



RPUG 2024
Road Profile Users' Group

April 29 - May 2



ST. AUGUSTINE
FLORIDA

New Technology For An Old World

CONTINUOUS TIRE- PAVEMENT FRICTION AND MACROTEXTURE: LEFT VS. RIGHT WHEEL PATHS

ISAAC BRISKIN

WDM USA LIMITED



RPUG
Road Profile Users' Group



OBJECTIVES

- 1) QUANTIFY THE DIFFERENCES IN THE DISTRIBUTIONS OF FRICTION AND MACROTEXTURE IN LEFT AND RIGHT WHEEL PATHS
- 2) EXPLORE THE BEHAVIOR OF OUTLIERS IN THESE COMPARISONS
- 3) IDENTIFY DRIVERS OF WHEEL PATH DIFFERENCES IN DIFFERENT GEOMETRIC SETTINGS

DATA ANALYZED

- FRICTION (MEAN SCRIM COEFFICIENT, MSC), MACROTEXTURE (MEAN PROFILE DEPTH, MPD), AND CURVE RADIUS, MEASURED BY SCRIM® (MAY - AUGUST 2023)
- 2,014 MILES OF MSC DATA COLLECTED IN BOTH WHEEL PATHS
- 1,119 MILES OF MPD DATA COLLECTED IN BOTH WHEEL PATHS
- FOR EACH DATASET/METRIC, 'DIFFERENCE' STATISTIC =
LEFT WHEEL PATH (LWP) – RIGHT WHEEL PATH (RWP)





DISCUSSION OF METHODS

- OUTLIERS WERE IDENTIFIED USING THE Z-SCORE METHOD, WHERE OBSERVATIONS WITH $|Z| > 3$ ARE CONSIDERED OUTLIERS
- DATA WERE SUMMARIZED AS MEAN (SD) AND 1ST QUANTILE, MEDIAN, AND 3RD QUANTILE, AND DISPLAYED WITH BOXPLOTS.
- DIFFERENCES IN DISTRIBUTIONS WERE TESTED USING THE NONPARAMETRIC MANN-WHITNEY U TEST
- SIGNIFICANCE THRESHOLDS GUIDED BY BONFERRONI ADJUSTMENTS, WHERE THE NULL HYPOTHESIS CAN BE REJECTED AT A THRESHOLD OF $0.05/\text{NUMBER OF TESTS}$.



INITIAL FINDINGS

Dataset	Miles	Left Wheel Path	Right Wheel Path	Difference
Friction, Mean (SD)	2,014	62.9 (12.4)	59.8 (13.1)	3.1 (7.3)
Macrotexture, Mean (SD)	1,119	0.99 (0.24)	1.06 (0.37)	-0.07 (0.3)

- RWP STANDARD DEVIATION > LWP STANDARD DEVIATION
- LWP FRICTION > RWP FRICTION
- LWP MACROTEXTURE < RWP MACROTEXTURE

IDENTIFYING OUTLIERS

- DIFFERENCE OUTLIERS (LWP – RWP) WERE IDENTIFIED USING THE Z-SCORE METHOD:

$$Z = \frac{x - \mu}{\sigma}$$

- DATA WITH $Z > |3|$ WERE LABELED AS OUTLIERS
- FRICTION DIFFERENCE OUTLIERS: 20.495 MILES
- MACROTEXTURE DIFFERENCE OUTLIERS: 12.31 MILES



