Caltrans TDDC | Report on Transit Technology Ecosystem

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Glossary

APC	Automated Passenger Counter
Cal-ITP	California Integrated Travel Project
CalSTA	California State Transportation Agency
CARB	California Air Resources Board
Caltrans	California Department of Transportation
CIM	California Integrated Mobility
DBE	Disadvantaged Business Enterprise
EMV	Europay, Mastercard, and Visa Standard
GTFS	General Transit Feed Specification
GTFS-RT	General Transit Feed Specification Realtime
LPA	Leveraged Procurement Agreement
MPO	Metropolitan Planning Organization
MSA	Master Service Agreement
MVP	Minimum Viable Product
RFP	Request for Proposal
SaaS	Software as a Service
TIRCP	Transit and Intercity Rail Capital Program
UCD	University of California, Davis
ZETCP	Zero Emission Transit Capital Program

1. Executive Summary

Transit providers in California leverage technology to support their operations and improve the rider experience. These transit technologies come in many shapes and sizes and are becoming increasingly integral to service provision. In California, there are over 250 fixed-route transit providers, each engaging with the broader transit technology market. Yet transit providers and state agencies alike lack a complete understanding of this market and its dynamics. This report is the culmination of an ecosystem mapping exercise to inform California's development of a strategy for deploying modular, scalable, and competitive statewide technology solutions to meet key policy objectives.

The report draws from a variety of data sources – both quantitative and qualitative – to arrive at several key findings. Previous experience has shown that providing direct technical assistance to transit providers is an effective way for California to influence technology implementation, and thereby advance adopted policy outcomes. Not only that, but transit providers want (and need) technical support for technology procurement and deployment. For many transit providers, technical support means hand holding and having California agencies take on a larger supporting role both at the technology scoping and acquisition phase and throughout the life of the contract to assist with vendor management.

In-house procurements remain the most common acquisition method to obtain transit technology, even for small agencies. These procurements are often done as a reaction to contract expirations or technology obsolescence. Of the transit technology categories identified in this report, safety and security technology tends to be the "least common dominator" for the current technologies used by transit providers, regardless of provider size or geographic service area.

Unsurprisingly, there is a correlation between the size of a transit provider and the number of transit technologies it uses. This correlation is largely related to the availability of resources – in terms of funds, staff time, and product market fit.

Providers are looking ahead to innovative technologies to improve their service but recognize they must establish a strong base of technologies to do so effectively. Both providers and vendors agree that integration and interoperability are critical to success and the resiliency of all their transit technologies (i.e., their transit tech stack). However, a strong base of interoperable and integrated technologies has been slow to be implemented. California can help bridge the gap between transit providers' operational priorities, passengers' interest in outcomes, and the market's ability to respond.

2. Context & Purpose

Public transit is fundamental to meeting the transportation needs of many Californians and is a core component of an integrated, sustainable, and equitable transportation network. In California alone, there are 250 fixed-route transit providers and nearly 600 paratransit and non-fixed route service providers, including non-profits. All of these transit providers leverage some form of transit technology to support their operations and potentially to improve the rider experience. However, the extent to which operators can obtain, implement, and maintain the latest transit technology is often dictated by availability of staff and resources.

The majority of California transit providers are relatively small and have limited staff and resource capacity. Particularly when it comes to assessing, adopting, and implementing new technology, many are too small to have the dedicated staff with technical skills needed to accomplish this in an economy in which many sectors are digitizing and automating. As a result, they are often unable to take advantage of modern information systems and data standards that improve service delivery, reduce operational costs, and meet rapidly evolving customer experience' expectations.

To support California's transit providers in transit technology implementation, the State of California is first mapping and analyzing the transit technology ecosystem to better understand the barriers and pain points. This assessment will inform California's strategy for modular, scalable, and competitive statewide technology solutions. In this first step, California undertook a data collection effort to augment its understanding of the current landscape. This report serves as a summary of the key findings emerging from the effort.

