7. Abstract of work completed during the quarter

Task 1b: Build Preliminary Models on Existing Data – During this quarter we completed Task 1b. We took a second approach in analyzing the British Columbia emissions and repair dataset. The goal was to make a connection between the measured change in emissions (that is, from before-repair to after-repair) and the repairs that were made to individual vehicles. We used the first approach to investigate the connection between the before-repair emissions and the types of repairs that were made. In that first approach, emissions were not able to distinguish EGR repairs from catalyst repairs – possibly because mechanics sometimes replace a catalyst instead of repairing a malfunctioning EGR system.

The second approach was to develop 1) expected emissions values for problem-free vehicles; 2) expected HC, CO, and NOx emissions changes associated with different repair types for different vehicle technologies; and 3) models that predict the probabilities that an EGR system is malfunctioning. These models would be based on the measured HC, CO, and NOx emissions of the vehicle, the expected problem-free emissions of the vehicle, and the known emissions-changing characteristics of repairs.

We used the British Columbia data and California data to develop a technique for estimating the problem-free emissions of individual vehicles. The estimates were made for combinations of make, model, engine, emission control system technology, and odometer. For each combination we estimated that the problem-free emissions as the median of the measured emissions of vehicles that passed the I/M program requirements on the first emissions test of their I/M inspection sequence. From British Columbia, we used all initial passes, which included some fast pass and some full pass I/M data. From California, we used only full ASM I/M test data.

To perform the emissions change analysis, we needed to obtain reliable measures of the after-repair and before-repair emissions. In a typical I/M program emissions dataset both of the measurements are biased. The after-repair emissions are biased if the I/M program uses a fast pass algorithm, and both British Columbia and Texas do, although their algorithms are different from each other. The before-repair emissions are biased because of regression toward the mean, which biases any data where subjects are selected based on a value that contains error, which in this case is the ASM emissions measurement. Each of these biases was investigated.

Since a portion of the passing vehicles in British Columbia receives a fast pass, not a full ASM test, the problem-free values based on British Columbia data are biased. To investigate and correct for this type of bias, we obtained California second-by-second ASM data from their roadside test program. This second-by-second data was used to calculate simulated British Columbia fast pass ASM measurements and full ASM measurements. We then used these values to develop models to predict full ASM test results from British Columbia fast pass ASM test results. The size of the bias is dependent on British Columbia's fast pass algorithm, which is substantially different from Texas' algorithm. We found that the full ASM2525 emissions values of (HC, CO, and NOx) are about 60% of the British Columbia fast pass values. The relationship for Texas will be different.

The influence of the regression-toward-the-mean (RTTM) bias on before-repair emissions was investigated through simulation. Simulations of measured emissions data, as well as information from the statistical literature, indicated that the size of RTTM bias is closely tied to the emissions variability of ASM emissions and the distribution of the measured ASM emissions of the fleet. Estimates of ASM emissions variability were taken from duplicate vehicle testing of a previous study. Estimates of the measured ASM emissions distributions were determined from a set of California full ASM measurements. While we did not calculate the size of the RTTM bias, pending a definite need for an estimate of the bias size, we defined the technique for making the calculation.

We performed a detailed emissions change analysis on six vehicle types that are relatively common in British Columbia and Texas. The particular vehicle types were chosen to provide the largest amount of repair data available in the British Columbia dataset. In this analysis we examined the before-repair and after-repair emissions and the association of these emissions and their changes with the types of repairs made and the estimated problem-free emissions of the vehicles. The graphical analysis was made in three-dimensional ASM HC, CO, and NOx space. The goal of the analysis was to determine if an EGR repair produced a consistent change in ASM emissions that was distinguishable from the changes produced by other types of repairs. We found, in general, that EGR repairs caused emissions to move in a similar direction as catalyst repairs did.

In summary, the results of the first approach in Task 1 indicate that vehicles that received EGR repairs and vehicles that received catalyst repairs have similar before-repair emissions. The results of the second approach in Task 1 indicate that EGR repairs cause emissions to change in a similar direction to the changes produced by catalyst repairs. Thus, overall, the analysis did not cause us to believe that even for individual vehicles types a recognizable emissions fingerprint for malfunctioning EGR systems was available for diagnostic model building. In light of these results, the scope for the remaining tasks in the project will be modified while still addressing the need for NOx reduction techniques for Texas. The analyses completed in Task 1 can be used to develop these techniques.