in the exact same way, reducing operating costs by lowering the cost of revenue collection, and reducing dwell times on buses due to slow cash fare payment on board.

The issued cards would be EMV-compatible and may be restricted for transit use only. Value would be added to the cards either online or through a retail network.

Cal-ITP would undertake the following to ensure that all residents and visitors have access to fare media that is accepted statewide:

- Initiate and support the creation of an entity that maintains customer accounts and issues EMV media (including mobile wallets) to customers
- Initiate and support the creation of a top-up network to fund the customer accounts

<u>In assessing the impacts of this initiative, we will assume the following:</u>

1. This initiative generally extends the benefits of contactless EMV to the unbanked and underbanked populations in California, many of whom ride transit.
2. There is no net benefit that results when a transit agency shifts from operating their own retail network to a retail network organized by the issuer of closed loop media (under which the operating costs are passed through to the transit agencies).

Expected Benefits of Centralized Closed Loop Media Issuance

- Contributes positively to the benefits described above for Initiative #2, Project #1 (EMV acceptance)

Expected Costs of Centralized Closed Loop Media Issuance

- Capital costs to procure a service provider
- Increased operating costs from closed loop EMV issuance
- 3% of fare revenues for commissions to maintain a retail network for top-ups
- Operating costs from digital payment processing fees

3.3.3 Improving 2D barcodes for interoperable mobile ticketing (Initiative #2, Project #3)

Cal-ITP aims to improve the marketplace for agencies through standardization of the 2D media specification. Cal-ITP will also standardize a payment and ticket sales API that would allow agencies to open up mobile ticket sales to any permitted third-party vendor.

In the last few years, penetration of 2D barcodes as tickets and payment media significantly increased and became more popular in transit. The most common application of 2D barcodes in transit are 1) barcodes as part the layout for pre-paid tickets (optical reader and/or digital inspection required), 2) barcodes generated by mobile applications for pre-paid passes or tickets (digital and/or visual inspection possible), and 3) barcodes as identifiers for mobile wallets to initiate pay-as-you-go payments (optical reader and electronic inspection required). The second type is today the most common application of barcodes used in payment in California. Recently, several mobile ticketing applications were launched in California that generate a barcode if the user has a valid ticket or pass. These codes can be inspected visually or by an optical reader. However, the way that the mobile ticketing ecosystem is currently organized does not allow for interoperability between transit agencies; tickets are not accepted or sold across different agencies through mobile ticketing apps.

Cal-ITP will therefore undertake the following actions:

- Initiate and support the standardization of 2D barcode specifications for mobile ticketing
- Initiate and support the standardization of a fare sales and payments API
- Provide a way for local agencies to source their 2D barcode front-end payment acceptance devices
- Provide a way for local agencies to source implementation support
- Create and maintain a program to establish compliance with the standardized interfaces

- Initiate and support the creation of business rules between transit agencies and third-parties selling trips

In assessing the impacts of this initiative, we assume that Cal-ITP will not promote any of the QR code use cases mentioned above but rather will encourage the implementation of contactless validation devices, based on the feedback received from transit operators.

Expected benefits of improving 2D barcodes for interoperable mobile ticketing

- Prevent vendor lock-in (not quantified in this study)
- Support transit in selling integrated trips across agencies and service areas (not quantified in this study)

Expected costs of improving 2D barcodes for interoperable mobile ticketing

- Implementation cost, borne by the State, of $1,000,000 to create a standard and procure a framework contract

3.3.4 Reducing the cost of digital payments (Initiative #2, Project #4)

Cal-ITP is aiming to prepare a statewide Master Service Agreement for Merchant Services:

Transit users are increasingly choosing to top-up transit smartcards with bankcards, purchase single tickets with Apple or Android Pay, or autoload their monthly pass to their smartcards. The current cost structure of payment acquiring in other sectors is based on tiered transaction volumes and transaction amounts. This cost structure significantly increases the cost for transit operators that allow their riders to pay for small value tickets (e.g. single ticket, day pass, top-up of $5) through digital payment methods. Looking ahead, acceptance of contactless bankcards for onboard payments will result in an increase in transactions with low dollar amounts. Due to the nature of the transaction acquiring business, entities that can promise large volumes of digital transactions are better able to negotiate a favorable fee structure.

Currently, many transit operators have their own merchant acquiring contracts with a relatively small number of annual transactions with a low total dollar amount. To improve the negotiating position of transit operators in California, Cal-ITP proposes to close an MSA for merchant acquiring services with payments industry contractors to handle digital payments for the benefit of transit agencies in the State of California. The resulting acquiring MSA aims to maximize the purchasing power of the state of California, onboarding as many transport operators as possible over time. The proposed MSA will only affect the acquiring

services portion of the transaction fees paid by transit agencies – interchange fees and fees paid to the payment schemes will not be affected.

In assessing the impacts of this initiative, we will assume the following:

1. Only the processing fee paid to the acquirer/processor of digital payments is affected. The scheme fees and interchange fees are not affected. In the evaluation, we assume that only the base per transaction processing fees are paid, excluding any fees for gateway usage and other services. Note that the benefits of this initiative extend to lowering the fees of these value-added services as well.
2. All the transit operators and agencies currently under their own acquiring contracts will switch to the statewide MSA in 5 years, starting in 2022.
3. The digital share of all transit sales in California is around 33%. This share may be expected to increase in the future, however when we model this initiative, we assume a static share of digital payments over time.

Expected Benefits of Statewide Merchant Service Agreement

- Decreased fixed transaction fees for transit agencies
- Decreased (fully eliminated) variable transaction fees for agencies

Expected Costs of Statewide Merchant Service Agreement

- Switching costs of $10,000 per agency plus 1% of the annual value of the digital transactions processed (we assume that 50% of agencies will incur switching costs)
- Implementation cost, borne by the State, of $500,000 for framework contract procurement

3.4 Create a statewide eligibility verification program for special groups (Initiative #3)

Certain special customer groups face even higher adversity than the average transit customer when it comes to fare payment. Cal-ITP aims to deploy one program to minimize the burden on these customers: A digitized eligibility verification system, wherein transit agencies can verify eligibility of customers through a single interface

Cal-ITP aims to establish a digitized eligibility verification system that will simplify the application process for eligible transit users to access discounted fares and will ease the verification process for transit agencies. Regions and transit agencies are increasingly introducing discounted fares for eligible populations. However,

there is no commonly recognized set of rules or processes for applying discounts to comply with federal and local requirements and the preferences of transit agencies. Therefore, transit agencies and customers both end up spending considerable effort to onboard customers for benefit programs. A standardized process is needed for verification of customers' status as a member of special groups (i.e. low-income, elderly, disabled, student, etc.).

In assessing the impacts of this initiative, we assume that this central system will use an existing administrative system (e.g. information available at DMV offices and/or databases provided by universities). As a start, the centralized system will focus on aged-based discounts (seniors, children), and veteran and student status. The ability to verify people with disabilities and low-income riders will also be incorporated.

Expected Benefits of Centralized Eligibility Verification System

- Savings for transit customers from decreased application fees, due to digitalization
- Savings for transit agencies from decreased customer onboarding costs, due to digitalization

Expected Cost of Digitized Eligibility Verification System

- Capital and operating costs to implement the digitized system are not evaluated in this study

3.5 Interdependencies between initiatives

Theoretically, each initiative proposed- by Cal-ITP can be implemented separately and has its own costs and benefits. However, implementation of multiple initiatives lowers the overall cost and results in synergies and increased benefits. The following interdependencies were identified:

- **Implementation of Merchant Service Agreement and EMV-media.** The operating costs of EMV-based solutions (bankcards, e-wallets) will be automatically lower if the statewide Merchant Service Agreement is already in place.
- **Implementation of EMV-media and issuance of EVM-media by the state.** Installing EMV-compatible readers on vehicles and stations, by itself, cannot cater to transit riders who are unbanked, underbanked or not willing to use their bank issued cards on public transit. State-issued EMV media would give an opportunity also for those riders to travel and pay seamlessly for transit statewide.

- **Issuance of EMV-media by the state and digitized eligibility verification.** Establishing a digitized eligibility verification process and having state-issued EMV-compatible transit cards would allow for transit operators and agencies to more easily initiate their own special fare programs. Low-income riders could be the first group to benefit from these initiatives: Based on the conditions set by transit operators, the digital system could check the eligibility of applicants and Cal-ITP (or an appointed entity) could issue a dedicated transit card with a preset discount on it.
- **Creation of a coordinating entity.** Most of the initiatives were designed such that they can be implemented separately. However, that would significantly increase the overall cost of the program and reduce the maximum achievable benefits. One of the main cost-saving aspects would be the establishment of a central Cal-ITP program entity. This entity, program or organizational structure would manage these initiatives, ensuring that the standardization and coordination goals are realized. The entity would deploy these programs, track the progress of the various initiatives and assess the impact of implementation. For the purpose of the analysis, we assume an ongoing annual operational expenditure solely for the management of this coordinating entity.

4 Results

4.1 Overview of analysis approach

Our analysis approaches feasibility from both a financial and economic perspective. We assess the impact of the initiatives described above to answer the question of whether the financial and economic benefits outweigh the costs:

- Financial analysis: Are the initiatives a good idea from a business perspective? When answered positively, this means conceptually that the initiator can make a normal business out of the initiative, or that the financial (cash flow) benefits outweigh the costs.
- Economic analysis: Are the initiatives a good idea from a societal perspective? When answered positively, this means conceptually that the economic benefits (when valued in monetary terms) outweigh the costs.

Both of the analyses start with a base case or 'do-nothing' scenario. In order to make a comparison between the situations *with* and *without* the initiatives, we first had to establish the so-called 'do-nothing' scenario. In this 'do-nothing' scenario the status quo situation before COVID-19 is taken as the starting point for a 15-year forecasting period in which we assume no material changes to the world of payment in transit. This means that we have assumed a normal continuation of the existing situation in which no meaningful capital investments are undertaken to improve payments in transit. The most important assumption of the base case scenario regards the expected growth or decline in ridership. We have assumed a flat profile for ridership in the base case, meaning that we have assumed ridership to be constant for the 15-year forecasting period.[14].

