UTA – WorldKlass Field Trial Summary #7

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EXECUTIVE SUMMARY

This status report was prepared for the UTA - WorldKlass Field Trial. It used MPG data collected between April 1, 2015 and September 30, 2015 *(i.e. 182 days)*. A total of 1262 MPG observations were analyzed – i.e. 600 from locomotives fitted with canisters and 662 from locomotives operating without canisters. The analysis has yielded the following conclusions:

- When the data are viewed in aggregate, locomotives fitted with canisters delivered 4.6% higher MPG than locomotives without canisters.
- When viewed on a month-by-month basis, the improvements range between 1.9% and 5.8%. Thus far, this evaluation has been unable to pin point the precise cause *(or causes)* of this variability. However, statistical evidence exists to indicate that two factors have a significant effect. These factors are: 1) The distance traveled by a locomotive in a month *(i.e. how hard the engine is worked)*; and 2) The month of the year *(i.e. operating conditions associated with the season)*. Other potential factors are:
  - Differences in engine idle times.
  - Engine age / mechanical integrity status.
  - The way an operator accelerates / decelerates.
- All of the locomotives operating with fuel canisters have statistically similar performance except unit #2. That locomotive shows statistically lower performance. *(NOTE: That lower performance is believed to be a function of the mechanical condition of the engine. It is near 'end-of-life'.)*.
- Locomotive MPG performance changes from month-to-month. So far, the month of May has recorded the highest MPG statistics. The month of July has provided the lowest.
- Given the improvements witnessed to date, it appears UTA could save an average of 300 gallons of fuel per day if all locomotives were fitted with the WorldKlass fuel treatment system. This translates into savings of between $160,000 and $195,000 per year.

DATA EVALUATION SUMMARY

In March 2015, UTA formally launched a field trial to test WorldKlass Technology's claim that their fuel treatment system improves fuel economy by at least 5%. According to this claim the improved performance is achieved *" . . . by increasing flame propagation, thus moving combustion closer to TDC and getting more power from each stroke. (*This facilitates*) . . .a more complete burn . . .* (thus reducing the amount of) *. . . fuel* (needed) *to complete the cycle."*

Rio Tinto Kennecott Copper was aware of both Worldklass Technology's claim and UTA's desire to perform a field trial. Since Kennecott is very interested in the outcome of this trial, the corporation volunteered to provide a statistician to analyze the data and report results as a third-party, independent observer. That offer was accepted by both UTA and WorldKlass.

To perform the field trial, UTA fitted 8 of their 17 Front Runner Locomotives with the WorldKlass fuel treatment *systems (i.e. canisters)*. Odometer Readings and Gallons Loaded are captured during each fueling operation. To date, a total of 1262 data observations have been collected – i.e. 600 for locomotives fitted with canisters and 662 from the control locomotives. Table 1 provides the summary statistics.

Loco	N	N*	MPG	Std Dev	Min	Median	Max	Canister
1	66	17	0.51482	0.03774	0.38168	0.51722	0.59727	No
3	89	6	0.51575	0.03851	0.41014	0.51653	0.63246	No
4	48	8	0.52046	0.06382	0.33271	0.53355	0.63297	No
5	33	2	0.51337	0.0569	0.36884	0.51699	0.65253	No
9	95	2	0.51559	0.06806	0.35774	0.51289	0.81500	No
11	86	10	0.56358	0.03893	0.46183	0.56209	0.66538	No
15	90	5	0.58268	0.08290	0.30959	0.58807	0.80056	No
19	67	8	0.56359	0.05682	0.35701	0.56008	0.69884	No
21	88	14	0.53742	0.04754	0.37856	0.54228	0.65705	No
2	55	12	0.51100	0.05393	0.42143	0.51219	0.80982	Yes
6	97	10	0.55768	0.07949	0.30697	0.55175	0.85415	Yes
7	75	7	0.57269	0.04279	0.43083	0.58249	0.64758	Yes
8	66	10	0.57082	0.06606	0.46195	0.56010	0.83000	Yes
10	66	10	0.57004	0.06367	0.45654	0.56962	0.89350	Yes
16	83	9	0.57765	0.05204	0.40315	0.57795	0.69004	Yes
17	77	8	0.57544	0.06103	0.44056	0.57218	0.80966	Yes
18	81	11	0.56155	0.05215	0.39625	0.56685	0.71525	Yes

