



METROPOLITAN
TRANSPORTATION
COMMISSION

Agenda Item 6a

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Memorandum

TO: Operations Committee

DATE: November 2, 2018

FR: Executive Director

W.I.: 1237

RE: Automated Vehicle Occupancy Enforcement Update

This memorandum shares the results of a three-month pilot to assess how accurate automated Vehicle Occupancy Detection (VOD) camera systems are at determining vehicle occupancies, and introduces smartphone app-based occupancy verification technology as an alternative to VOD systems, which use cameras and machine learning algorithms to automatically determine occupancies from captured images. Staff plans to pilot smartphone app-based occupancy verification technology in 2019 for potential use in a Bay Area express lane. Neither of these existing enforcement technologies is likely to be cost-effective or practical for use in High Occupancy Vehicle (HOV) lanes due to the need for power, communications and license plate cameras not present in those lanes today.

Background

MTC's goal is to improve HOV lane performance to increase person-throughput on congested bridges and freeways and boost the attractiveness of carpooling and express buses as alternatives to driving alone. A significant number of Bay Area HOV lanes are degraded, failing to meet federally-required speed standards of 45 mph, due in part to the use by vehicles not meeting the minimum occupancy requirements. The Operations Committee has acknowledged the challenges CHP faces in performing occupancy enforcement and has directed staff to explore automated options to better enforce vehicle occupancy requirements.

VOD Systems and Pilot Results

In July 2017, as a first step towards addressing the issue of HOV occupancy violations, this Committee approved a pre-qualified bench of VOD system vendors for the purposes of testing their technologies in the Bay Area. The VOD vendors included: Conduent, Transcore (in association with NEC), and Indra.

In December 2017, staff invited these vendors to pilot their existing systems on Interstate 880, such that staff could verify system accuracy and gain a better understanding of VOD technology. Conduent conducted its pilot in March, followed by Transcore/NEC in April, and Indra in May. During the pilot period, independent verification activities were conducted by staff from MTC, a consultant, and Caltrans (refer to Attachment A).

The results of the pilot are summarized in the table below. Overall, the system accuracy rates, as determined and reported by the vendors, ranged between 78% and 88%, which was consistent with what was determined independently through a manual image review of 440 images per vendor (77% to 89%).

Vendor Self-Reported Results	Range of Results
System Accuracy Rate	78% to 88%
Independent Verification Results	Range of Results
System Accuracy Rate (based on Manual Image Review)	77% to 89%
System Accuracy Rate (based on Controlled Test Runs)	37% to 75%
Vehicle Count Capture Rate (based on independent video camera)	97% to 99%

The relatively low system accuracy rates seen from the pilot suggest the technology is not ready for use in issuing automated warnings or citations in a full-scale deployment on Bay Area express or HOV lanes. Due to the open access nature of these lanes, a robust network of VOD equipment would be needed to deter most cheaters – perhaps at one or more locations per mile. Aside from the capital cost for system development and integration, on-site equipment/infrastructure, power, and communications, the annual operating cost could be significant, given the need to perform manual review on a large number of images to confirm the occupancies to avoid issuing too many citations in error.

Smartphone App-Based Occupancy Verification Systems

In recent months, MTC staff has been approached by several firms to pilot new smartphone app-based occupancy verification systems. In general, each person in a carpool vehicle has a smartphone with the app (or a vendor-supplied device for those without smartphones). The systems pair and count individual smartphones in the vehicle, thereby providing a verified count of passengers that can be used to determine whether vehicles meet the lane occupancy requirement. Theoretically, data from the systems could be paired with toll tag or license plate camera data to charge cheaters a toll in express lanes or issue an automated citation in HOV lanes.

MTC staff did initial research and believes these systems may be a viable alternative to VOD camera systems. An app-based approach may offer other benefits that VOD systems cannot, such as serving as a tool to form carpools, distribute financial incentives, verify clean air vehicle eligibility and collect aggregate travel pattern data. In an express lane, this technology requires no additional roadside equipment in order to charge cheaters the toll owed. In an HOV lane, this technology would be more challenging and expensive to deploy due to the lack of license plate cameras, the need to require all carpoolers to use the system, and other issues. To staff's knowledge, no public agency is using this technology for automated occupancy enforcement in HOV lanes, but Dallas, Texas is moving forward next year to offer carpool rewards on their express lanes using an app-based system.