FRICITION/MSC

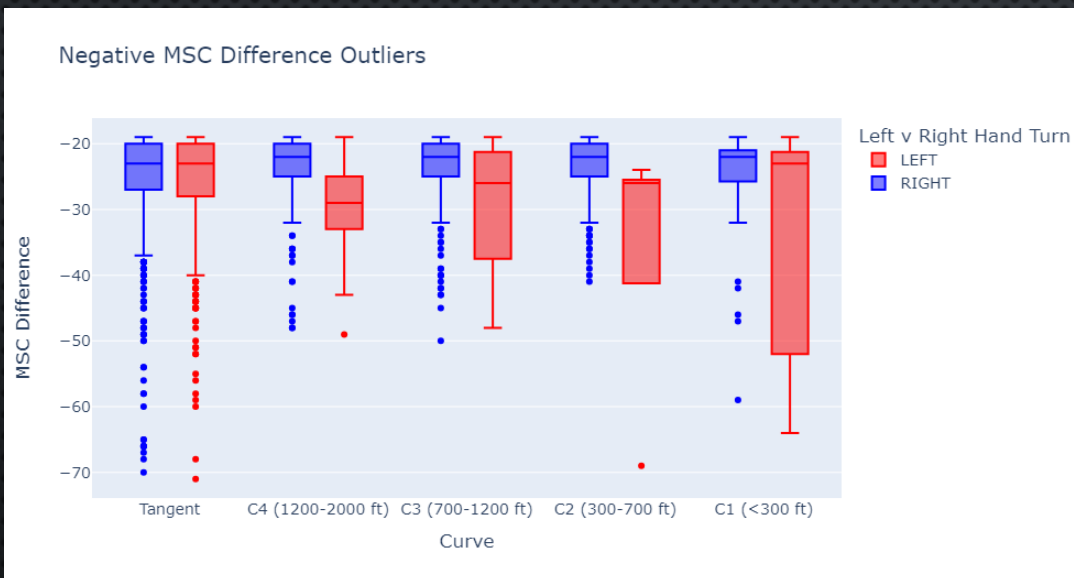
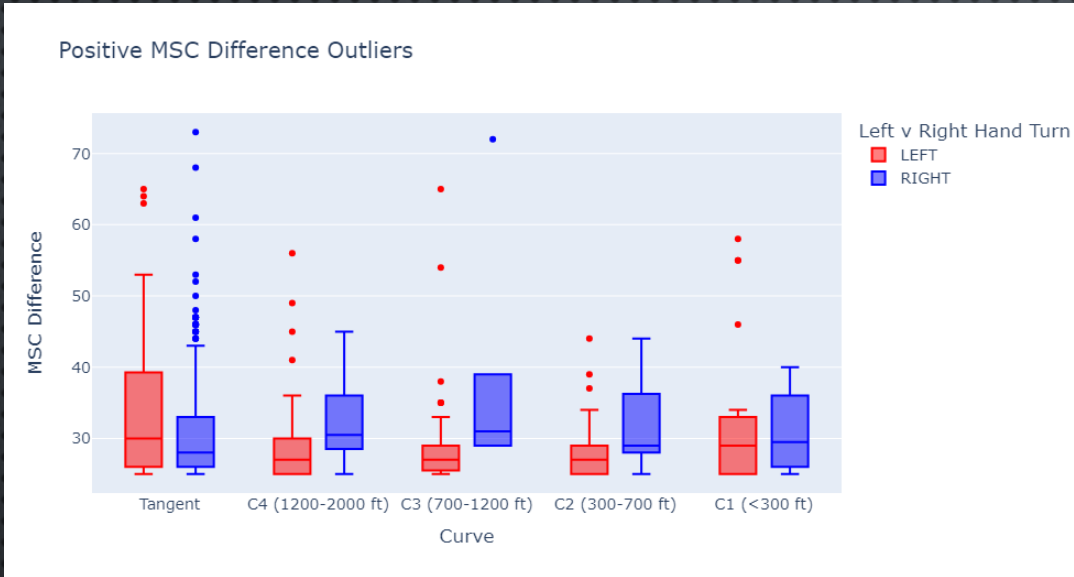
Outliers: 20.495 miles

Non-Outliers: 1993.92 miles

	LWP	RWP	Difference	Curve Radius	LWP	RWP	Difference	Curve Radius
MEAN (SD)	58.4 (16.2)	64.8 (21.9)	-6.5 (26.7)	7684 (10650)	63.0 (12.4)	59.8 (12.9)	3.2 (6.7)	15944 (12405)
Q1	46	52	-24	781	54	50	-1	4687
Median	57	67	-20	2187	62	59	3	10937
Q3	69	79	26	8203	71	68	8	32810

- MSC Difference is -6.5 for the outliers, but 3.2 for the rest of the dataset (red).
- Outlier MSC Difference SD > Non-Outliers MSC Difference SD (red).
- RWP MSC SD > LWP MSC SD, however this difference is far larger among the outliers (green).
- Curve Radius indicates these differences may occur on curves (blue).