Table 1: Summary Statistics (April 1, 2015 – September 30, 2015)

On June 9, 2015, the statistician from Rio Tinto Kennecott Copper released a report that summarized findings associated with data collected between March 12, 2015 and May 31, 2015. That report contained the following statement:

> *The data collected thus far for the fuel canister comparison support the hypothesis that the WorldKlass fuel treatment system increases MPG performance by 4%.*

That statement fulfilled the team's fundamental objective for the trial - i.e. provide statistically significant evidence to support the hypothesis that the WorldKlass fuel treatment system improves vehicle MPG. The team then asked the question, *"Shall we accept these results and stop the trial? Or shall we continue testing until year end to increase our confidence?"* The team decided to continue testing.

Since making that decision, four additional months of data have been collected. The analysis *(using the original data plus the four additional months of observations)* continues to support the hypothesis that the WorldKlass fuel treatment system improves MPG performance by at least 4%. Figure 1 compares the overall performance of locomotives fitted with canisters to those without canisters. Since the confidence intervals on this graph do not overlap, the findings are statistically significant. Locomotives fitted with

canisters have demonstrated a 4.6% MPG improvement over locomotives operating without the fuel treatment system.

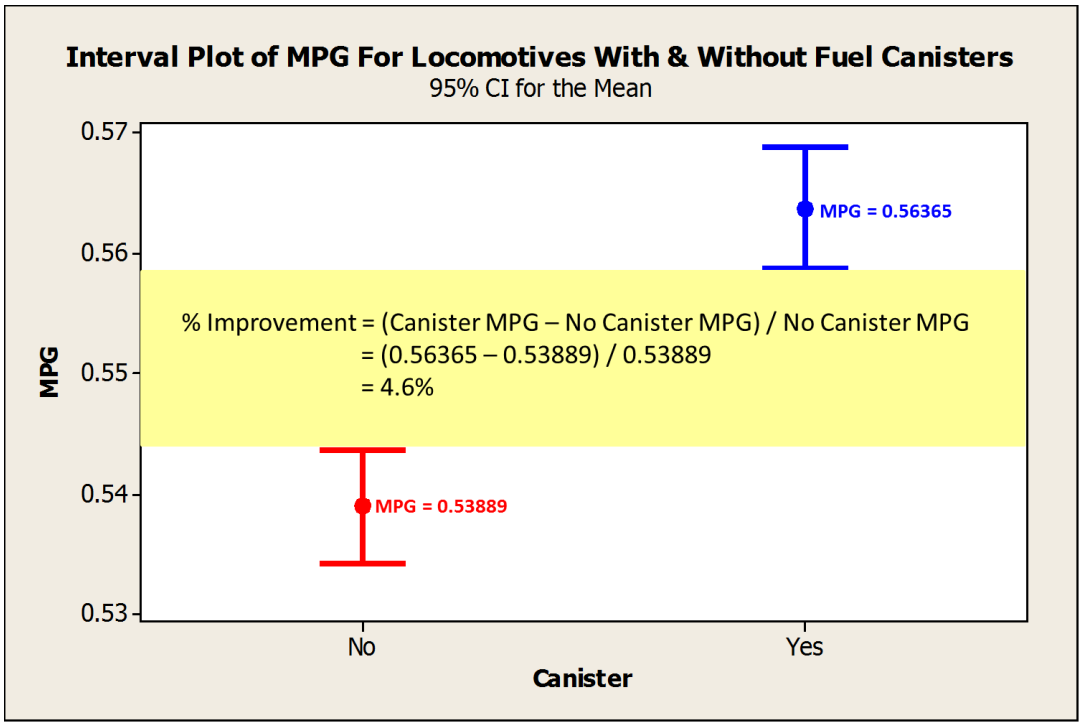

Figure 1: Statistically Significant Results Indicate That WorldKlass Fuel Treatment Systems Improves Fuel MPG

Figure 2 provides a visual comparison of the average MPG performance of the locomotives in the trial. A study of this comparison identified two potential behavioral patterns. They are:

- All locomotives fitted with canisters tend to have statistically similar performance with the exception of Locomotive 2. That leads to the question, *"What is different about Locomotive 2 when compared to locomotives 6, 7, 8, 10, 16, 17, and 18?"* According to feedback provided by UTA maintenance personnel, this difference is most probably a function of the mechanical integrity of Locomotive #2. That unit tends to smoke more than the other units, and it is rapidly approaching an engine rebuild / overhaul.
- Locomotives without canisters appear to operate in three performance bands. Operating in the upper performance band is Locomotive 15 *(i.e. MPG equals 0.583)*; delivering mid-level performance are Locomotives 11, 19, and 21 *(i.e. MPGs between 0.537 and 0.564)*; and bringing up the rear are Locomotives 1, 3, 4, 5, and 9 *(i.e. MPGs between 0.513 and 0.520)*.

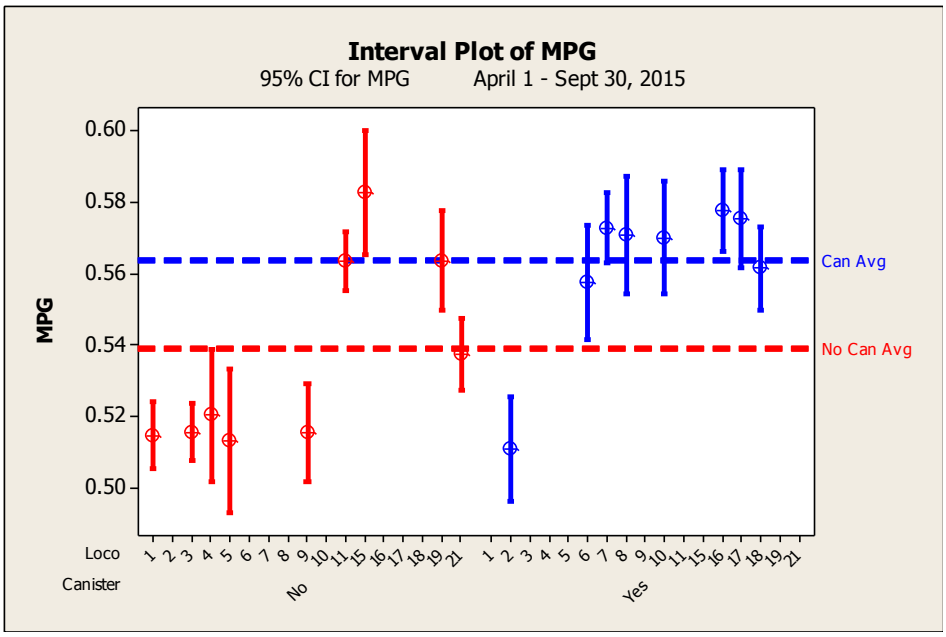

Figure 2: 95% MPG Confidence Intervals For Locomotives Used In The Trial

The minutes from the team's conference call in June stated WorldKlass' belief that " . . . *the difference in performance between the two groups of locomotives will continue to increase as the performance of the equipped locomotives continue to improve*." Based upon this statement, Figure 3 was created. This graph plots the month-by-month performance advantage provided by the WorldKlass canisters. It shows that the MPG performance of locomotives fitted with canisters improved continuously from April through June. Then in July, improvements dropped to about half their previous level *(i.e. from 5.3% to 2.4%)*. This degradation came as a surprise, and it prompted several serious discussions and follow-up actions. These actions are summarized on pages 5 and 8 of this report. During the month of August, the improvement returned to their aforementioned level *(i.e. 5.8%)*. That level of improvement was sustained through the month of September *(i.e. 5.7%)*.