3. Data Sources & Samples

This report is informed by data from a variety of sources.

- **California Provider Map** | Originally created in 2019 by Cal-ITP and updated in 2024, this dataset provides an overview of the transit providers in California.
- **NTD 2022 Reports** | Datasets created each year by the National Transit Database from mandated reporting. The key datasets within the NTD reports include the funding and vehicle counts.
- **Funding Sources** | Created by Cal-ITP to describe transit providers receiving federal funds from two sources: FTA 5307 grants and FTA 5311 grants.
- **Contract Database** | Cal-ITP, on behalf of Caltrans, requested transit providers submit their existing vendor contracts. This database is a reflection of the contracts received to date (March 2024) and examined systematically for key contract terms.
- **UC Davis Survey** | Survey created and administered jointly with UC Davis, focused on assessing the existing transit technology "stacks" of transit providers, the challenges experienced by transit providers, and the support that transit providers desire from Caltrans.
- **Follow-up Transit Provider Interviews** | Interviews conducted with UC Davis survey respondents to gain additional insights on their responses.
- **Transit Provider / Vendor Webinars** | A series of two webinars, hosted through CTA (in partnership with CALACT for the transit provider webinar), with one geared toward transit providers and the other geared toward vendors. Included interactive Q&A with anonymous responses.
- **Senate Bill 125 (SB125) Google Survey Responses** | As a part of a pilot program for reporting templates for SB125 funds, the survey collected data on procurement, fare payments, and scheduling technologies.

Detailed descriptions of these sources, their use, and their sample size can be found in the appendix to this report.

3.1 Transit Provider Base Sample

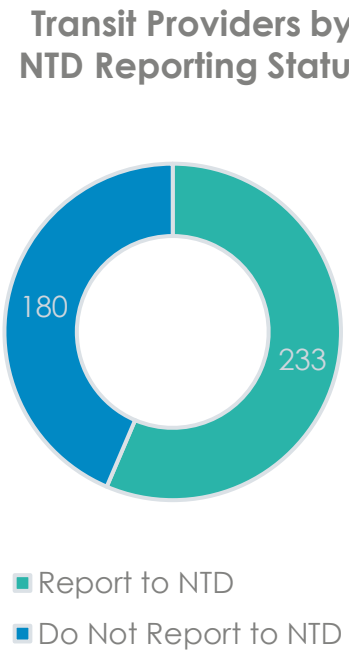
This report is based on the subset of transit providers in California ("Base Sample") that report to NTD (both mandatory and voluntarily) and meet the Provider Map definition[1] totaling 233 providers. This scoping decision was made based on the logic that transit providers who meet the definition criteria are both more likely to engage with the State of California and its programs. In addition, these providers are believed to be more likely to be impacted by state actions as opposed to privately operated and funded providers which function largely – if not completely – independently from the government.

The list of transit providers for the Base Sample comes from combining the 2019 and 2024 iterations of the California Provider Map. When combined, the 2019 and 2024 California Provider Map includes a total of 413 transit providers with varying levels of column details.

[1] Defined as: "all publicly-funded transit providers in California that provide fixed-route service that is available for the general public to ride without advance reservations."

- The 2019 version identified 401 transit providers including publicly and privately funded transit operations as well as fixed-route and on-demand services.
- The 2024 version included a smaller number of transit providers (227) as it was updated to reflect a more focused subset of these transit providers: "all publicly-funded transit providers in California that provide fixed-route service that is available for the general public to ride without advance reservations."[2] For this subset, additional columns of information were included such as Caltrans District, public entity status, public operating status, and funding sources.

