



# California Air Resources Board (CARB) updates to brake Emissions FACtors (EMFAC) using dynamometer tests for light-duty vehicles

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# CARB approach to non-exhaust emissions

2

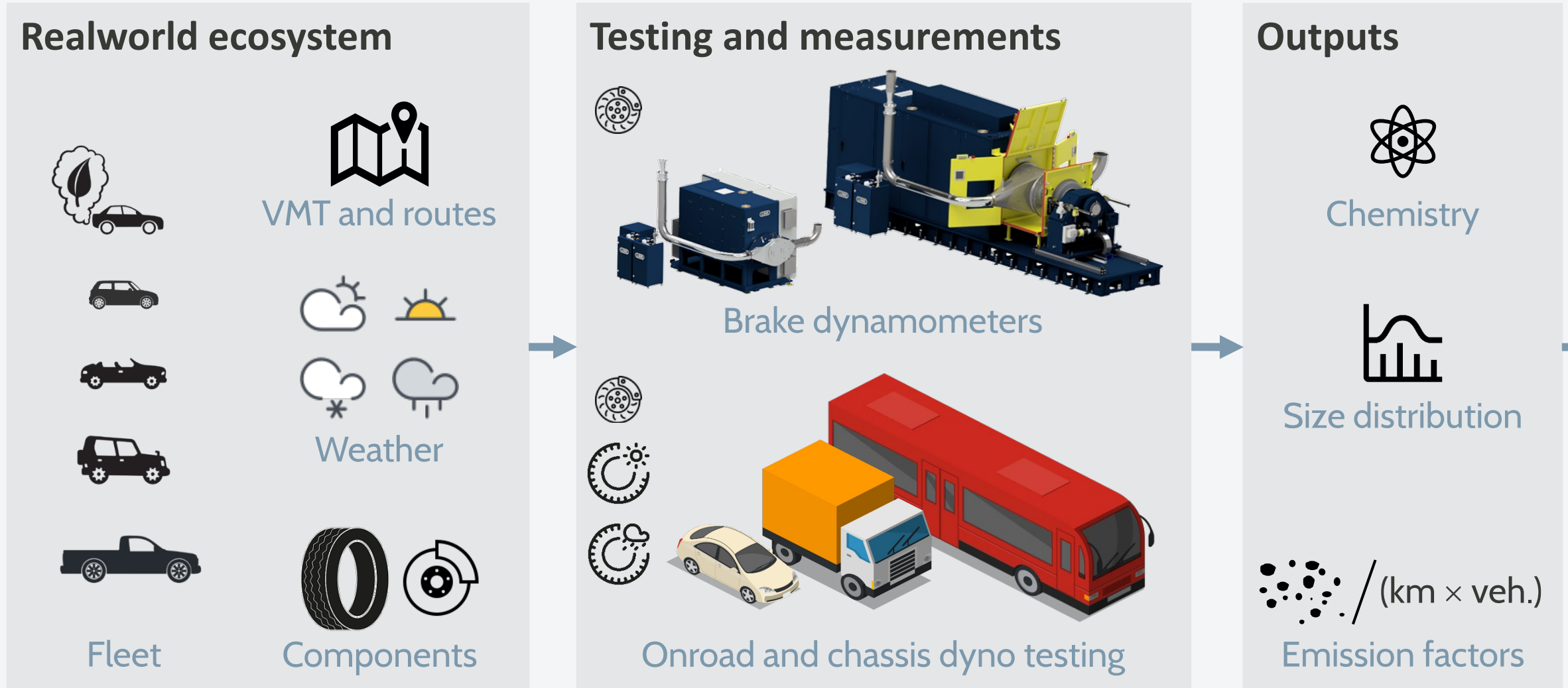
Interconnecting all dimensions and working with critical stakeholders



# The development cycle

3

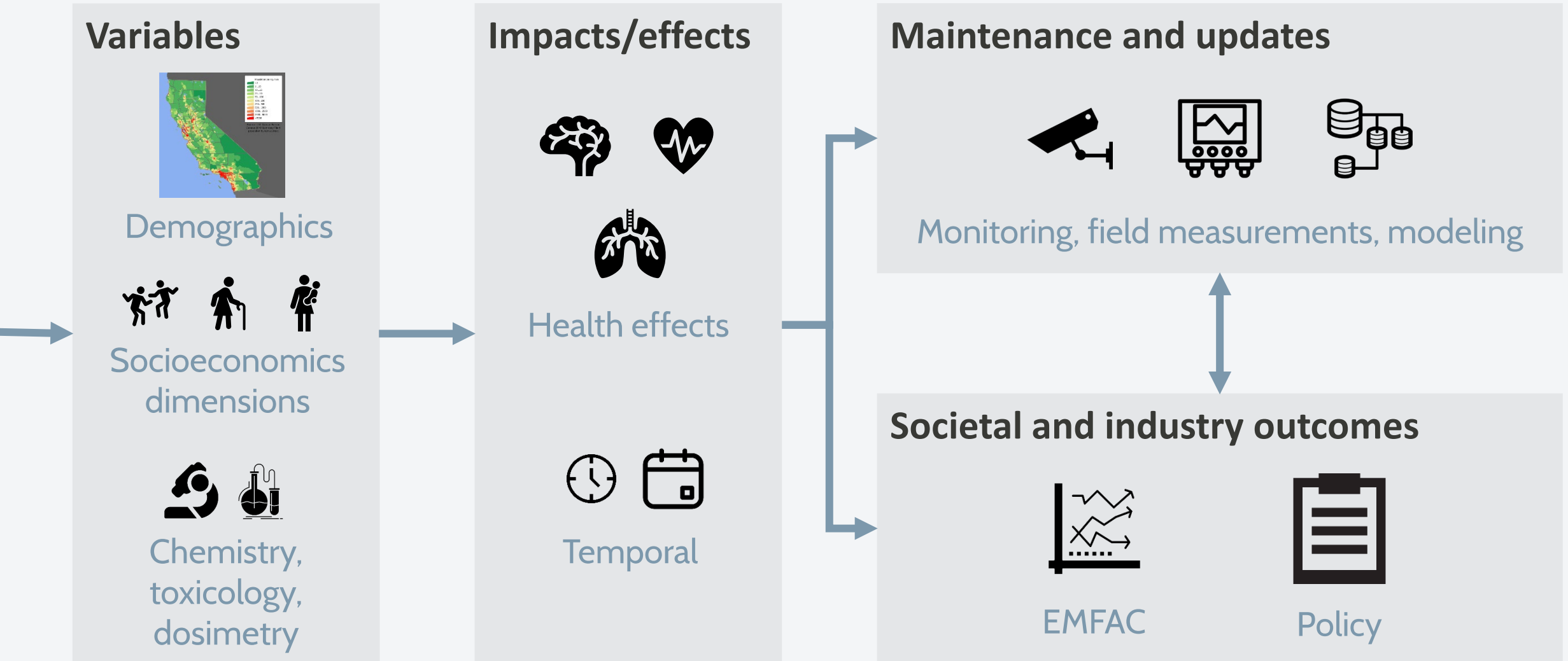
To get measurements, policies, and vehicle technologies right



