



Board Report

File #: 2023-0160, **File Type:** Motion / Motion Response

Agenda Number: 25.

**EXECUTIVE MANAGEMENT COMMITTEE
OPERATIONS, SAFETY AND CUSTOMER EXPERIENCE COMMITTEE
JUNE 15, 2023**

SUBJECT: BUS SENSOR TECHNOLOGY

ACTION: RECEIVE AND FILE

RECOMMENDATION

RECEIVE AND FILE status report on Bus Sensor Technology.

ISSUE

At its February 23, 2023 meeting, the Board approved Item 14, Bus Sensor Technology Motion (Attachment A), by Directors Hahn, Horvath, Mitchell, Solis, and Krekorian. The motion directed the Chief Executive Officer to report back in June 2023 with recommendations on safety features such as Pedestrian Detection technology and the feasibility of (1) incorporating them into new bus procurements, (2) installing them into our existing bus fleets, in order to reduce pedestrian collisions and to ensure that bus operators are alerted in the event of a pedestrian-involved collision, and (3) exploring other emerging collision avoidance technologies, pursuant to Metro's Street Safety Data Sharing and Collaboration Policy and Action Plan.

BACKGROUND

Metro is in the process of concluding two separate passenger collision avoidance studies. In 2017 Metro partnered with New Flyer (NF), and the Center for Transportation and the Environment (CTE) on a Federal Transit Administration (FTA) grant funded study. The study evaluates commercially available collision avoidance systems on 40-foot transit buses operating in revenue service within downtown Los Angeles. The study was recently concluded, and the final report is anticipated in July 2023. Metro is also currently conducting an internal study with BYD to evaluate the effectiveness of MirrorEye electronic rear/side view monitors.

DISCUSSION

Mobileye Study with NF and CTE:

The intent of the FTA grant funded study with NF and CTE was to identify five (5) commercial collision avoidance options and choose two (2) to install and test on Metro's transit buses. It is also important to note that this study was led by the FTA, and analysis led by CTE. Metro's role was to

provide the vehicles and facilitate the study as a participant. After initial vetting, it was determined that of the five options initially considered there was only one that was viable. Accordingly, the team moved forward in September 2019 to test Mobileye Shield + ADAS (Advanced Driver Assistance System) on 50 of Metro's 40' NF buses. Specifically, the features listed below, offered on Mobileye Shield + ADAS, were tested. (Please see Attachment B):

1. Lane Departure Warning with Display
2. Forward Collision Warning with Display
3. Pedestrian Detection/Pedestrian Warning with Left and Right Displays
4. Pedestrian Blindspot Monitoring

APAS (Advanced Pedestrian Alert System) integrates with Mobileye Shield + and provides an exterior audio alert to pedestrians when a bus is approaching.

Numerous technical challenges arose during the system interface and installation process, compounded by the circumstances brought about by the COVID-19 pandemic. These challenges led to delays in engineering support as Mobileye's engineering team was based in Israel. Additionally, the initial data collection was hindered by a high number of false positive and false negative alerts, hampering progress. Consequently, the system had to remain in stealth mode, collecting data without displaying warnings to operators until the project team could ensure its safety for activation.

By May 2021, the installation of Mobileye systems on all 50 buses was completed, with the system operating in stealth mode. In December 2021, 40 buses transitioned to active mode, enabling continued data collection until its conclusion in June 2022. However, the preliminary findings of the study yielded inconclusive results, lacking sufficient evidence to demonstrate safety improvements compared to transit buses without active systems.

Differentiating performance between the modified and non-modified buses proved challenging, as the observed differences were minor and difficult to attribute solely to the technology. Factors such as operating conditions, environmental variables, limited reliable data collection due to the use of GPS-speed data, assessing operator response, and the limited number of buses and mileage contributed to this difficulty. The project's data gathering and analysis section was not adequately detailed, limiting its ability to provide comprehensive insights.

By the time the project team recognized the necessity of an external data collection methodology to independently evaluate system effectiveness, insufficient budget remained to procure or utilize the required tools, such as wheel speed sensors on each bus. It was initially believed that the existing systems installed on Metro buses would suffice. The final report is expected to be available in July 2023.