Challenges

There are challenges to overcome before using any type of occupancy enforcement system in an automated way:

- Institutional – Depending on how the systems are used, Caltrans and CHP may need to agree on how to proceed, given their ownership and enforcement roles.
- Legal – California has strict privacy laws that limit a public agency's ability to share information with CHP. There could be other laws affecting use of these technologies.
- Funding – While express lanes may use toll revenue to fund these systems, HOV lanes have no dedicated revenue source.

Next Steps

Staff will issue a Request for Information (RFI) this fall to learn more about the smartphone app-based technology and its operation. Staff will then likely procure and deploy a pilot of one or more app-based systems in 2019 to gauge acceptance, understand operations, inform costs, and test accuracy. Upon completion of the pilot, MTC staff will present the findings to this Committee.



Steve Heminger

Attachment:

- Attachment A: Independently-Verified Results

SH:ll/pg

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Independent Verification Methods and Results

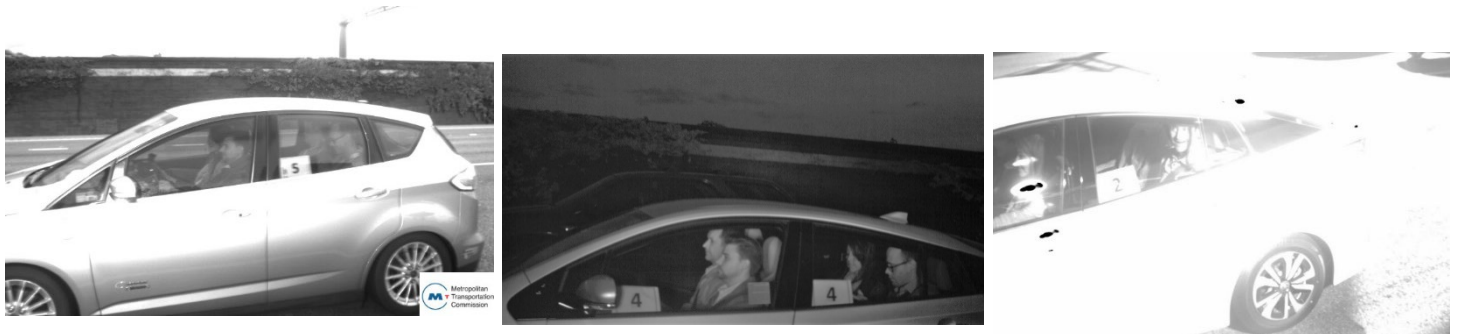
Verification Method 1: Manual Image Review

Purpose: To compare system-declared occupancies against occupancies that have been determined by manually reviewing each image

How: Reviewed 440 images per vendor to determine occupancy; image reviews were conducted by MTC and a consultant

Results: Of the total number of images reviewed, reviewers were able to determine the occupancies in 76% and 92% of them. Of these images, a comparison of the manually-reviewed occupancies with the system-declared occupancies resulted in a 77% to 89% match rate.

	Range of Results
Able to Determine Occupancy	76% to 92%
Manual Review Matched System-Declared Occupancy	77% to 89%