# The development cycle

4

To get measurements, policies, and vehicle technologies right





# Ultimately, foster new technologies

5

To reduce overall anthropogenic environmental load and effects



Electrification



Coatings and materials

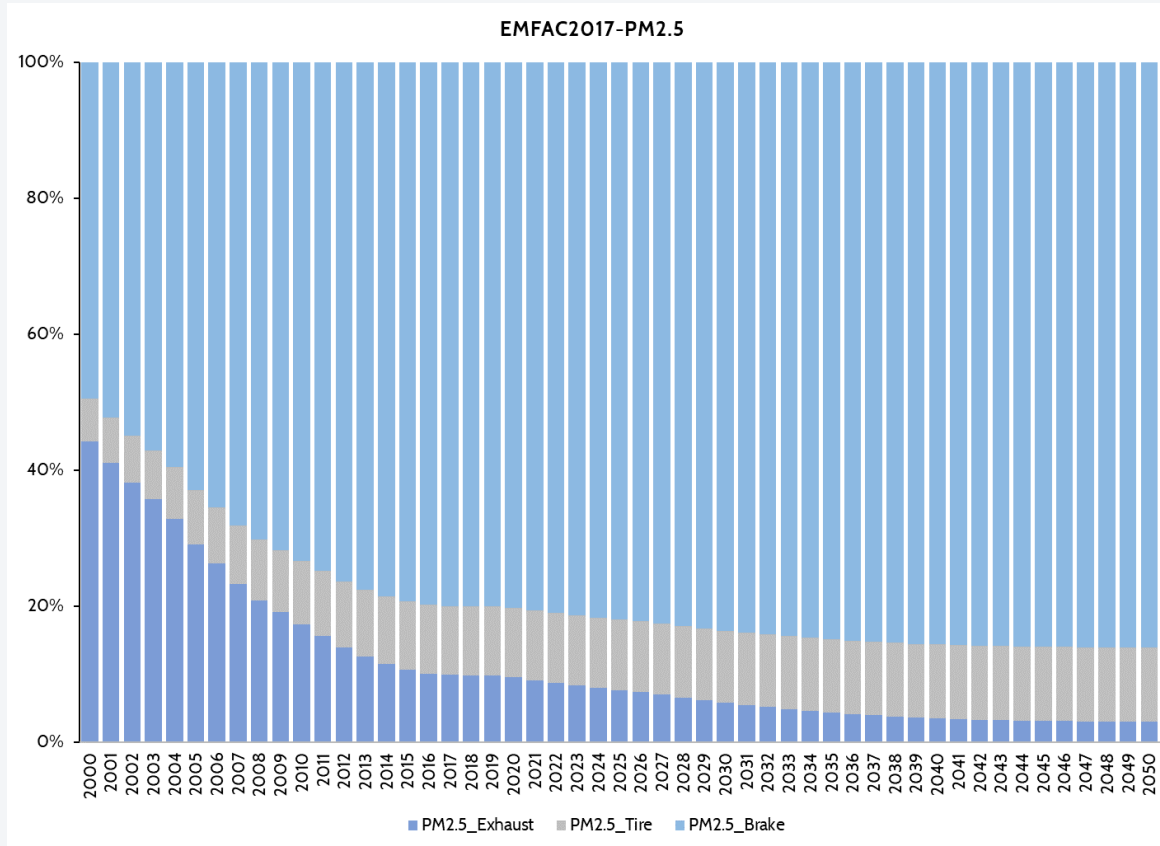


Lightweight vehicles

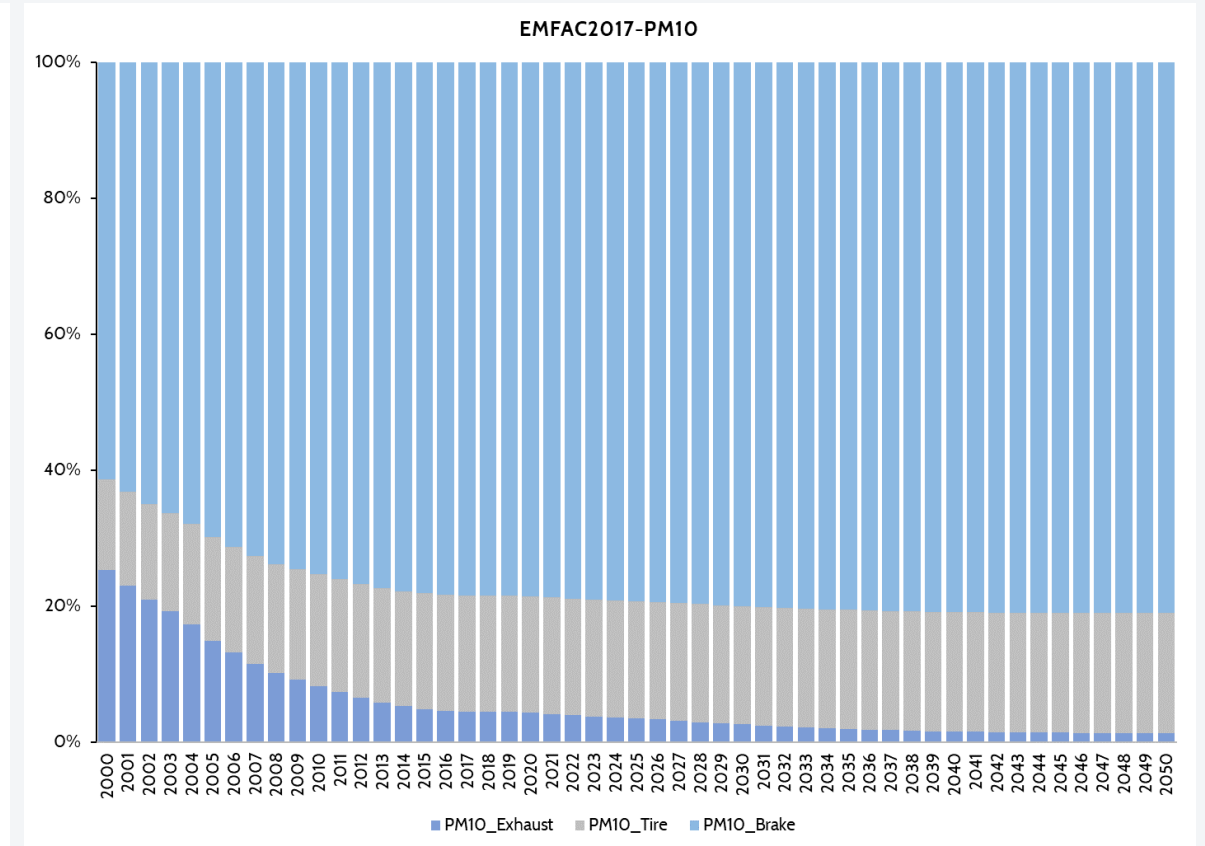
# EMFAC2017 PM projections for light-duty vehicles