MirrorEye study with BYD:

In addition to the Mobileye evaluation, Metro is also conducting a study on MirrorEye electronic rear/side view monitors. The California Highway Patrol (CHP) authorized Metro to test the MirrorEye on the G Line (Orange) buses for a period of five years. Metro and BYD are currently evaluating the effectiveness of MirrorEye electronic rear/side view monitors to provide legally required fields of view. Although the system was initially installed to mimic the rear-view mirrors, it enables useful features such as night vision and marking lanes. The system currently being studied does not provide alerts to

the operator but allows bus network integration, potentially enabling sensor automated functions. The evaluation is presently being conducted on five (5) 60-foot BYD buses and five (5) 40-foot BYD buses. This study is expected to conclude with published results by the Summer of 2024. (See **Figure 2**).

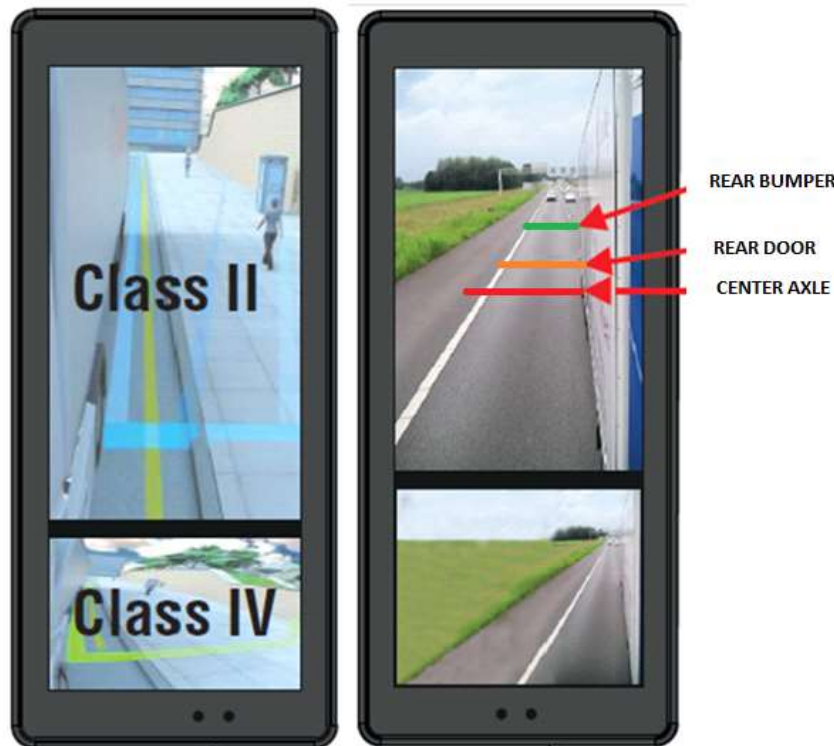


Figure 2

Staff Response to Board Motion Items:

In response to item (1) *incorporating them [Pedestrian Detection safety technology] into new bus procurements*, staff has included language in the Technical Specification for new bus procurements to include vehicle safety technologies such as: pedestrian detection, lane departure warning, and the capability to integrate Advance Driver Assistance from levels 0 to 5 as defined in SAE J3016_021806. A supplemental graphic from SAE International of J3016 is provided in Attachment C, but in summary:

- 0 - provides warnings and momentary assistance. Automatic emergency braking, blind spot warning, lane departure warning
- 1 - Provides steering OR brake/acceleration support, lane centering OR adaptive cruise control
- 2 - Provides steering AND brake/acceleration support, lane centering AND adaptive cruise control at the same time
- 3- Driver is not actively operating the vehicle unless instructed to by features. Technology will drive the vehicle under limited conditions. Example is full driving during a traffic jam

- 4 - Automated features will not require you to take over driving. Examples is a local driverless taxi. Vehicle pedals/steering may or may not be installed
- 5- Vehicle can operate autonomously under all conditions

In response to item (2) *installing them into our existing bus fleets, in order to reduce pedestrian collisions and to ensure that bus operators are alerted in the event of a pedestrian-involved collision*, staff is not recommending the retrofit of Mobileye on the existing system as the operational/system benefits are inconclusive, but will continue to assess technologies for the existing bus fleet as they mature and benefits are demonstrated.

In response to item (3) *exploring other emerging collision avoidance technologies* staff will continue to explore new technologies as they emerge and merit additional evaluation.

EQUITY PLATFORM

The technology is intended to improve traffic safety and reduce disproportionate harm for vulnerable road users. As noted in the Street Safety Policy, traffic violence kills and injures "Black, Latino, Native Hawaiian and other Pacific islander and unhoused residents as well as people walking and cycling at greater rates than other people."

