STATE OF CALIFORNIA
AIR RESOURCE BOARD

Proposed 2016 State Strategy for the State Implementation Plan, and Draft Environmental Analysis (Appendix B)	**))))**	**Board Hearing Date: September 22, 2016**

COMMENTS OF THE TRUCK AND ENGINE MANUFACTURERS ASSOCIATION

July 18, 2016

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Introduction

The Truck and Engine Manufacturers Association ("EMA") hereby submits its comments on the Proposed 2016 State Strategy for the State Implementation Plan, and the accompanying Draft Environmental Analysis (hereinafter, the "2016 SIP Strategy") that the California Air Resources Board ("CARB") made available for public comment on May 17, 2016. EMA appreciates the opportunity to submit these comments on the 2016 SIP Strategy, and is doing so to help improve the accuracy and reasonableness of CARB's strategic plan to continue to improve air quality throughout California. EMA looks forward to following up with CARB staff on the important issues identified in these comments.

EMA is the not-for-profit trade association that represents the world's leading manufacturers of internal combustion engines, and the vehicles and equipment that those engines power, other than passenger cars. Heavy-duty on-highway ("HDOH") engines and vehicles are included among the array of products that EMA's members manufacture. Since a linch-pin of the 2016 SIP Strategy is the proposed adoption of new low-NO_x emission standards for HDOH engines, EMA's members have a direct and substantial interest in ensuring that the 2016 SIP Strategy is based on well-reasoned and validated emissions inventory assumptions and modeling. As explained below, that is not the case.

The 2016 SIP Strategy, as it relates to HDOH engines and vehicles, is premised on significant over-estimations of future ozone levels in the South Coast Air Basin ("SCAB"). CARB has derived those over-estimations from its use and application of the Community Multi-Scale Air Quality ("CMAQ") model, which, as applied by CARB, consistently has over-predicted future ozone levels in the SCAB for the past 25 years, including as recently as 2012 when CARB developed its last SIP submissions. In light of those consistent over-predictions of ozone, CARB's assertion that ozone attainment requires an additional 90% reduction in NO_x emissions from HDOH engines and vehicles – over and above the rigorous NO_x-control regulations that are already in place – is simply not supported by the actual facts. While some future HDOH emission requirements may prove to be warranted and reasonable, the assumed premise for adopting a 90% lower NO_x standard in 2019 is flawed and incorrect.

CARB's EMFAC model – the tool for estimating future levels of individual precursor emission, and in particular NO_x – also is over-estimating the magnitude of future-year emission inventories, and is utilizing emission inputs and related data that are significantly out-of-date. This, too, is a fundamental problem that CARB should remedy before adopting any specific menu of SIP strategies, especially strategies that are estimated to cost in excess of $10 billion.

CARB's assertion that it is justified in proposing to adopt non-aligned "Phase 2" greenhouse gas ("GHG") emission standards for HDOH vocational vehicles is similarly flawed. Specifically, CARB asserts that it intends to "layer additional requirements for vocational vehicle aerodynamics onto the federal Phase 2 program." (2016 SIP Strategy, p. 52.) That proposal is unreasonable.

The feasibility and cost-effectiveness of the Phase 2 GHG program (which will be finalized near the end of July) is premised upon complete alignment and harmonization between U.S. EPA and CARB. HDOH vehicle manufacturers cannot afford to build separate vehicles to meet California's purported need for unique incremental GHG requirements. Moreover, the notion that enhanced aerodynamics features are suitable for vocational vehicle applications is wrong. The very broad array of vocational vehicle applications, from dump trucks and garbage trucks to transit buses and school buses, and the urban and multi-purpose drive cycles over which they operate, are fundamentally ill-suited to enhanced aerodynamics. That is the reason why U.S. EPA -- which in this instance has the exact same regulatory interest as CARB -- eschewed requiring enhanced aerodynamic performance for vocational vehicles. Putting a vocational vehicle on California roads or placing that vehicle under CARB's jurisdiction does not change the fundamental aerodynamic limitations under which vocational vehicles operate.

CARB Has Failed To Provide
<u>For A Fair Notice And Comment Process</u>

As an initial matter, CARB has failed to provide for a fair and reasonable notice and comment process relating to the 2016 SIP Strategy. Specifically, CARB has based its 2016 SIP Strategy, and each of the proposed control measures, on the numerous modeling files and results that CARB and the SCAQMD have developed for the SCAQMD's 2016 Air Quality Management Plan ("AQMP"). While the text of the AQMP was just released on June 30, 2016, the underlying modeling files and results have not been made available for public review and comment. That is a clear abrogation of administrative due process, and should require a new notice and comment process when the data and methods underlying the 2016 AQMP become publicly available. In that regard, all of the modeling methods, data and results that CARB and the SCAQMD are relying on their preparation of the 2016 AQMP and SIP Strategy (including all "Appendix III" and "Appendix V" materials) should be released for public scrutiny as soon as possible.

CMAQ Over-Predicts
<u>SCAB Ozone Levels</u>

CMAQ modeling is the cornerstone of the 2016 SIP Strategy. In that regard, "ARB and the South Coast have been collaborating on air quality modeling to provide estimates of the reductions needed to attain the ozone and $PM_{2.5}$ standards." (2016 SIP Strategy, p.12.) The resultant estimates from those collaboratory modeling runs of the necessary emission reductions are very large. As CARB explains:

> Current modeling indicates that NO_x emissions will need to decline to approximately 130 tons per day (tpd) [in the SCAB] in 2023, and 90 tpd in 2031 to provide for attainment in the remaining portions of the region that do not yet meet the standards. Reaching these levels will require an approximate 70 percent reduction from today's levels by 2023, and an overall 80 percent reduction by 2031. (Id.)[1]

Based on those same modeling efforts, CARB is proposing to adopt in 2019 low-NO_x standards that will "provide 90 percent overall NO_x emission reductions from the current engine and emission control technologies." (2016 SIP Strategy, p.49.) "For heavy-duty vehicles, the State SIP Strategy calls for combustion engine technology that is effectively 90 percent cleaner than today's standards." (2016 SIP Strategy, p. 4.)