6

Projections till 2050 with dominance of non-exhaust brake emissions



PM<sub>2.5</sub> for all propulsion systems → 2050



PM<sub>10</sub> for all propulsion systems → 2050



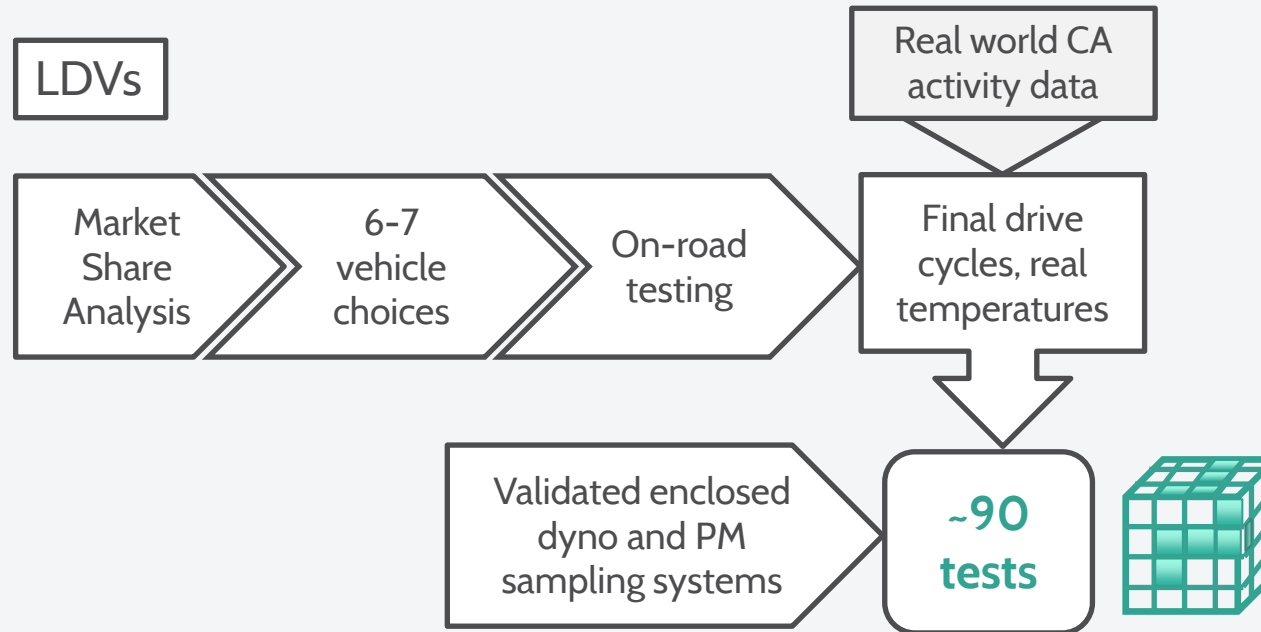
## EMFAC Gaps

- Data sources: 1983...2003
- Brake cycles not reflecting driving cycles
- Vehicles and brakes not reflecting current fleet

# CARB 17RD016 project to close the gap

8

Tiered approach, including on-road, chassis, and brake dyno testing



Vehicle N:  
CBDC dyno testing  
PMP-based test setup  
Brake Wear Index  
Front brake pads  
Rear brake pads/drums  
Popular aftermarket pads  
Loaded/unloaded  
Replicates