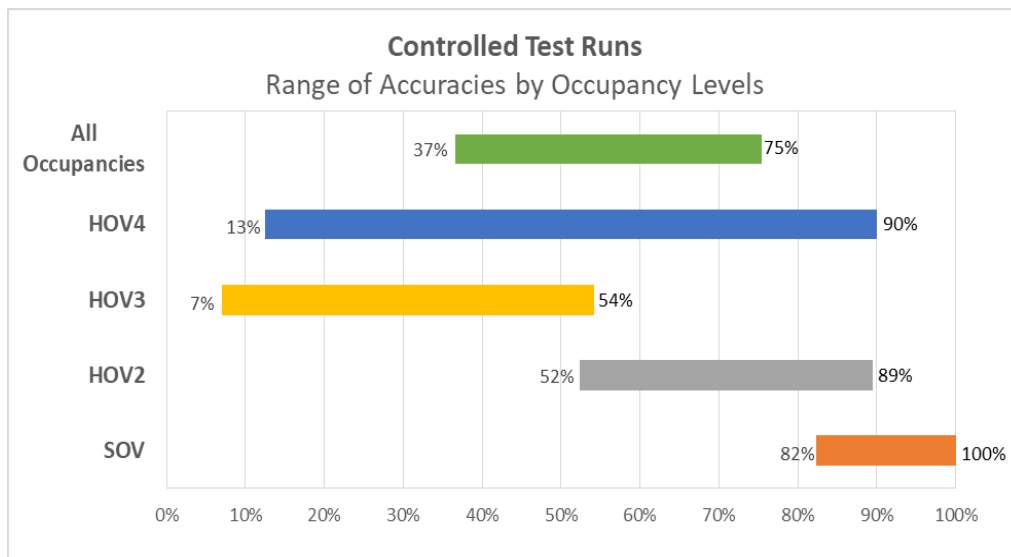


Method 2: Controlled Test Runs

Purpose: To compare system-declared occupancies against known occupancies in control vehicles

How: Conducted 70 to 90 test runs per vendor; controlled test runs were performed by MTC, Caltrans, and a consultant

Results: In general, the system accuracies increased as the number of occupants decreased, except in the case of HOV4, where the sample size was extremely low. The accuracy rates of all occupancies combined ranged from 37% to 75%.



Verification Method 3: Vehicle Count

Purpose: To assess each system's ability to accurately capture every vehicle passing the site

How: Vehicle counts were captured using a third-party video camera installed at the site

Results: Percent Vehicle Capture rates ranged from 97.3% to 99.5%, which indicates the vendor systems performed well in capturing almost all passing vehicles.



Automated Vehicle Occupancy Enforcement

MTC Operations Committee
November 9, 2018



Camera-based Vehicle Occupancy Detection (VOD) Activities To-Date



Staff presents HOV violation data to Operations Committee

Commission approves funding to deploy VOD pilots

Staff issues RFQ to create VOD bench

Operations Committee approves VOD bench

Staff initiates discussions with VOD vendors to deploy pilots



MTC prepares pilot site location

VOD Vendor #1 deploys pilot

VOD Vendor #2 deploys pilot

VOD Vendor #3 deploys pilot

Staff concludes VOD pilots and analyzes results

Pilot Objectives:

- ✓ Assess system accuracy in determining vehicle occupancy
- ✓ Gain better understanding of VOD technology
- ✓ Inform future decisions for possible full-scale deployment in the Bay Area

Pilot Site Location

Freeway: I-880

Location: Between Industrial Parkway and Tennyson Road

Lane: Northbound HOV lane

Occupancy Requirement: 2 or more persons

HOV hours: 5:00-9:00am and 3:00-7:00pm



Pilot Schedule and Requirements

MARCH	APRIL	MAY
CONDUENT  (formerly Xerox) HQ in Maryland	 NEC HQ in Texas	 indra HQ in Spain

