The Effect of Train Mounted TOR-FM on Wheel Life and Defects

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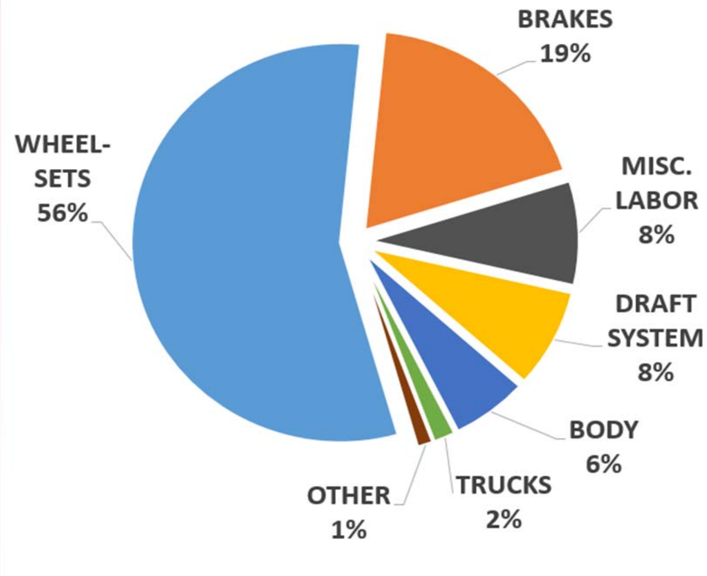
Presentation Overview

1. Introduction
2. Mobile TOR Application
3. TOR Friction Management
4. Study Basis and Analytical Methods
5. Results
6. Conclusions

Introduction

- **North American rolling stock is made up of ~ 1.5 million Cars**
- **Car Repair Billing (CRB)[1]**
  - Represents reported industry repairs (> $1.2 billion in 2013)
  - Wheel component $672 million
- **Wheels are the predominant cause of wheelset changes**



CRB Spending by Category
Source: CRB Data Exchange, 2013

1 - © TTCI/AAR, 1/15/2014. p2

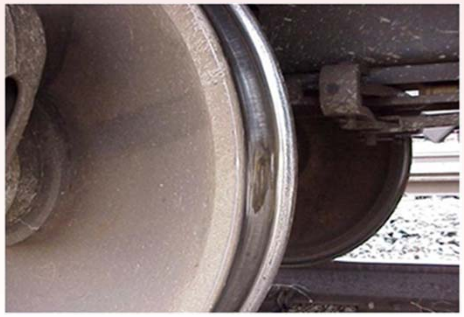
Wheel Replacements

- **Biggest causes of wheel replacement are:**

  1) Tread damage, 2) High Kips, 3) Wear

- **Tread damage is commonly due to RCF leading to shelling**
- **High Impact loads (kips) due to either shelling/spalling or flats**

Wheel Shelling



Wheel Slid Flat (high impact)

1 - © TTCI/AAR, ® 2010, PP10_13TOURNAY WRI Seminar p2

AutoPilot™ Train Mounted TOR Application

- Delivers a precise amount of Friction Modifier to the wheel-rail interface

➢ Large territory coverage

➢ Customisable application strategy

➢ Minimal train crew involvement

➢ Remote Performance Monitoring

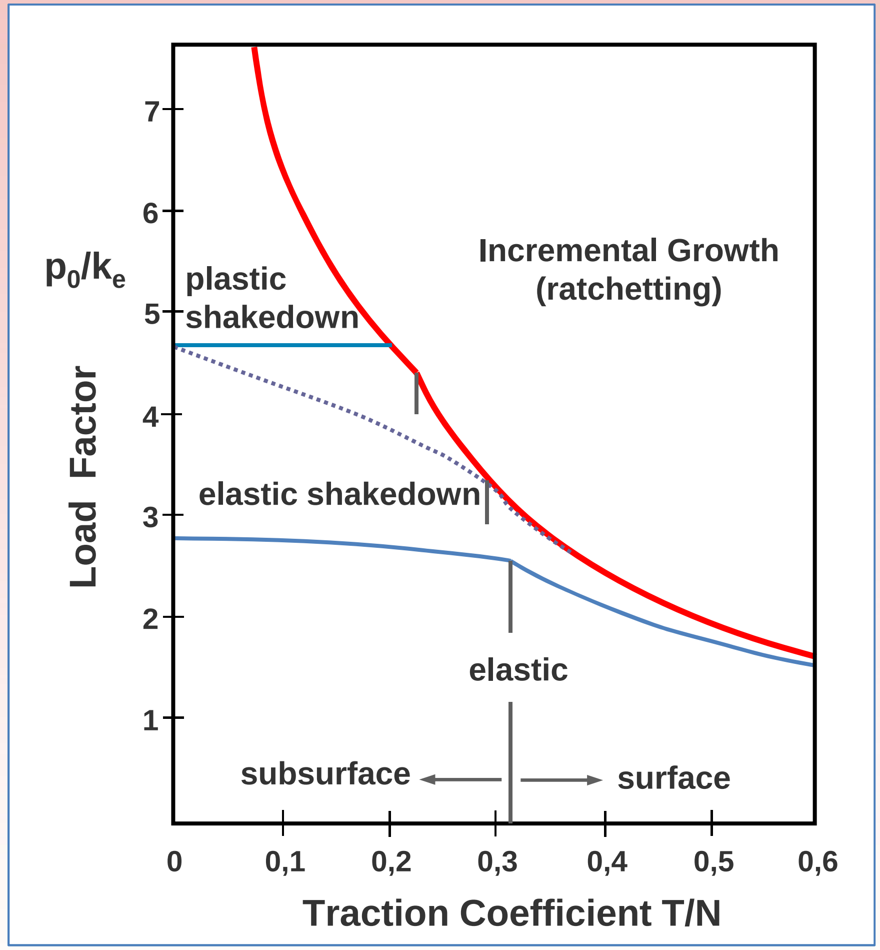
➢ Outsourced maintenance, high uptime (>90%)