## Project team

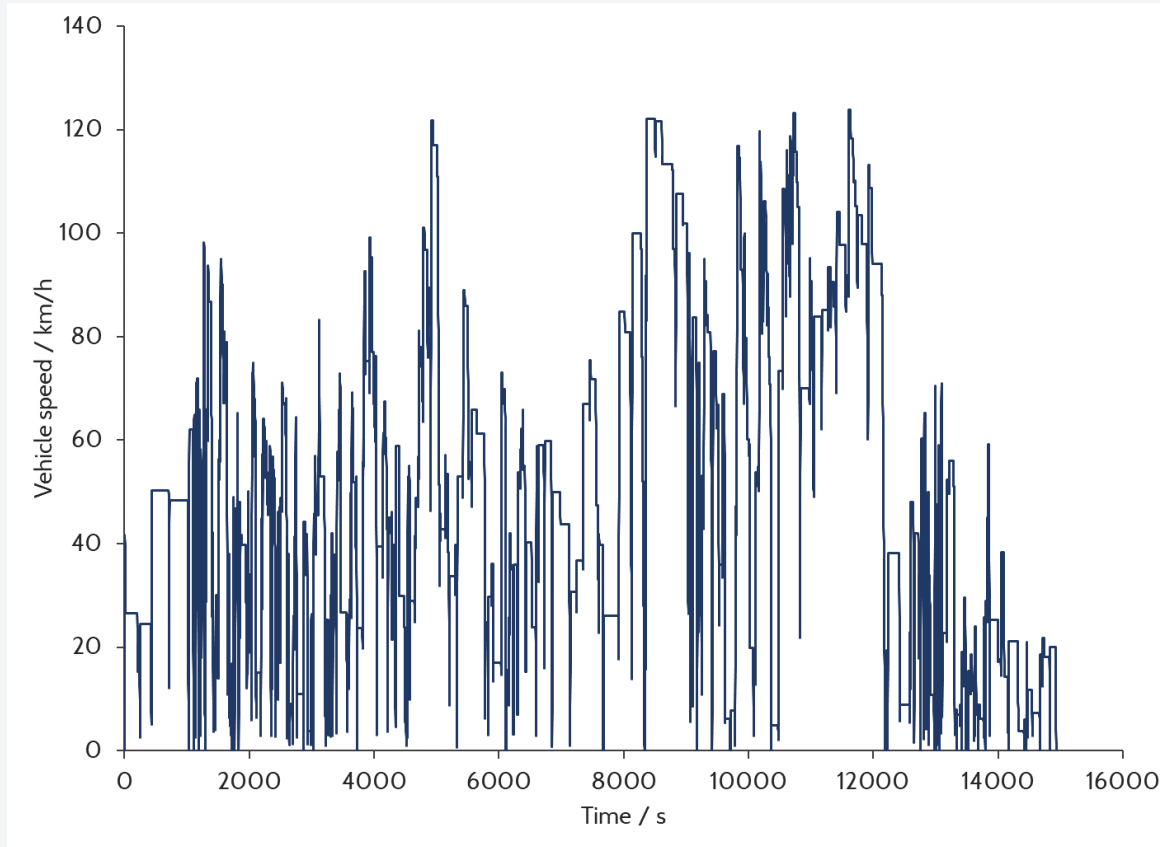




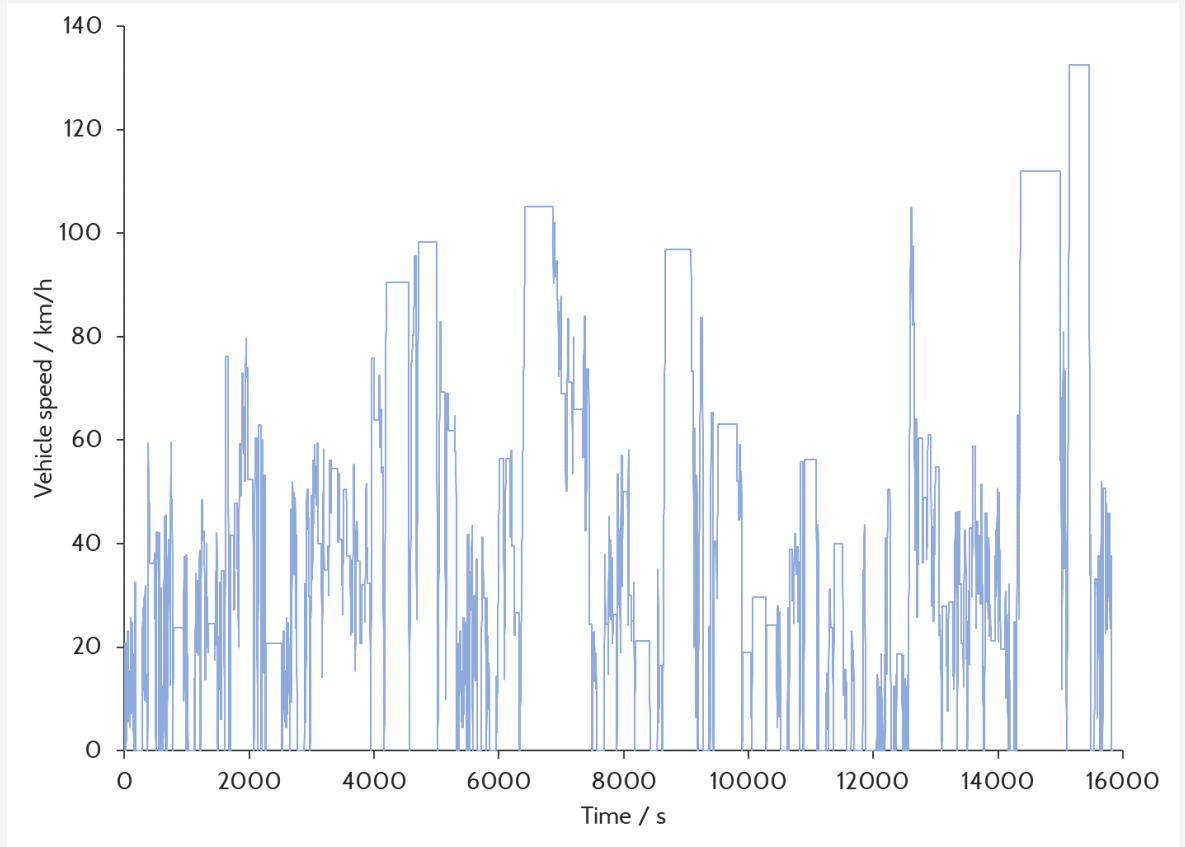
# Test cycle using vehicle activity, similar to PMP cycle