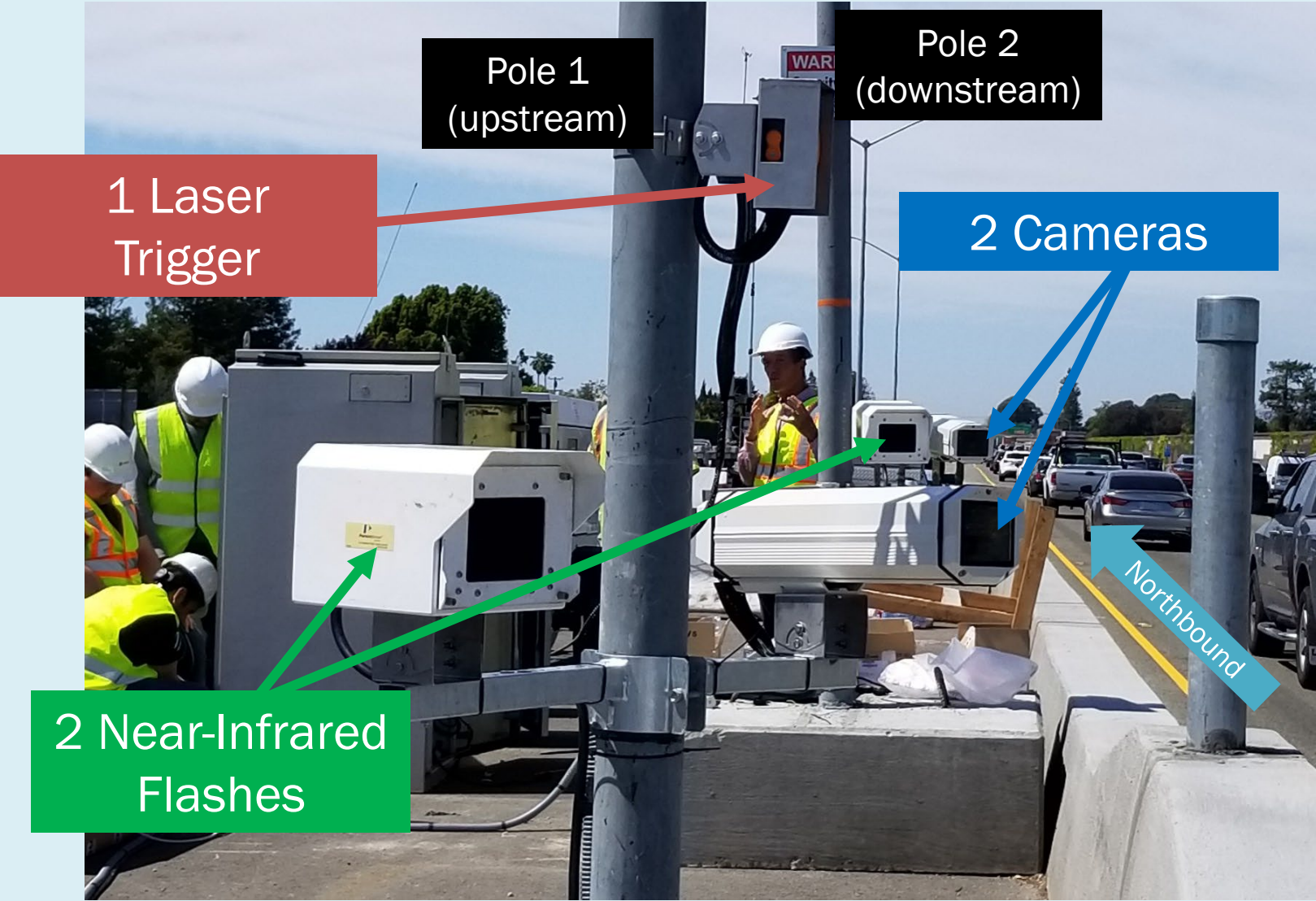
Pilot Month:

- ✓ Set up VOD system (e.g., cameras, triggers, flashes, processors, etc.)
- ✓ Calibrate and fine-tune system
- ✓ Collect six days of data (10 hours/day)
 - Weekday 5:00-10:00am (HOV hours + 1 extra hour)
 - Weekend 3:00-8:00pm
- ✓ Decommission system and remove all vendor equipment

Post Pilot Month:

- ✓ Reduce data
- ✓ Submit final report

Sample VOD System Equipment



System Comparison

System Elements	Conduent	Transcore/ NEC	Indra
Number of Cameras	2	1	2
Number of Near-Infrared Flashes	2	2	2
Number of Laser Triggers	1	1	1

Photo: Indra VOD system

Vendor-Reported Results

Overall System Accuracy Rate = 78% to 88%

System Accuracy Rate = % True Positives + % True Negatives, where:

- % True Positives = Actual SOV, System Accurately Identified as SOV
- % True Negatives = Actual HOV2 (or HOV3+), System Accurately Identified as HOV2 (or HOV3+)
- % False Positives = Actual HOV2 or HOV3+, but System Inaccurately Identified as SOV
- % False Negatives = All Other Inaccurate Occupancy Determinations