Both of the analyses compare the base case with the 'project-case'. The gist of any benefit-cost analysis is the comparison of the 'project case' with the base-case or 'do-nothing' case. This comparison delivers – in itself – an answer to the question of whether the project is a good idea or not (i.e. whether we can reasonably expect the project to generate net financial and economic benefits). In this particular case, the 'project-case' is the situation in which the initiatives (as discussed in chapter 3) are implemented.

To evaluate the net financial and economic benefits of the initiatives, we use a combination of net present values (NPV) and switching values. Cost-benefit analyses usually try to assess the NPV of the project case tested against the NPV of the base case. The investment is considered to be beneficial if the NPV of the project case is larger than that of the base case. To calculate the NPVs, the analysis requires a full bottom-up calculation of the costs and benefits for both the base case and the project case.

In this study, we faced severe limitations regarding data availability. As a result, we decided that for some initiatives, using switching values would be more

[14] See Appendix 2 for further explanation on this.

appropriate due to the absence of data needed to complete a bottom-up analysis. A switching value is the value of a variable at which point the project investment decision is changed.

In order to give an answer on whether the initiatives are a good idea from a societal perspective, we evaluated the effects of the initiatives with respect to two dimensions, namely:

1) Whether the initiative allows people to reduce their time spent on transit including preparing for transit
2) Whether the initiative results in the reduction of carbon emissions due to the modal shift from private vehicles to transit

To compare the economic costs and benefits of the initiatives, the time saving benefits of transit users are assumed to have a monetary value of $18.44 per hour.[15] In order to assess the value of air pollution reduction, we have estimated the annual economic benefit of a modal shift per person, based on 1) the number of person-miles traveled for both modes of transportation, 2) estimates of the CO_2 emitted per mile, and 3) the social cost of a ton of CO_2 emissions. This has resulted in the estimated value of a modal shift of $66.20 per rider per year from reduced carbon emissions.[16] This value then has been applied to test the economic benefits of interventions.

4.2 Results of our analysis

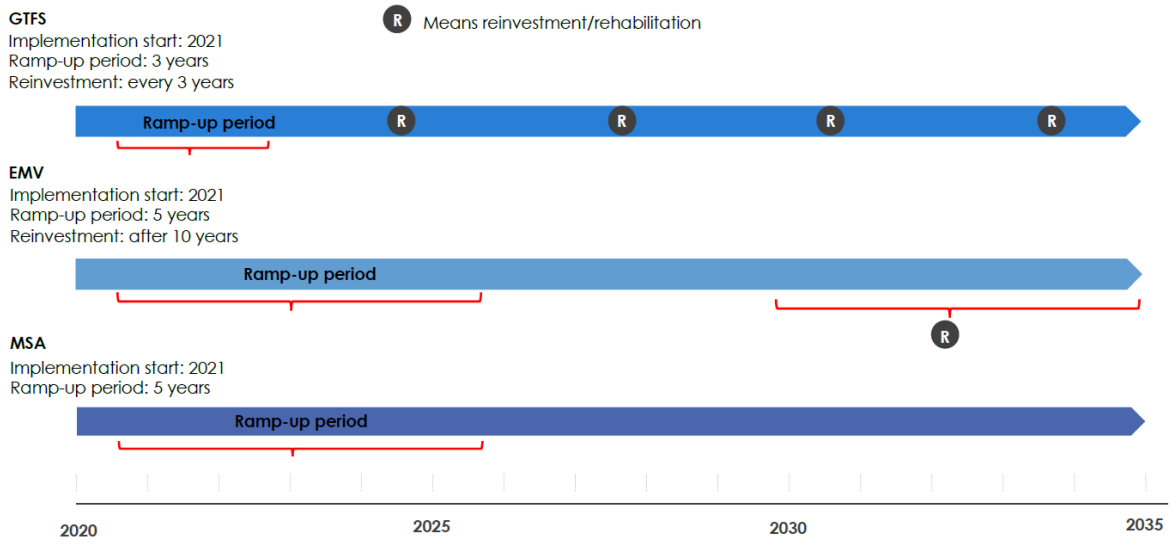
The following results include a financial and economic evaluation of the net benefits generated from the implementation of each initiative. The financial net benefits are calculated by discounting all cash flows at the discount rate over the 15-year evaluation period. This calculation is used to show a breakeven value for the key input assumption that is driving the NPV, by setting the NPV of net benefits equal to zero. The economic analysis shows the additional economic benefit to society from implementing the initiative, if the breakeven value is assumed. If the breakeven variable is above the breakeven value, economic benefits will be greater than the values displayed below.

A high-level overview of the timing of the initiatives can be found below.

[15] See Appendix 2 for calculation source.

[16] See Appendix 2 for calculation source.

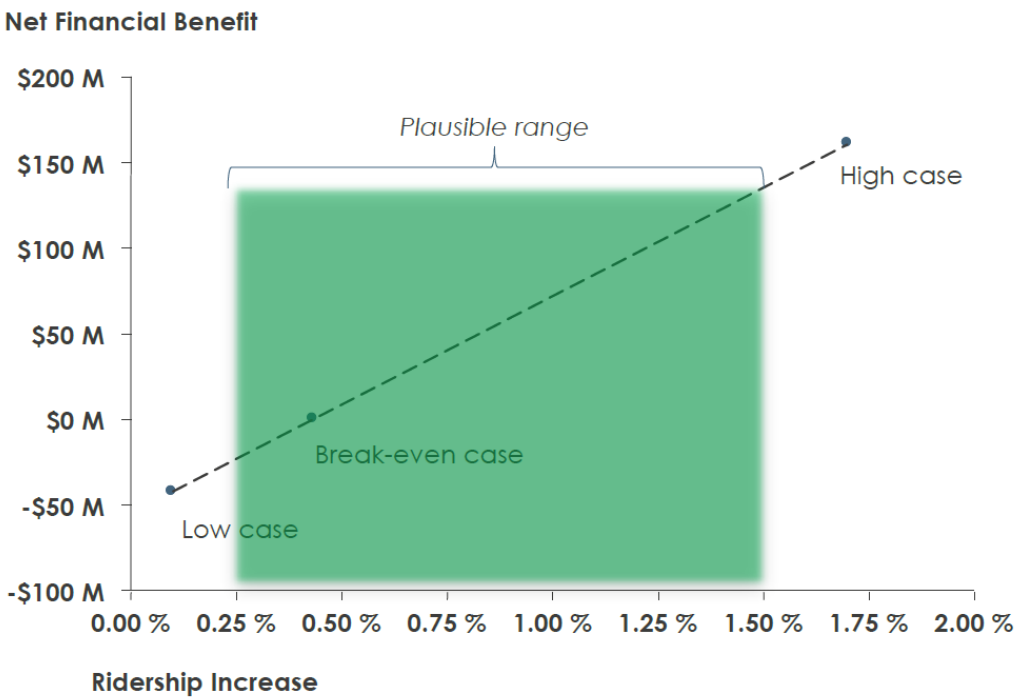
Figure 5 – Timing of Proposed Initiatives



4.2.1 Feasibility of Initiative #1: Ensure access to reliable and accurate transit information

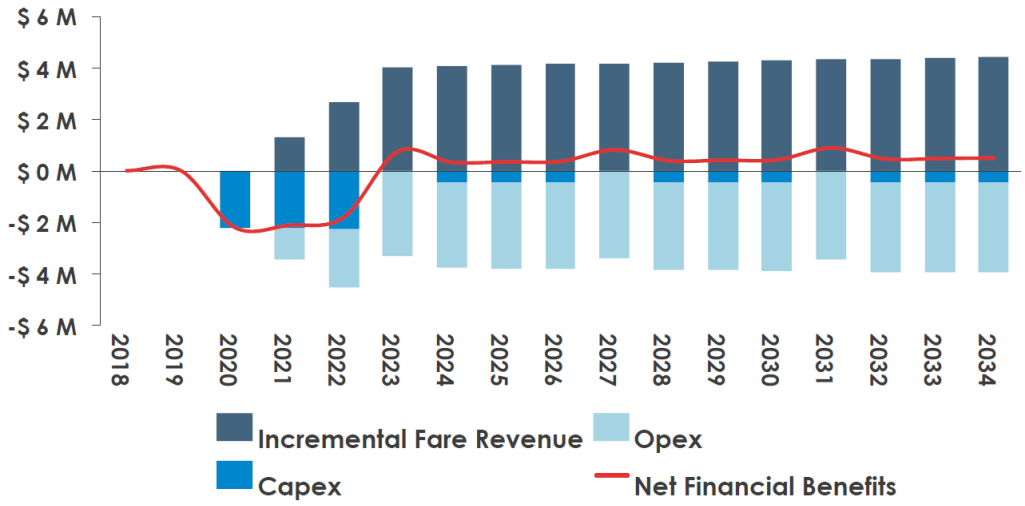
The results of our financial analysis demonstrate that a one-time ridership increase of 0.4% or higher – affecting only the agencies that implement GTFS real-time – would be necessary to break even. In other words, the incremental fare revenue generated by a 0.4% increase in ridership is exactly enough to cover the capital and operating costs to implement the initiative.

Figure 6 – GTFS Financial Analysis



We consider a minimum ridership increase of 0.4% a conservative estimation for the expected ridership impacts, taking into consideration that research[17] shows that a ridership increase of 1.7% has been registered as the result of real-time passenger information in the United States. Therefore, we view this result as a positive one for the feasibility of implementing GTFS.