TOR Spray Application

RCF Development: Shakedown

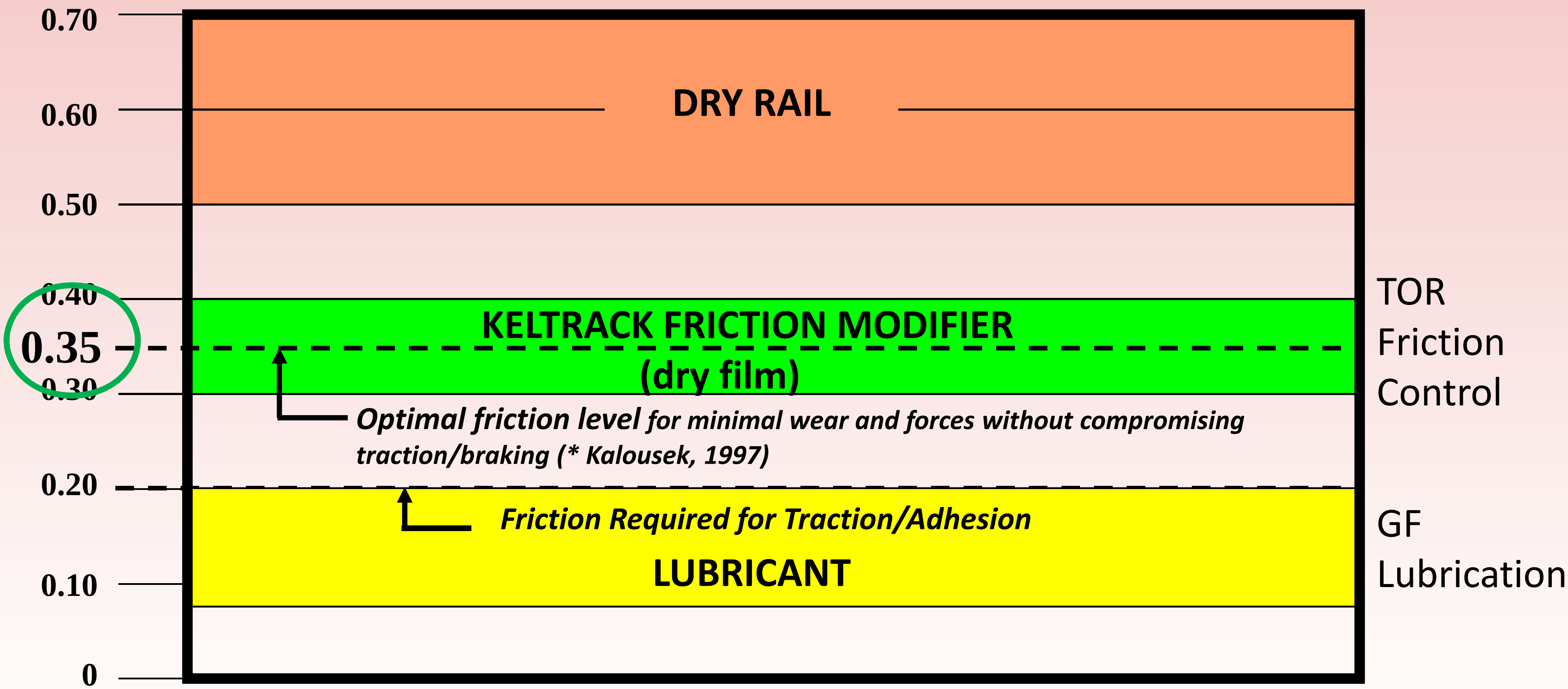
Increased Mat'l Shear Strength

Reduced Stress
(e.g. wheel/rail profiles)



Reduced Traction Coefficient
(e.g. reduced friction)

Top of Rail Friction Control

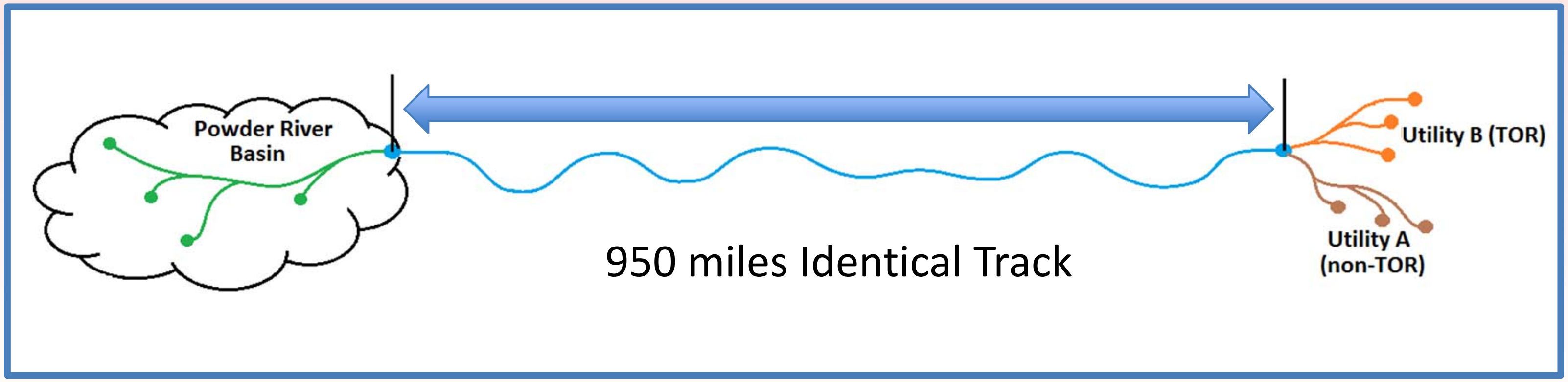


(Railway Track and Structure, "Modifying and Managing Friction", by Dr Joe Kalousek, NRC Center for Surface Transportation Technology May 1997)*

Study Basis & Fleet Information

Wheel Analysis Design

- WILD data – progression of high Impact forces (kips)
- Wayside wheel profile measurements
  - – wheel wear rates & wheel replacements
- UP CRB database
- Two utilities sharing about 90% of identical track



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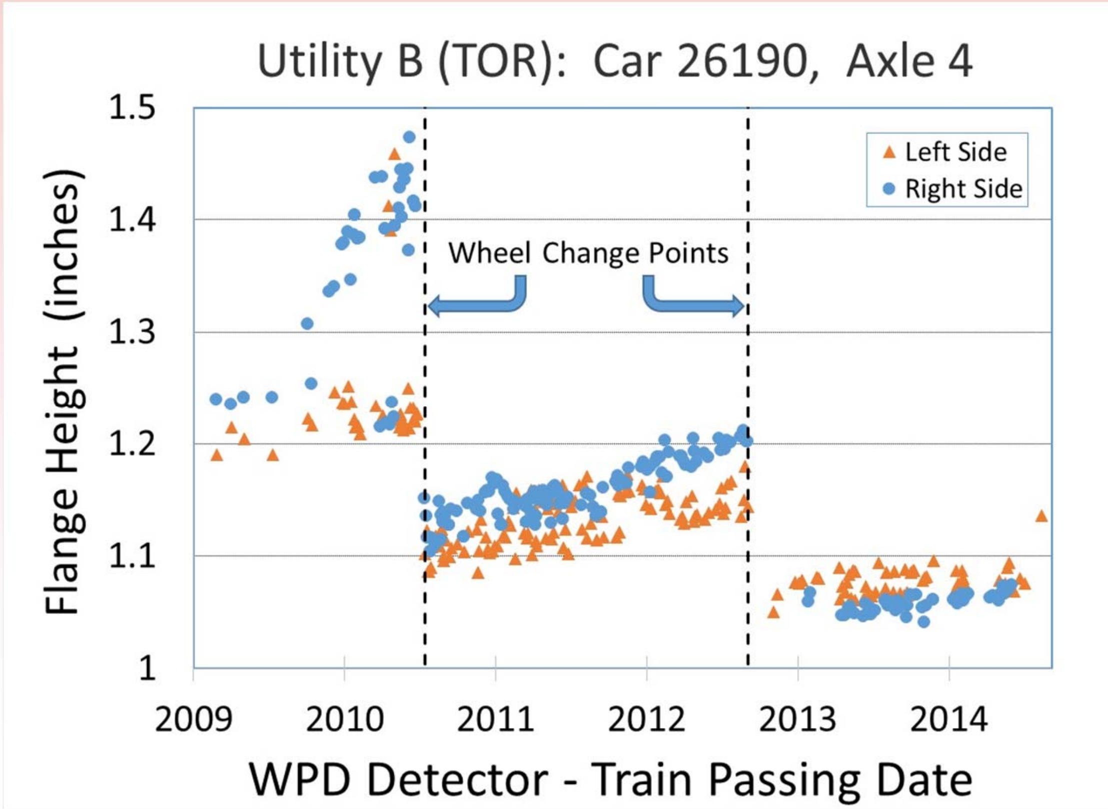
	Utility A	Utility B
Phase I April 2009 – March 2012	No TOR	No TOR
Phase II April 2012 – October 2014	No TOR	**TOR**