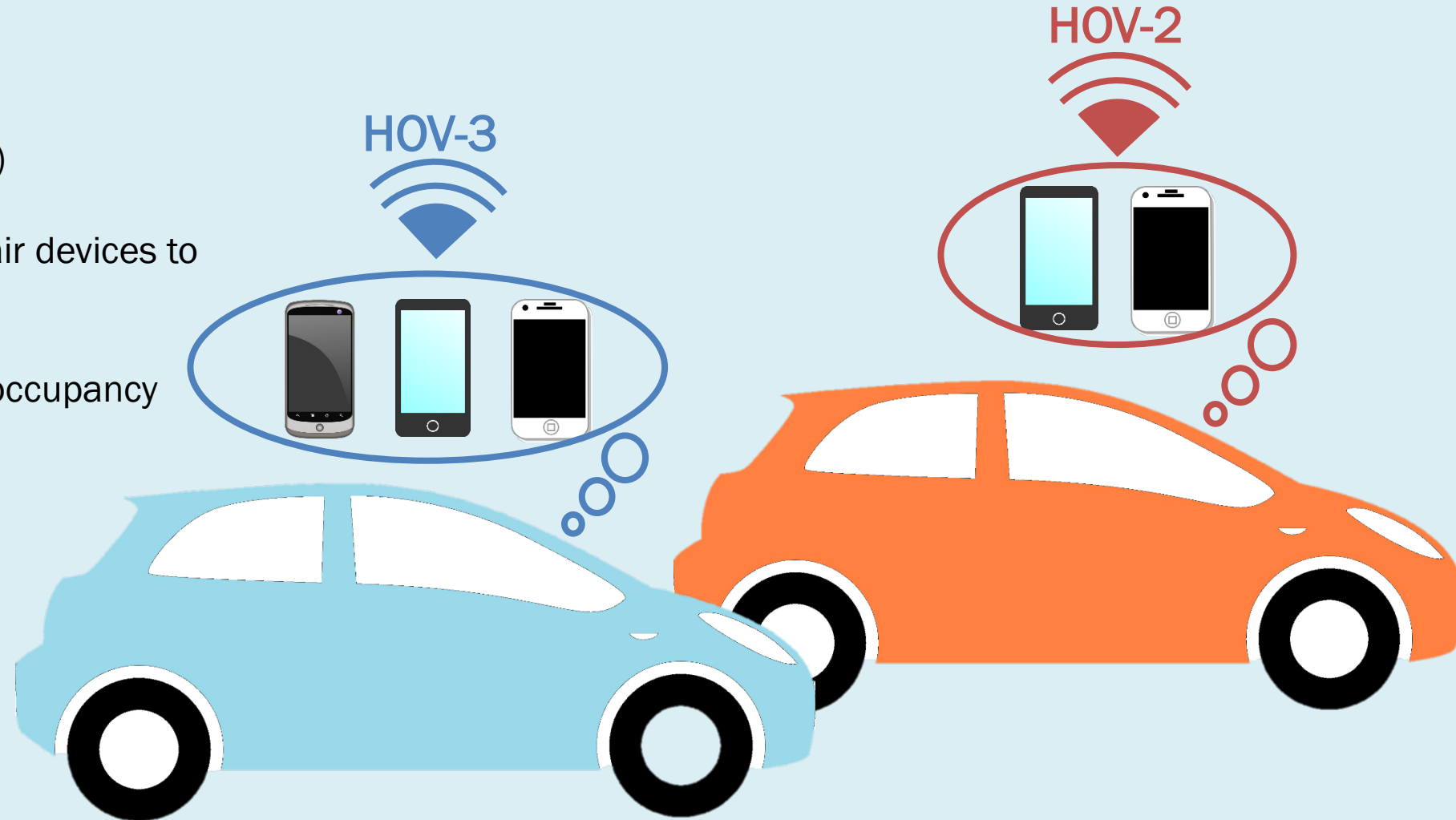
Accurate	System-Declared Occupancy	Actual Occupancy	Range of Results
% True Positives	SOV	SOV	34% to 44%
% True Negatives	HOV	HOV	37% to 48%
Inaccurate	System-Declared Occupancy	Actual Occupancy	Range of Results
% False Positives	SOV	HOV	5% to 6%
% False Negatives	HOV	SOV	7% to 16%