There is great overlap between the project's service areas and areas that Metro defines as Equity Focus Communities. The improvements are targeted to benefit communities with some of the greatest mobility needs in Los Angeles County. The Project's service corridors are composed of 88 percent in Low-Income Communities as identified by AB 1550 (Figure 3 - Attachment D), 73 percent disadvantaged Communities as identified by SB 535 (Figure 4 - Attachment D), and 61% Equity Focus Communities as defined by Metro's EFC definition (Figure 5- Attachment D). The investment brings benefits to the community beyond the transit riders themselves: zero emissions, quieter exterior and interior noise not only attracts riders but provides a benefit to the community as well.

IMPLEMENTATION OF STRATEGIC PLAN GOALS

These recommendations support Goal #2, Deliver outstanding trip experiences for all users of the transportation system, Goal #3, Enhance communities and lives through mobility and access to opportunity, and Goal #5, Provide responsive, accountable, and trustworthy governance within the Metro organization.

NEXT STEPS

Staff will include language in the Technical Specifications for new bus procurements to include Pedestrian Detection safety technology.

Staff will continue to monitor the development of emerging Pedestrian Detection safety technologies and will pilot promising solutions to enhance safety on our bus network.

ATTACHMENTS

Attachment A - Motion # 2023-0102 by Directors Hahn, Horvath, Mitchell, Solis and Krekorian

Attachment B "Mobileye Shield V4 W/ Apas" Operator Reference-

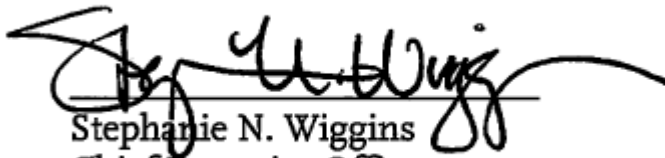
Attachment C - SAE J3016 Levels of Driving Automation

Attachment D - Equity Platform Figures 3 - 5

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Metro

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**Board Report**

File #: 2023-0102, **File Type:** Motion / Motion Response**Agenda Number:** 14.

**EXECUTIVE MANAGEMENT COMMITTEE
FEBRUARY 16, 2023****Motion by:****DIRECTORS HAHN, HORVATH, MITCHELL, SOLIS, AND KREKORIAN****Bus Sensor Technology**

The Los Angeles County Metropolitan Transportation Authority (Metro) has a bus fleet of approximately 2,200 buses serving about 800,000 daily passenger boardings. Every day Metro moves hundreds of thousands of Angelenos almost entirely without incident, getting people safely to jobs, to school, and to see family. Metro buses have, on a few rare occasions, struck a pedestrian. In some of those instances, the bus operator was unaware of the collision until sometime later, tragically leaving behind a person who was seriously harmed.

In recent years, vehicle safety technology has become increasingly available, providing drivers with tools such as: pedestrian detection, traffic light detection, and lane marking identification. Integrating safety technology like Pedestrian Detection can help reduce the risk of serious and fatal accidents.

Pedestrian Detection consists of a camera fitted in front of the interior rear-view mirror to identify objects, radar sensor(s) integrated into the vehicle's grille to determine the position of nearby obstacles, and a central control unit to analyze the data collected and coordinate the system functions. When a Pedestrian Detection system identifies a potential collision, the system either provides an alert to the bus operator to apply the brakes or the system can automatically apply the brakes to avoid potential collisions. Emerging technologies that have the potential to complement and enhance commercially available pedestrian detection systems, such as connected vehicle technology, may also soon become available.

While these types of technology may not always be able to help avoid a collision completely, they can help reduce occurrences as well as help minimize injuries if impacts do occur.

SUBJECT: BUS SENSOR TECHNOLOGY MOTION**RECOMMENDATION**

APPROVE Motion by Directors Hahn, Horvath, Mitchell, Solis, and Krekorian that the Board direct the Chief Executive Officer to report back in June 2023 with recommendations on these new safety features and the feasibility of (1) incorporating them into new bus procurements, (2) installing them

into our existing bus fleets, in order to reduce pedestrian collisions and to ensure that bus operators are alerted in the event of a pedestrian-involved collision, and (3) exploring other emerging collision avoidance technologies, pursuant to Metro's Street Safety Data Sharing and Collaboration Policy and Action Plan.