Automated Calculation of:

1. Wheel change points (replacements)
2. Wheel utilization (MTM)
3. **<u>Wheel wear rate (in/MTM)</u>**

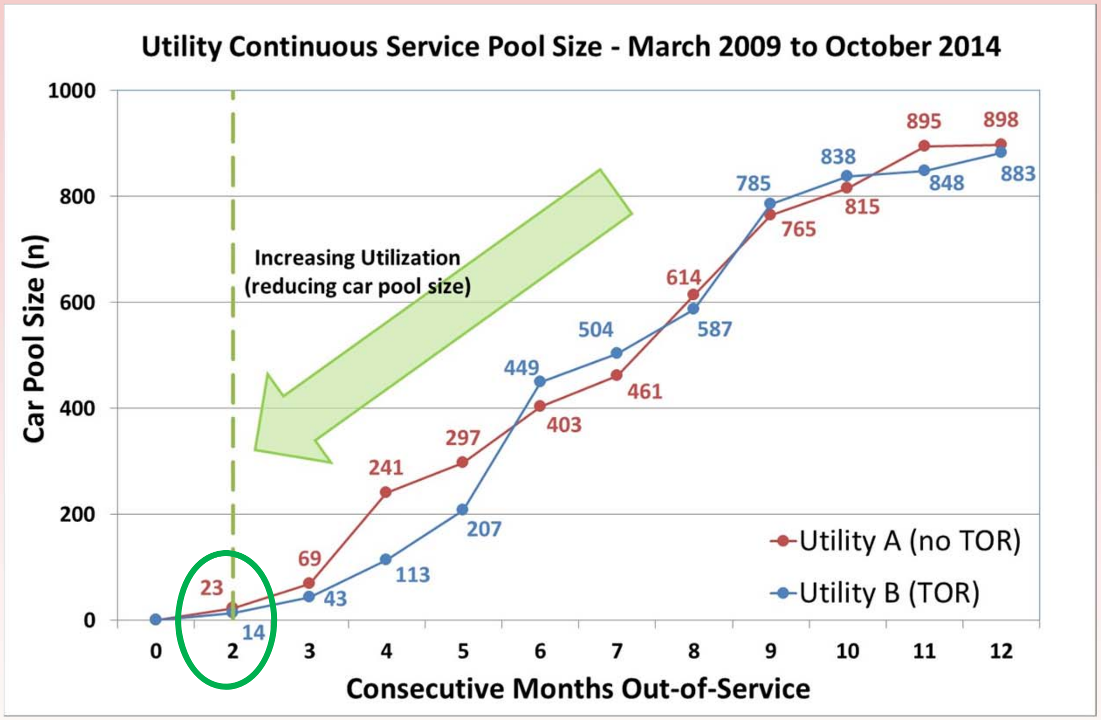


Analysis Fleet Information

Detail	Utility A (no TOR)	Utility B (TOR)
Unit Coal Trains	PRB to mid-western US electric plants	
Car Inventories	2,667	3,103
Average Trip mileage	1061	1037
Average Wheel Service	1.0 MTM / year	1.2 MTM / year
Typical Car type	Aluminum Gondolas	
Typical Truck type	Motion Control	
Typical Brake type	Body Mounted	
Brake Shoes	HF Composition 10-30% Tread Conditioning 70-90%	
Wheel Type	36", Class C	
Typical Train Makeup	Power: 2 x 1 (DPU), 135-140 Cars	

Car Selection for Wheel Measurements

- AEI database analyzed for utility inventory monthly car utilization



- Cars out of service more than 2 months excluded

Utility A (no TOR) = 23 cars

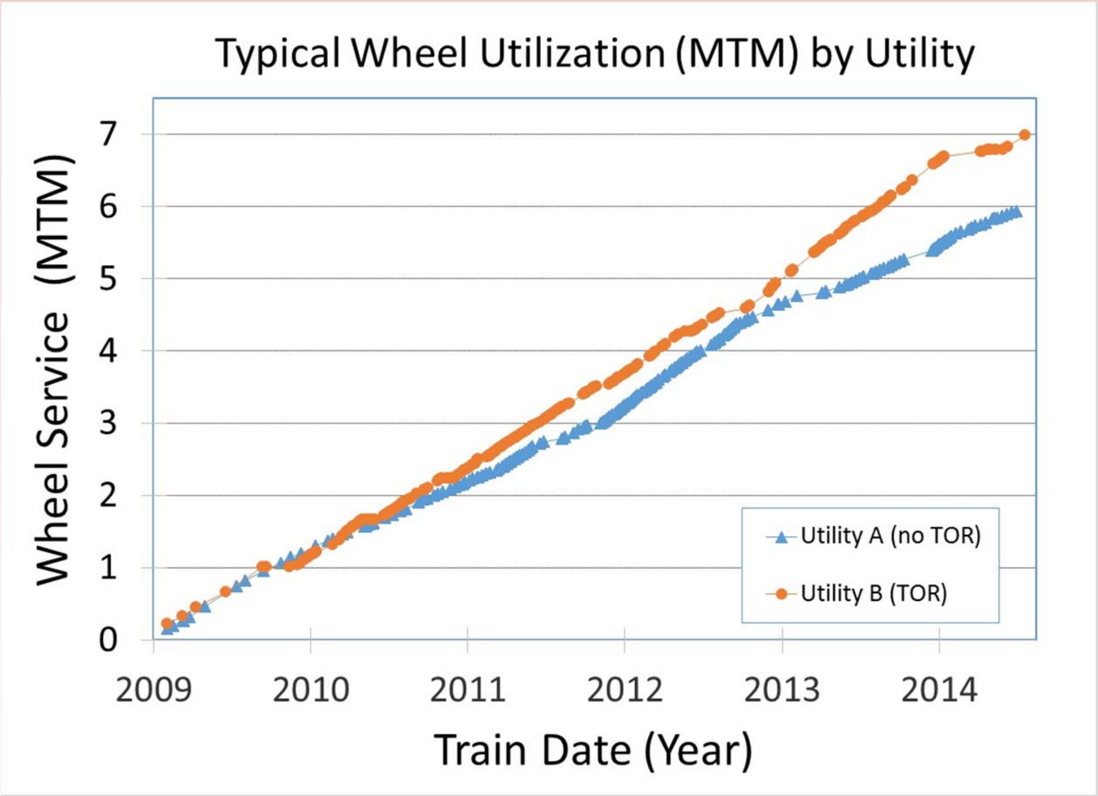
Utility B (TOR) = 14 cars

Determining Car wheel MTM

- Car pool AEI database analyzed to identify car trips and mileages

- Car wheel loading based on 286,000 Lbs Gross Rail Load

- Wheel service normalized for MTM



Example wheel utilization over study period

WHEEL PEAK VERTICAL FORCE PROGRESSION (WILD)

UP Wayside WILD Detector Sites:

- Gothenburg, Nebraska
- Martin Bay, Nebraska

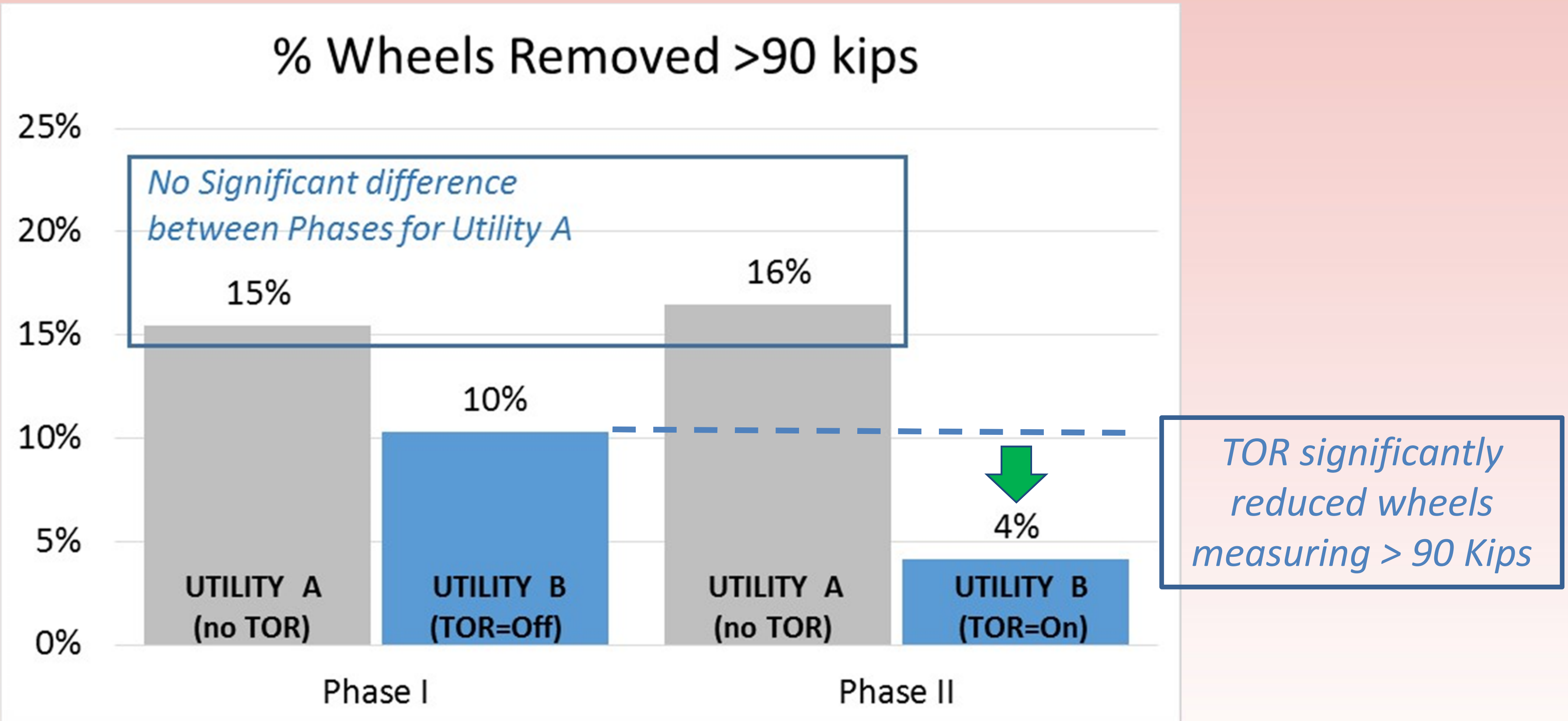
Wheel High Vertical Impact (kips) Relationship to RCF Development

New Wheel Tread

Shelled Wheel Tread

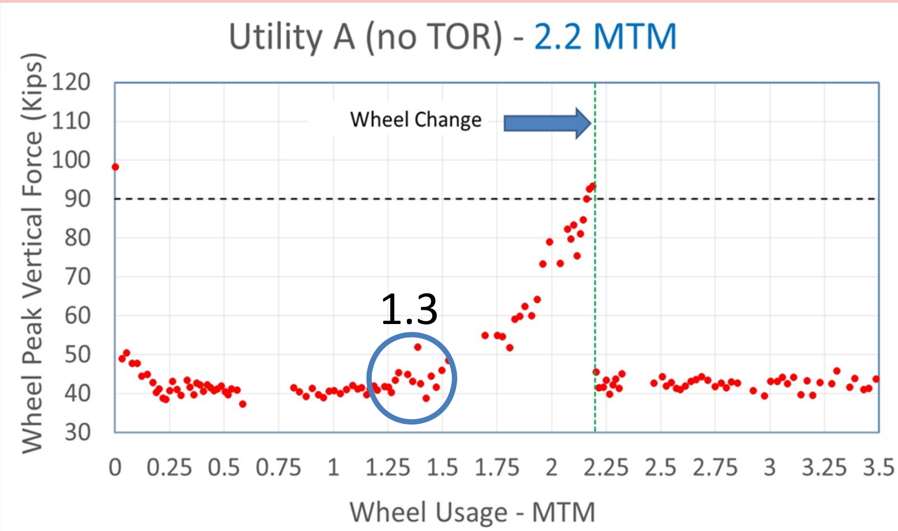
- As tread RCF advances - defect size and scale enlarges increasing vertical impact forces
- AAR regulations regarding high impacts:
  - > 140 kips specify immediate wheel replacement
  - > 90 kips typically wheels replaced within 3 months

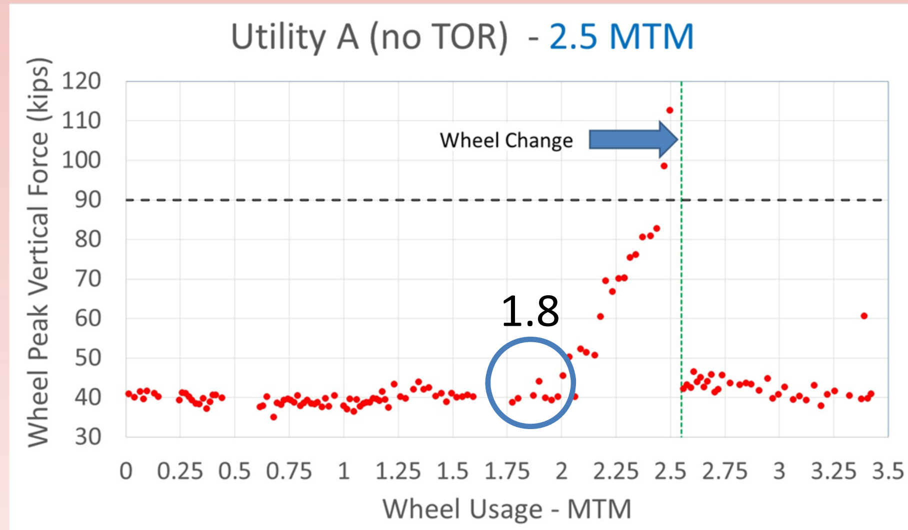
TOR Reduced Incidence of Measured Wheel Impacts > 90 Kips