To create the Base Sample, the combined California Provider Map was filtered between NTD reporters and non-NTD reporters. Of the 413 transit providers, 233 report to NTD. NTD reporting was a key indicator of data availability for each transit provider listed in the California Provider Map. The NTD reports provided critical information and also allowed for "matching" of providers across sources using the NTD ID as a unifier.
The 180 which do not report to NTD exhibit one or more of the following characteristics: 1) paratransit, on-demand, or rail service, 2) non-profit or private provider, and/or 3) small public providers not receiving federal funds. Transit providers that do not report to NTD have been largely excluded from the findings in this report because there is little to no public data available about them.



3.1.1 Transit Provider Classification

To provide deeper analysis of California transit providers, this report uses two identification criteria based on size and service area.

Size

There is not a universal transit provider sizing metric to categorize transit providers.[3] For this analysis, the decision was made to classify transit providers as either "small", "medium", "large", or "extra-large" based on the total number of vehicles operating in revenue service ("revenue vehicles"). Revenue vehicle count was drawn from the latest edition of the National Transit Database (NTD) "Vehicles (Type Count by Agency)" data set (2022). These classifications are defined below.

- Small (0 – 10 total revenue vehicles)
- Medium (11 – 25 total revenue vehicles)
- Large (26 – 100 total revenue vehicles)

[2] Cal-ITP Mobility Marketplace - https://www.camobilitymarketplace.org/provider-map

[3] Definitions can be numerous. For example, CARB categorizes transit agencies as either "large" or "small" in its Innovative Clean Transit (ICT) regulation, defining a "large transit agency" as an agency that operates either more than 65 or 100 buses in annual maximum service (depending on their operating region), and "small transit agency" as "any transit agency not a large transit agency". Transit literature also varies in size categorization. For example, basing it on population of area served (Ederer, et. al. 2019) and cost per vehicle revenue hour (Iseki 2008).

- Extra Large (>100 total revenue vehicles)

The following table compares the size characteristics of transit providers in the Base Sample against two key additional data sources.[4]

Transit Providers	in Base Sample	in UCD Survey	in Contract Database
Small	76 (35%)	6 (14%)	3 (10%)
Medium	49 (22%)	7 (17%)	5 (17%)
Large	54 (25%)	16 (38%)	10 (34%)
Extra-large	40 (18%)	11 (26%)	11(38%)
Regional Rail[5]	-	2 (5%)	-
Total	**219**	**42**	**29**

Service Area

To capture differences that could be associated with a transit provider's service area, each transit provider is categorized as either "rural", "urban", or "suburban" (a mix of rural and urban). Receipt of FTA 5311 Formula Grants for Rural Areas and FTA 5307 Urbanized Area Formula Grants are used as proxies to determine rural and urban service areas, respectively. Transit providers receiving funds from both grants were classified as suburban. Nearly all the sample respondents have received one or both. In the few instances in which a provider has no record of receiving either formula grant, a "best guess" distinction was made using the geographic profile of the transit provider.[6] The following table compares the service area characteristics of transit providers in the Base Sample across two key data sources.[7]

Transit Providers	in Base Sample	in UCD Survey	in Contract Database
Rural	52 (22%)	12 (29%)	10 (34%)
Urban	54 (23%)	13 (31%)	10 (34%)
Suburban	30 (13%)	12 (29%)	9 (31%)
Regional Rail[8]	-	2 (5%)	-
Unknown[9]	97 (42%)	3 (7%)	-
Total	**233**	**42**	**29**

[4] Percentages in the table may not add up to 100% due to rounding.
[5] The classification is only used for the UCD Survey and applies to Capital Corridor Joint Powers Authority (CCJPA) and Sonoma-Marin Area Rail Transit District (SMART).
[6] In the UCD Survey and Contract Database, we classified the following transit providers as urban: Anaheim Transportation Network, Golden Empire Transit District, California Vanpool Authority, rural: Nevada County Transit Services, and suburban: Tahoe Transportation District, Palos Verdes Peninsula Transit Authority.
[7] Percentages in the table may not add up to 100% due to rounding.
[8] The classification is only used for the UCD Survey and applies to Capital Corridor Joint Powers Authority (CCJPA) and Sonoma-Marin Area Rail Transit District (SMART).
[9] Multiple entries in the transit provider base sample did not receive either FTA 5311 or 5307 grant funding, and therefore could not be accurately classified.