"MOBILEYE® SHIELD+™ V4 w/ APAS" OPERATOR REFERENCE



LEFT SIDE DISPLAY w/ APAS*

- OFF**
 - No illumination.
 - No pedestrian or cyclist threat on left side of moving bus.
 - With pedestrian / bicyclist in proximity of moving bus the external audio message is 'Caution Bys Approaching'.
- DETECTION**
 - Yellow solid illumination with no sound.
 - Informs the operator a pedestrian or cyclist has been detected near the left front or left side of bus.
 - Operator should exercise additional caution until verifying that the danger of collision has passed.
- ALERT**
 - Red flashing with beeping sound.
 - Informs the operator a pedestrian or cyclist has been detected in the left front or left side of bus and collision is imminent.
 - Operator should take action to carefully stop bus to avoid collision.

*Advanced Pedestrian Alert System

RIGHT SIDE DISPLAY w/ APAS*

- OFF**
 - No illumination.
 - No pedestrian or cyclist threat on right side of moving bus.
 - With pedestrian / bicyclist in proximity of moving bus the external audio message is 'Caution Bus Approaching'.
- DETECTION**
 - Yellow illumination with no sound.
 - Informs the operator a pedestrian or cyclist has been detected near the right side of bus.
 - Operator should exercise additional caution until verifying that the danger of collision has passed.
- ALERT**
 - Red flash with beeping sound and external audio message of 'Danger Step Back'.
 - Informs the operator a pedestrian or cyclist has been detected on the right side of bus and collision is imminent.
 - Operator should take action to carefully stop bus to avoid collision.

*Advanced Pedestrian Alert System

CENTER DISPLAY & EYEWATCH

- DETECTION**
 - Contains the Pedestrian Display and EyeWatch.
 - The EyeWatch readouts and explanations can be found below on this document.
 - No pedestrian or cyclist threat in front of moving bus.
 - Illuminated green LED indicates system operational.
- DETECTION**
 - Yellow illumination with no sound.
 - Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus.
 - Operator should exercise additional caution until verifying that the danger of collision has passed.
 - Illuminated green LED indicates system operational.
- ALERT**
 - Red flashing with beeping sound.
 - Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus and collision is imminent.
 - Operator should take action to carefully stop bus to avoid collision.
 - Illuminated green LED indicates system operational.

EYEWATCH READOUTS FOR VEHICLE DETECTION ONLY

<ul style="list-style-type: none"> Solid yellow lines. System is operational with bus at 0 speed. Illuminated green LED in center display indicates system operational (See Center Display and EyeWatch). 	<ul style="list-style-type: none"> Speed Limit Indicator (SLI) Appears when the bus is traveling at least 5 MPH (adjustable) over the last posted speed limit sign. Two vertical white hash lines on each side of the EyeWatch will appear with a white number indicating miles over the last posted speed limit. Operator should reduce speed to keep within the speed limit. 	<ul style="list-style-type: none"> Headway Monitoring (HMW) Appears as green car. Indicates detection of a vehicle in the path of the bus. No number shown if bus is traveling a safe distance behind the vehicle in front or when bus is traveling below 19 MPH. 	<ul style="list-style-type: none"> Headway Monitoring (HMW) Appears as green car and number. Indicates how far the vehicle in front of the bus is in seconds. The 2.5 indicates the seconds until a collision could occur if the front vehicle were to come to a stop. Operator is advised to reduce speed if time to collision falls below preset seconds and car turns red. Has a chime sound (optional). 	<ul style="list-style-type: none"> Headway Monitoring Warning (HMW). Appears as a red car with an audible chime. Indicates the distance between bus and vehicle in front has fallen below a safe threshold. Operator is advised to reduce speed to increase distance to a safe level. 	<ul style="list-style-type: none"> Urban Forward Collision Warning (UFCW) Virtual bumper set as follows: <ul style="list-style-type: none"> Without bicycle rack - 39" (1m) With bicycle rack - 78" (2m) Visual and audio chime when approaching stopped vehicle. Active at 0.6mph. 	<ul style="list-style-type: none"> Forward Collision Warning (FCW) Appears as flashing red car with a high pitched beeping sound. Indicates rear end collision is imminent. Operator must stop the bus immediately.

T: 718.408.7388

Note: Pedestrian and cyclist detection requires minimum low light of 15 LUX.