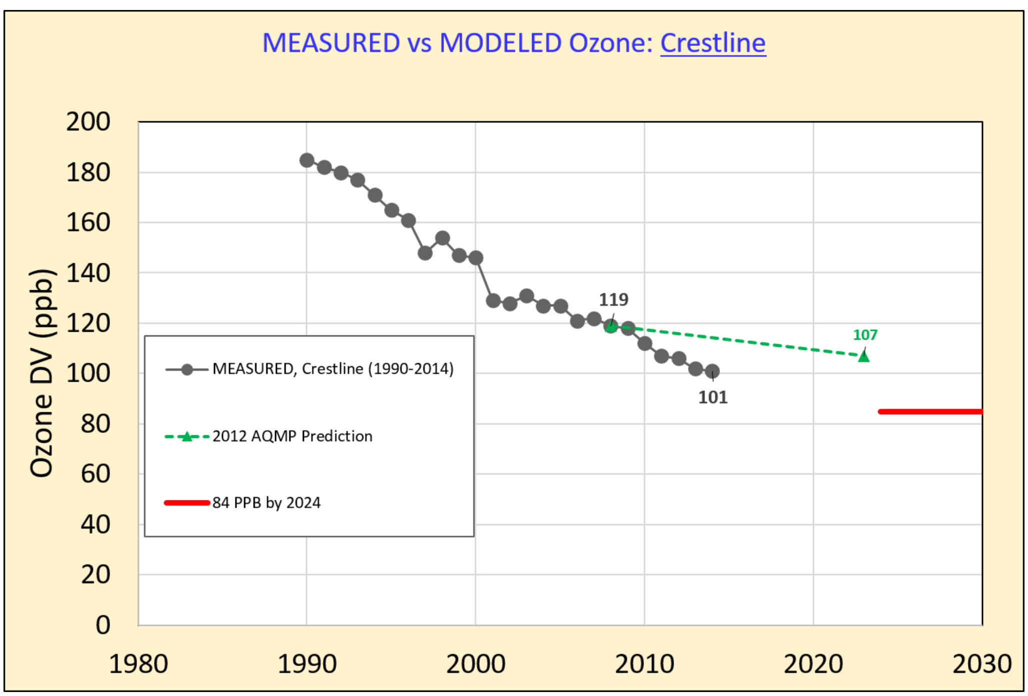
As noted above, CARB's call for an additional 90% reduction of the NO_x standard applicable to HDOH engines is premised on its utilization and application of CMAQ in a manner that consistently has over-predicted future ozone levels in the SCAB. EMA has worked with leading experts from Ramboll Environ to develop comprehensive analyses comparing CMAQ-modeled levels of ozone in the SCAB against actual monitored levels of ozone in the SCAB (hereinafter, the "Ramboll Analysis"). In addition, EMA is working with Sonoma Technology, Inc. ("STI") to perform additional analyses of NO_x and VOC trends, and to develop detailed comparisons between the available ambient data and the modeled emissions inventories for the SCAB. The Ramboll Analysis shows that, dating back to 1990, monitored levels of ozone have declined at a rate (ppb/year) that is 2 times faster than the CMAQ-modeled levels. The performance of CMAQ has been even worse over the more recent time period (2008-2014), during which time the observed and monitored trend in the reduction of ozone (on a ppb/year basis) has been 2 to 8 times faster than the CMAQ-predicted trend.

The specifics of the Ramboll Analysis bear this out. It is undisputed that at 14 out of 16 air quality monitoring stations in the SCAB, actual measured levels of ozone already were significantly lower in 2014 than the ozone levels that CMAQ predicted (for purposes of the 2012 SIP) would be achieved in 2023. Stated differently, actual ozone results already were significantly better in 2014 than the results CMAQ predicted for 2023, a full nine years later. The following chart depicts this significant disparity (all units are in ppb):

[1] It is very interesting to note that the 2016 AQMP asserts a different conclusion in this regard. The AQMP claims that "[t]he carrying capacities, the maximum allowable NO_x emissions to meet the ozone standards, are estimated to be 150 TPD NO_x in 2023 [not 130 tpd], and 100 TPD NO_x in 2031 [not 90 tpd]. (See AQMP, p.5-9.) Consequently, it is clear that, at best, one of those sets of estimates, either CARB's or the SCAQMD's, is wrong.

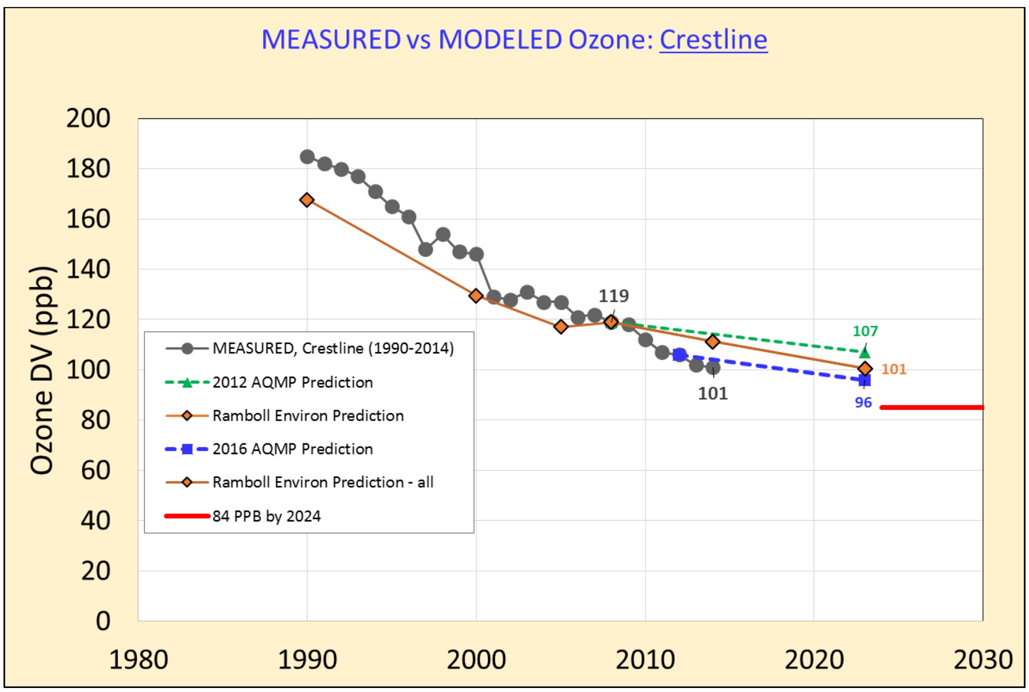
Location	2014 measured O_3 DV	2023 projections (Table 5-5, 2012 AQMP)
San Bernardino	97	108
Crestline	101	107
Glendora	93	107
Upland	96	106
Fontana	99	104
Redlands	102	103
Riverside	93	100
Pomona	86	100
Azusa	80	95
Santa Clarita	97	94
Banning	93	94
Pasadena	78	92
Reseda	87	90
Perris	89	88
Lake Elsinore	82	85
Burbank	88	76
Basin-Wide Max	102	108

The Ramboll Analysis explored this disparity in greater depth. Specifically, that analysis assessed, on a year-by-year basis, how CMAQ-modeled ozone levels and trends compare against actual monitored ozone levels and trends. Set forth below is an example of such a detailed comparison, focusing on the Crestline monitoring site, which historically has been the highest "design value" for the SCAB.