4. Data Limitations

While this report leverages diverse and robust data sources, key gaps and limitations exist and are identified below.

Procurement Capability | No comprehensive data source exists to systematically analyze transit providers' procurement capabilities. To fill this gap, innovative methods including web scraping were tested, but were unable to generate results of a sufficient quality for use in this report. Extensive qualitative data – including engagement with all transit providers in the state – would be necessary to truly understand the full extent of their procurement capabilities. In the absence of a comprehensive data source, this report examines procurement capabilities through the UCD survey responses.

Sample Representativeness (Survey Response Rate & Contract Database) | The UCD survey garnered responses from 42 transit providers, roughly 18% of the 233 transit providers in the larger sample. These responses, while very informative, may not capture the full nuance of the transit technology landscape. Similarly, the Contract Database represents 29 transit providers who responded to Caltrans' request for contract information, and collectively skew towards larger agencies. Thus, they are neither a fully representative sample of transit providers nor their technology stacks. Moreover, despite reviewing 103 contract documents, several technology categories were very underrepresented (e.g. only one contract for connectivity technologies, two for integration technologies, and two for onboard rider communication technologies).

State and Local Funds | There is no comprehensive data source that provides the allocation of state funds to individual transit providers. Obtaining a full picture of the funding sources for each provider would be difficult and time-consuming. The lump sum amount of state and local funding can be found in National Transit Database (NTD) reports, for those transit providers who report, but lacks a level of detail on the specific funding sources themselves. This funding data can also be found by reviewing individual transit providers' budgets, which may not be easily accessible or published with that level of detail.

Private Transit Providers | Private transit operators lack the typical reporting requirements and linkage with key channels that provide data on other transit providers, leading to a lack of data transparency for this sub-sector. However, the importance of this limitation is decreased by the fact that California's policies, programs, and other tools are less relevant for private operators.

Paratransit and On-Demand Providers | Paratransit and on-demand providers are not fully represented in any of the data sets used. It is important to recognize that these providers both experience different challenges than fixed-route providers and leverage different technology stacks; and this means that fully understanding the dynamics in this sub-sector requires further research with a different set of resources,tools, and underlying policies.

5. Findings

Providing direct technical assistance to transit providers is an effective way for California to achieve policy objectives, particularly given the number of upcoming, planned transit technology investments. | State endorsements (by Caltrans, Cal-ITP, CARB, etc.) of certain transit technologies and/or standards – combined with state technical assistance for the given technology / standard – have led to dramatic increases in the uptake of specific technologies. Key recent examples of this phenomenon include the adoption of the GTFS and EMV standards. These endorsements, when implemented strategically, can simultaneously support transit agencies and achieve state-level policy objectives. California should prioritize its resources and efforts on technologies that most effectively reinforce larger state strategies and targets (e.g., VMT reductions) and drive customer-focused outcomes. Now is the ideal time to being this work at a state level given the number of transit providers who are in the market currently – or anticipate heading to the market in the next 1-3 years – for transit technology.

Transit providers want (and need) technical support. For many transit providers, technical support means hand holding. | Transit technologies are evolving rapidly, and most transit providers do not have dedicated staff with the technology expertise needed to keep up with the rate of change. This is especially true for smaller and more rural transit providers who face additional challenges such as no dedicated transit staff, connectivity dead zones, and long distances from key resources (vendor staff, maintenance facilities, etc.). A lack of resources makes it more challenging to write and manage a procurement/contract, particularly for more technical systems requiring significant subject matter expertise. For smaller agencies, the time and complexity associated with specifying requirements for an RFP result in a tendency to reuse language from other agencies. Various rural and small providers mentioned copying scope of work language verbatim from other RFPs and making minor adjustments to fit their specific needs. Transit providers tend to support each other during these procurements and provide input when requested by their peers. While boilerplate and template contracts are helpful, transit providers also need technical support to understand the technology's nuances, how best to implement and use it, and how to manage it.