9

CBDC v. WLTP-Brake cycle for light vehicles



California Brake Dynamometer Cycle

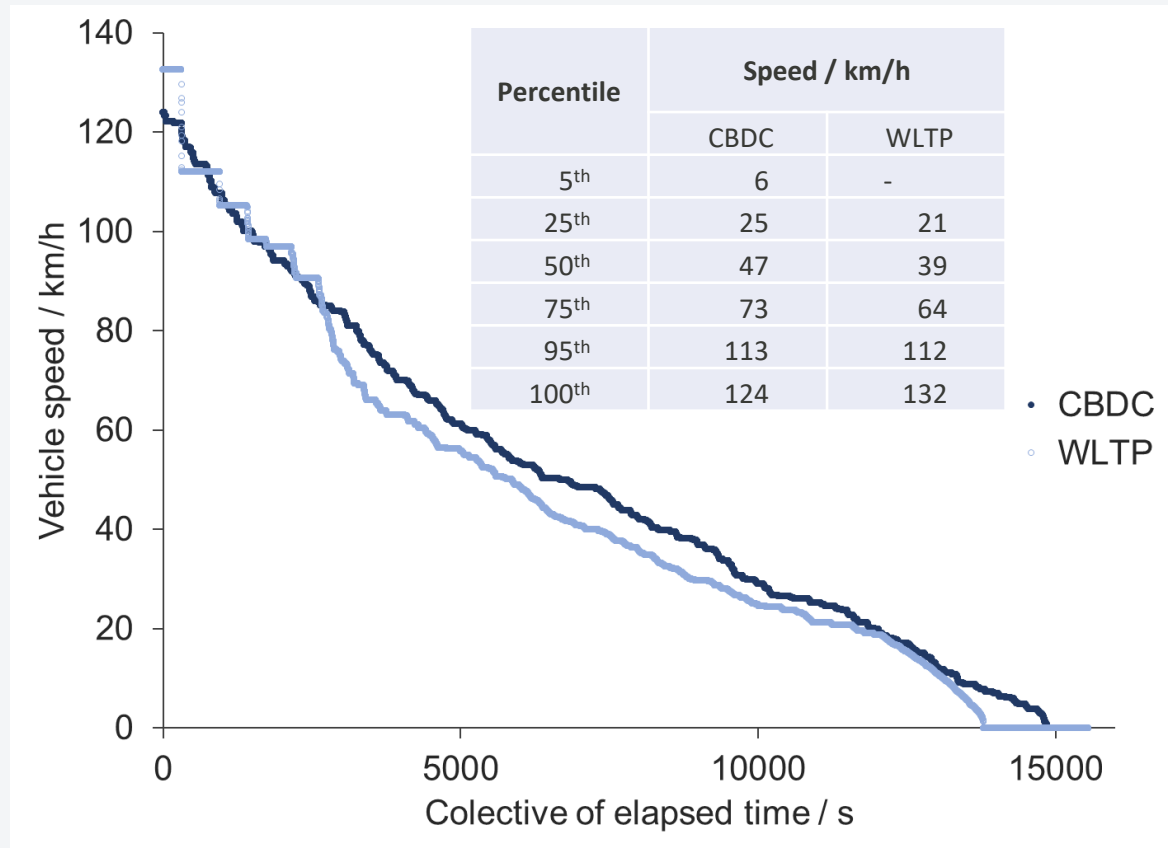


Worldwide harmonized Light vehicles Test Procedure

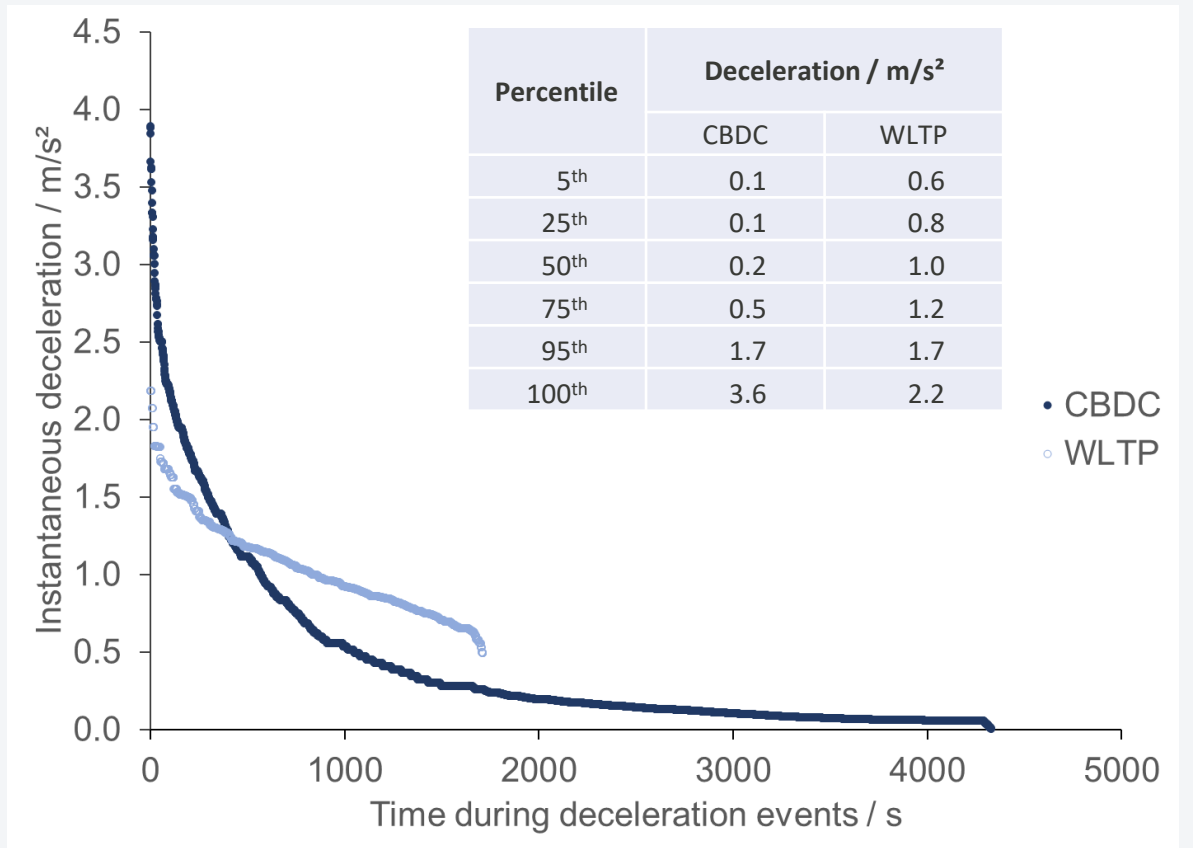
# CBDC speed and deceleration content

10

CDCC has higher speeds in the 25...75<sup>th</sup> percentile and lower overall decels