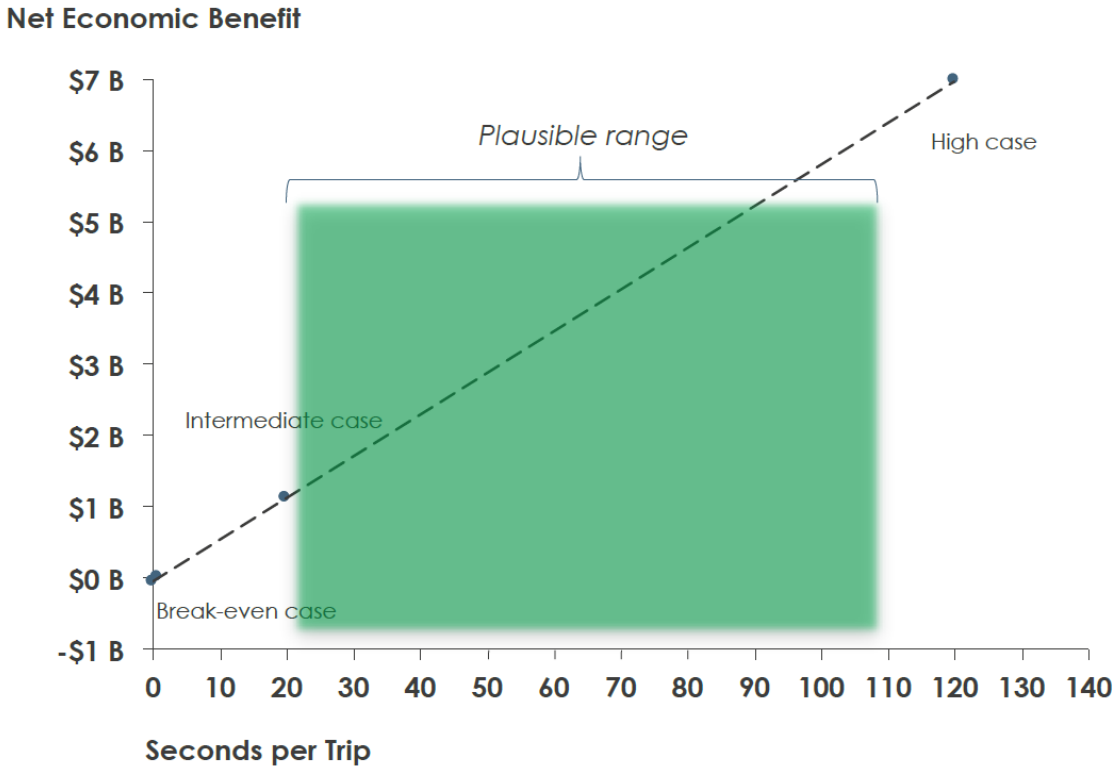
Figure 7 – GTFS Project Cash Flows



The results of our economic analysis demonstrate that the GTFS initiative would be positive for the economy of California if the time savings per trip exceed 0.8 seconds, without any ridership increase being taken into consideration in the calculation.

[17] Watkins, K.E., & Brakewood, C. (2016). Research Pays Off Assessing the Impacts of Real-Time Transit Information. TR News 303, pp.43-44

Figure 8 – GTFS Economic Analysis

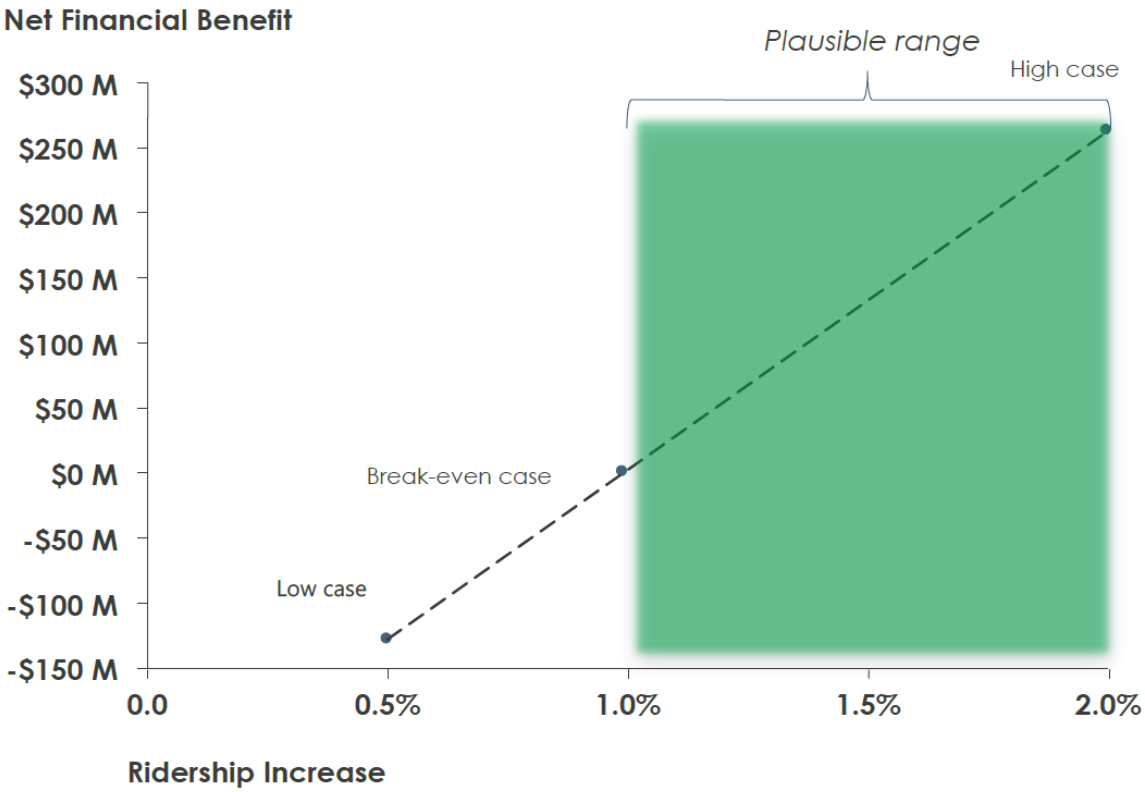


Again, we believe the effect will exceed this value. The same Transportation Research Board study analyzes time savings of 2 minutes per passenger per trip. If we were to assume conservatively that in California, the actual time savings per trip will be 20 seconds, this initiative will realize an additional $1.1 billion in economic benefits for society.

4.2.2 Feasibility of Initiative #2: Reduce friction in payments

The results of our financial analysis demonstrate that an expected ridership increase of at least 1.0% would be necessary to justify investing in standardizing fare payments to EMV and rolling out EMV technology throughout California. This result assumes that all agencies take advantage of lower processing fees. If this were not the case, the required ridership increase would be 1.1%.

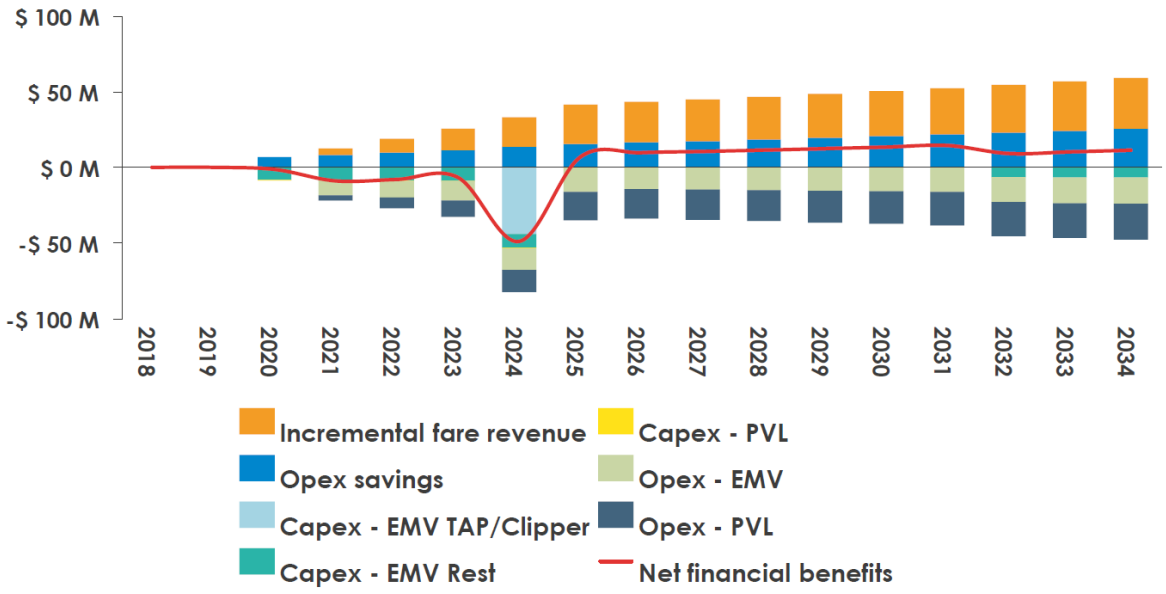
Figure 9 – EMV Financial Analysis



The team has not found definitive studies documenting the ridership effects of accepting payments cards in transit, but other studies, such as a Transport for London analysis that shows a ridership increase of 3-5% as the result of going from a paper and cash ticketing system to a contactless pay-as-you-go system (as happened with the introduction of the Oyster card), give indications that there may be significant ridership effects especially in areas that are not covered by one of the existing contactless pay-as-you-go systems such as TAP and Clipper.