> ***"For a small transit agency, it is already hard to deliver service with all the mandates and requirements. We do not have the staff, funding and talent to stay on top of technology."***

> ***"Template good to get started, but then couple hours with a Cal-ITP [or state agency] rep to go through it to refine it would be even better."***

This technical support does not stop with acquisition but should continue ad hoc throughout the life of the contract to provide support with vendor management. | Transit providers consistently cited frustrations with managing their vendors and holding them to their contractual obligations. While the vendor engagement may have been high when selling their product(s), the actual implementation period saw many complaints about vendors' inability to "follow through or provide ongoing support." Smaller and more rural providers felt this particularly acutely, with one provider anecdotally reporting experiencing weeks of delay between submitting changes to their GTFS data and seeing the relevant updates in their public facing feed. Given the rural area served by this provider, the delays and lack of accurate data directly impacted whether customers chose to take their transit system or not. At the same time, vendors cite transit providers' lack of technical expertise, mismatched expectations, and limited staff resources to manage procurements and projects as key barriers to developing a positive working relationship.

In-house procurements remain the most common acquisition method for transit providers, even for small agencies. | This preference for in-house procurement is driven both by a lack of knowledge of alternatives and perceived convenience. Specifically, transit provider staff are not always aware of other potential procurement and purchase mechanisms -- such as Master Service Agreements (MSAs) and other forms of Leveraged Procurement Agreements (LPAs) -- and may lack the authority to use them without board approvals. Identifying and using other types of procurements for preexisting technologies can be convoluted and involve a learning curve, diverting already scarce staff resources. In addition to knowledge-based barriers, capacity is a known challenge for many transit providers. Interestingly, 50% of smaller transit providers say they have little or no available procurement resources, yet they are the most likely to use in-house procurement, explaining this seeming contradiction as a product of only needing a small number of procurements. Logistics can also factor into the procurement mechanism selected. If the timing of contract expirations is not well-aligned with other providers' needs and/or if technology is bundled into a bus purchase, joint purchasing mechanisms may be less attractive. In the context of these preferences and challenges, there may be an opportunity for a

state-led procurement function to enhance – not replace – transit providers' procurement capabilities.