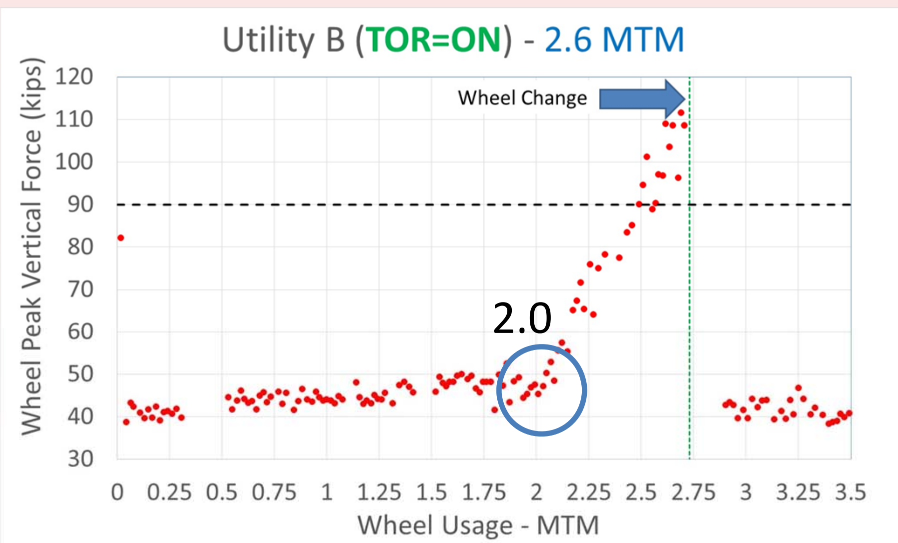


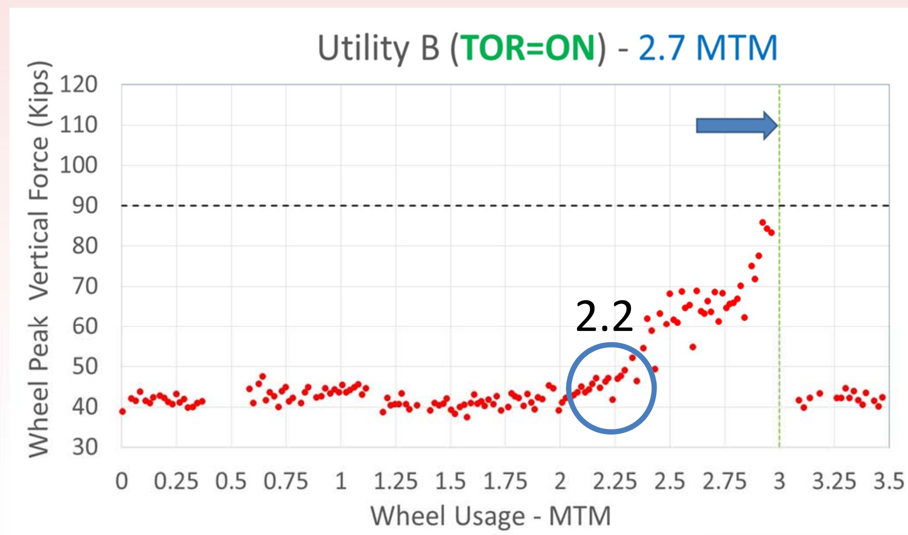
- Similar trend observed at lower peak vertical force thresholds (kips)

- In General → TOR seen to delay onset of increasing wheel vertical peak forces





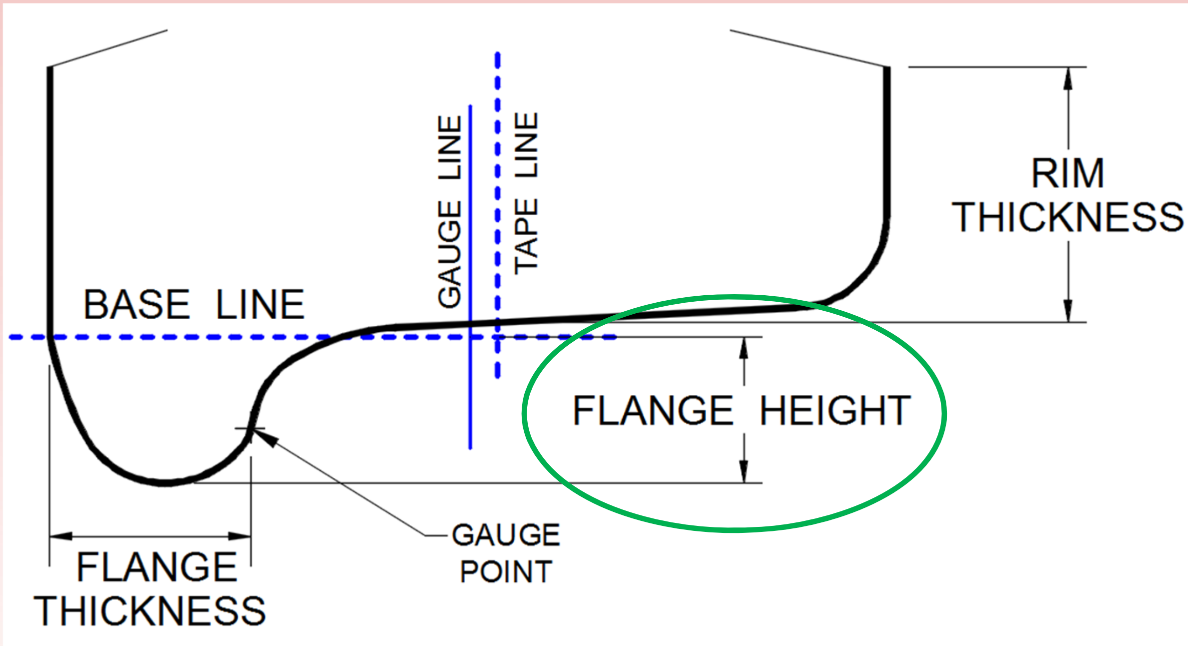




Wheel Wear Analytical Method

UP Wheel Profile Measurement Site:

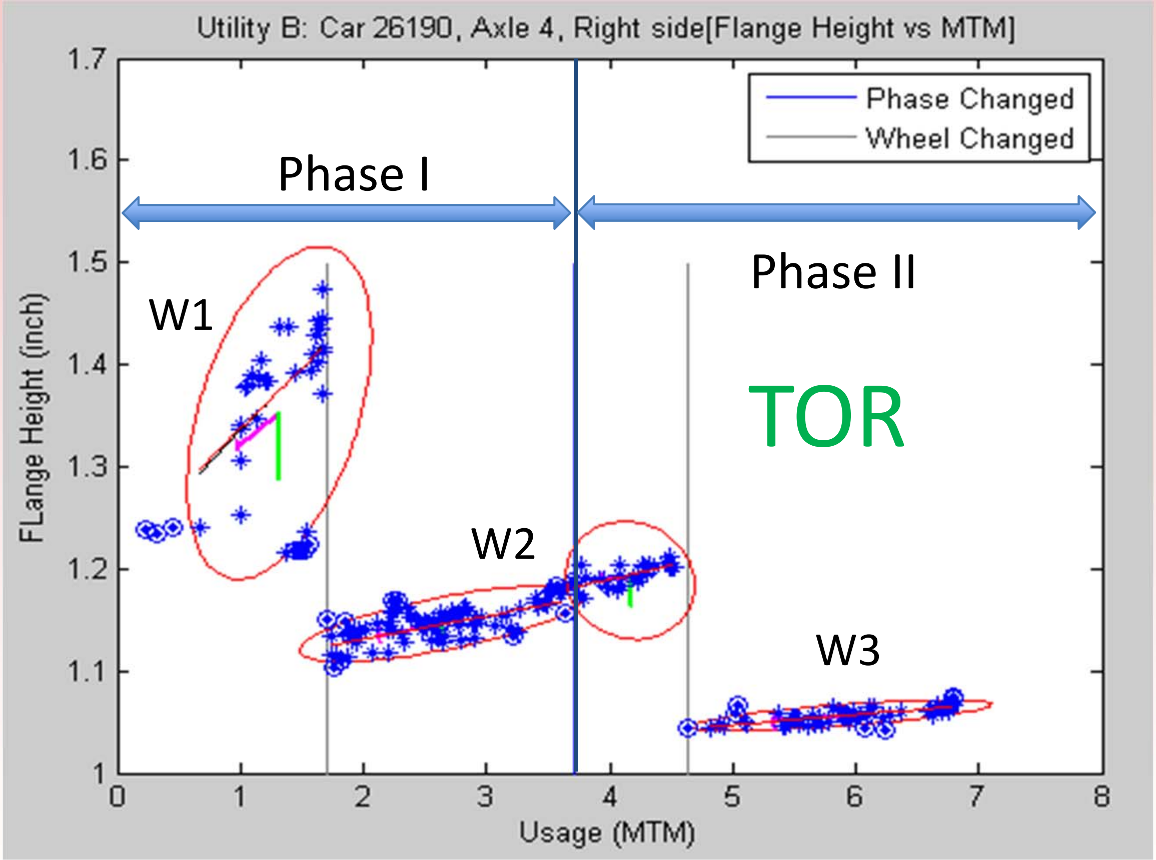
- Gothenburg, Nebraska



- Flange height measurements provided consistent detection of wheel change points
  - Provided progression of tread wear and hollowing

Determining Wheel Wear Rate (WWR)

- W1, W2, W3 are same position on car, two change outs



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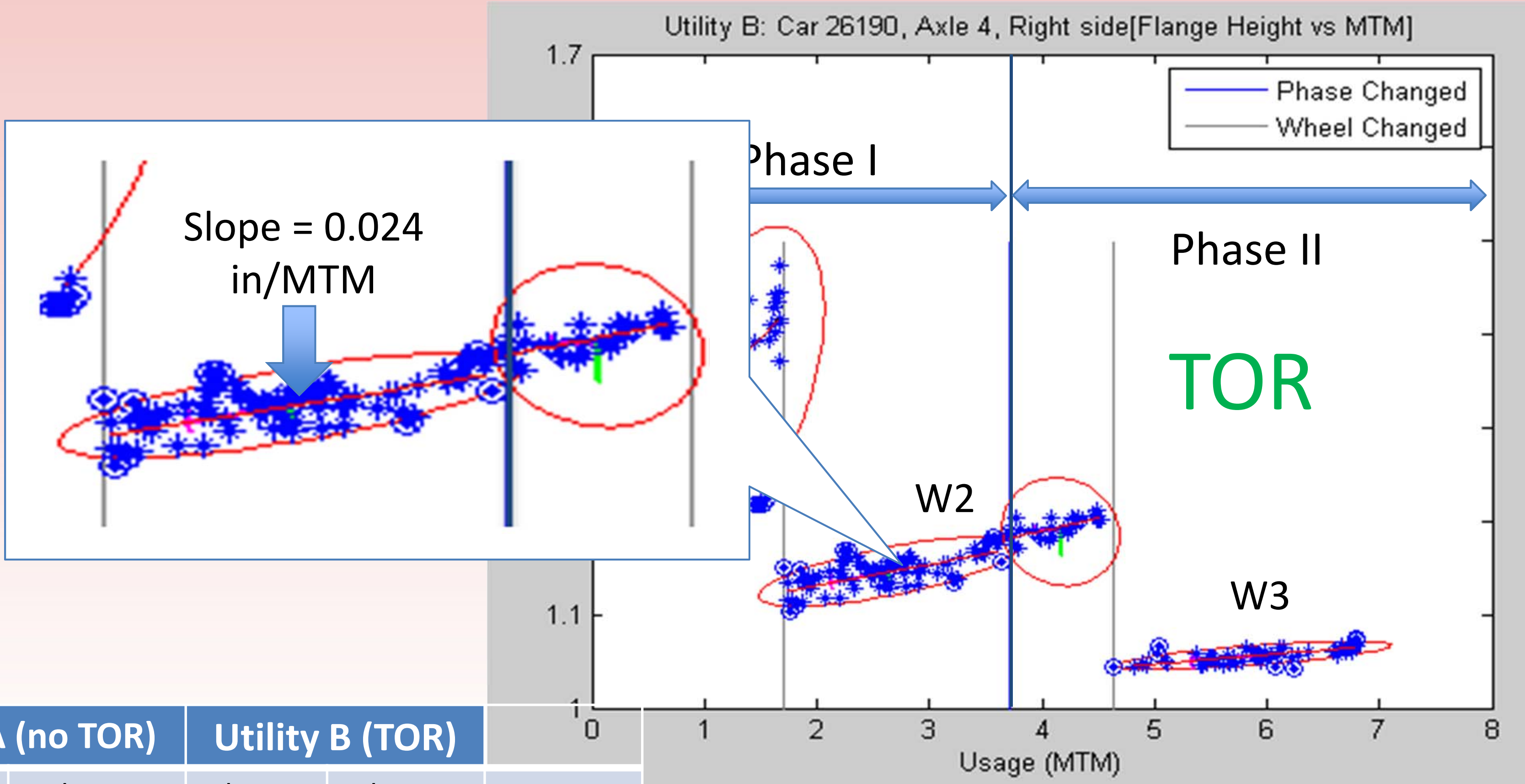
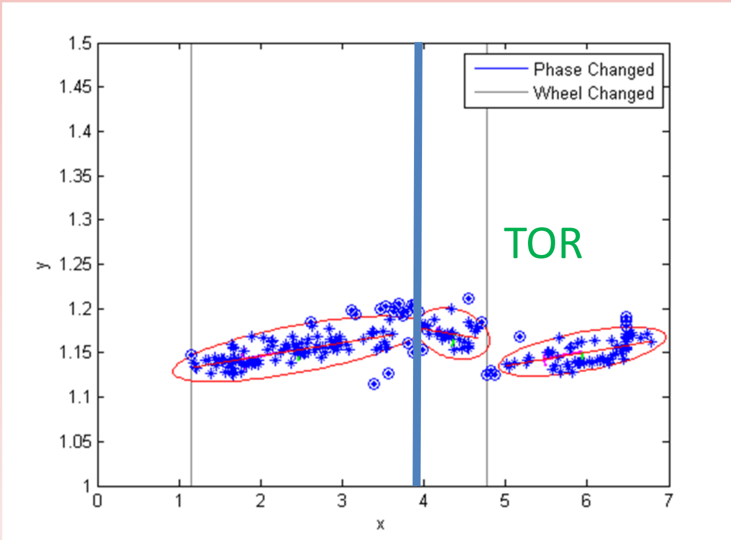