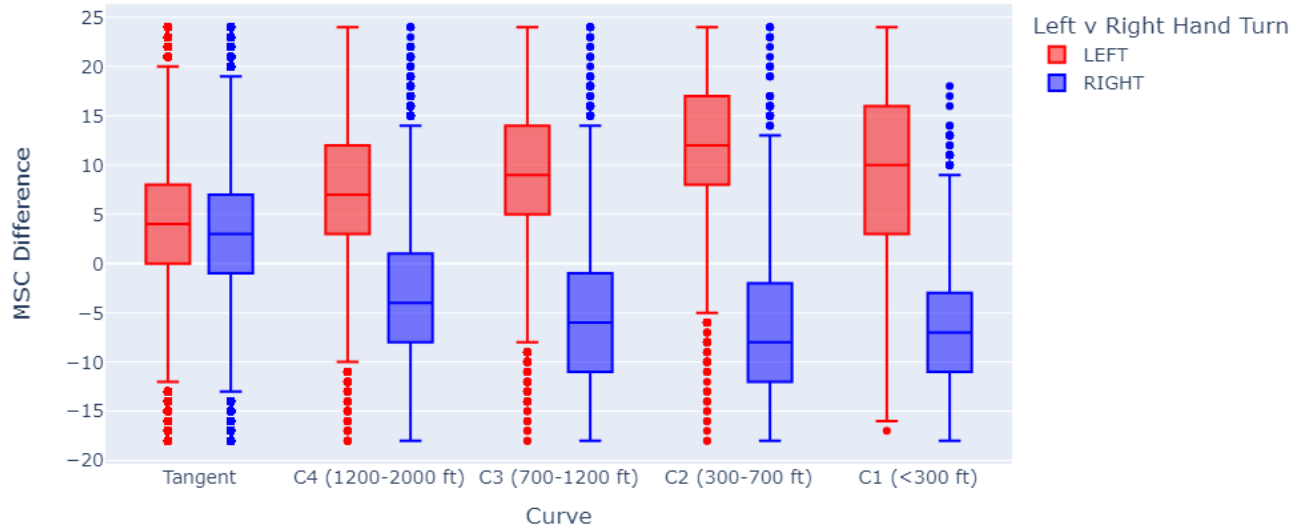
FRICTION/MSC OUTLIERS



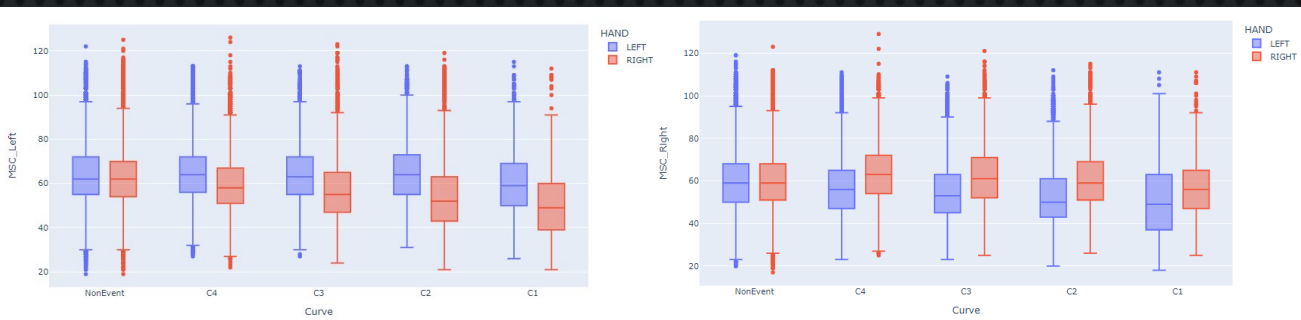
- Mann Whitney U tests indicate that on curves, the LWP-RWP Difference is dependent on curve direction.
- For Positive outliers, or segments where LWP MSC >> RWP MSC, the MSC Difference is greater on right hand curves.
- For Negative outliers, or segments where RWP MSC >> LWP MSC, the MSC Difference is greater on left hand curves.
- More positive outliers occur on right hand curves, and more negative outliers occur on left hand curves.

FRICTION/MSC ANALYSIS

MSC Difference by Curve Type and Direction of Turn (Non-Outliers)



- Mann Whitney U tests indicate that on curves, the Difference is dependent on curve direction.
- As curves shrink in radius (become tighter curves), the friction difference between wheel paths increases.
- On left hand curves, LWP friction > RWP friction
- Right hand curves, RWP friction > LWP friction
- **The outer wheel path has lower friction than the inner wheel path on curves. The difference expands on tighter curves.**