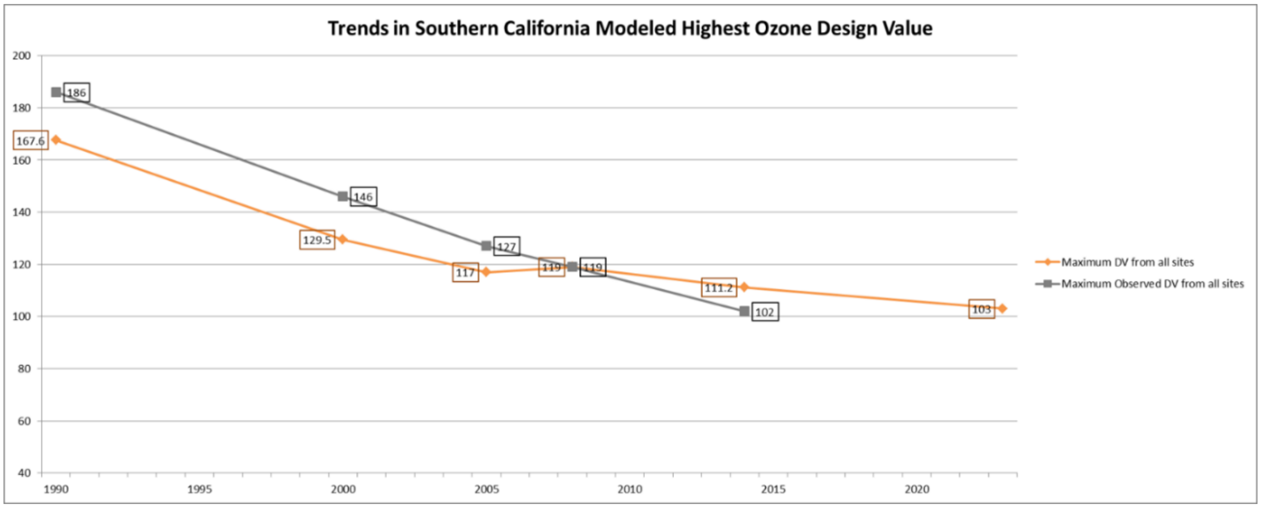


The foregoing chart compares the trend line for actual ozone reductions against the trend line that CARB derived in 2012 using CMAQ (and utilizing a 2008 base year). As is evident from the chart, the actual monitored ozone value at Crestline in 2014 (101 ppb) was significantly better than the CMAQ-predicted value for Crestline in 2023 (107 ppb). Moreover, the trend line that CMAQ predicted (just four years ago as a component of the 2012 SIP submissions) was much flatter, and much less responsive, than the trend line for the actual ozone reductions observed at Crestline. Significantly, the same holds true at almost every other monitoring site in the SCAB as well.

To check on the responsiveness of the CMAQ model, the Ramboll Analysis performed a "dynamic evaluation," including "backcasts" using CMAQ, and modeled past ozone levels that could be directly compared on a year-to-year basis against actual monitored ozone levels. Once again, those backcasts confirmed that the CMAQ-derived trend lines were flatter and less responsive than the actual trend lines, not just with respect to forecasted ozone levels, but against past ozone levels as well. CMAQ's lack of responsiveness is depicted in the following chart (see the orange line) for the Crestline monitoring site.



The phenomenon observed at Crestline – that both forecasted and backcasted ozone trends derived from CMAQ are flatter and less responsive than actual monitored trends—also holds at almost every other monitoring site in the SCAB. The net result is that CMAQ-modeled ozone forecasts, as developed by CARB, have been and are over-predicting future ozone levels in the SCAB. In addition, it also is clear that actual ozone levels in 2014 already were significantly lower than the ozone levels that CARB forecasted for 2023, and that the actual rates of decline in ozone levels in the SCAB (on a ppb/year basis) are greater than the CMAQ-modeled rates by a factor ranging from 2 to 8, as depicted in the following charts:



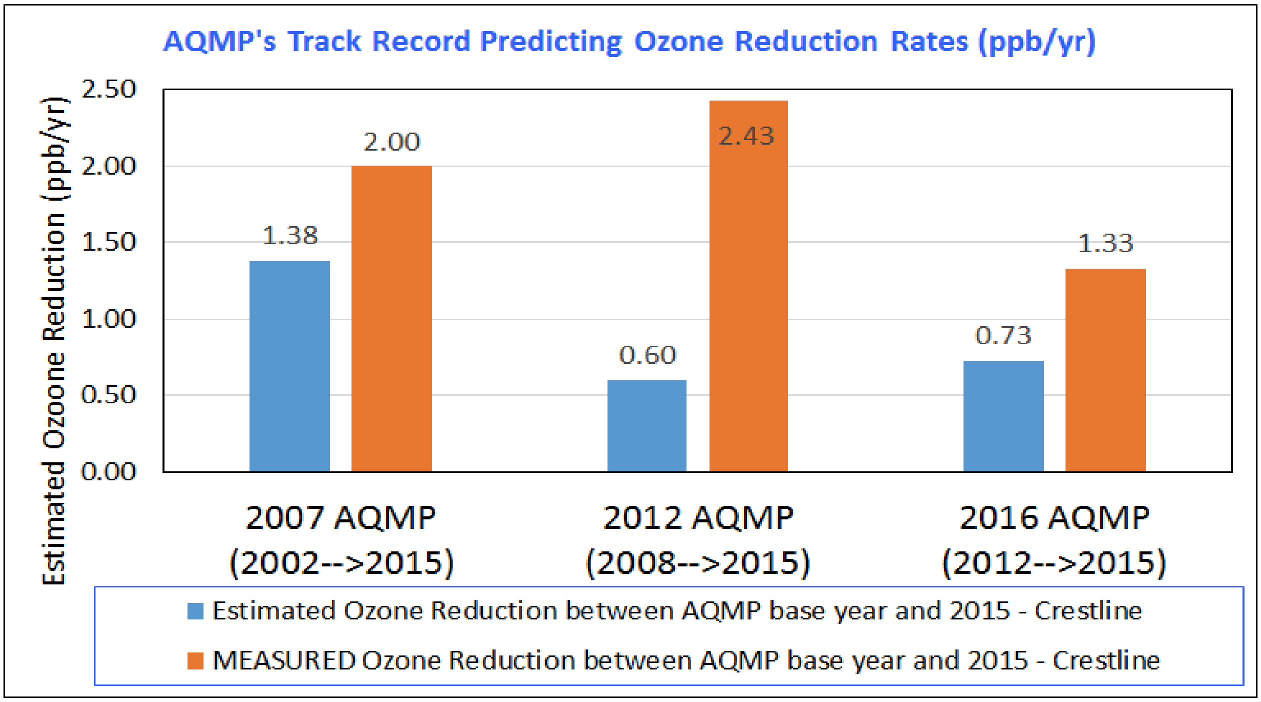
Location	Measured ΔO_3 (ppb)	Modeled ΔO_3 (ppb) [2012 AQMP]	Measured/Modeled ΔO_3
Azusa	-16	-2	8
Crestline	-18	-9	2
Fontana	-13	-2	7
Glendora	-14	-2	7
Pomona	-17	-4	4
Redlands	-14	-7	2
Riverside	-14	-6	2
San Bernardino	-19	-5	4
Santa Clarita	-8	-5	2
Upland	-14	-2	7
Basin-Wide Max	-17	-8	2

Rebutting the clear facts that the Ramboll Analysis has brought to light requires more than just a claim that CARB's 2016 runs of CMAQ (utilizing a 2012 base year instead of a 2008 base year) will be better. Simply anchoring CMAQ in more contemporary emissions inventory data does nothing to answer the question of why CMAQ, as applied by CARB, has been consistently biased for more than 20 years in a manner that is less responsive than the actual response of ozone formation in the actual environment. Moreover, there is no evidence that CARB's "do-overs" of its NO_x and VOC inventory estimates, and its corollary CMAQ modeling runs, yield any better forecasted results. In fact, the relevant evidence clearly suggests the contrary.