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SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
What do these features do?	These are driver support features			These are automated driving features		
	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	<ul style="list-style-type: none"> • automatic emergency braking • blind spot warning • lane departure warning 	<ul style="list-style-type: none"> • lane centering OR • adaptive cruise control 	<ul style="list-style-type: none"> • lane centering AND • adaptive cruise control at the same time 	<ul style="list-style-type: none"> • traffic jam chauffeur 	<ul style="list-style-type: none"> • local driverless taxi • pedals/steering wheel may or may not be installed 	<ul style="list-style-type: none"> • same as level 4, but feature can drive everywhere in all conditions

For a more complete description, please download a free copy of SAE J3016: https://www.sae.org/standards/content/J3016_201806/

EQUITY PLATFORM FIGURES 3 - 5

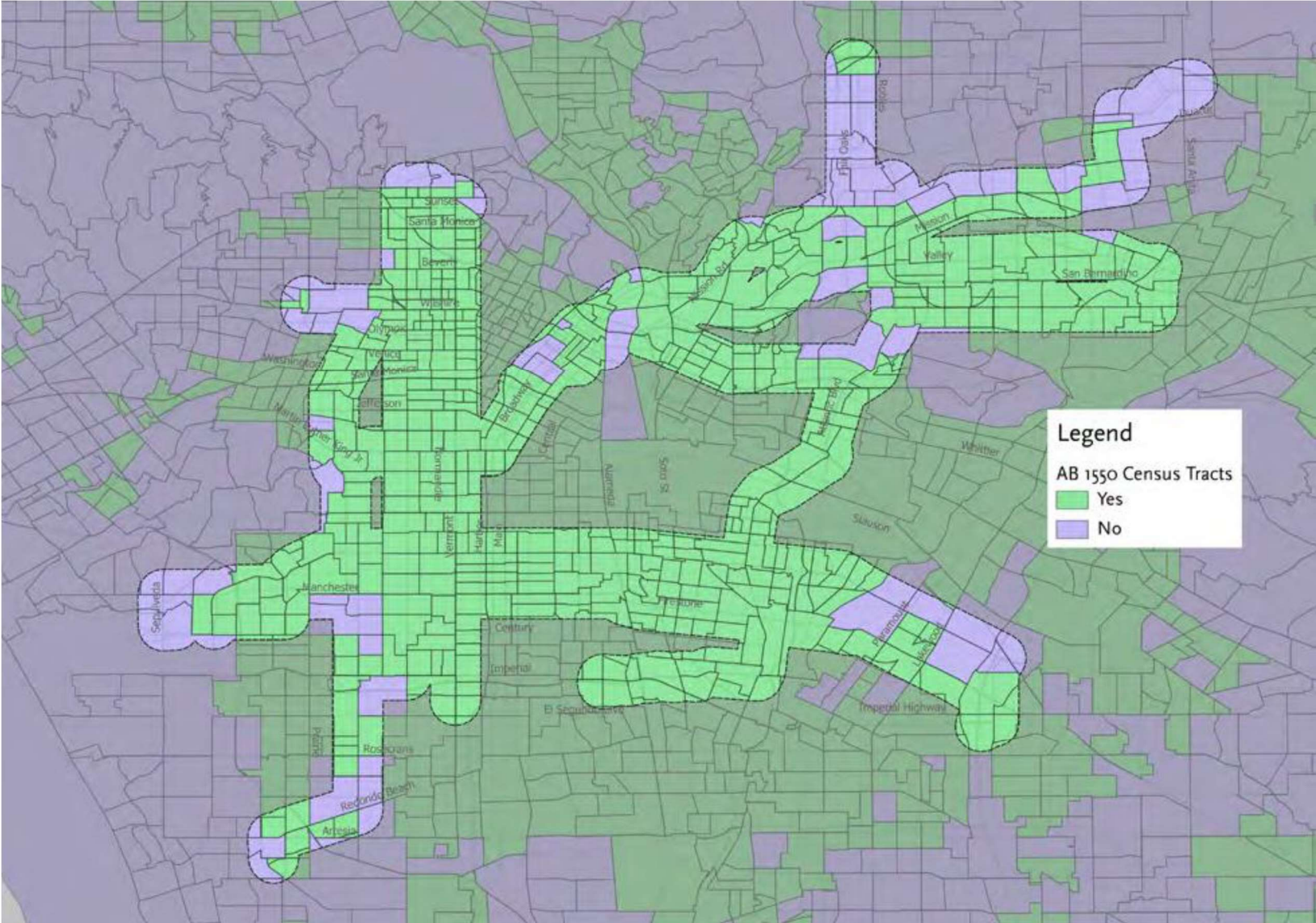


Figure 3: AB 1550 Census Tracts (Green) in the Project Corridors

EQUITY PLATFORM FIGURES 3 - 5

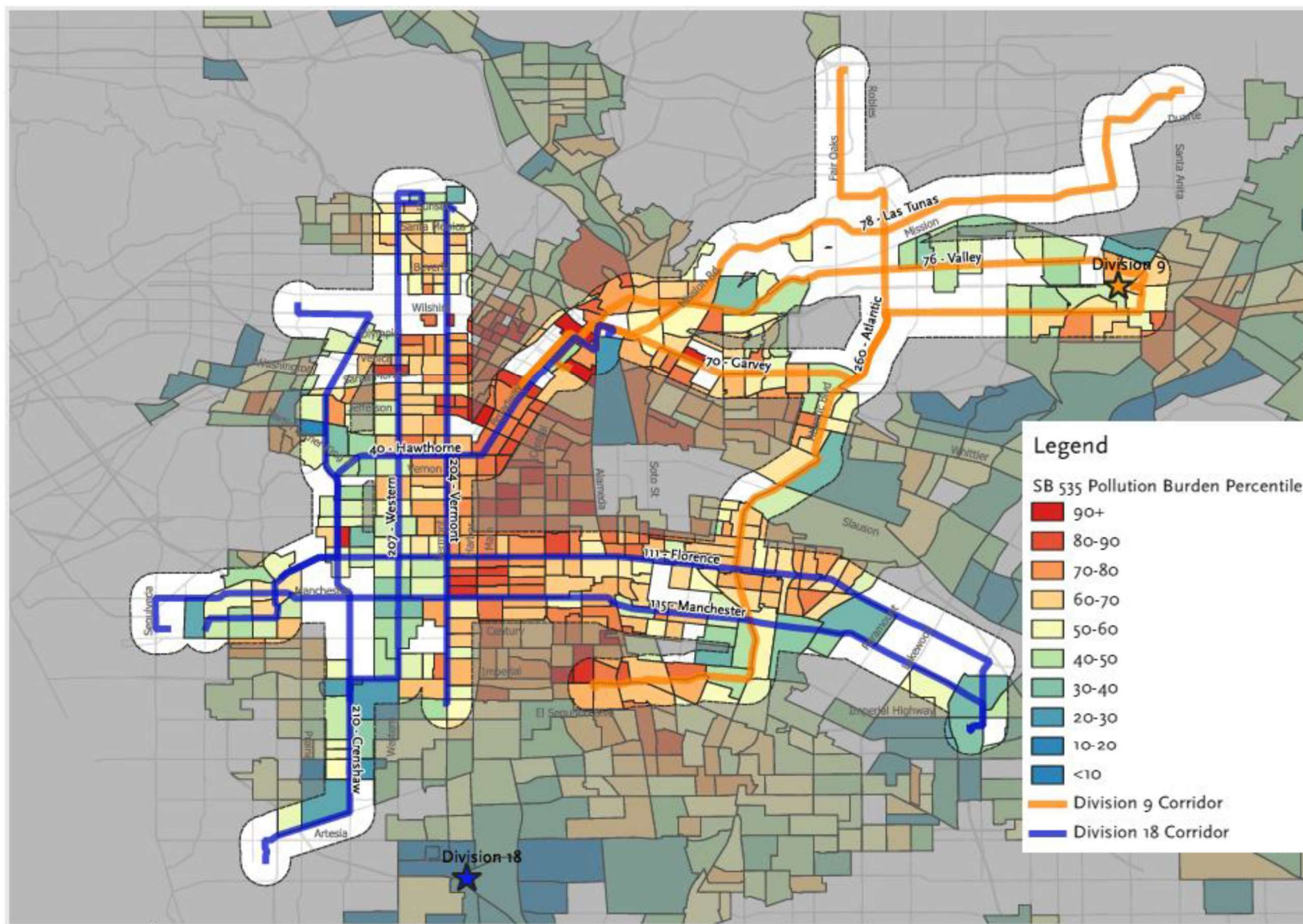


Figure 4: Census Tract Pollution Burden Percentile in the Project Corridors

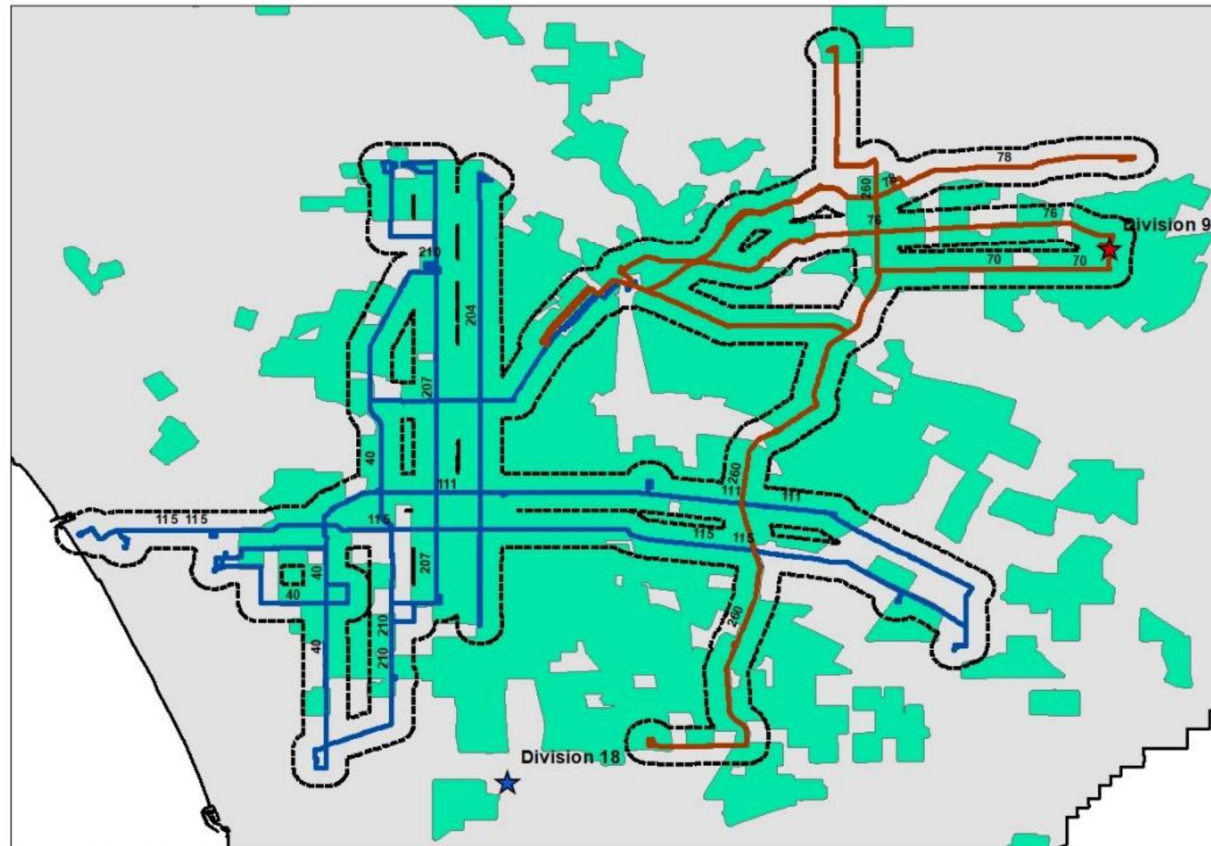
EQUITY PLATFORM FIGURES 3 - 5



Division 9 and 18 Transit Corridors Overlaid with Equity Focused Communities

Legend

-  Division 9
-  Division 18
-  Division 9 Corridors
-  Division 18 Corridors
-  Division 18 Corridors
-  Division 9 and 18 Transit Corridor Service Area
-  Equity Focused Communities
-  Non Equity Focused Communities



Prepared by Metro Service Planning

December, 2022

Figure 5: EFC Overlay Map

The background of the slide features the LA Metro logo, which consists of a stylized 'M' made of white, 3D-looking rectangular blocks. The 'M' is set against a green circular background, which is itself set against a larger orange circular background. The bottom left corner of the slide is black.

LA Metro Bus Sensor Technology

June 2023



Metro

Introduction

Metro Board approved Item 14, Bus Sensor Technology Motion. The motion requested Metro Staff to report recommendations on safety features such as pedestrian detection by June 2023. Specifically, the following responses were requested:

1. Determine feasibility of incorporating additional safety features into new procurement.
2. Determine feasibility of installing additional safety features on our existing bus fleets.
3. Explore other emerging collision avoidance technologies.