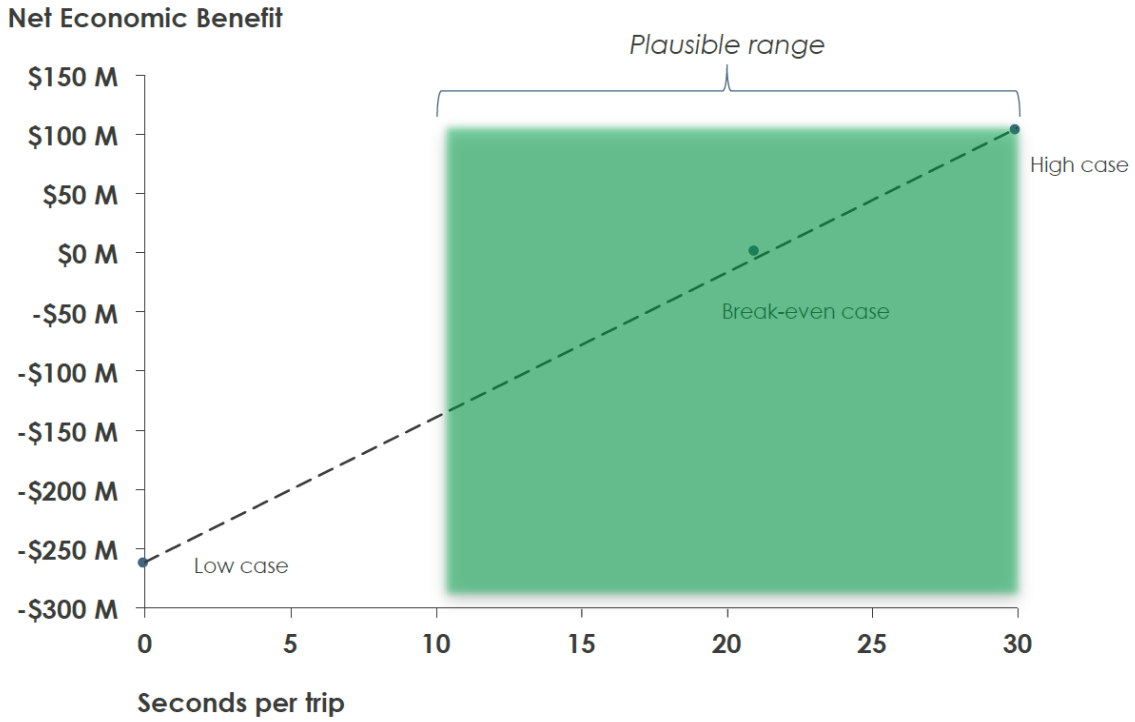
The graph below shows the key financial effects of introducing EMV acceptance through time. Note that we have assumed a 12-year lifetime for the capital investment, meaning that a rehabilitation/reinvestment is not in the evaluation period.

Figure 10 – EMV Project Cash Flows



Note that whereas our evaluation assumes capital investments and rehabilitation expenditures for supporting EMV, the analysis does not take into account the capital expenditures and rehabilitation costs of the existing payment systems. If we would have been able to estimate this with a reasonable degree of accuracy, and if we could assume that agencies would forego investing in and rehabilitating the existing payment methods once the new EMV system is proven and covers all customer use cases, the required ridership increase would be significantly lower or even negative.

Figure 11 – EMV Economic Analysis



The results of our economic analysis show that, absent any ridership increase, 21 seconds of time savings per trip would result in a positive economic case. Whereas there have been no conclusive studies estimating the time savings of EMV payments in transit, we would not find it unreasonable to assume that this is achievable in light of 1) parts of population can forego topping-up transit cards or buying single tickets at vending machines, kiosks, retailers; 2) vehicle dwell times would decrease due to lower share of cash payments; and passenger boarding times would decrease if they switch from cash payments to contactless payments.

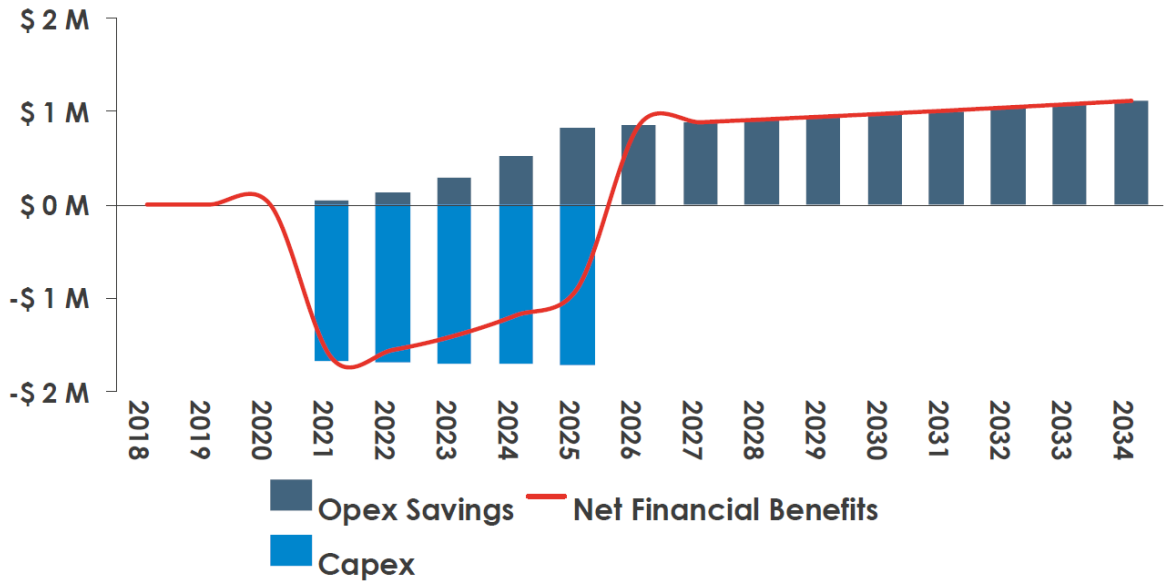
If we assume a 1.0% ridership increase, and average passenger time savings per trip of 21 seconds, the net economic benefit would be $8M, comprised fully of carbon emissions savings.

The project to onboard all agencies onto a merchant agreement with an acquirer-processor with competitive fees – resulting from leveraging the state's buying power – results in an NPV of 15 million USD if the project is implemented, without implementing EMV or realizing ridership increases from any of the initiatives.

Table 3 – MSA Project Results

Financial Net Benefit Calculation:	NPV
Opex savings	$23M
Capex	($8M)
Financial Net Benefit	*$15M*

Figure 12 – MSA Project Cash Flows



The contribution of the MSA project on the EMV initiative is an NPV of $29 million, but those savings have already been factored in the EMV financial net benefits.

Initiative #2 Results: Sensitivity Analysis

Results shown above are for the "base case" of the sensitivity analysis and include the implementation of EMV across all agencies in California. Due to the relatively large influence of TAP and Clipper (issued by LA Metro and MTC) on the statewide incremental revenues and implementation costs, we also tested the results of the analysis taking into account 1) all agencies *except* TAP and Clipper accepting agencies, and 2) *only* TAP and MTC accepting agencies.

Table 4 – EMV Scenario Analysis on the Impact of TAP and Clipper

Scenarios	**Financial Net Benefit**	**Required ridership increase**	Economic Net Benefit **at 21 seconds per trip** and required ridership increase
Base: All agencies	$0	1.0%	$8M
All except TAP and Clipper	$0	2.2%	($78M)
TAP and Clipper only	$0	1.2%	($26M)

Other key assumptions for which we have evaluated the sensitivity are shown in the following table.

Table 5 – EMV Sensitivity Analysis on Key Parameters

Sensitivity Factor		**M$ NPV - EMV**	**M$ NPV - MSA**
Average pass value			
Low value	-50.00%	(4)	1
Base value ($80)	-	0	1
High value	50.00%	1	1
Average top-up value			
Low value	-50.00%	(10)	4
Base value ($8)	-	0	1
High value	50.00%	3	0
Number of trips per aggregation period			
Low value	-50.00%	(138)	(16)
Base value (2.5)	-	0	1
High value	50.00%	46	6
Acquirer processing fees			
Low value	-50.00%	12	12
Base value ($0.008)	-	0	1
High value	50.00%	(12)	(11)
EMV central system cost (capex)			
Low value	-50.00%	39	1
Base value ($20M)	-	(0)	1
High value	50.00%	(39)	1
EMV capex per vehicle			
Low value	-50.00%	16	1

Sensitivity Factor		M$ NPV - EMV	M$ NPV - MSA
Base value ($1,500)	-	(0)	1
High value	50.00%	(16)	1
EMV capex TAP			
Low value	-50.00%	58	1
Base value ($30M)	-	(0)	1
High value	50.00%	(58)	1
EMV capex MTC			
Low value	-50.00%	4	1
Base value ($8M)	-	(0)	1
High value	50.00%	(4)	1

The parameters that stand out with a high impact on the financial feasibility of the initiative are:

1. **Number of trips per aggregation period.** This factor may have been estimated incorrectly – the actual value may be higher or lower – depending on the number of trips an average user makes on a certain day. The value may also be influenced by increasing the period over which trips are aggregated. Note that increasing this period has a negative impact on the user experience.
2. **Capital investment in a central system.** Whereas central systems may be realized at significantly lower cost than assumed – i.e. in a SaaS model or buying off the shelf – the impact of cost overruns here have a significant impact on the NPV of the project.
3. **Sensitivity to investments made by LA Metro in upgrading the TAP system to accept EMV.** If this is done in a forced manner, wherein all investments are allocated to supporting EMV only, the investment may be significantly higher and the NPV of the project decreases. However, if TAP anticipates a substantial system upgrade for other purposes, and only the incremental cost to support EMV are considered, then the investment may be lower, and the benefit-cost analysis improves in favor of EMV.

4.2.3 Feasibility of Initiative #3: Create a statewide benefit verification program for special groups

The results of our financial analysis show that $10 million in net present value is created by implementing the eligibility verification project. Due to the lack of availability of data needed to estimate the costs and cost structure of the program, this value is treated as a cap for what the program costs could be (in NPV terms) in order to reach a breakeven point.