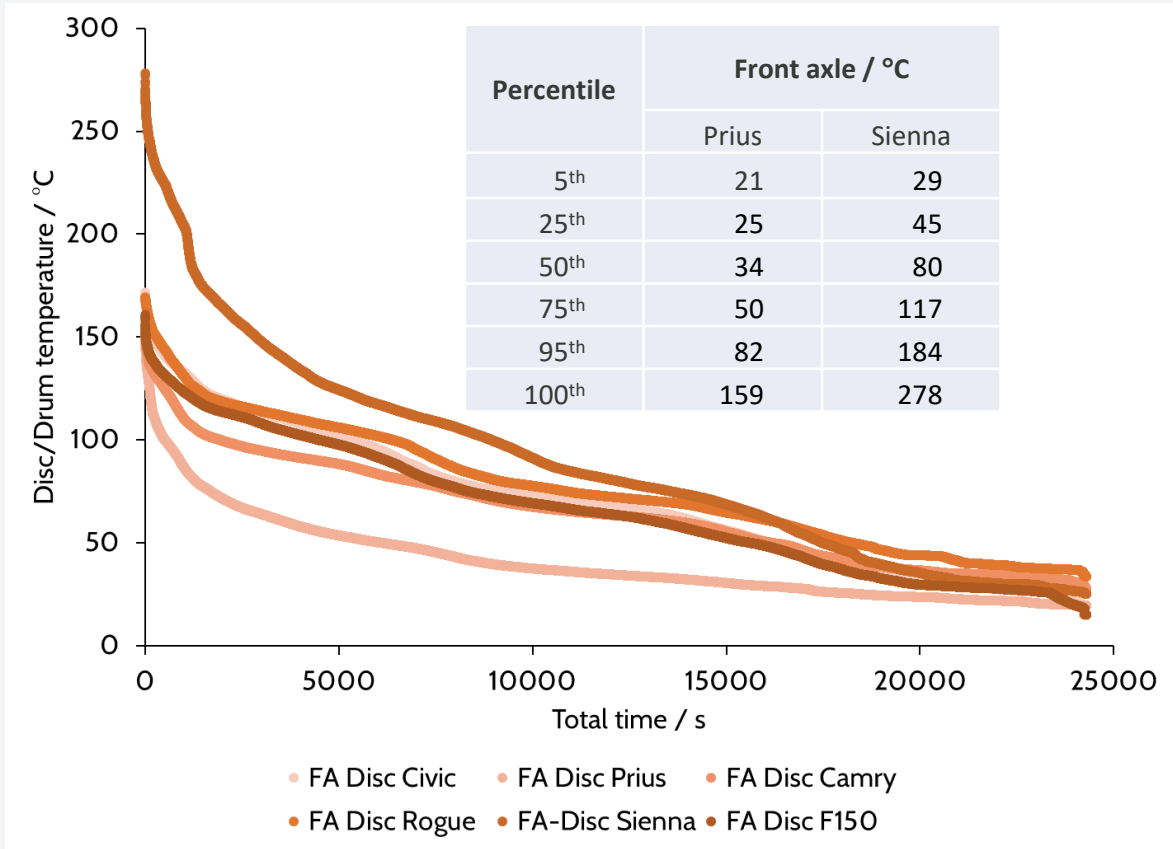
Speed colectives for CBDC and WLTP



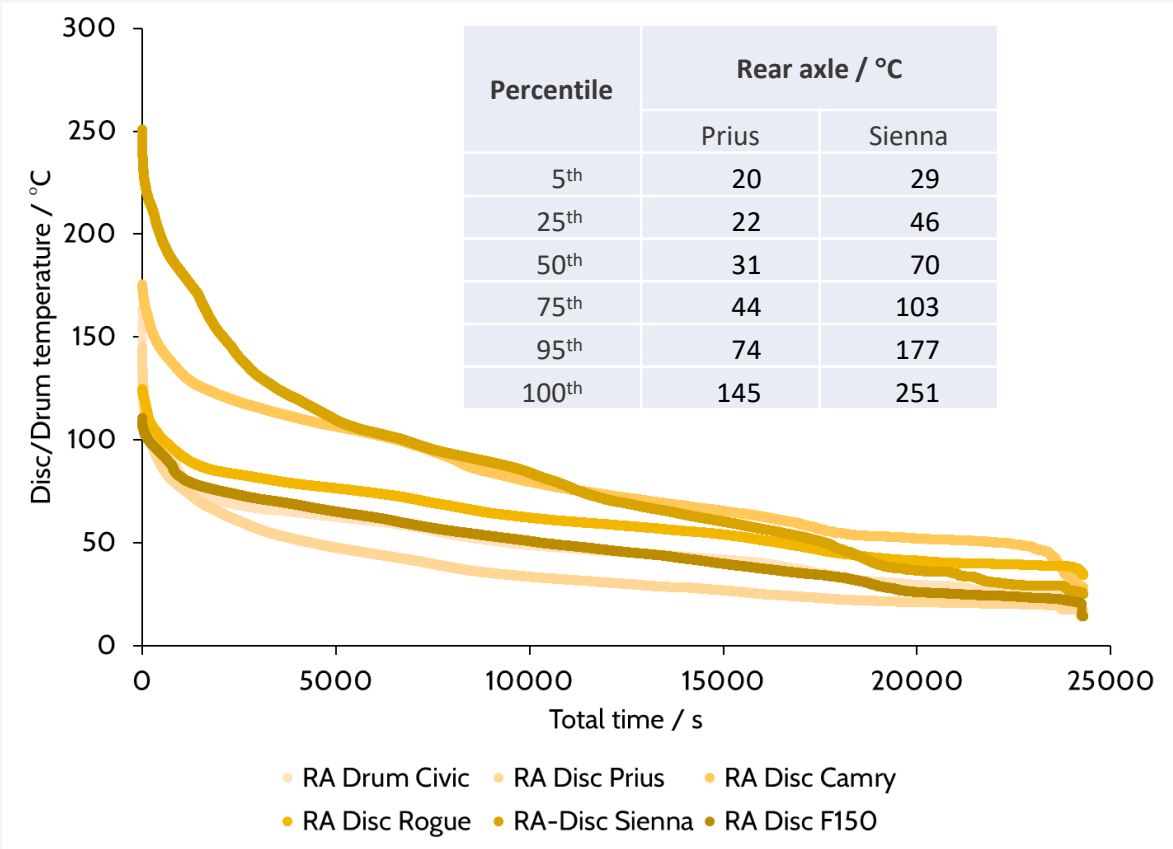
Deceleration colectives for CDBD and WLTP