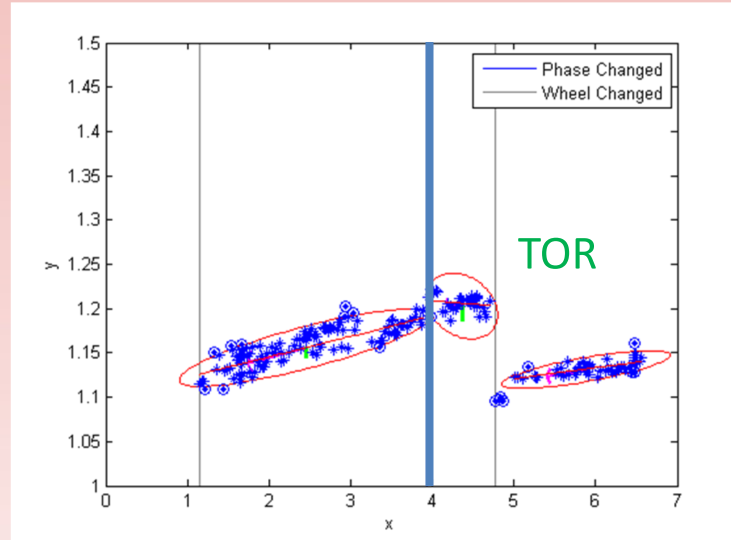
Utility A (no TOR)		Utility B (TOR)		
Phase I	Phase II	Phase I	Phase II	WWR segments
276	231	157	141	

Wheel Wear Rates (randomly selected)

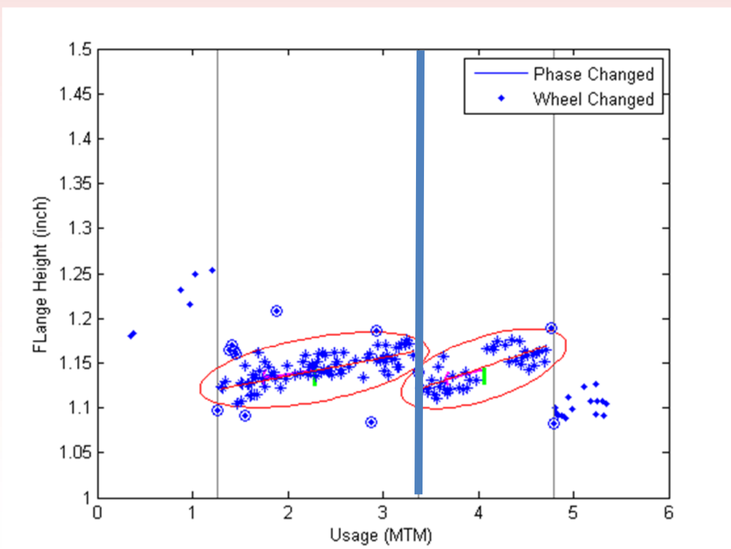
Utility B
Car 26151 L4
(TOR)



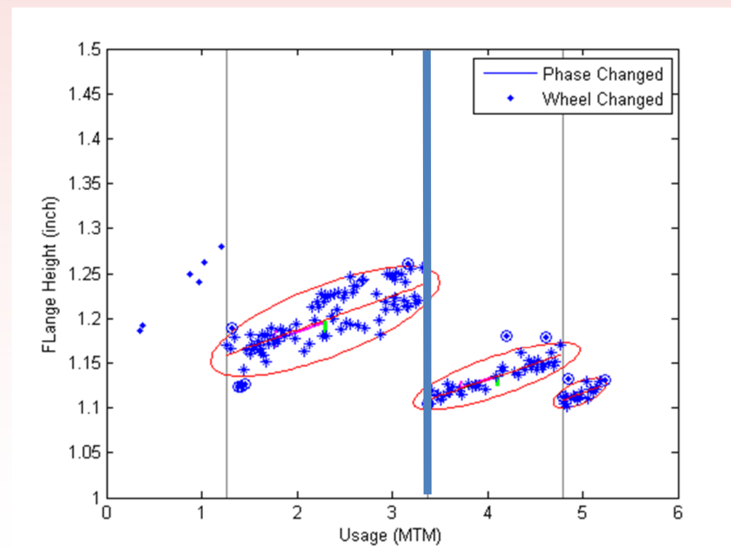
Utility B
Car 26151 R4
(TOR)

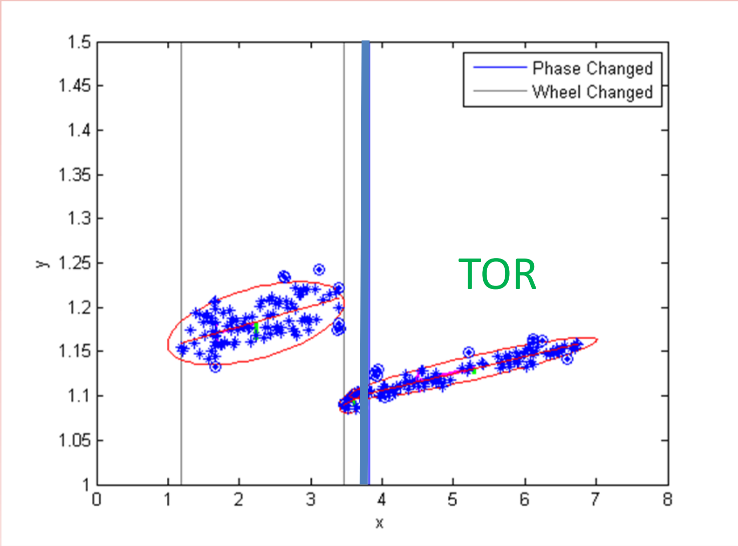


Utility A
Car 25111 L3
(non -TOR)

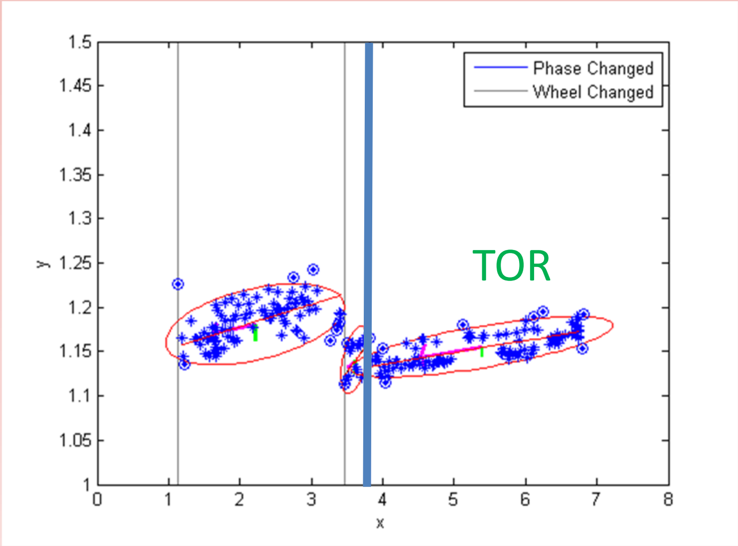


Utility A
Car 25111 R3
(non -TOR)