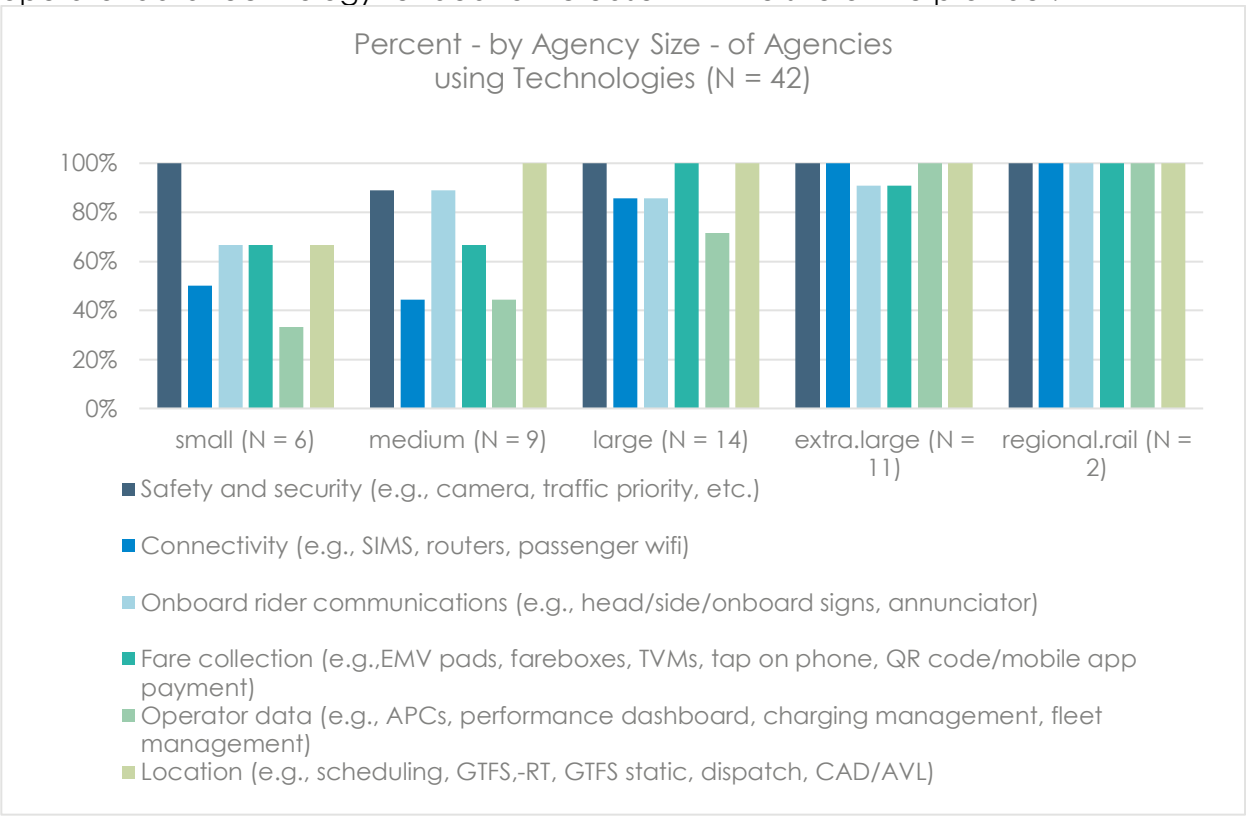
> ***In terms of procurement, I'm looking for the path of least resistance. I want whatever is easiest. The less work to get it up and running, the better.***
>
> ***It would be great to "have a point of contact where a transit agency can go and say, 'I want to implement X technology, is there something that's already out there to do this?'"***

Procurements are often done in reaction to contract expirations or technology depreciation. | The decision to procure for technology is often not a defined process or policy decision, but rather a reactive measure or a last resort. Because of the effort associated with a procurement, transit providers tend to prioritize using the "path of least resistance" which on one hand can mean extending existing contracts to avoid re-procurement or using the easiest / most familiar procurement vehicle available to them. Transit providers spoke of continuing relationships with vendors with whom they were only "somewhat" satisfied because it was too difficult – or costly – to switch. This is particularly noticeable in proprietary systems where system components are not interchangeable often due to vendor lock-in. When a system component fails or reaches end of life, the transit provider is left with a decision to replace that component with the "latest" vendor product as a band-aid for continued functionality or replace the entire system with a new vendor. Often, constraints on staff time and limited funding forces transit providers to opt for the short-term solution of component replacement rather than a potentially superior and more sustainable option either from a different vendor or through an entire system replacement.

Safety and security technology tends to be the "least common dominator" for the current technologies used by transit providers, regardless of provider size or geographic service area. | Nearly all providers surveyed reported using some type of technology which falls into the safety and security category. Smaller and more rural providers tended to use on-board cameras, whereas the larger and more urban transit providers also employed traffic signal priority technology. The emphasis on safety technology also reflects that transit providers see riders' perception of safety – or the lack thereof – when using their services as a barrier to choosing transit, a view confirmed in discussion responses in the transit provider webinar.