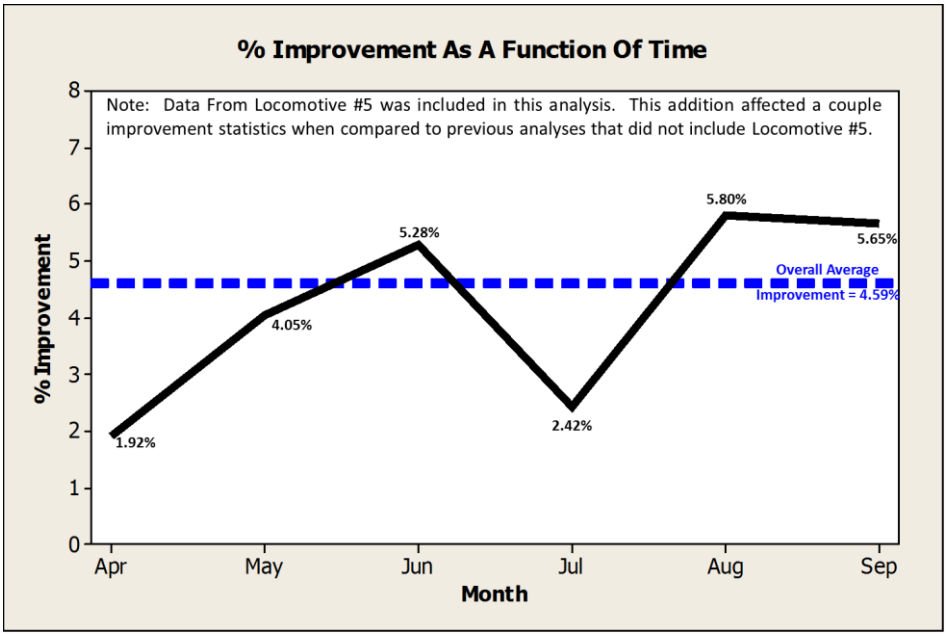

Figure 3: Time Series Plot Showing % MPG Improvement by Month

While attempting to explain the July degradation in MPG improvement, three hypotheses were put forward. They were:

Hypothesis #1: The field trial database is either inaccurate or corrupted. This subsequently affected the accuracy of the July statistics.

Hypothesis #2: MPG performance is a function of the work performed by the locomotive engine. During the month of July, locomotives fitted with canisters were worked at levels that precluded their abilities to obtain higher levels of improvements.

Hypothesis #3: Ambient weather conditions affect engine performance. It drives the operational protocol used by UTA. These conditions aligned in such a way during the month of July to influence fuel performance.

In the paragraphs that follow, a summary of the work performed to test these hypotheses is provided.

Hypothesis #1: Inaccurate Or Corrupted Database

To test the hypothesis that the database was inaccurate or corrupted, Thomas Frawley *(P.E. and WorldKlass Representative)* painstakingly reviewed all 9,624 data entries from the April – July database *(i.e. a table containing 1203 rows by 8 columns)*. Thomas flagged 108 entries as potential anomalies. He and Aaron Breen *(Kennecott statistician)* reviewed each flagged entry. That review uncovered no database construction issues. It did, however, trigger a follow-up action. That action called for reloading the April data. Starting in May, the Field Trial team adopted a new data download / data exchange procedure. To eliminate any potential questions associated with data integrity, Thomas and Aaron thought it sensible to utilize the same protocol for the April data.

The April data was reloaded. A paired t-Test was conducted to investigate potential differences between the "old April data" and the "new April data". The results of that test are shown in Table 2. These results indicate that no difference exists between the two data sets. Reloading the April data ensured that all data transfers used during the field trial followed the same standard procedure. It does not change nor influence the outcome of the previous analyses.

H_o: Avg Diff = 0 vs H_a: Avg Diff ≠ 0

Variable	N	Mean	StDev	SE Mean	95% CI	T	P
Difference	212	-0.00037	0.01624	0.00112	(-0.00257, 0.00183)	-0.33	0.740

Accept the Ho. There is no statistical difference between the "new April" mpg values and the "old April" mpg values.

Table 2: Results From Paired t-Test For "Old" and "New" April Data

Hypothesis #2: Locomotives Fitted With Canisters Were Worked At Levels That Precluded Their Abilities To Obtain Higher Levels Of Improvements

According to this hypothesis, the MPG performance of locomotives fitted with WorldKlass canisters improves as the total miles driven per month increases. Based upon this belief, Figures 4 and 5 were created.