# Brake disc/drum temperatures during WLTP vehicle testing

WLTP-Brake cycle was used to develop cooling rates for dyno testing



brake disc colectives for front brakes

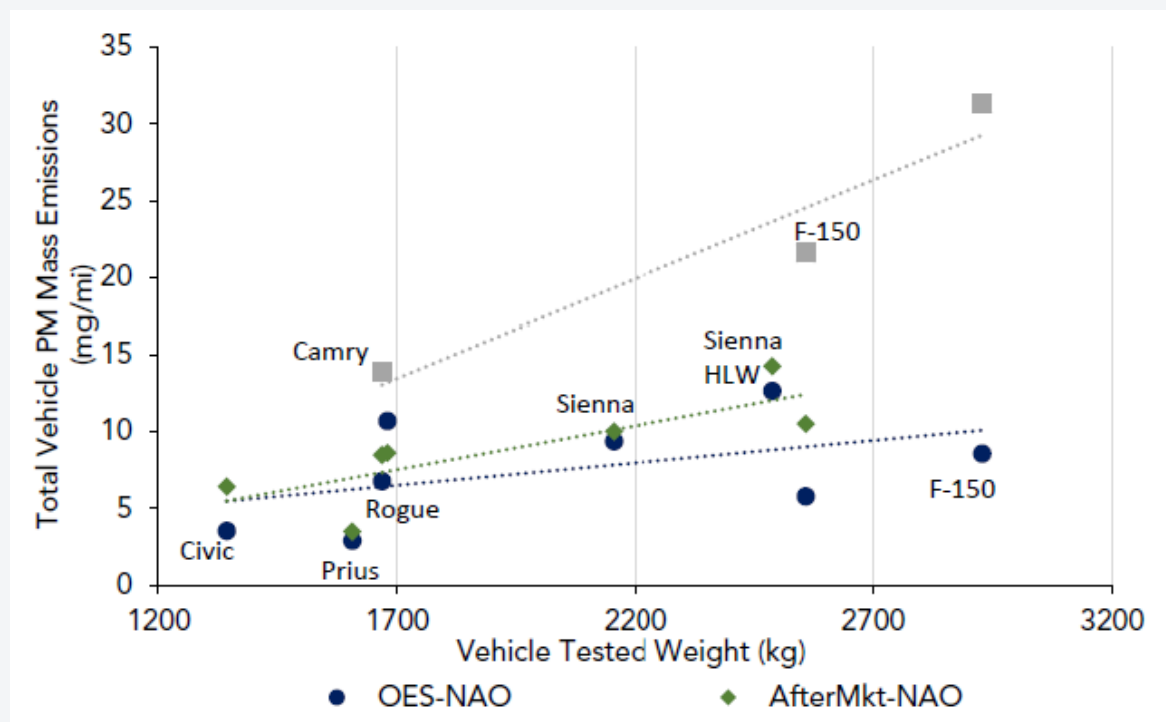


Brake disc/drum colectives for rear brakes

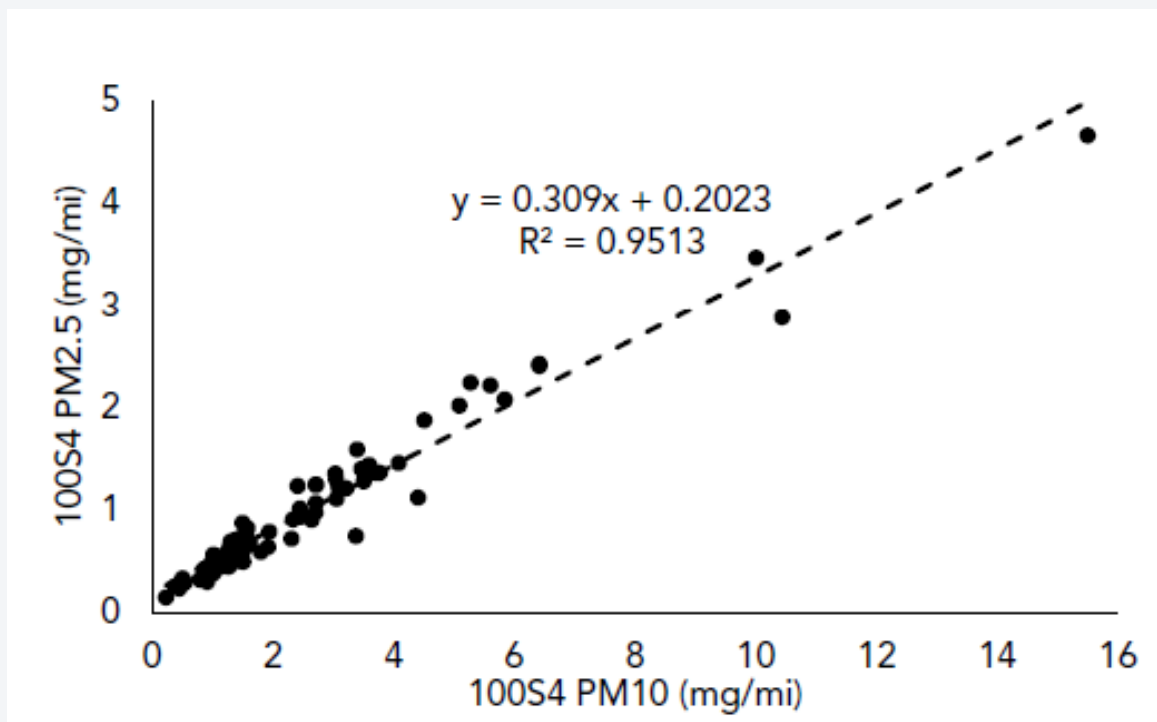
# Updated emission factors and relationships between PM fractions

12

Emissions factors differ by vehicle class and friction material



Total PM<sub>10</sub> v. vehicle mass and pad material



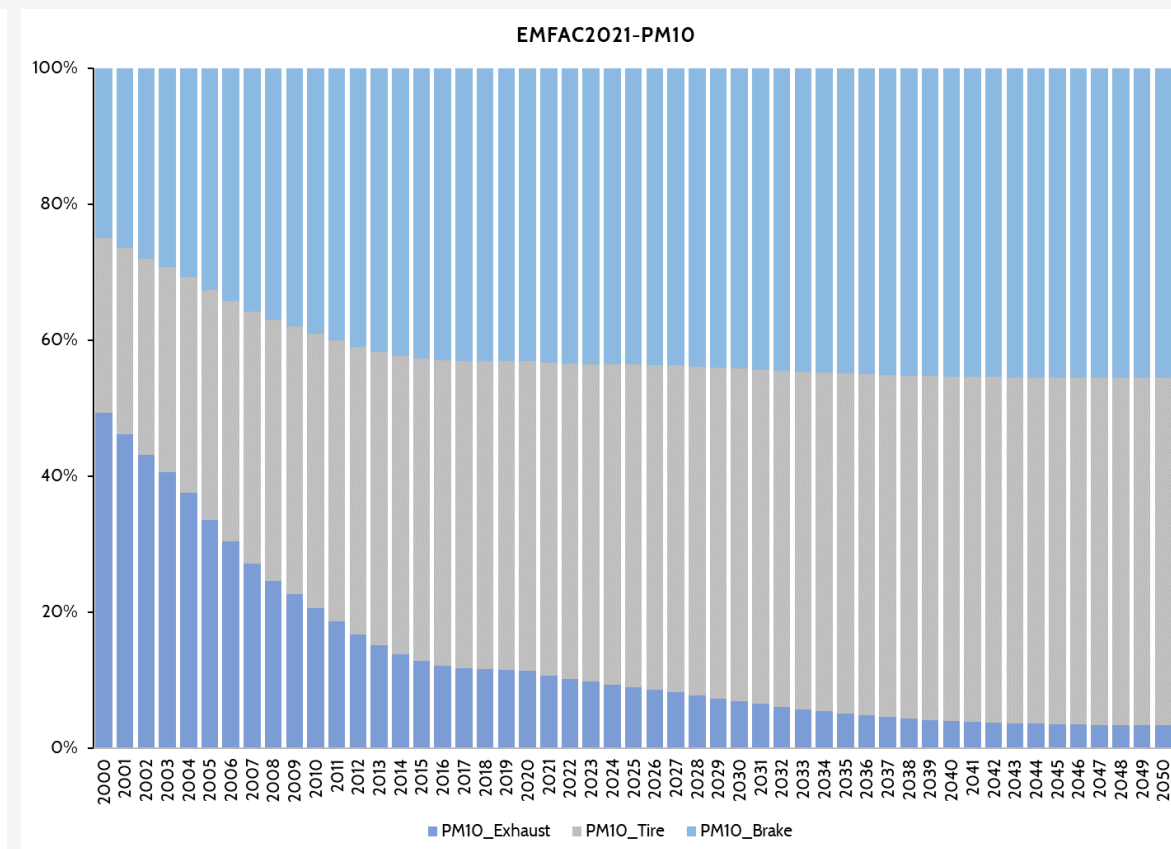
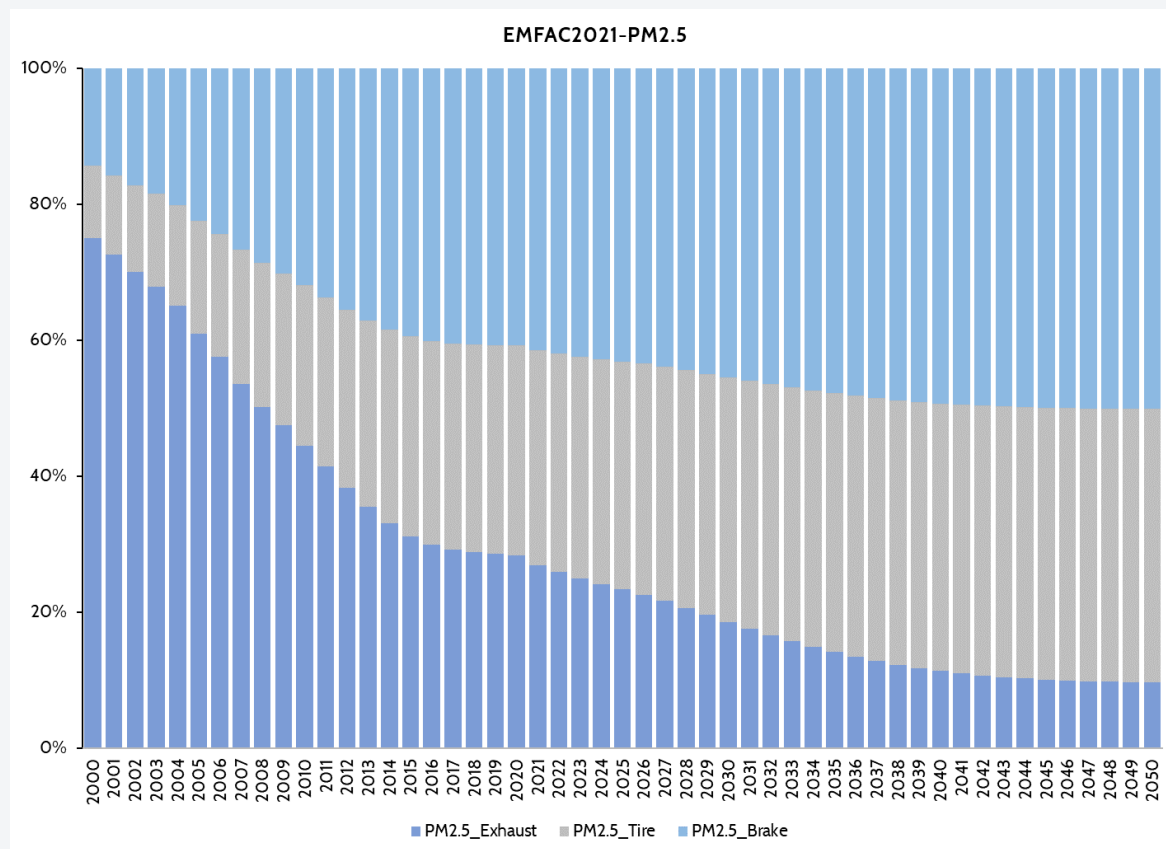
Correlation between PM<sub>2.5</sub> and PM<sub>10</sub>