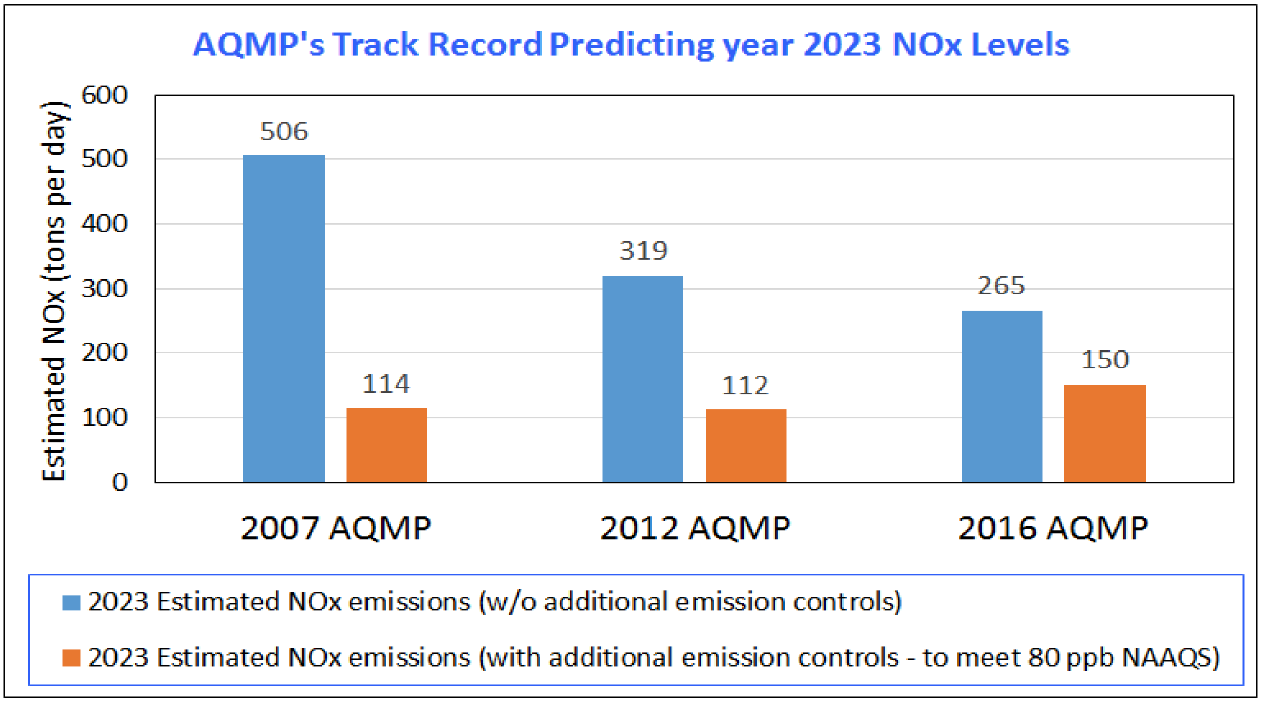
For example, just four years ago, in 2012, CARB re-ran CMAQ (utilizing a 2008 base year) to prepare its 2012 SIP submissions. By 2014 – in a span of just 2 years – the CMAQ modeled results were already off by nearly 15% at the SCAB design value site (Crestline), projecting an ozone level in 2014 of approximately 115 ppb, when the actual measured ozone level was 101 ppb in 2014. (See chart, supra.) Similarly, as confirmed by the just-released draft 2016 AQMP (albeit released without the necessary Appendix materials), between the time of the 2012 SIP submittals and the 2016 updates – just a 4-year time period – the estimate of the baseline NO_x inventory for 2023 dropped from 319 tpd to 265 tpd. That amounts to a 17% difference between the two modeling efforts over just a 4-year interval.

In addition, the projections of the SCAB's NO_x carrying capacity in 2023 have increased from an estimate of 112 tpd in the 2012 SIP to an estimate of 150 tpd in the 2016 SIP – a 34% increase in the SCAB's estimated NO_x carrying capacity in just 4 years. The estimates of the additional NO_x reductions purportedly required to demonstrate attainment are equally varied and imprecise. Specifically, the draft SIP submissions now assert than an additional 43% reduction in NO_x emissions is required by 2023. Just four years ago, however, the 2012 SIP asserted that an additional 65% reduction was necessary. That again amounts to a 34% difference or error between the estimates relating to the nearer-term ozone NAAQS attainment date. The estimates pertaining to the longer-term attainment date in 2031 are certainly even more error-prone and imprecise. Thus, based on past performance, there is no indication that the current round of CMAQ-derived predictions will prove to be more reliable than the last.

The following charts depict the manner in which CARB has been under-predicting ozone reduction rates and over-predicting NO_x levels in the SCAB since 2007, a period encompassing the preparation of three SIP submissions (and AQMPs) utilizing CMAQ.



(The AQMP ozone reductions are calculated between the base year and 2023. For the purpose of this chart, the rate of those reductions is assumed to be the same (linear) between the base year and 2015.)



In light of the consistent and significant discrepancies between modeled and measured levels of ozone and NO_x in the SCAB, CARB should not finalize or approve the 2016 SIP Strategy until such time as CARB's latest projections can be fully assessed and validated. To that end, and before seeking approval of the 2016 SIP Strategy, CARB should utilize the validation methods and analyses that U.S. EPA recommends, including "dynamic evaluations" that assess and take into account the past performance of air quality modeling efforts.

This is not simply an academic concern. The costs of erroneous projections are extremely high. In fact, the SCAQMD is anticipating that its draft AQMP will have an implementation price tag ranging from $10-$12 billion. Those enormous costs raise very serious questions about the unintended adverse consequences of flawed air quality modeling and emission inventory estimates. Those questions became even more pointed when the actual current rate of progress in reducing ozone levels is considered.

The draft AQMP states (at p.5-4) that the measured 8-hour ozone design value in the SCAB has been declining at a rate of 2.3 ppb per year over the 14-year period from 2001 to 2014. At that same rate, the ozone level at Crestline (which was 101 ppb in 2014) would be 80 ppb in 2023 and 62 ppb in 2031. That rate of decline would result in an ozone level that would be well below the targeted attainment level in 2031 and very near attainment in 2023, without any additional control measures whatsoever. All of this cautions against finalizing a $12 billion SIP Strategy before each of the very significant modeling uncertainties at issue is resolved.

It is clear that CMAQ, as applied by CARB and the SCAQMD, does (and will) over-predict future ozone levels in the SCAB. Consequently, CARB's CMAQ-based assertions that an 80% reduction in NO_x emissions is required to reach NAAQS attainment, and that the NO_x standard for HDOH engines must be reduced by 90% to hit that 80% reduction target, are both derived from a significant over-prediction of what ozone (and NO_x) levels will be in 2031. From that, it also follows that CARB's intent to enter into a binding SIP commitment to adopt a new low-NO_x

standard for HDOH engines (at a 0.02 g/bph-hr level) is based on a significantly flawed premise. The 2016 SIP Strategy should not be approved in its current form. In fact, and as noted above, given CARB's consistent history of generating over-stated results through its application of CMAQ, the 2016 SIP Strategy should not be finalized or approved until such time as CARB can complete and publish a thorough validation and dynamic evaluation of its 2016 ozone modeling efforts, as recommended by EPA.

Underlying NO_x Inventories
<u>Are Substantially Overstated</u>

CARB's estimates of future reductions in ambient levels of NO_x and total NO_x emissions, both with and without additional NO_x-control measures, are only as reliable as CARB's emission inventory assessments and models. If past is prologue, the reliability of CARB's estimates of future NO_x levels in the SCAB is highly questionable and uncertain. That uncertainty is compounded by the fact that the 2016 AQMP NO_x inventory estimates have not been available for review and public comment (specifically, Appendix III and Appendix V). Nonetheless, even without knowing what the updated and detailed 2016 numbers might be, there are a number of well-known problems with CARB's NO_x inventory estimates that need to be addressed and corrected before CARB finalizes the 2016 SIP Strategy.

Zero-Mile Emission Rates

CARB uses EMFAC to estimate real-world in-use emissions from various sources, including HDOH vehicles. CARB has utilized EMFAC to develop state-wide and district- specific NO_x inventories for several decades, and EMFAC is updated at regular intervals to make changes in modeling methods, and to incorporate the impact of new emission standards and other emission reduction programs.