Figure 4 shows a histogram of the monthly miles travelled by each locomotive. The histogram was fitted with a curve *(i.e. a 3-parameter lognormal statistical distribution).* That enabled the evaluation team to divide the monthly miles travelled into 5 distinct categories. These categories are:

Category	Description	Miles Travelled In The Month	% Of Data Points
0	Extremely Low Miles	Less than 4,000	12%
1	Low Miles	4,000 – 5,950	22%
2	Moderately Low Miles	5,951 – 7,350	22%
3	Moderately High Miles	7,351 – 10,300	22%
4	High Miles	Greater than 10,300	22%

Table 3: Dividing Monthly Miles Into Logical Categories

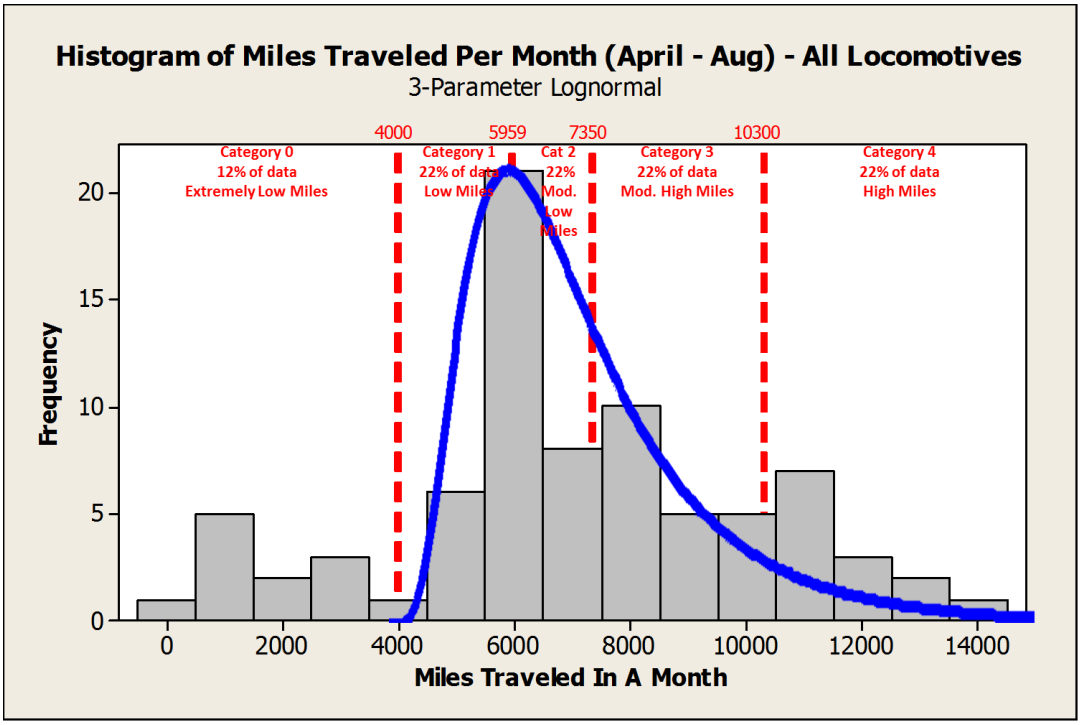

Figure 4: Histogram of Monthly Miles Divided Into Categories

Figure 5 shows the interval plots for locomotives running with and without canisters *(using the April – September dataset)*. Each interval plot has been fitted with a linear regression curve. These curves show that the MPG performance of all locomotives improves as miles travelled increases.