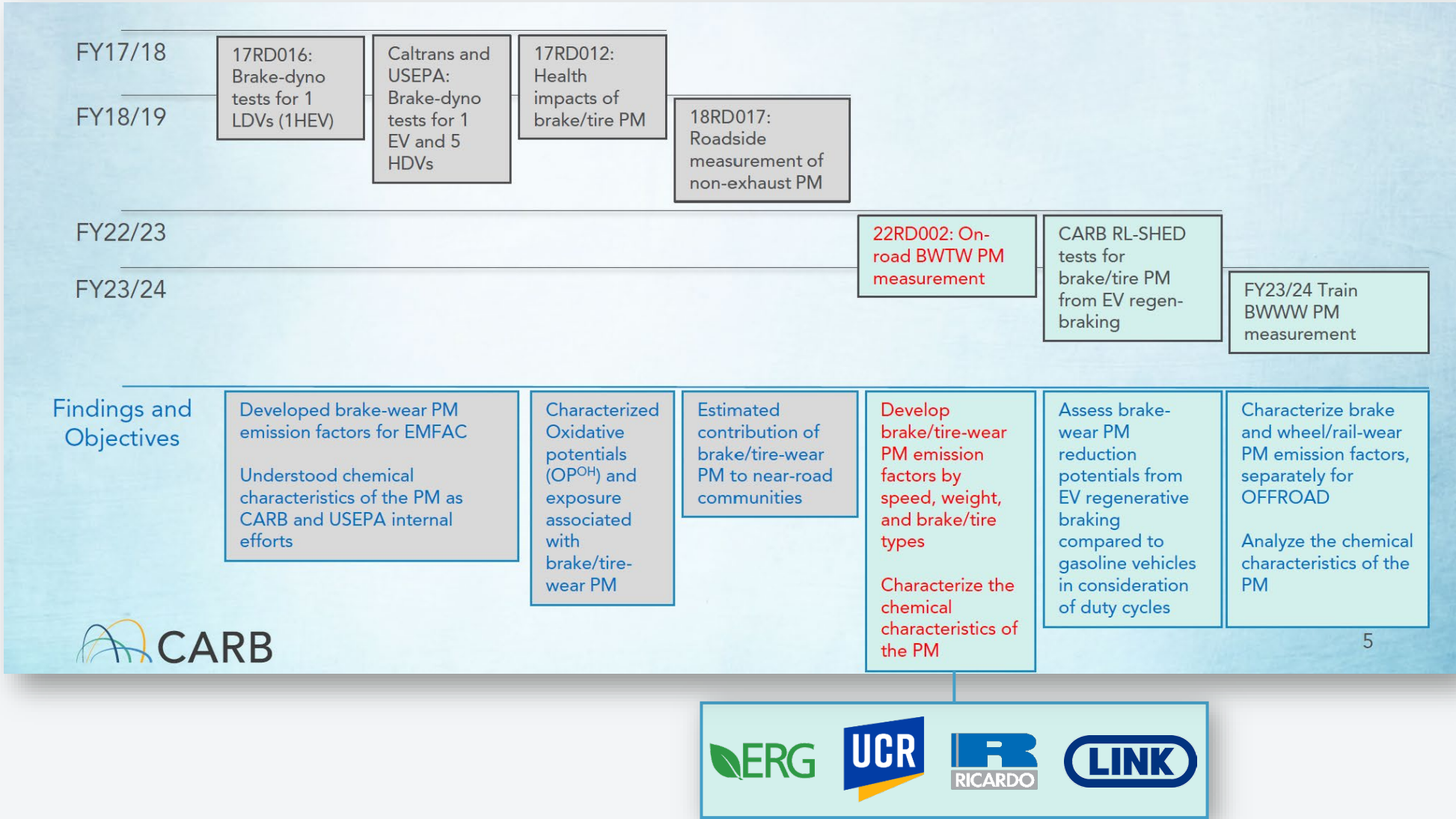
# EMFAC2021 PM projections for light-duty vehicles

13

Significant reduction (~75%) of brake contribution compared to EMFAC2017



# Non-exhaust PM study findings and objectives







# New Research on Brake Wear Particulate Matter Emissions from Several Heavy Truck Vocations in California

STATE OF CALIFORNIA REPORT CA21-3232







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Research Division



*“What we call the beginning is often the end. And to make an end is to make a beginning. The end is where we start from.”*

*T.S. Eliot , circa 1940*

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