The current version of EMFAC is referred to as "EMFAC2014" and was released in December of 2015. Counter-intuitively, EMFAC2014 significantly *increased* the estimate of NO_x emissions from HDOH vehicles equipped with 2010 and later model year heavy-duty engines, as compared with the previous version of EMFAC – which was referred to as EMFAC2011.

EMFAC's estimate of the in-use emissions from HDOH vehicles takes several factors into consideration, including vehicle type, mileage, speed, load and deterioration. The fundamental underlying emission rate, however, is referred to as the "zero-mile rate" or "ZMR." The ZMR is meant to represent the emission rate for new (and relatively new), well-maintained HDOH vehicles operating on California roads, and is subject to various adjustment factors, including speed correction factors. The ZMR is expressed in units of grams/mile ("g/mi") and varies with vehicle size, tare (unloaded) weight, and load factor. All else being equal, the ZMR increases with vehicle size, tare weight and load factor.

The certified emission rates for HDOH vehicles and engines are different and utilize a different metric. HDOH engines are certified separately on an engine dynamometer to standards expressed in units of grams/brake horsepower–hour ("g/bhp-hr"). Since the denominator for this standard is, in essence, work performed, the standard can be a constant, and does not vary with engine size or power rating.

The historical "rule of thumb" is that the in-use NO_x emissions from a Class 8 line-haul truck (which are in units of g/mi) operating on California roads over a duty cycle similar to the certification test procedure (i.e., the "UDDS transient cycle") are generally assumed to be 3.5 times the engine dynamometer-based certification emission standard (which is in units of g/bhp-hr). This "rule of thumb" ratio, or conversion factor, is a function of calculating (g/mi)/ (g/bhp-hr) or bhp-hr/mi, and, generally, represents the work needed to move a Class 8 line-haul truck one mile.

The NO_x emission standard for 2010 and later model year heavy-duty engines is 0.20 g/bhp-hr. Therefore, the general "rule of thumb" estimate of the in-use ZMR NO_x emission rate for a Class 8 line-haul truck over the representative UDDS duty cycle is 0.70 g/mi (0.20 x 3.5 = 0.70).

Significantly, the ZMR for 2010 model year and later Class 8 line-haul trucks that is used in EMFAC2014 is 1.89 g/mi. Obviously, this is much higher – nearly three (3) times higher – than the "rule of thumb" estimate (which, as noted, would be 0.70g/mi). By contrast, the analogous ZMR in the prior version of EMFAC (EMFAC2011) was 1.14 – markedly lower than the EMFAC2014 value. This calls into question whether the ZMR for HDOH vehicles in EMFAC2014 is materially over-estimating the actual emissions from 2010 and later model year HDOH vehicles.

The EMFAC2014 ZMR for HDOH vehicles was based on very limited testing that CARB and the SCAQMD conducted at CARB's chassis-dynamometer test facilities in Los Angeles. Specifically, eight HDOH vehicles were tested, three powered by engines certified to the 2007 through 2009 model year requirements, and just five certified to the 2010 and later standards. Of those five engines, however, only two (2) were actually certified to the 0.20 g/bhp-hr NO_x standard; the other three used emissions credits and were certified to a level above the 0.20g/bhp-hr NO_x standard. Further, the two engines certified to the 0.20 NO_x standard – already an unreasonably small sample size – were both produced by the same engine manufacturer.

The first of those two 0.20g vehicles was powered by a 2010 model year engine, and recorded a 1.95 g/mi NO_x level when tested over the UDDS test cycle. The second vehicle was powered by a 2011 model year engine, and yielded a 1.98 g/mi NO_x level when operated over the UDDS cycle. As noted, the UDDS cycle is a chassis-dynamometer-based test cycle that, when the proper loading is applied to the vehicle being tested, is reasonably similar to the engine-dynamometer transient certification test.

Due to the important policy and regulatory impacts of EMFAC modeling, as well as in light of the very small number of vehicles – just two – on which CARB's ZMR result is based, EMA arranged for a follow-up ZMR study. EMA contracted with CE-CERT to perform the ZMR study, and coordinated with CARB in setting up the test plan to ensure that the results could be directly compared against the results of the original CARB/SCAQMD ZMR study.

Based on the joint input from EMA and CARB, the CE-CERT study involved testing five late-model year, low-mileage heavy-duty line-haul vehicles produced by a variety of manufacturers that participate in the HDOH market. The same battery of tests as run in the original ZMR study were performed at CE-CERT with the vehicles loaded to the same level and otherwise tested under the same circumstances. CARB requested and arranged to have three of the five vehicles tested at its Los Angeles facility.

The average validated results for the vehicles tested at CE-CERT yield a significantly different result than what is assumed in EMFAC2014. Specifically, the average "rule of thumb" or conversion ratio – that ratio being the UDDS value divided by certification NO_x standard of 0.20 -- of the HDOH vehicles tested and validated at CE-CERT is 4.04, reasonably close to the expected "rule of thumb" scaling factor of 3.5. That corresponds to an average UDDS level of 0.81 g/mi. Since the tested vehicles all had low accumulated mileage, the 0.81 g/mi value would be a good approximation for the ZMR. That value is well below – more than two times below -- the EMFAC2014 ZMR value of 1.89 g/mi, and provides clear evidence that the current version of EMFAC is programmed in a manner to yield materially over-stated estimates of future-year NO_x emissions. EMFAC clearly needs to be revised.

Unreasonable TM&M Rates and Impacts

EMFAC2014's incorporation of unreasonably over-estimated tampering, malfunction and malmaintenance ("TM&M") rates, and its inclusion of unreasonably over-estimated emission increases ascribed to those incidences of TM&M, also raise significant concerns regarding the model's accuracy. In that regard, CARB did not update the TM&M assumptions that were used in the earlier versions of EMFAC. Those assumptions, however, are based principally on surveys of trucking fleets and repair facilities conducted in 1988 (a study conducted for CARB by Radian Corporation) and in 1998 (a study for EPA conducted by Engine, Fuel and Emissions Engineering, Inc.) – surveys prepared some 28 and 18 years ago. Quite obviously, those earlier surveys are long out-of-date, and include many assumptions that no longer pertain to recent and current model year HDOH vehicles that operate with advanced electronically-controlled after-treatment systems, fully integrated and comprehensive OBD systems, and multiple "inducements" to ensure emissions compliance.

An example of the out-of-date TM&M assumptions that CARB continues to rely on in the current version of EMFAC is set forth in the attached "Appendix C" from CARB's earlier technical support document for EMFAC. That Appendix lists the assumed lifetime TM&M rates and NOx emissions impacts for 2010 and later model year HDOH engines. Even with OBD requirements factored in, CARB assumes that over the assumed 1,000,000-mile life of a HDOH vehicle, more than 40% of those miles will be driven by vehicles having a failed NOx sensor, and that more than 12% of all miles will be driven by HDOH vehicles with a continuously malfunctioning NOx aftertreatment system, yielding a 200% to 300% increase in NOx emissions over all of those miles. Those types of over-stated and outdated assumptions have a very material impact on the modeled level of future NO_x emission inventories. In fact, the net effect of those TM&M assumptions is that the modeled NO_x level for each and every 2010 and later model year vehicle increases by .07 g/mi every 10,000 miles, starting off at near 2 g/mi and ending up (at the 1,000,000 mile mark) at 9 g/mi. That is more than 11 times higher than the reasonable ZMR of 0.81 g/mi for the relevant HDOH vehicles.