There is a correlation between the size of a transit provider and the layers of their transit technology stack. | Larger transit providers often have more resources than their smaller peers and are more likely to self-identify as having "some" or "significant" procurement resources, which may make these agencies more likely to invest in additional and standalone technologies. Qualitative feedback from the transit provider webinar also indicated that small providers struggle to access the staff, funding, and talent required to "stay on top of" technology. Providers see technology as a "non-traditional" focus area for transit when compared to their core focus of delivering reliable service. To that end, smaller providers tend to invest in more "basic" transit technology stack layers, often settling for cash collection given their relatively small ridership and decision not to prioritize operator data collection which may have

supported the efficiency of service but did not directly contribute to rider experience until contactless was available. Investments in fare collection technologies and operator data technology tended to increase with the size of the provider.



Providers are looking ahead to innovative technologies to improve their service but recognize they must establish a strong technology base to do so effectively. | When asked about which technologies they were curious to learn more about, providers jumped to artificial intelligence (AI) and autonomous vehicles. They also expressed interest in seeing buses match the level of technology now commonplace in personal vehicles (ex., lane departure warnings, blind spot alerts). Providers recognized that some of the more advanced technologies required a strong technology base from which to build on, emphasizing that while curious about forward-looking technologies, the next few years and near-term technology investments will be focused on more "low-hanging fruit" such as digitizing record-keeping systems, APCs, updated fare collection systems, scheduling and CAD/AVL systems, and real time operations monitoring. Many stakeholders also expressed concern about and interest in cybersecurity, due to the proliferation of internet and cloud-based technology services. Still others are focused on the upcoming zero-emission transition, focusing on supporting technology like battery electric bus (BEB) charge management software.

Both providers and vendors agree that interoperability is critical to success. | As new transit technology is added to the bus environment, it increasingly needs to interact with other systems. Interoperability between newer technologies, and seamless integrations with legacy systems, is increasingly recognized as a hallmark of successful implementation. Not only does interoperability help new technology work more effectively, but it also can help reduce redundancies in transit technology. Interoperability, and where necessary, integration, can be achieved through several

mechanisms. The most notable solutions from both vendors and transit providers were the use of data standards and open APIs. Vendors see standardization and open APIs as reducing the cost of having to create a custom solution for each transit provider and each layer of the technology stack. At the same time, transit providers see standards and APIs as allowing for easier integration with legacy systems and a less complex procurement process. Note, however, that while both transit providers and vendors agreed on the importance of integration through standardization and open APIs, transit providers cited frequent problems with integrations being more difficult than they anticipated which caused delays in implementation. As there is only one data standard in transit today, GTFS, and it is relatively new, interoperability of technologies producing and/or using it is still emerging – often requiring custom integrations. Most other transit technology is either custom or proprietary to the vendor and APIs are not always able to achieve a straightforward integration, stressing the capacity of agencies to manage custom integrations.

California can help bridge the gap between transit providers' operational priorities and passengers' interest in outcomes. | Transit providers identified "improving customer experience (CX)" as the most important factor driving new technology adoption, and thus that this goal should be their "north star." The industry literature cites frequency and reliability as main drivers to ridership increases[10] and transit providers report the same, yet providers' technology investments are not always aligned with these CX outcomes. Often the technology purchased is a compromise based on available funding and existing vendor products, causing transit providers to purchase products that may not best support the CX experience. Moreover, there is a trade off in resource allocation: funds used to purchase technology to improve operations or back office effectiveness cannot necessarily also be used to improve CX and spur ridership growth. Understanding this tension, California could assist in mapping how different technology solutions (potentially working in tandem) can support desired CX outcomes while simultaneously improving operations.

[10] Transit Center – Who's on board 2019: How to win back America's transit riders

6. Next Steps

The findings of this report indicate that there is a critical role for California to play in the transit technology ecosystem, particularly when it comes to supporting transit providers and in supporting standards. This role may take several forms but should at a minimum focus on providing key technical support prior to, during, and after technology procurement(s).

The next stage of work will focus on how California can implement this support role and tailor it to different transit technologies that may be at differing levels of development and market maturity.