Table 6 – Eligibility Verification Project Results

Financial Benefit Calculation:	**NPV**
Opex savings – agencies	$15M
Financial savings - customers	($5M)
Financial benefit	*$10M*

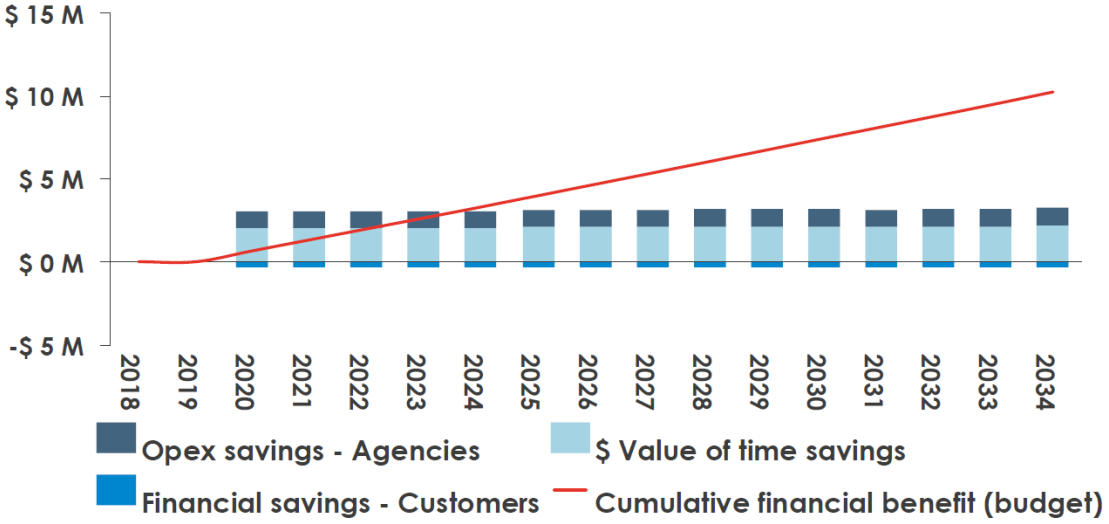
In other words, $10 million is the "budget" for the initiative, including capital costs and operating costs over the 15-year evaluation timeline. This will likely be insufficient to realize a statewide eligibility verification program. However, due to the lack of information on potential costs and the full range of potential benefits, we view this analysis as only as preliminary. The next step would be to conduct more comprehensive research to estimate the number of California residents that would qualify for *all* possible benefit programs. We have taken the conservative approach to only include age-based benefits in our evaluation, which may underestimate possible savings. We have also taken a conservative assumption that eligible customers would still spend time and money to onboard onto a statewide program, but this may not be true if the eligibility verification program can strategically leverage existing administrative processes. For example, a plurality of Californians has a driver's license and as such must be periodically in contact with the Department of Motor Vehicles which could – and already does – verify personal attributes. As more information is gathered on both the benefits and costs of this initiative, this analysis should be updated and reassessed to evaluate whether the business case improves.

Table 7 – Eligibility Verification Economic Analysis

Economic Net Benefit Calculation:	**NPV**
$ Value of Time Savings	$31M
Economic Benefit	*$31M*

The results of our economic analysis show that $31 million in economic benefits may be realized from the implementation of the initiative due to time savings.

Figure 11 – Eligibility Verification Financial and Economic Benefits



5 Conclusions

As this report illustrates, public transportation in California is facing serious obstacles to success. A lack of investment in operational performance and the rise of convenient alternatives to transit is threatening the long-term sustainability of the public transportation ecosystem. Implementing the initiatives described in this report will not replace the need for other investments to expand transit services and improve its service quality and reliability. However, investing in operational service improvements without also considering necessary upgrades to trip planning and fare payment infrastructure would be imprudent. Therefore, we recommend that Cal-ITP mobilize the resources and key stakeholders necessary to ensure that these initiatives are carried out.

The three initiatives recommended in this report can all be considered financially feasible under relatively loose assumptions and will yield additional economic benefits to the State of California. Due to the lack of data needed to carry out a comprehensive bottom-up calculation of the NPV of each initiative, we chose to disaggregate the analysis and, in some cases, focus on the key assumptions that drive the financial output by using the switching values method. We also relied on sensitivity analysis to test the robustness of our conclusions under various parameters.

Our analysis determined that the implementation of GTFS would be a good investment (i.e. the NPV of the initiative would be greater than $0) if the incremental increase in ridership were to be 0.43% or greater. We believe that a 0.43% increase in ridership is highly probable and achievable. We furthermore believe that the time savings achieved will not only surpass the switching value of 0.8 seconds per trip but will lead to net economic benefits at least $1.1 billion over the 15-year period, reasonably assuming 20 seconds passenger time savings per trip.

We also concluded that the implementation of EMV acceptance, in conjunction with the issuance of a statewide closed-loop payment card, would be feasible if the incremental increase in ridership were to be 1.0% of greater. We believe that this value is probable and achievable if the implementation is done in a prudent manner, leveraging private sector investments and innovations, and keeping all transit agencies in California aligned. In addition, significant additional financial benefits can be achieved if agencies sunset existing fare payment methods in due time. Net economic benefits of implementing EMV may be achieved if the time savings per passenger trip surpass 21 seconds. We believe this is not an unreasonable assumption but unfortunately no studies have been performed that could back this statement.

We concluded separately that implementation of the MSA, another component of the initiative to standardize fare payment, would yield on its own an additional net financial benefit of 14 million USD in NPV terms. However, taken in combination with the EMV initiative, the financial benefits increase with $29M due to the larger amounts that are processed through this channel. The final

component of Initiative #2 to standardize QR codes and mobile ticketing applications, was not measured in this study, but the cost to set-up the program and create standards have been included in the analysis of implementing EMV.

Finally, we concluded that the implementation of a digitized eligibility verification program would create a financial benefit of $10 million and an economic benefit of $31 million, in NPV terms. Due to uncertainty about the cost structure of this initiative, and a lack of data regarding potential costs, the results of these analyses were modeled to communicate a potential cap, or budget, on what total costs may not exceed in order to break even. While we cannot conclusively comment on the financial feasibility of this initiative without examining the cost side, we recommend considering moving forward with this initiative because the distribution of benefits will accrue most toward the transit customers that have the greatest need. A first step could be to further detail a few different implementation options to develop a range of cost estimates. More research can also be conducted to comprehensively value the financial and economic benefits of both age-based and other benefit programs, which can be used to update the business case analysis.

Taken together, this package of initiatives would go a long way toward improving the state of public transportation in California. Transit agencies, customers and the State as a whole all stand to benefit from a transit ecosystem with more reliable and convenient trip planning, fare payment and benefit accessibility. We urge Cal-ITP and its partners to take the next steps to implement these investments.

Table 8 – Summary of Results

Initiative	Financial Analysis	Economic Analysis
Ensure access to reliable and accurate transit information	NPV $0 @ 0.4% ridership increase	NPV $0 @ 0.8 second per trip NPV $1.1B @ 20 seconds per trip
Reduce friction in payments:		
Accepting EMV	NPV $0 @ 1.0% ridership increase	NPV $0 @ 21 seconds saved per trip
Issue closed-loop media	No individual financial assessment, financial impact included in 'Accepting EMV'	No individual economic assessment, economic impact included in 'Accepting EMV'

Initiative	Financial Analysis	Economic Analysis
Improve 2D barcodes	No individual financial assessment, financial impact included in 'Accepting EMV'	No individual economic assessment, economic impact included in 'Accepting EMV'
Reduce cost of digital payments	NPV $14 without accepting EMV NPV $43M with accepting EMV*	No individual economic assessment
Create statewide eligibility verification program	$10M budget to invest and operate	$31M

* Included in the EMV Acceptance project

Appendix 1 - Definitions

2D barcodes: Two-dimensional barcodes that can be used to store a machine-readable ticket or token

Account-based ticketing: A fare payment system architecture that uses a back office to apply relevant business rules and determine the fare, rather than having this information stored on a payment card

Acquirer/Processor: Private company that provides payment processing services for digital payments

Acquiring fees: Fees paid by merchants as part of a digital transaction, which often include both a fixed ($ per transaction) and variable (% of transaction) portion

Application programming interface (API): A set of routines, protocols and tools for building software applications

AVL equipment: On-vehicle and transit agency equipment to continuously track the location of vehicles

CAD-AVL: A Computer-Aided Dispatch / Automatic Vehicle Location system connects vehicles with back office scheduling and dispatching software.

Capex: Capital expenditures are funds used to undertake new projects, often to acquire or upgrade physical assets such as property or equipment.

Central system: A back-office tool that is used to administer the operations of the fare collection system, which is used to provide financial management, such as the clearing and settling of funds and the distribution of revenue between operators, and other services

Closed loop payment card: A transit fare payment card can only be used within a single transit system or partnership of transit systems (e.g. a proprietary fare card)

Contactless bankcard: A credit or debit card that uses near field communication (NFC) technology to communicate with payment readers, which allows cardholders to "tap and pay" for services

Digital fare collection: Fare collection that uses credit cards, debit cards, electronic web transfers and mobile applications as viable fare payment methods (i.e. non-cash)

E-wallet: A mobile application that provisions a virtual bank-issued credit, debit or prepaid card in a mobile device (sometimes these wallets are called "pays," e.g., Google Pay, Apple Pay, and Samsung Pay)

EMV payment technology: EMV is a payment method based upon a technical standard for smart payment cards and for payment terminals and automated teller machines that can accept them (EMV originally stood for "Europay, Mastercard, and Visa", the three companies that created the standard)

Fare capping: A method to cap the fares paid by a customer in a certain period, typically at the price of the pass over the same period

Fare collection costs: The operating costs for a public transportation operator to collect fares, including categories such as issuance of cards, maintenance of ticket vending machines and revenue collection staff (often expressed as a percentage of revenue)

Fare passes: A fare payment card that allows a cardholder to use transportation services in a specialized way, such as for time-based unlimited passes (i.e. daily, weekly, monthly), rather than storing value that is deducted for pay-as-you-go single journey tickets

Farebox revenue: Revenue collected by public transportation operators directly from the collection of fares paid by customers

Front-end equipment: The hardware used in a fare collection system or point of sale, including faregates, on-board validators, payment terminals, and vending machines

GTFS-rt: General Transit Feed Specification "real-time" data is used for live, current information regarding the location of a train or vehicle and offers users valuable up-to-date information regarding arrival and departure times, which requires GPS or similar hardware to be installed on board.

GTFS-static: General Transit Feed Specification "static" data is a common format for transit agencies to share schedules and associated geographical information with mobile app developers.