In an effort to improve EMFAC (and thereby avoid the unreasonable consequences of inaccurate and overstated emission inventories), EMA is working to develop better and more accurate information relating to actual TM&M rates for recent and current model year HDOH engines, and the likely resultant impacts on emissions from potential incidences of TM&M. Such an updated database would enable EMFAC to incorporate actual rates (and declining trends) of malfunctions for current HDOH vehicles, coupled with current assessments of emissions impacts, as opposed to CARB's assumed rates based principally on surveys conducted in 1988 and 1998.

CARB's assumptions, and the current EMFAC model, also fail to account for the mitigating effects of comprehensive OBD systems as well as the advanced "inducement" systems that de-power or disable the re-start function of HDOH vehicles that are experiencing potential emission-related problems, specifically those that could increase NO_x emissions. The inducements that EPA and CARB require as a condition for the certification of current model HDOH vehicles preclude any significant amount of miles of operation of any HDOH vehicle that has any malfunctioning SCR-related components. Those inducements, and the related OBD requirements, do not expire or shut-off at 500,000 miles (as implicitly assumed in EMFAC), and quite simply eliminate many if not all of the most significant NO_x increases from TM&M that CARB is still including in EMFAC – again, based on studies dating back to 1988. Indeed, as CARB itself noted in its January 2013 Field Evaluation Report:

> CARB staff believes that companies and truck operators will simply not tamper with the HDD vehicles and risk costly repairs and/or possible fines, especially when those vehicles will cause the engine's power to degrade causing delivery delay and general inconvenience.

EMFAC's increase in NO_x emissions for 2010 and later HDOH vehicles by multiples of the underlying emission standard after 500,000 miles is significantly over-stated and will drive unreasonable and significantly over-stated estimates of future NO_x inventories. EMFAC must be revised to account for the mitigating impacts of comprehensive OBD systems and inducements. Otherwise, CARB's SIP Strategy will be premised on unreasonable emissions data, in addition to flawed modeling.

CARB's Intent to Pursue
Separate GHG Standards For
Vocational Vehicles Is Misguided

The 2016 SIP Strategy also includes CARB's proposed commitment to adopt medium and heavy-duty GHG "Phase 2" standards to harmonize with the GHG "Phase 2" standards that U.S. EPA will finalize near the end of July. However, CARB's proposed SIP commitment goes well beyond harmonization. Specifically, CARB's proposal "may include some more stringent, California-only provisions that are necessary to meet California's unique air quality challenges. For example, the California Phase 2 proposal may layer additional requirements for vocational vehicle aerodynamics onto the federal Phase 2 program." (2016 SIP Strategy, p.52.)

CARB should not include a California Phase 2 proposal in the 2016 SIP Strategy, which is focused on ozone attainment in the SCAB. Such a proposal is not germane to the SIP process, is not necessary, and is not reasonable. Full harmonization between U.S. EPA and CARB on the anticipated Phase 2 GHG standards is a basic prerequisite to their feasibility and cost-effectiveness. Separate CARB standards therefore are directly at odds with the core Phase 2 rulemaking premise that there will be one nationwide set of next-phase GHG standards. Further, the notion that there are additional enhanced requirements for "vocational vehicle aerodynamics" that CARB can devise and implement in a feasible and cost-effective manner is unfounded. Vocational vehicles are not suited to an enhanced "layer" of aerodynamic demands. Those vehicles spend a significant percentage of time in parked-idle or drive-idle modes; they routinely engage in stop-and-go operations; they typically operate at non-highway speeds and in non-cruise driving modes; and they otherwise operate on (and are certified on) urban and multi-purpose drive cycles that do not lend themselves to enhanced aerodynamics. Indeed, less than 5% of vocational vehicles operate on the regional duty cycle that theoretically might accommodate increased aerodynamic performance.

Further, as expressly conceded in the 2016 SIP Strategy (see id. at p.52), CARB has not attempted to quantify the "criteria emission reductions" that might result from California-only Phase 2 requirements. Thus, in addition to being entirely out of context in an ozone SIP Strategy, CARB's envisioned Phase 2 GHG add-ons are not calculated to yield any benefits for the attainment demonstrations at issue.

More fundamentally, U.S. EPA – which has the same regulatory objective as CARB – has carefully examined the appropriate Phase 2 GHG standards for vocational vehicles. EPA has determined properly that, for all the reasons noted above (and more), enhanced aerodynamic requirements are not appropriate for vocational vehicles. CARB should not assume in its SIP Strategy that a different conclusion is warranted.

Conclusion

The 2016 SIP Strategy, as it relates to HDOH engines and vehicles, is premised on significant over-estimations of future NO_x and ozone levels in the South Coast Air Basin ("SCAB"). CARB has derived those over-estimations from an outdated version of EMFAC and from its application of the Community Multi-Scale Air Quality ("CMAQ") model, which consistently has over-predicted future ozone levels in the SCAB over the past 25 years, including as recently as 2012 when CARB developed its last SIP submissions. In light of those consistent over-predictions of NO_x and ozone, CARB's assertion that ozone attainment in 2031 requires an additional 90% reduction in NO_x emissions from HDOH engines and vehicles – over and above the rigorous NO_x-control regulations that are already in place – is simply incorrect. While some future HDOH emission requirements may prove to be warranted and reasonable, the assumed premise for adopting a 90% lower NO_x standard in 2019 is fundamentally flawed. As a result, the 2016 SIP Strategy needs substantial revision, and should not be approved or adopted in its current form.

Similarly flawed is CARB's intended adoption of unique California-only Phase 2 GHG requirements for vocational vehicles. Separate California GHG requirements are directly at odds with the core premise of the pending U.S. EPA rulemaking for a nationwide Phase 2 GHG program, and are inherently unreasonable given the aerodynamic constraints under which vocational vehicles operate.

EMA appreciates the opportunity to submit these comments on the 2016 SIP Strategy, and we look forward to working with CARB staff to improve the accuracy of the underlying CMAQ and EMFAC models.

Respectfully submitted,

TRUCK AND ENGINE
MANUFACTURERS ASSOCIATION

Appendix C. Frequency of Occurrence of T&M and Malfunction and Resulting Emission Impact for 2010+ Model Year HHDD Trucks

Tampering and malmaintenance (T&M) and malfunction rates were developed for the model year group of 2010 and subsequent model year heavy-duty vehicles. This appendix provides a description of the frequency of occurrence of T&M and malfunction categories and the resulting emission impact for 2010+ model year HHDD trucks (further detail can be found in the staff report for the HDV OBD regulation; see Footnote 4 of this memo).

Frequency of Occurrence Rates

The table below shows the revisions to the frequency of occurrence of T&M and malfunction categories for 2010+ model year group.