MACROTEXTURE/MPD

Outliers: 12.31 miles

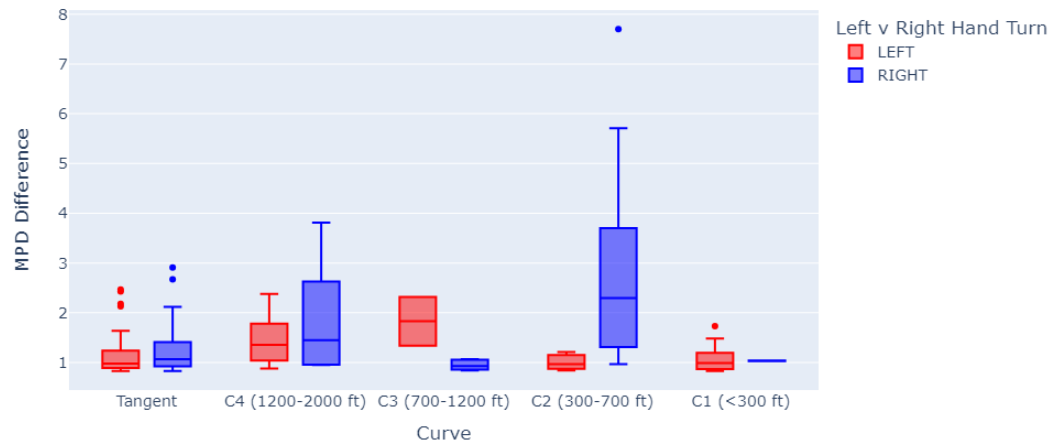
Non-Outliers: 1107.425 miles

	LWP	RWP	Difference	Curve Radius	LWP	RWP	Difference	Curve Radius
MEAN (SD)	1.11 (0.56)	3.10 (1.42)	-1.97 (1.58)	16386 (12107)	0.99 (0.23)	1.04 (0.26)	-0.05 (0.15)	16369 (12201)
Q1	0.89	2.20	-2.62	6562	0.82	0.84	-0.11	5468
Median	0.98	2.74	-1.72	10937	0.97	1.01	-0.04	10937
Q3	1.12	3.66	-1.19	32810	1.13	1.20	0.03	32810

- MPD Difference is -1.97 for the outliers, but -0.05 for the rest of the dataset (red).
- Outlier MPD Difference SD > Non-Outliers MPD Difference SD (red)
- RWP MPD SD > LWP MPD SD, however this difference is far larger among the outliers.

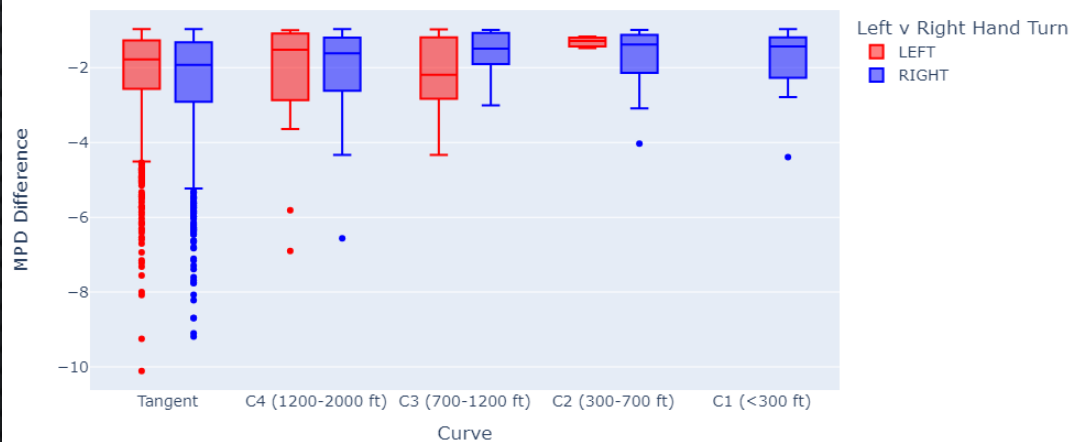
MACROTEXTURE/MPD OUTLIERS

Positive MPD Difference Outliers



- The patterns among the MPD outliers are inconsistent, and do not resemble those of the MSC outliers.