Interchange fees: Transaction fees paid by merchant's when a customer uses a credit or debit card to purchase goods or services

Master services agreement (MSA): A contract between parties that defines the terms that govern future transactions or agreements (in the context of transit, an agreement reached by a coordinating entity with a contractor/vendor that allows individual operators to receive the same contracted terms)

Mobile ticketing application: A smartphone software application that enables a rider to order, pay for, obtain, and validate a transit ticket (which is a separate function from mobile payment from e-wallets)

Net present value (NPV): The difference between the present value of cash inflows and the present value of cash outflows over a period of time, used in capital budgeting and investment planning to analyze the profitability of a project or investment.

Open-loop payment system: An account-based transit fare payment system that is able to accept third-party payment media such as bank cards and mobile device as its fare media

Opex: Operating expenditures are funds used for ongoing costs related to regular business operations.

Pay-as-you-go: In the context of transit, a method of paying for rides that involves paying for single journey tickets as those rides are used (can be either through open-loop payments, which charges the rider's credit or debit card for the journey, or through a closed loop fare card, which deducts the single fare amount from the rider's stored-value card)

Pre-paid passes: Includes either a stored-value fare card that allows riders to pay in advance for multiple fares (and perhaps receive volume discounts) or an unlimited pass product (i.e. daily, weekly, monthly)

Private label (PVL): In the context of transit, this refers to closed loop fare media that are routed within the transit agency's own network.

Public transportation operator: Organizations, such as transit agencies and joint powers authorities, responsible for providing public transportation services such as subways, light rail, commuter rail, bus rapid transit, commuter bus, demand response and other specialized transportation services (this does not encompass private transportation services, such as private tolling operators)

QR codes: A "quick response" code is a type of 2D barcode containing a matrix of black and white dots, used to rapidly scan and read information, such as the details of a mobile transit ticket

Ridership: The number of passengers who board public transportation vehicles, usually expressed as an annual number of unlinked trips (passengers are counted each time they board vehicles, disregarding potential transfers from other public transportation vehicles)

Scheme fees: Transaction fees paid by acquirer-processors to the credit card companies ("schemes"), which are passed on to the merchants, either as a per-transaction charge or bundled charge

SaaS: Software as a Service, a business model wherein software is made available to the client as a service.

Smartcard or transit card: A plastic card with a built-in microprocessor, used typically for digital processes such as financial transactions and personal identification

Switching value: Also known as a "breakeven value," it is the value of a key variable at which point the project investment decision is changed (i.e. the NPV is less than $0)

Top-ups: The monetary value added to a closed loop transit or EMV card, usually through channels such as ticket vending machines, ticket offices, retailers or mobile ticketing applications

Transportation network companies (TNCs): A company that connects passengers with vehicles for hire through websites and mobile applications, also commonly referred to as ride-hailing or ride-sharing companies

Visual validation: The process of in-person, physical inspection of fare media by a public transportation vehicle operator or ticket inspector

Appendix 2 - Analysis Details

Data sources

During the research period, our team faced severe limitations regarding data availability and consistency. Therefore, our team decided to build its own database, hereinafter referred to as the Rebel Analysis Database. The database's primary source is the National Transit Database (NTD) published by the Federal Transit Administration, and includes information from transit agencies in California, from private parties and from the research of Cal-ITP's advisory team.

To create a comprehensive list of transit operators and agencies in California, the dataset was combined with data from the State Controller's Office. Eventually, the consolidation of the two databases was unsuccessful due to differences in reported variables. Our team decided to rely on the National Transit Database and only take into account those transit agencies and operators who reported ridership in 2018. This excluded 16 agencies, which collectively cover only 2% of fare revenue and 1% of ridership in California. The final list consisted of 215 transit agencies and operators providing transit and on demand services.

From the NTD database, we collected historical information on revenue, ridership, capital expenditure, operating expenditure and funding sources. The number of vehicles in maximum service and the number of stations in 2018 were also collected from NTD. In collaboration with other parties, our team identified the list of transit agencies publishing GTFS and GTFS real-time information in California.

With the help of transit operators and operators of the largest smartcard systems, our team received the following information which we used as proxies for the transit system in California as a whole:

- Share of smartcard usage per fare revenue of transit agencies
- Share of mobile application usage per fare revenue
- Share of credit/debit cards usage to top-up smartcard and purchase tickets
- Share of passes and other tickets
- Cost of fare collection (cash and digital media).

Our team received additional information from private companies and other industry experts about the capital and operating costs of GTFS and EMV, and the transaction costs for digital payments. This data was also used to create applicable statewide proxies.

Due to the large number of transit operators and limited data availability regarding fare payment, our team cannot guarantee the completeness of the dataset despite our best efforts.

Base case inputs and assumptions

Timing

- The analysis assumes that Cal-ITP will start enabling the initiatives in 2020. Therefore, 2020 has been set as the starting year of the evaluation. We assume an evaluation period of 15 years, which is long enough for all initiatives to be implemented and their impacts realized, and coincides with the average duration of the technology lifecycle in fare payments. A longer evaluation period would likely not sufficiently account for innovations affecting reinvestment costs.

Escalation and discounting inputs

- We assume a 2.5% escalation rate for operating costs and for the dollar value of economic benefits. This is based on the five-year average for average annual inflation, reported by the State of California Department of Industrial Relations from 2015 to 2018.
- We assume a 2.85% escalation rate for the average fare. This is based on the real rate of fare escalation in California over the last 5 years.
- We use a 2% discount rate used for NPV calculations. This is based on the current cost of capital for the State of California (long-term general obligation bond yields).

Economic benefits

- The U.S. government routinely evaluates the monetary value of time saved, especially in the context of cost-benefit analyses assessing the benefits of transportation infrastructure investments. The U.S. Department of Transportation publishes periodic guidance on its value of time estimates, based on household income and wage data. Most recently, it published revised estimates in 2016 with different values based on the trip purpose (for example, would time saved be spent towards productive pursuits or leisure activities?). The relevant categories for this analysis are "local personal travel" and "intercity travel" at $13.60 / hour (50% of average hourly income) and $19.00 / hour (70% of average hourly income) respectively, in 2015 dollars. We assume a 50/50 split in travel between these two modes for the analysis and have escalated these values at the rate of inflation to express the values in 2020 dollars. The resulting value of time savings is $18.44 / hour.
- The Social Cost of Carbon Emissions is a measure, in dollars, of the long-term damages done by each ton of carbon dioxide (CO_2) emitted in a given year. This dollar figure can also represent the monetized value of environmental damages saved after emission reductions caused by the modal shift from private vehicles to more sustainable modes of transport,

such as public transit. In this sense, one can estimate the average annual economic benefits of individuals deciding to commute with public transit instead of private vehicles, as follows:

> *Individual economic benefits of modal shift ($/person year) = SC (car) – SC (transit)*

SC (car) and SC (transit) represent, respectively, the annual social costs per ton of CO_2 emitted by an individual driving a car or using public transit. For each mode of transport considered in this study, the social costs of CO_2 emissions were estimated as follows:

> *SC (car) or (transit) = Social costs/ton CO_2 year * Vehicle emissions/ mile * Avg. Annual PMT*

Where:

- Social costs/ ton CO_2 year: $48;
- Vehicle emissions/ mile (private car): 3.60 tons of CO_2/ per person by mile traveled in a year;
- Vehicle emissions/ mile (transit): 1.32 tons of CO_2/ per person by mile traveled in a year;

The *social costs / ton CO_2 year*, published in 2014 by the California High-Speed Rail Authority, is a projected measure considering a long-term time span of 40 years, from 2011 until 2050. Both the *average annual PMT transit* and *vehicle emissions per mile* were based on data made available by the U.S government (Bureau of Transportation Statistics and the U.S. Environmental Protection Agency). The first measures the *average amount of person miles traveled* (PMT) in a given year per person assuming fixed vehicle occupancies on different modes (VOC), and the average amount of vehicle miles traveled in a year. The second, *vehicle emissions per mile*, takes into account the efficiency of different modes in terms of miles per gallon (MPG), and an estimate of CO_2 emissions from typical passenger vehicles. The *average annual PMT* and *emissions per mile* were estimated as follows:

> *Avg. Annual PMT (transit or car) = VOC (transit or car) * Avg. VMT/ person year*
>
> *Vehicle emissions/ mile = MPG (transit or car) * Tons of CO_2 produced / gallon*

Where:

- VOC (car): 1.70 individuals / vehicle;
- VOC (transit): 10 individuals/vehicle;
- MPG (car): 22.30 miles / gallon;
- MPG (transit):18.10 miles / gallon;

- Tons of CO_2 emitted / gallon: 8.887 tons / gallon (typical passenger vehicle);

The average annual VMT per person in a year (avg. VMT/ person year) was determined by relating the average annual VMT per household, also made available by the Bureau of Transportation Statistics, with the average household size in California (U.S. Census Bureau), and the proportion of person miles traveled by mode (National Household Travel Survey):

*Avg. VMT / person year= Household size * % VMT by mode * Avg. annual VMT/ household*

Where:

- Household size: 2.96;
- % VMT car: 87.30%;
- % VMT transit: 1.80%;

In addition, we assumed that for each additional 100 trips resulting from the initiatives, only 60 represent a modal shift from private car to transit.

Ridership

- Ridership: The analysis takes into account the 215 transit agencies that reported Annual Unlinked Trips in the National Transit Database in 2018. This results in 1.3 billion transit trips per year in California.
- Ridership Growth: We have assumed a flat profile for ridership, meaning that we have assumed ridership to be constant for the 15-year forecasting period of the base case. This could be deemed a weakness of this analysis, as we can be reasonably certain that actual ridership will not be a constant. Recent developments in ridership for instance do not suggest that ridership will be constant over the next 15 years. Ridership statewide has actually been in decline in recent years. However, if we would have taken 'past performance' as a starting point for the base case scenario, which could (ceteris paribus) methodologically be justified, the base case would assume a falling ridership for the next 15 years. At the same time, we know that aside from any improvements in payment for transit, a myriad of factors also influences actual transit ridership developments in California over the next 15 years. This myriad comprises more general economic factors such as underlying economic growth, income distribution, taxation and more. Also affecting ridership are specific federal, state and local transportation policy developments. We know for instance that the State of California and many local governments in the State have pro-transit policies in place and have decided on investment programs to improve public transportation. Against this background, we have chosen the most neutral position possible on ridership for the base case, assuming a constant ridership for the forecasting period.