Table C1. Frequency of Occurrence of T&M and Malfunction Acts for 2010+ HHDDTs[a]

EMFAC2002		Revised		
T&M Act	2003+	T&M **and Malfunction** Act	2010+	
			No OBD	**w/ OBD**
Timing Advanced	2%	Timing Advanced	2%	**1.33%**
Timing Retarded	2%	Timing Retarded	2%	**1.33%**
Minor Injector Problem	8%	**Injector Problem (Minor/Moderate/Severe)**	13%	**8.67%**
Moderate Injector Problem	5%	**NOx Aftertreatment Sensor**	**52.7%**	**40.1%**
Severe Injector Problem	0%	**Replacement NOx Aftertreatment Sensor**	**1.8%**	**10.8%**
Puff Limiter Misset	0%	**PM Filter Leak**	**13.9%**	**9.75%**
Puff Limiter Disabled	0%	**PM Filter Disabled**	**2%**	**1.33%**
Max Fuel High	0%	**Fuel Pressure High**	0%	0%
Clogged Air Filter	15%	Clogged Air Filter	15%	**10%**
Wrong/Worn Turbo	5%	Wrong/Worn Turbo	5%	**3.33%**
Intercooler Clogged	5%	Intercooler Clogged	5%	**3.33%**
Other Air Problem	8%	Other Air Problem	8%	**5.33%**
Engine Mechanical Failure	2%	Engine Mechanical Failure	2%	**1.33%**
Excessive Oil Consumption	3%	Excessive Oil Consumption	3%	**2%**
Electronics Failed	3%	Electronics Failed	**30%**	**20%**
Electronics Tampered	5%	Electronics Tampered	5%	**3.33%**
Catalyst Removed	0%	**Oxidation Catalyst Malfunction/Removed**	**5%**	**3.33%**
EGR Stuck Open	0%	**NOx Aftertreatment Malfunction**	**17.1%**	**12%**
EGR Disabled	10%	EGR Disabled**/Low Flow**	**20%**	**13.3%**

a. Revised values shown in boldface (see text for discussions).

For the frequency of occurrence rates in Table C1, staff modified several of the existing components to better reflect the technology that is expected to be used on 2010 and subsequent engines as well as to account for malfunction of components in addition to tampering or malmaintenance. Specifically, staff added categories for PM filter leaks, missing/tampered PM filters, NOx aftertreatment system malfunctions, and NOx aftertreatment control sensor malfunctions. Staff eliminated the categories deemed to be not applicable to 2010+ model years, such as puff limiter misset, puff limiter disabled, and EGR stuck open. Staff also merged minor, moderate, and severe injector problems into a single injector problem category, expanded EGR disabled to include EGR low flow/performance malfunctions, and modified the category for catalyst removed to oxidation catalyst malfunction/removed. The frequency of occurrence in Table C1 represents an average failure rate over the life of the 2010+ model year vehicles.

For the baseline "without OBD" values, staff estimated various failure rates for the categories. For the existing categories in the table (except for the electronics failed category), staff did not modify the estimated failure rates. However, for the added and modified categories staff estimated failure rates based on information from manufacturers, suppliers, and, where appropriate, experience with similar components in light-duty. In all cases, staff assumed any failures occurring during the warranty period would be fixed immediately, and thus a failure rate of 0% was assumed during the warranty period.

For EGR, staff increased the failure rate from 10% to 20% to account for nearly every engine using EGR in the 2010 timeframe and for the increased sensitivity and reliance to proper EGR performance on those engines. For the oxidation catalysts, staff increased the failure rate from 0% to 5% to account for nearly every engine being equipped with a catalyst, for combining oxidation catalyst performance malfunctions with oxidation catalyst tampered/removed into a single category, and for the increased sensitivity and reliance on proper oxidation catalyst performance to achieve PM filter regeneration.

For the electronics failed category, staff increased the frequency of occurrence from 3% to 30% to account for the significant increase in complexity of the 2010+ emission control systems. For these engines, a substantial number of sensors (e.g., temperature, mass air flow, pressure) and actuators (e.g., intake or exhaust throttles) are being added and other components have become more complex (e.g., high pressure common rail fuel injection system components, variable geometry turbos). In addition to actual sensor or actuator failures, each sensor and actuator has additional circuits and wiring that increase the chance for a failure in-use.

For the added category of PM filter leak, staff estimated a failure rate that increased over time starting with an approximately 6% failure rate at the end of useful life (~450,000 miles) and ramping up to a failure rate of 37% at 1,000,000 miles. In setting this failure rate, staff largely discounted the high failure rates currently being observed in the heavy-duty fleet (both OEM-equipped and retrofit) and estimated much more conservative failure rates. For the category of PM filter disabled (largely due to tampering), staff assumed a rate of only 2%.

At present, two competing NOx aftertreatment technologies are being considered for 2010 model year applications. Accordingly, staff analyzed both systems and their associated components. It was assumed that a blend of the two would exist in the fleet, with some using a selective catalytic reduction (SCR) system with a single NOx control sensor and reductant delivery (e.g., urea) and some using a NOx adsorber system with upstream and downstream air-fuel (A/F) control sensors. For the category of NOx aftertreatment in Table C1, staff grouped together the SCR catalyst and the components associated with reductant storage and delivery or, in the case of an adsorber system, included failures of the adsorber itself. For these failures, staff again estimated a failure rate that increased over time. The failure rate for this category was ramped in starting with a 10% failure rate at 500,000 miles (50,000 miles beyond useful life) to a 50% failure rate by 1,000,000 miles. While failures of an SCR catalyst itself may be fairly limited, the associated hardware includes urea tank, tank heaters, in-exhaust injector, compressed air delivery to the injector, and urea supply pump and control system are all components subject to malfunction and can have the same emission impact as an SCR catalyst failure. In assuming that only half of the trucks left on the road at 1,000,000 miles will have experienced a failure of any one of these components at some point in its 1,000,000-mile life, staff believes the estimate is fairly conservative. For an adsorber system, the adsorber itself will likely have a significant failure rate in a 1,000,000-mile timeframe given the sensitivity to thermal damage and the need for periodic desulfation that must be conducted at temperatures extremely close to the thermal damage point. Further, each desulfation event will likely slightly deteriorate the performance of the adsorber leading to an eventual fail on some share of the engines. In some cases, adsorber systems may also rely on in-exhaust injectors, fuel supply lines, control, and metering systems that are subject to malfunction and can have a similar emission impact.

For the two NOx aftertreatment control sensor categories, a two-part failure rate was estimated and modeled as two separate categories. For SCR systems using a single NOx control sensor, the model assumes the sensor has an initial fail, some portion of those sensors are replaced, and a second fail occurs later in the life of the new sensor. For NOx adsorber systems with two A/F sensors, the model assumes one of the two sensors has an initial fail, some portion of those sensors are replaced, and a second fail occurs later in the life of the engine which could be either a failure of the replaced sensor or a an initial failure of the other A/F sensor on the vehicle.

For the initial failure in both systems, a single failure of a control sensor was estimated to ramp in starting with a 35% failure by 250,000 miles and peaking at a 90% failure rate after a subsequent 200,000 miles (i.e., by 450,000 miles). Staff based these failure rates on discussions with engine manufacturers expressing concern that they had not been convinced that NOx sensor durability was sufficient to last 100,000 miles, much less the useful life period of 450,000 miles. Discussions with sensor suppliers suggest significant potential for further improvement in durability over the next few years. Accordingly staff assumed essentially a 0% failure rate for twice the current expected life of the sensor before ramping the failure up to near complete failure at 4.5 times the current expected sensor life. Further, A/F sensors are commonplace in light- and medium-duty vehicles and Inspection and Maintenance (I/M) program data indicates these sensors are failing in I/M on approximately 2.5% of the fleet at 100,000 miles. Assuming this failure rate were to grow linearly at a failure rate of 2.5% per 100,000 miles, that would represent a cumulative failure rate of 7.5% at 250,000 miles. Additionally, this 2.5% failure rate only includes the subset of vehicles with a malfunctioning A/F sensor vehicles that ignore an illuminated warning light and actually fail the I/M test. Data from non-I/M areas would support that the actual in-use failure rate is higher than that and is a result of a portion of the people fixing the vehicle prior to the I/M test. When adjusting that number to reflect the more realistic situation that the failure rate increases non-linearly over time, that the actual in-use failure rate in light-duty is actually higher than the 2.5% that show up in I/M, and that each engine with a NOx adsorber system is projected to use two A/F sensors, a 35% failure rate at 250,000 miles is reasonable. To further assume that 90% of the sensors will have failed once by 450,000 miles is consistent with a continued increase of the failure rate and engine manufacturers' expressed opinions that the sensors will not last through the useful life. This initial failure of the control sensor is represented in the category for NOx Aftertreatment Sensor.