Further, Metro is in the process of concluding two separate passenger collision avoidance studies.

Background | MobileEye

FTA Grant Funded study to evaluate commercially available collision avoidance systems. Study evaluated several technologies available in 2017.

1. Selected Mobileye Shield + to test in partnership with NF, CTE, and the FTA on 50 LA Metro buses. Final Report expected to be available July 2023.
2. Preliminary findings are inconclusive, lacking sufficient evidence to demonstrate safety improvements over transit buses without active collision avoidance systems.

“MOBILEYE® SHIELD+™ V4 w/ APAS” OPERATOR REFERENCE



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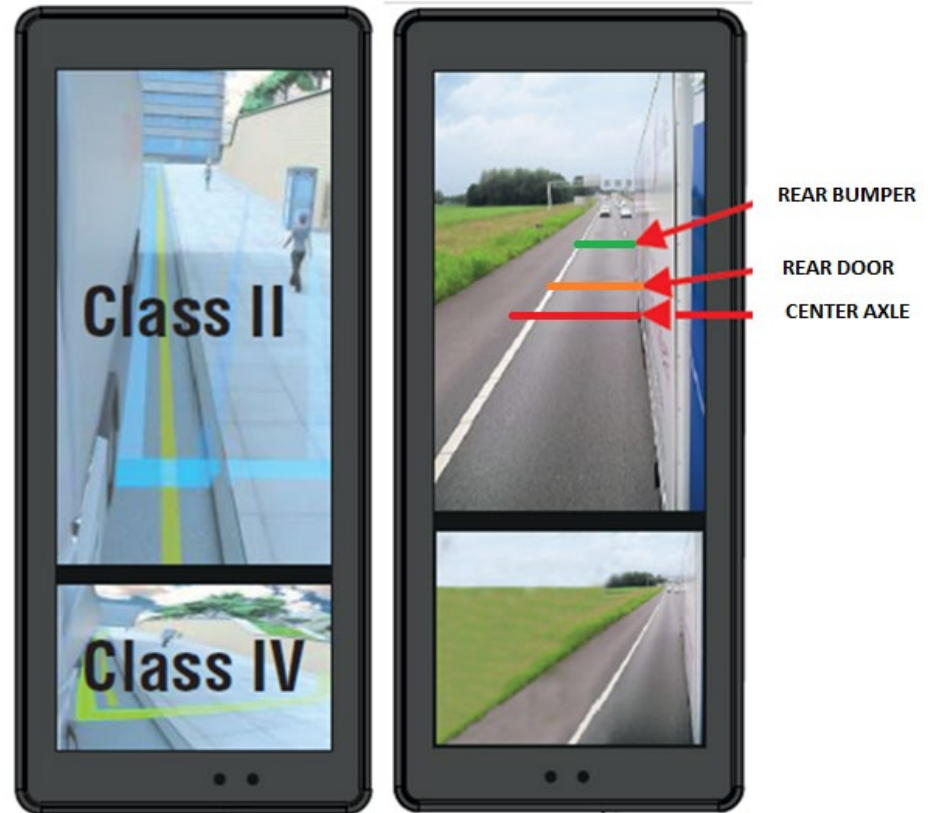


Metro

Background – MirrorEye

MirrorEye Study with BYD

1. Discussions with BYD and MirrorEye began in June 2019.
2. Electronic rear/side view monitors were tested on 5 BYD 60-foot buses and 5 BYD 40-foot buses. Features include night vision & lane marking.
3. Study ongoing, results expected to be published Summer of 2024.



Recommendations to Board Motion Responses (1-3)

1. *Determine feasibility of incorporating additional safety features into new procurement.* Staff has included language in the Technical Specification for new bus procurements to include vehicle safety technologies such as pedestrian detection, lane departure warnings, and Advanced Driver Assistance features.
2. *Determine feasibility of installing additional safety features on our existing bus fleets.* Staff is not recommending the retrofit with MobileEye as benefits were inconclusive, but staff will continue to assess technologies for the existing bus fleet as technologies mature.
3. *Explore other emerging collision avoidance technologies.* Staff will continue to explore new technologies as they emerge and merit additional evaluation.





Thank you.