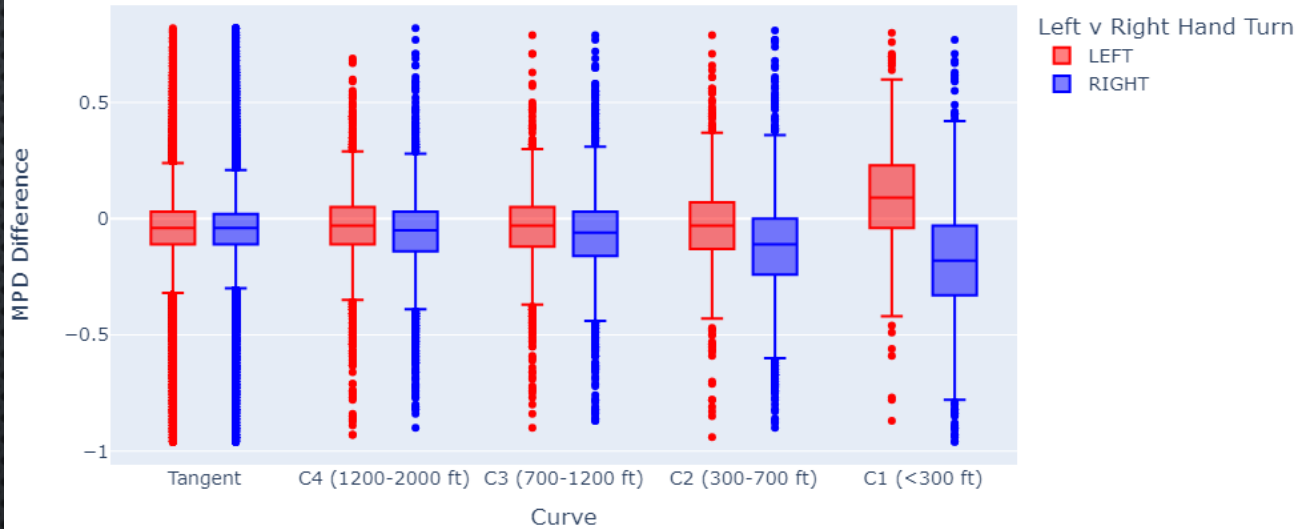
Negative MPD Difference Outliers



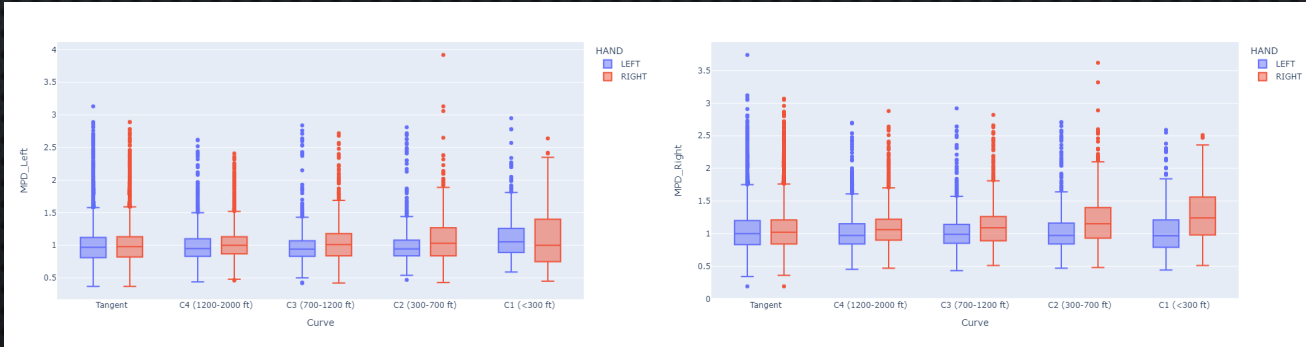


MACROTEXTURE/MPD ANALYSIS

MPD Difference by Curve Type and Direction of Turn (Non-Outliers)



- Mann Whitney U tests indicate that on curves with less than 300-ft radius:
 - On left hand curves, LWP MPD > RWP MPD
 - Right hand curves, RWP MPD > LWP MPD
- **The outer wheel path has lower macrotexture than the inner wheel path on curves with radii below 300 feet.**



SUMMARY OF FINDINGS

- AMONG NONOUTLIERS, LWP FRICTION $>$ RWP FRICTION (+3.2), HOWEVER THIS PATTERN REVERSES IN THE OUTLIERS.
- AMONG NONOUTLIERS, LWP MACROTEXTURE $<$ RWP MACROTEXTURE (-0.05), AND THIS PATTERNS MORE EXTREME IN THE OUTLIERS.
- ACROSS ALL BREAKDOWNS, RWP VARIANCE $>$ LWP VARIANCE.
- THE OUTER WHEEL PATH HAS LOWER FRICTION THAN THE INNER WHEEL PATH ON CURVES. THE DIFFERENCE EXPANDS ON TIGHTER CURVES.
- THE OUTER WHEEL PATH HAS LOWER MACROTEXTURE THAN THE INNER WHEEL PATH ON CURVES WITH RADII BELOW 300 FEET.
- SPECIAL THANKS TO RYLAND POTTER, WDM USA & MIKE VAUGHN, KYTC