Revenue

- Revenue: The Analysis takes into account the 215 transit agencies that reported Annual Unlinked Trips in the National Transit Database in 2018. These agencies generated $1.9 billion in fare revenue in 2018.
- The evaluation has applied average values for fares and top-ups based on the following (expressed in 2018 dollars):
    - Single ticket price: An average single ticket price of $2 has been assumed by analyzing both the two largest transit agencies and also cross-checking prices with some smaller transit agencies.
    - Top-up value: We have no data points on the average value for a top-up of transit cards. We have assumed this to be 4 times the single ticket price, which we believe is a conservative assumption.
    - Pass value: An average pass value of $80 has been assumed by analyzing both the two largest transit agencies and also cross-checking prices with some smaller transit agencies.
    - Average fare: The average fare has been determined by dividing the total fare revenue by total unlinked trips.
- The revenue ratios between transit smartcard, mobile and other payment systems is based on the following assumptions:
    - Transit smartcard: We received data on the penetration of smartcards for the Clipper, Connect and TAP systems. For the rest of the identified smartcard systems, we applied the average penetration ratios from the Clipper, Connect and TAP systems.
    - Mobile applications: We received limited information on mobile app penetration. Based on select data points, we assumed that if an agency's only digital fare collection solution is a mobile app, then the penetration is 15% of the non-smartcard revenue. If a smartcard system is also present, then the penetration drops to 10%.
    - Other payment method: Revenue going through other payment solutions was determined based on the overall fare revenue in California and subtracting the smartcard and mobile application fare revenue.
- The revenue ratios between digital payments and cash usage were determined as follows:
    - Transit smartcard: In the cases of TAP, Compass and Connect we received the share of topping-up transit cards with cash or through digital transactions. For the rest of the card systems, we applied the average of TAP, Compass and Connect. The average share of digital transactions is 32% of fare revenue.

  - Mobile application: We assumed that 100% of fare revenue collected through mobile apps are paid through a digital solution.
  - Other payment method: In case of the other payment methods, we faced serious data limitations. Due to the high penetration of cash fareboxes, we assumed a 25% share of digital payments, lower than the transit smartcard case.
- The ratio between passes and single tickets is based on information we received from the Clipper and TAP systems on the value of pass and other ticket type sales. Since the share of passes in total revenue was relatively similar in the case of Clipper and TAP, we used the average (40%) share of the two systems. Due to data limitations, we applied the same ratio to the rest of the transit agencies' fare revenue.

Fare Collection

- The team has received proprietary information from a limited number of sources about the cost of collecting fares using transit cards, paper tickets and tokens. This information has been used previously in the MTC study determining the cost of collecting fares in the Bay Area. Using detailed information about the cost of the different ticketing methods, we have estimated which cost items are mostly variable, and which are mostly fixed. In addition, we have analyzed which factors most influence the variable costs of fare collection. This analysis led to the following results:

Table 9 – Cost of Fare Collection for Transit Cards, Paper Tickets and Tokens

Cost item	Example costs	Cost driver	Average value
Fixed (general) cost of revenue collection	Inspection personnel, marketing personnel	Operating expenses	4.3%
Fixed cost of transit card	Back-office maintenance, licenses, customer service, cash collection costs	All fare revenues	2.1%
Variable cost of transit card	Acquiring fees, card costs, retail network costs	Transit card fare revenues	2.1%

Cost item	Example costs	Cost driver	Average value
Fixed cost of paper ticketing	Cash collection costs	All fare revenues	2.2%
Variable cost of paper ticketing	Acquiring fees, paper costs	Cash and paper ticket fare revenues	2.7%
Fixed cost of mobile ticketing	License fees, maintenance fees	All fare revenues	0.8%
Variable cost of mobile ticketing	Share of revenue	Mobile ticket revenues	5%

The values above exclude capital expenditures and state-of-good-repair (SOGR) investments, since we have not found or received conclusive information that would allow us to factor these in. This means that the actual lifecycle costs of the existing fare collection methods will be higher, since some of the capex costs and SOGR costs are also likely to be variable, and thus decrease as part of a transition to EMV. In other words, our model underestimates the cost savings from switching to EMV.

In evaluating the impact of implementing EMV, we assume that the operating costs of the existing fare collection methods decrease, with the variable cost percentage changing pro-rata with the shift in revenue from existing methods to EMV.

Digital payments

Our analysis on the costs of digital payments comprises the following four fees which are paid to the acquirer-processors:

- Transaction processing fees: These fees are paid per transaction and may comprise a transaction volume-based component and/or a transaction amount-based percentage component. There are no data points readily available to Cal-ITP that pertain to the fees currently paid by agencies for digital payments. Cal-ITP has received just one acquiring-processing services agreement from an agency. In this agreement, the transaction processing fee is $0.20 plus 0.37% of the transaction amount. As we did not want to use this as a proxy for all agencies in the state, we looked at two master services agreements for electronic payments that the California Department of General Services has available for all State and local agencies to join. The lowest fee in the lowest tier (this tier applies to all

agencies in California except LA Metro) is a fixed fee of $0.014 per transaction. Since we know that all agencies can already avail themselves of this rate, we assume this fee to be the most conservative assumption for our evaluation. We find it unlikely that many agencies have been able to negotiate a better agreement and are extremely confident that the majority of agencies currently pay higher fees.[18] Therefore, in the base case, we take the less conservative assumption that the total fees paid by all agencies in California is $0.014 per transaction plus 0.10% of the transaction amount.

- Scheme fees: These fees are passed through to the global payment schemes (i.e. VISA, Mastercard, Discover, Amex). We assume an average rate of 0.13% of the transaction amount, based on the published rates by these payment schemes.
- Interchange fees: These fees are passed through to the issuers and depend on a myriad of factors. They are comprised of a transaction volume-based component and a transaction amount-based percentage component. We assume that the share of regulated debit cards is 30%, the share of exempt debit cards is 20% and the share of credit cards 50%. The average fees for these in transit we have set at:
    - Regulated cards interchange fee – Fixed: $0.21
    - Regulated cards interchange fee – Variable: 0.05%
    - Exempt cards interchange fee – Fixed: $0.05
    - Exempt cards interchange fee – Variable: 1.55%
    - Credit cards interchange fee – Fixed: $0.04
    - Credit cards interchange fee – Variable: 1.55%
- Value added services fees: These fees are paid for additional services provided by the acquirer-processor, such as online payments. These fees are not considered in our analysis.

Initiative Inputs

Initiative #1: Ensure standardized statewide access to reliable transit information

- The analysis assumes that Cal-ITP will start the GTFS initiative in 2020 with getting agencies onto GTFS static and piloting a GTFS compliance program. Subsequently, over the course of 3 years, all agencies that are currently not yet publishing GTFS real-time information will begin to publish real-time passenger information.
- The implementation of real-time passenger information by all agencies in California requires that all vehicles be equipped with automatic vehicle location (AVL) systems. We assume a worst-case scenario wherein all

[18] The other master services agreement's lowest tier fees are $0.025 per transaction.

agencies that do not currently publish GTFS-rt require a new AVL system. Since we know that many agencies already have these systems in place, our assumption places an upper boundary on the actual cost of realizing GTFS-rt. These costs include the implementation cost and an ongoing operational expenditure, either per route or per vehicle.

- Identifying agencies not supporting GTFS real-time: There are two main sources of GTFS real-time information in California: www.511.org run by the Metropolitan Transportation Commission and https://transitfeeds.com/ run by Open Mobility Data. Based on these sources we identified 24 transit agencies supporting GTFS real-time in California. The advisory team of Cal-ITP conducted a previous research effort on the usage of GTFS static, and merging their research with the Rebel Analysis Database, we identified 89 agencies that do not publish GTFS static information.
- Determining cost drivers: To estimate the cost of migrating to GTFS-real time, we first consider the cost of migrating from no GTFS to GTFS static (route-based pricing). Next, we consider the cost of migrating from GTFS static to GTFS real-time (vehicle-based pricing). The number of vehicles per mode is based on information from the National Transit Database, published annually. In the case of GTFS, we only take into account non-demand response vehicles (Vanpool, Demand Response and Demand Response-Taxis were excluded). Since NTD does not publish information on the number of routes per agency, we used information from 19 agencies to determine a vehicle per route proxy. We applied this proxy on the number of vehicles operated by those agencies that currently do not support GTFS.
- Capital expenditures:
    - The study assumes a capital expenditure of $4,600,000 to realize improved GTFS and setting up a compliance program. In addition, an investment to get a master services agreement into place with one or more CAD-AVL or GTFS-rt service providers is assumed to cost the state $500,000 for consulting fees and the time of DGS personnel to execute the procurement.
    - Agencies that have no GTFS implementation should assume a cost of $250 per route to configure their service onto GTFS static. This is the most competitive going rate in California.
    - For all agencies that do not publish GTFS-rt, we have taken the most conservative scenario and assumed that these agencies do not have a CAD-AVL system which allows publishing of high-quality GTFS-rt data. In most cases, they do have vehicle tracking capabilities but do not publish GTFS-rt. We have used proprietary sources to determine a cost-effective implementation or replacement of a simple CAD-AVL system. This allows us to calculate the following capital expenditures per vehicle:
        - Android device, mounting and cables: $150

    - SIM-card: $10
    - AVL app and system: Operating expenditures only
- Operating expenditures:
    - We assume an ongoing expense by the state of $200,000 per year to aid agencies in GTFS compliance.
    - For all routes that have been configured on GTFS static as a result of Cal-ITP, we assume an ongoing maintenance cost of $250 per route per year for the agencies. We see this as the upper boundary of ongoing costs.
    - For CAD-AVL and on-board data connectivity, we assume $20 per vehicle per month for CAD-AVL service, including an Android app. In addition, we assume $8 per vehicle per month for data connectivity.