Drivers wrongly identified as potential violators



App-Based Declaration & Verification

- ✓ Smartphones required (or vendor-provided devices)
- ✓ No self-declaration: apps pair devices to verify vehicle occupancy
- ✓ Data allows for automated occupancy enforcement

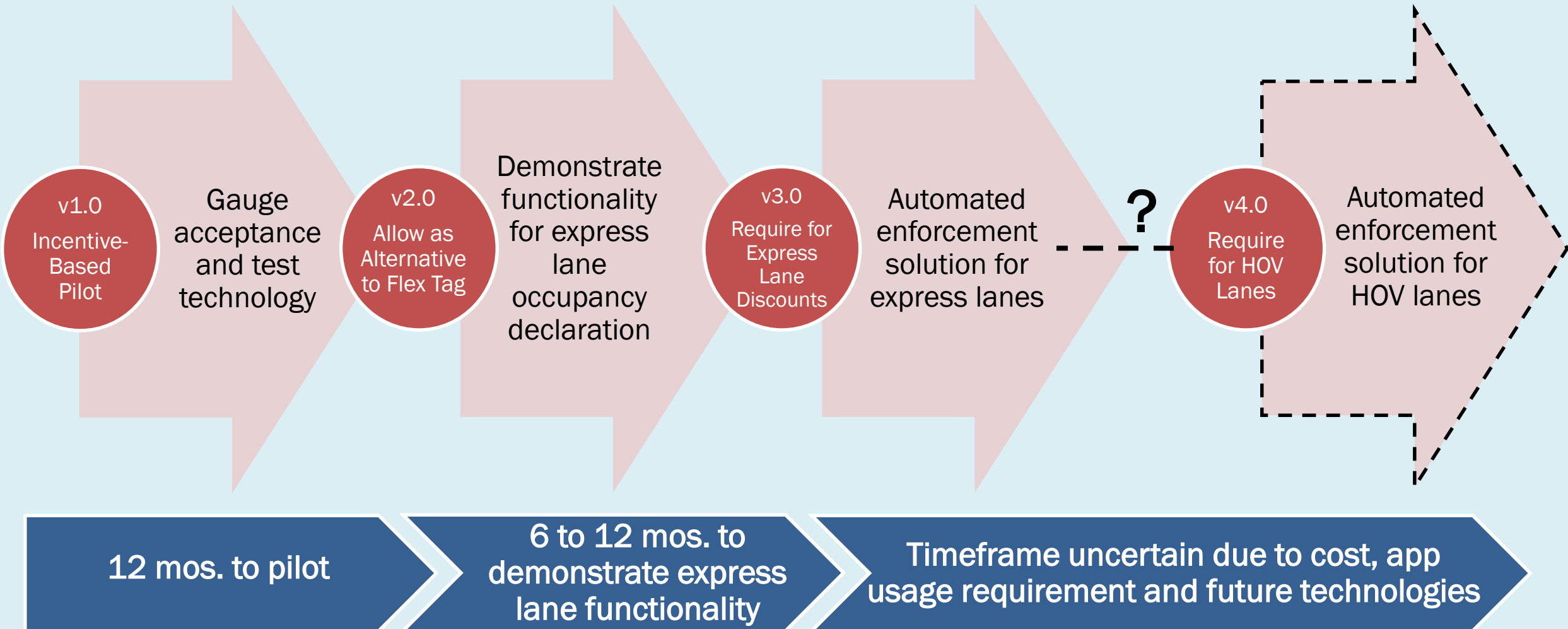


Why App-Based Declaration & Verification?