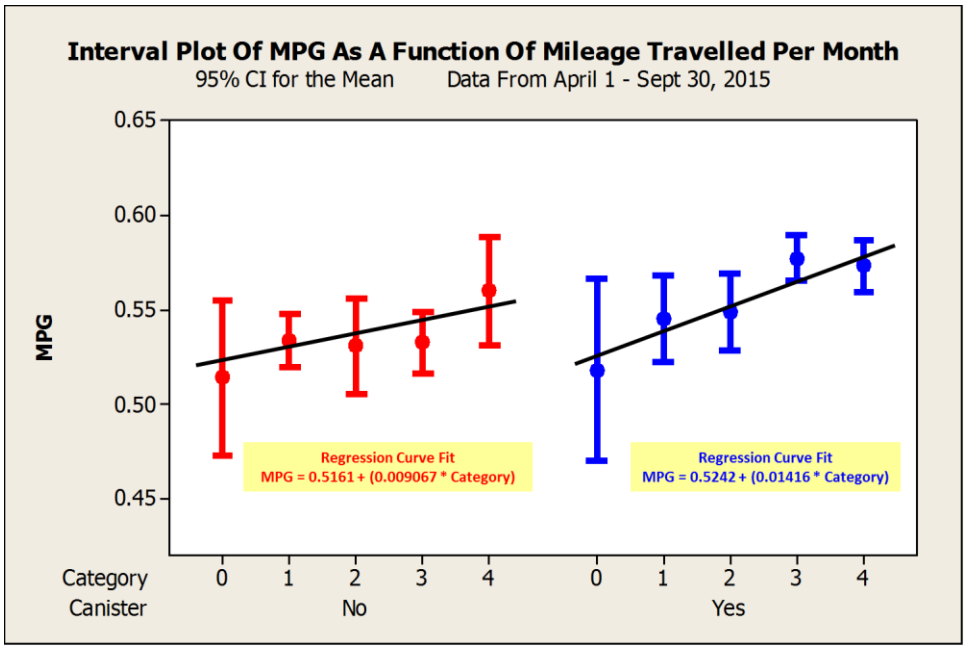

Figure 5: Fuel performance improvements as a function of miles travelled.

Figure 5 possesses a couple interesting features. Those features are most easily identified if a new graph is created which overlays the two regression curves. That new graph is shown in Figure 6.

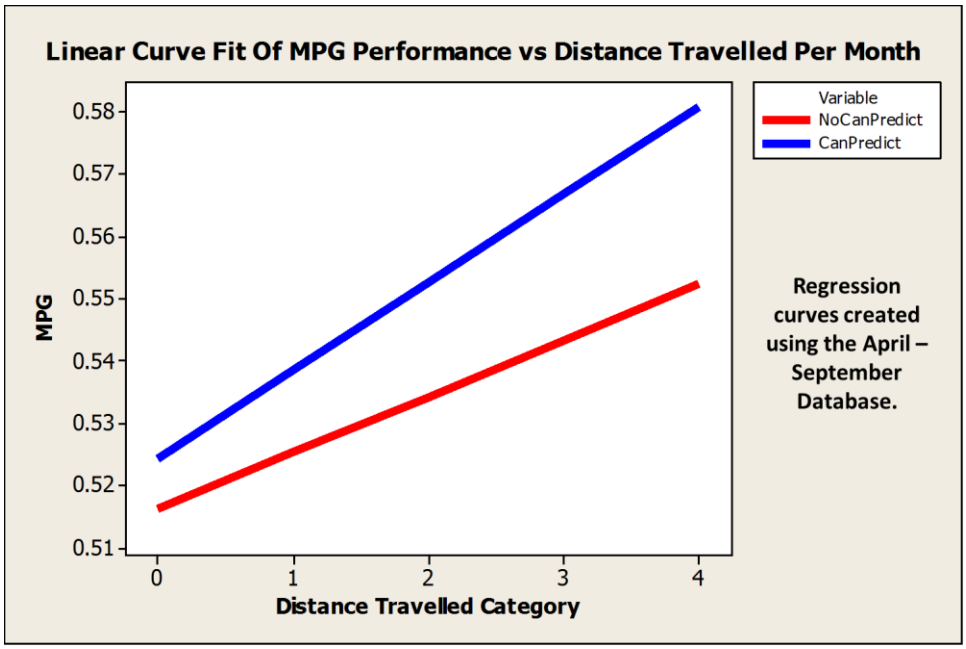

Figure 6: Linear curve fit comparing MPG performance of locomotives with & without fuel treatment canisters.

If one studies Figure 6, the following will be noted:

- MPG performance of all locomotives improves as the monthly mileage increases.
- Regardless of the mileage group, locomotives with canisters outperform locomotives without canisters.

- The rate of improvement of locomotives fitted with canisters is slightly better than the rate of improvement of locomotives without canisters. In other words, the slope of the Canister line is steeper than the slope of the Non-Canister line *(i.e. 0.01416 vs 0.00907)*.