The second part of the failure rate for the NOx aftertreatment control sensor categories estimates the percentage of the fleet that will repair/replace the first failed sensor and then experience a subsequent failure of the repair/replaced sensor while still within the first 1,000,000 miles of the engine life. For this failure rate, staff assumed the same sensor durability and failure rate (i.e., failure rate ramps in at 35% beginning 250,0000 miles after the previous sensor repair/replacement and peaks at 90% after an additional 200,000 miles) but only applied it to the fraction of vehicles which were estimated to already have a failed sensor and a subsequent repair. This second part of the failure rate of the control sensor is represented in the category for Replacement NOx Aftertreatment Sensor.

<u>OBD Repair Rate</u>

While the frequency of occurrence rates shown in Table C1 are a single number that represents the average failure rate, or probability of occurrence, the model actually assumes that there are constantly some additional failures and repairs that are occurring in the fleet. For the baseline (without OBD) scenario described above, these numbers represent the failures that are above and beyond what is being routinely repaired in the field.

To account for the adopted HD OBD program, staff estimated a repair rate for all the categories in Table C1. A 33% reduction in the frequency of occurrence across all categories was estimated to simulate the malfunctions that are repaired due to the presence of the OBD system. The rationale for the 33% repair rate was that all the malfunctions estimated in the categories would likely result in MIL illumination. It is expected that some fraction of vehicle owners or operators would take repair action simply because they were alerted to the presence of a malfunction by the MIL. Additionally, California has two inspection programs that are applicable to heavy-duty vehicles. First, the heavy-duty vehicle inspection program (HDVIP) conducts roadside testing and issues citations or notice-of-violations for trucks that fail either a snap-idle opacity test or a visual inspection. This inspection program currently tests about 6% of the heavy-duty fleet in California. Secondly, California has a fleet annual self-inspection program whereby all fleets (defined as anybody with two or more trucks) are required to perform self-inspections for snap-idle opacity on an annual basis, repair any vehicles that fail the inspection, and retain records of the inspection for review by ARB inspectors. Currently, about 75% of the California fleet is subject to this fleet self-inspection.

While both programs are currently focused on smoke emissions and visual tamper inspections, it is expected that they will both be updated to include an inspection of the OBD system and to fail vehicles that have an illuminated MIL. When combining these three factors together (voluntary response to an illuminated MIL, HDVIP inspections, and fleet self-inspections), staff believes it is fairly conservative to expect that one third of the illuminated MILs will be repaired.

Staff also considered that some malfunctions could also cause degraded drivability, performance, or fuel economy, and those impacts would also influence the repair rate. However, as stated above, these failure rates already assume that additional failures and repairs are currently occurring in the fleet and will continue to. Furthermore, in analyzing the categories created by staff, the failures with the largest emission impacts (e.g., PM filter malfunctions and NOx aftertreatment related categories) are not expected to have an adverse impact on drivability or performance and may actually result in an improvement to fuel economy, thus negating any additional incentive to repair the detected malfunction.

Malfunction Emission Rates

Staff also modified the associated emission rates for each of the categories of Table C1 to better reflect the best estimates available at this time based on the expected 2010 and subsequent emission control systems. For the existing categories that result in an increase in PM emissions, staff reduced the estimates for the PM emission increases by a factor of 0.95 based on the expectation that all 2010 engines will be equipped with a PM filter which will trap 95% of any engine-out increases in PM. For the added categories of PM filter leaks and PM filter missing/tampered, staff estimated PM increases of 600% and 1,000%, respectively. For the PM filter leaks, this represents an emission level of 0.07 g/bhp-hr, which is above the adopted OBD threshold of 0.05 g/bhp-hr but reflects industry's contention that most PM filter leaks will rapidly grow beyond a small leak. For the category of PM filter missing/tampered, staff estimated the emissions would approach that of an engine without a PM filter for an increase of 1000% (to 0.10 g/bhp-hr).

For HC emission rates for the existing categories, staff estimated the presence of larger oxidation catalysts to achieve sufficient exotherms for PM filter regeneration would convert 50% of any increases in engine-out HC rates and thus reduced the HC emission increases by a factor of 0.5. For the added categories related to PM filters and malfunctions associated with NOx aftertreatment or the aftertreatment control sensors, staff assumed a small HC increase due to reduced conversion of HCs within the PM trap itself or improper reductant malfunctions (e.g., overdosing fuel in a NOx adsorber system). For a malfunction of the oxidation catalyst itself, staff assumed a 50% increase in HC emissions.

For NOx emission rates for those existing categories, staff estimated that engine-out NOx increases would be reduced by the presence of NOx aftertreatment to varying degrees. For smaller engine-out NOx increases, the aftertreatment was estimated to convert 75% of the excess NOx (thus reducing the emission rate by multiplying by a factor of 0.25). For larger engine-out NOx increases, a lower aftertreatment conversion efficiency (65%) was used to reflect the reduced ability of the system to handle large feed gas concentration increases. For the added categories of NOx aftertreatment control sensors, an emission increase of

200% (to a tailpipe emission level of 0.6 g/bhp-hr NOx) was assigned based on the assumption that a loss of feedback control (either a NOx sensor for SCR or an A/F sensor for an adsorber) would result in significantly lower NOx conversion rates because the system would likely shut off reductant delivery or go into a conservative open loop operation that injects minimal reductant to minimize the risk of overdosing or inefficient use of reductant. For the added category of NOx aftertreatment, a failure was calculated to have a 300% increase (to reflect a tailpipe emission level of 0.8 g/bhp-hr NOx). This represents an intermediate level between an MIL failure (at 0.5 g/bhp-hr) and a complete loss of NOx aftertreatment (at 1.2 g/bhp-hr). Considering that this category includes failures of the SCR catalyst or adsorber itself as well as failures of the reductant delivery system (exhaust injectors, reductant tank, reductant delivery lines, reductant metering, reductant heaters, and compressed air delivery system), many of which would likely result in shutting off reductant delivery or defaulting to open loop operation, a 300% emission increase seems to be appropriate. Staff also adjusted the emission rates and frequency of occurrence rates for both the NOx aftertreatment system category and the NOx aftertreatment sensor categories to properly account for the combined emission impact (e.g., an engine with a failure in both categories will get a 300% NOx increase, not a combined 200% NOx increase from the aftertreament control sensor failure and an additional 300% NOx increase from the aftertreatment failure). Lastly, while there is a category for EGR malfunctions in EMFAC, the NOx emission increase associated with an EGR failure was previous set to a 0.0% increase. This was modified to a NOx emission increase of 150% (to a tailpipe level of 0.5 g/bhp-hr NOx). This emission rate was calculated by assuming a complete loss of EGR would cause engine-out NOx to go from 1.2 to 2.4 g/bhp-hr for an increase of 1.2 g/bhp-hr and then assuming that the NOx aftertreatment would convert 60% of that increase leaving a tailpipe increase of 0.48 g/bhp-hr. Thus, EGR failures were estimated to range from the OBD MIL on point of 0.3 g/bhp-hr to a complete loss of EGR at 0.68 g/bhp-hr with a nominal middle failure point of 0.5 g/bhp-hr.