- ✓ Less roadside equipment
- ✓ Reduces need for CHP to enforce occupancy in express lanes
- ✓ Replaces switchable toll tags
- ✓ “Smarter” technology with more potential

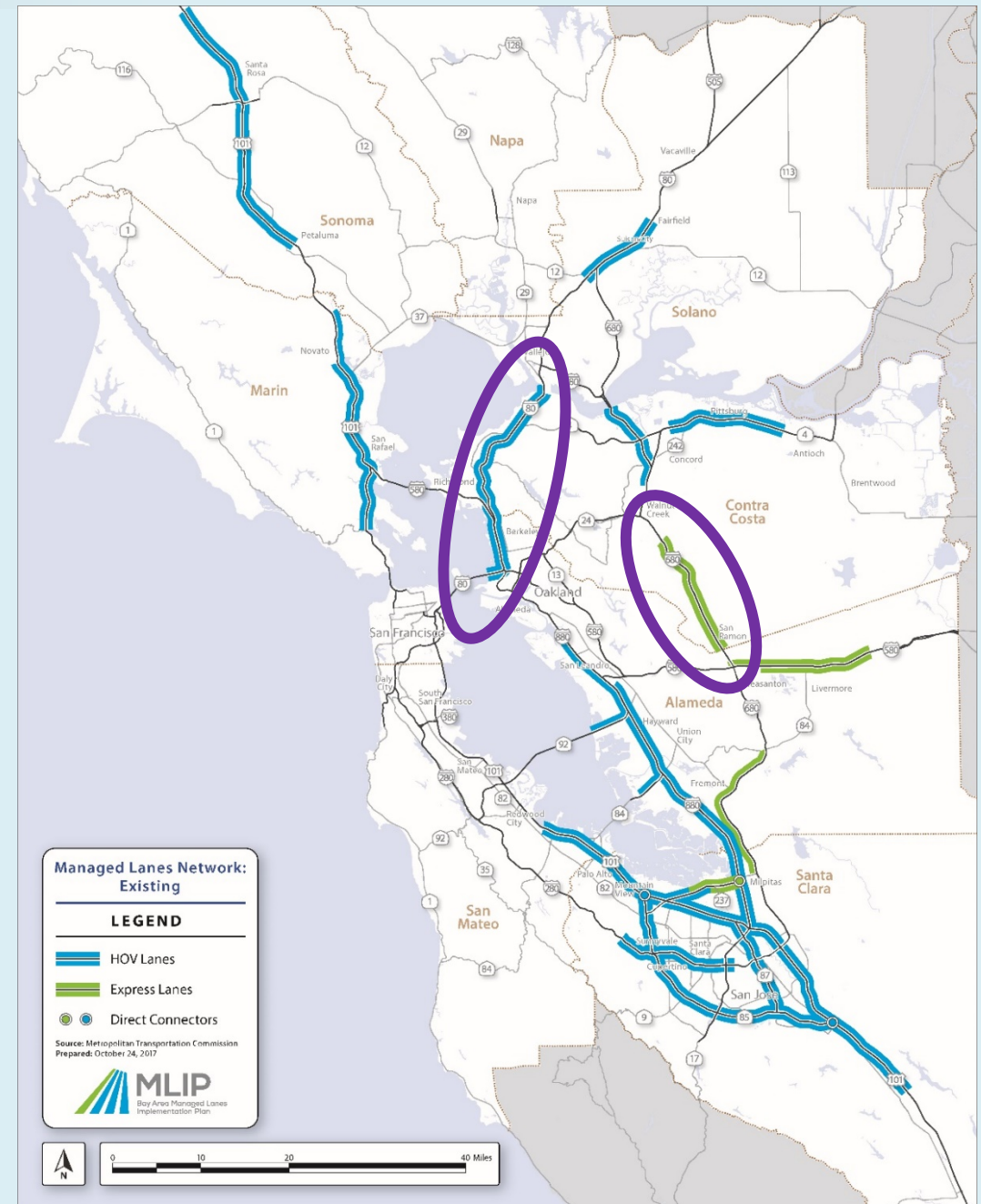


Potential Path to App Deployment



App Pilot Concept

1. Target I-80 HOV Corridor and Contra Costa I-680 Express Lanes
2. Incentivize carpools to use the app
3. Collect data and evaluate



Next Steps

- ✓ Issue a Request For Information this Fall.
- ✓ Procure and pilot an app-based system.
- ✓ Share pilot findings with this Committee.