Hypothesis #3: Month-To-Month Variation Impacts Fuel Efficiency Improvements

A baseline analysis was completed prior to the launch of the field trial. That evaluation utilized 6 years of data *(i.e. 2008 through 2014)*, and it processed inputs from 18 locomotives. The study identified statistically significant month-to-month changes in MPG. Hypotheses #3 assumes the July improvement degradation can be explained by seasonal variation *(and the associated operational changes introduced by UTA to address them)*. To evaluate this hypothesis, Figure 7 was created. It compares MPG performance during the WorldKlass Field Trial to that of the Baseline Period. If one studies this graphic, the following will be noted:

- All three systems showed improved MPG performance from
  - April to May
  - August to September
- All three systems showed degraded performance from May through July.
- Field Trial performance (both with and without canisters) is better than the baseline performance.
- Locomotives fitted with canisters show the best performance.

Although Figure 7 does not provide hard evidence to allow the blind acceptance of the hypothesis that the WorldKlass improvement slippage in July was a function of seasonal operating conditions, it does show a strong correlation. Therefore, it is reasonable to believe that the operating conditions did have some effect upon the fuel system performance.

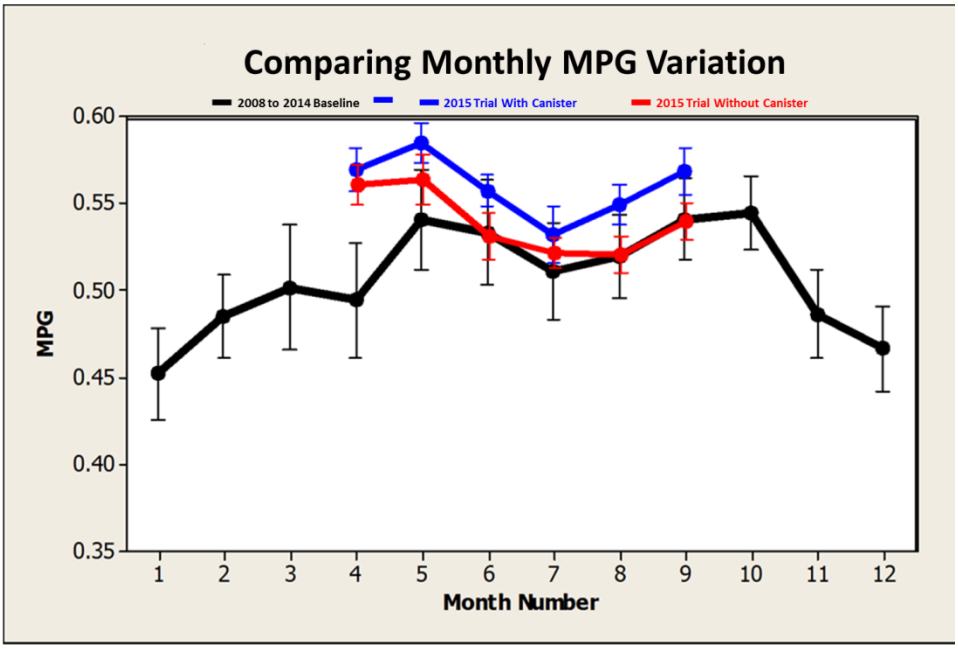

Figure 7: Comparing Performance On A Month-By-Month Basis

Value Generation

As stated previously, the UTA – WorldKlass Field Trial has been underway for six months *(i.e. 182 days)*. In that time, locomotives fitted with canisters have traveled 334,661 miles and consumed 597,958 gallons of fuel. If one accepts the 4.6% improvement level identified in Figure 1, calculations can be performed to determine how many gallons of fuel have been saved. Given the numbers listed above, that translates into approximately 27,500 gallons. Similar calculations can be made to determine the quantity of fuel that could have been saved had the "control" locomotives been fitted with canisters. These locomotives travelled 348,537 miles and consumed 647,126 gallons of fuel. If one assumes the MPG performance of these units would have improved by 4.6%, UTA would have saved approximately 28,500 gallons of fuel. Dividing the total fuel savings (i.e. 27,500 + 28,500 = 56,000 gallons) across the 182 days of the trial, one can conclude that UTA has the potential to save an average of 300 gallons of fuel per day (or 2,100 gallons / week) by fitting their entire fleet with canisters. Building upon these numbers, we can conclude that savings between $160,000 and $195,000 are possible on an annualized basis if fuel costs reside between $1.50 / gallon and $1.75 / gallon.