Initiative #2: Reducing friction in payments

Project 1 – Accepting contactless EMV-media as payment method

- EMV acceptance and issuance of closed loop EMV tokens have been evaluated as a single project case. Whereas the MSA project has been evaluated separately as well, the EMV project assumes that the MSA for acquiring-processing has been fully deployed.
- Our evaluation assumes that the roll-out of EMV acceptance throughout California is done over a period of 5 years. The investments are done in the period 2020 - 2024 and the results are visible in the ramp-up period starting in 2021, realizing full coverage by the end of 2025. For all agencies, the ramp-up period is modeled with investments and deployment increasing by 20% per year, except for the investments by LA Metro and Clipper, which are assumed complete in 2024.
- Our evaluation assumes that the issuance of closed loop EMV-compatible tokens is a service sourced by the state that is deployed in 2021.
- The key capital investments to realize this initiative are the following:
    - $8 million to enable EMV in the Clipper environment. $7 million is the value in the Clipper 2.0 contract, and we have assumed an additional $1 million for MTC internal costs. In addition, we have assumed a configuration cost of $2 million. Whereas we believe that most of the system configuration will be part of the Clipper 2.0 project, the safe approach is to keep this as a contingency.
    - Enabling EMV in the TAP environment: The Cal-ITP team does not have sufficient sources to calculate an accurate investment to enable EMV. On one hand, rolling out a stand-alone EMV acceptance system next to the existing TAP system could be realized for as little as $10-15 million, based on the number of vehicles and

stations. On the other hand, we find this an unlikely scenario for LA Metro to pursue and take a contingency factor to account for integration costs. We arrived at the assumption of a $30 million system investment and add to that a $2 million configuration cost.

  - For all other agencies, we have taken the number of vehicles and stations as the main cost driver, which we use for a bottom-up calculation. Only those fixed-routes vehicles were considered that support onboard EMV validation. For each vehicle, we assume that two low-price validation devices will be installed at a cost of $1,500. For each station, we assume an investment of $15,000. In addition, we have taken a configuration cost into account of $50,000 per agency.
  - To allow agencies to source these devices, we have budgeted $1,500,000 for the state to have one or more master services agreements in place and help agencies with implementation.
  - To standardize 2D barcode ticketing and put master services agreements in place with vendors of visual validation technology, we included an investment of $1 million.
  - We have assumed a central system investment of $20 million. This is considerable, taken into account that most vendors now have off-the-shelf technology and other vendors provide this as a SaaS solution. However, we do not want to underestimate the complexity in California and as such have taken this conservative approach.
  - We assume that the economic lifetime of the investments is 10 years, meaning the analysis includes a reinvestment of the same magnitude 10 years after the initial investment.
  - Note that we have refrained from assuming that agencies have their own dedicated back-office with their own servers in a room or data center. We strongly believe that agencies are well-served by having access to APIs and web pages allowing them to configure and monitor their system and run reports.

- The operational expenditures considered are the following:
  - We assume that for every dollar invested, an operational expenditure of 20% per year applies. This is on the high side of the bandwidth in the market right now.
  - For the issuance of EMV-compatible closed loop cards, we have assumed a cost of $1.50 per card/token per user, replaced every 4 years.
  - In addition, we assume that the cost to maintain a top-up network runs at 3.5% of top-up value on closed loop EMV tokens. This rate is in line with the commissions currently paid by MTC and LA Metro for retail services. No additional investments have been assumed.

  - Lastly, we calculate the digital payment fees for open loop users based on the acquiring-processing fees (including MSA), the scheme fees and the interchange fees as explained above.

- Transition scenario:
  - The analysis models a shift of 50% of existing customers now using transit cards to EMV, no shift from mobile ticketing customers to EMV and a shift of 50% of existing customers using other ticketing methods (paper, token) to EMV.
  - The analysis assumes that this 50% is evenly distributed over all payment methods and fare products and does not lead to a behavior shift except that the ratio of customers paying with bank cards increases. Notably, the behavior shifts that are *not modelled* are the following:
    - Ratio between single trips and passes
    - The method that customers use to top-up transit cards or buy paper tickets/passes

Project 2 – Reducing cost of digital payments

- Start year and ramp-up period: 2021 and 5 years (same as EMV)
- Explanation of assumption that all agencies will join MSA
- To determine the expected benefits of the Merchant Service Agreement, we focused on estimating the lowering of acquiring fees and the value and volume of digital transactions (credit and debit cards, digital wallets, online payment) in transit in California. Based on one of the existing State EPAY MSAs, we calculated the expected cost of digital payments if every agency were to hold a separate acquiring contract. This comfortably underestimates the actual costs of acquiring, since even the lower tier pricing is at a level only achieved by the largest agencies in California and was established by the Department of General Services after a professionally conducted competitive procurement. To set a more realistic base case, we added a 0.10% fee based on a merchant agreement we received from a transit agency. After that, we calculated the expected cost of digital transactions when the State of California holds one contract on behalf of all transit agencies. This allowed us to lower the cost of digital transactions. Additionally, we assumed the cost of organizing the MSA and the cost associated with switching from one acquirer to another. A 5-year ramp-up period was used, as that is the typical contract duration for acquiring services.
- To calculate the value of digital transactions, we separately worked out the share of smartcards, mobile applications and other payment media usage for every agency. In this calculation, we relied on the following information:

- Penetration of smartcard usage per agency, received from the operators of the largest smartcard system
- Agencies having mobile applications in place (our own research), and the penetration of mobile applications (data points received from transit operators)
- Due to the large number of smaller agencies and limited available information, for the rest of the agencies we assumed no digital fare payment solution in place.

Table 15 – Share of Revenue Collected on Smartcards, Mobile and Other

	Smartcard	Mobile	Other
Share of revenue collected	51%	2%	46%

In the case of the larger smartcard systems (Clipper, TAP, Compass and Connect), we received information on the share of digital payments (e.g. credit/debit card usage to top-up smartcards), which showed that on average 32% of the revenue was digitally paid. Revenue collected through mobile application is 100% digital, and for the rest of the collected fares we assumed a lower digital share of 25%. Overall, we calculated that the value of digital transactions is $562 million.

- To calculate the number of digital transactions, we received information on the revenue share of passes for smartcards (30%) and other tickets (70%). We applied this ratio to revenue collected through mobile applications and other forms. After that, we assumed an average $80 monthly pass price, $2.00 for single tickets and $8 for top-up. Based on these prices, we estimated that the volume of transactions is 93 million.
- Based on the value and volume of digital transactions, the pre- and post-MSA transaction fees were calculated with the fixed and variable prices shown below.

Table 16 – Transaction Costs for Digital Transactions

Tier	Tier size	Fixed Fee (per transaction)	Variable fee (%)
1	<25 million	0.014	0.10%
5	75 - 100 million	0.08	(zero)

- We assumed a $500.000 MSA contracting cost and modelled switching costs at $10.000 per agency and 1% the value of digital transactions processed by switching agencies. We assume that 50% of all agencies have to switch in order to benefit from the MSA, and that the other 50% does not have to switch to benefit. The 1% of digital transactions was used as a proxy for the size and complexity of the switching agencies' payment systems.
- The assumptions used to evaluate this initiative underestimate the actual fees that are currently paid by the transit agencies and the card operators. The transaction fee in the lowest tier for one of the other EPAY MSAs is $0.045 – more than double the base case transaction fee evaluated. Also, the data point we had for an individual agency's MSA was that of a relatively large agency which – according to their own statement – had been able to grandfather in their terms of the cities' favorable agreement. In addition, our estimate of aggregate switching costs will likely overestimate the actual switching costs, since many agencies will be able to leverage the MSA fees without switching. These agencies either already have an agreement with one of the acquirers, or they can negotiate a better deal with their existing acquirer using the MSA as leverage.

Initiative #3: Create a statewide eligibility verification program

- The eligibility initiative is built on two, age-based eligibility groups: youth (up to 18 years) and seniors (from 65 years). By focusing only on these groups, we can demonstrate the value of a centralized eligibility verification system and at the same time safely underestimate the budget that originates from the cost savings of transit agencies.
- We only took into account those Californians that will be born or will turn 65 during the 15-year evaluation period, which are numbers based on population predictions published by the Department of Finance (State of California).[19] To determine the number of expected eligibility applications, we assumed that 23%[20] of Californians frequently or infrequently use transit and we applied this ratio to the future youth and senior population. We also assumed that 100% of seniors and youth would apply for discounted fares, which resulted in an expected 9.7 million new eligibility applications during the 15-year evaluation period. In case of lost proof of eligibility, there is no need to verify the eligibility again but only to apply for a new physical proof. Therefore, we did not assume renewal cases of eligibility.
- To determine the cost of eligibility verification in the base case and the implementation case, we applied the following assumptions:

[19] Source: http://dof.ca.gov/Forecasting/Demographics/Projections/ - last accessed: 02/26/2020
[20] Source: UCLA Falling Transit Ridership Report – ITS - 2018

  - Transit agencies that are part of a smartcard system require their users to acquire physical proof of eligibility once (through an online platform or in-person). Where digital payment solutions are not available, proving eligibility is either part of the regular sales process (e.g. showing ID while purchasing monthly pass at sales office) or not required during sales. Based on the ridership of the smartcard systems and acknowledging that outside of the smartcard systems several agencies require an agency issued card to prove eligibility, we assumed that 50% of transit riders are required to prove their eligibility.
  - In the base case, when a smartcard system is in place, we assumed that transit agencies spend $15 on every application (based on time and the average salary of administrative personnel), while the users have an additional cost of $3 dollars (e.g. photo, document copy, travel) and spend 2 hours on an application. We believe these assumptions safely underestimate the actual costs. In the case of non-digital payment systems, we assumed no additional cost for the transit agencies or riders.
  - In the implementation case, we assumed that every transit agency would spend $3 on each application, while every transit user would spend 0.5 hours. We also estimated a $3 administrative cost for the users per application, but in the implementation case this would be absorbed by the state and therefore it is part of the final budget.
- When determining the economic benefits of centralized eligibility verification, we assumed that the value of transit users time is $18.44 per hour.