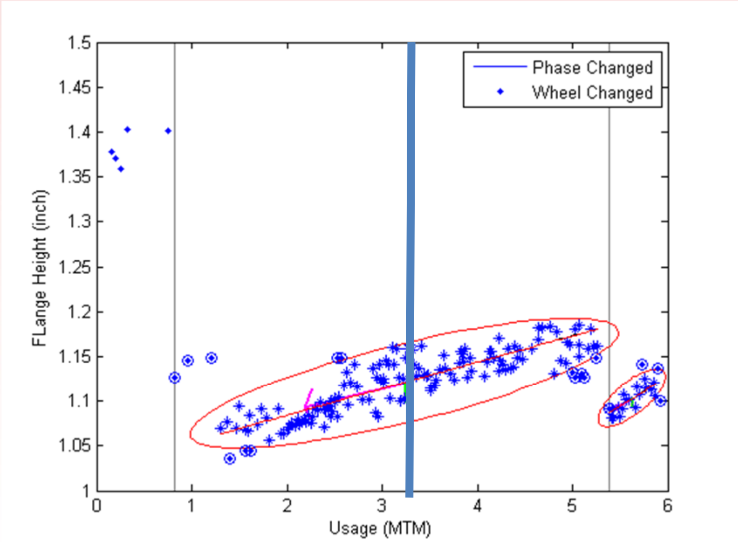




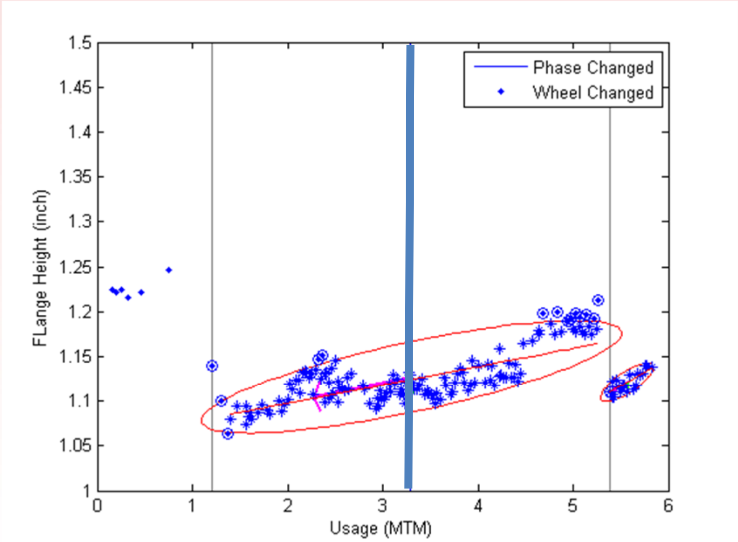
Utility B Car 26202 L4 (TOR)



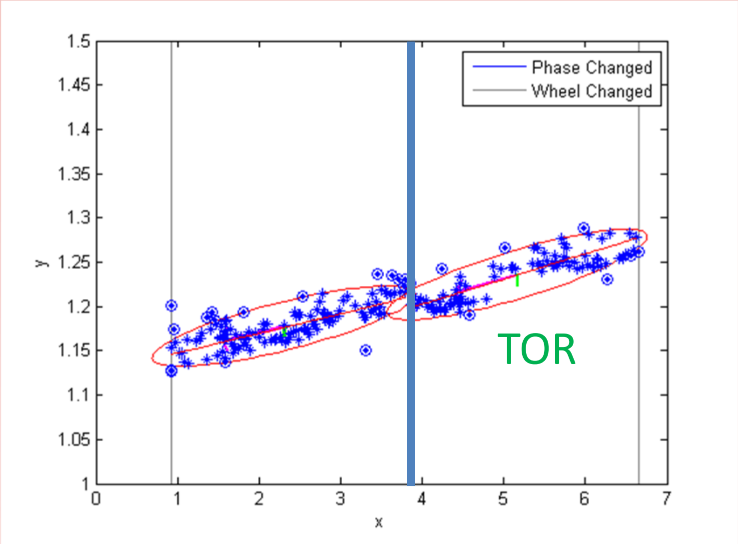
Utility B Car 26202 R4 (TOR)



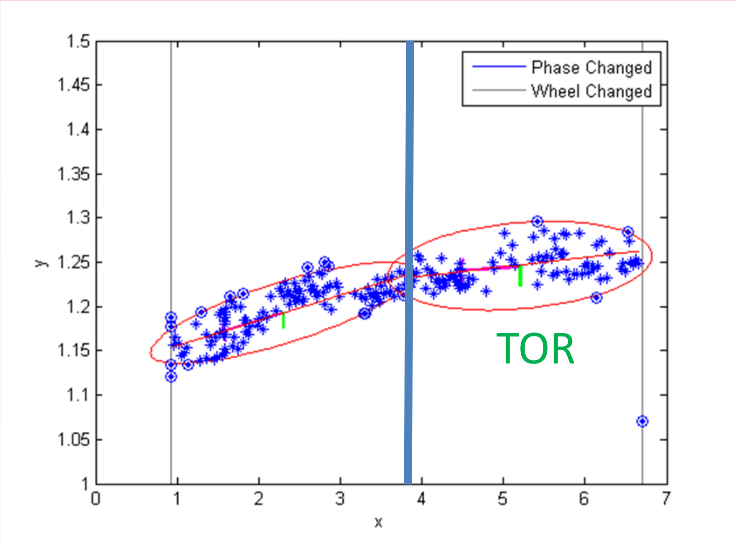
Utility A Car 25110 L4 (non -TOR)



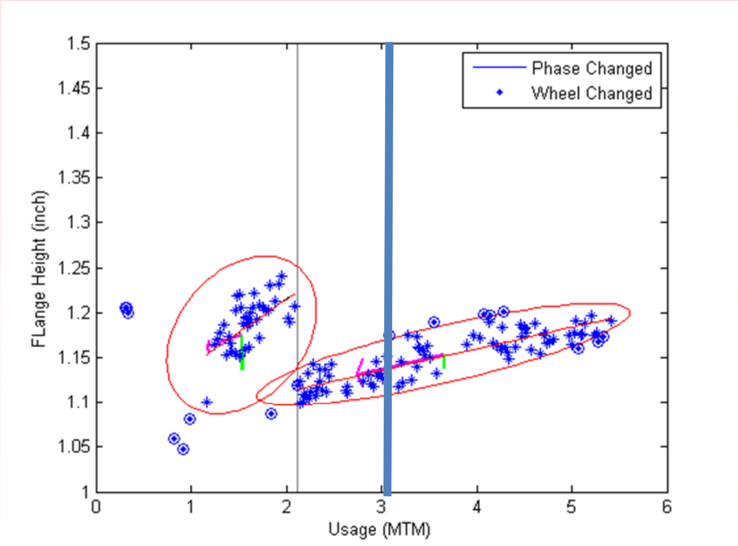
Utility A Car 25110 R4 (non -TOR)



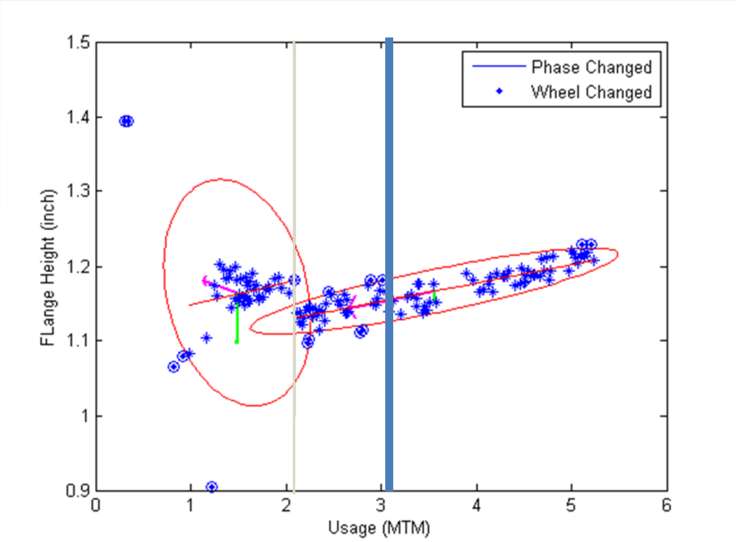
Utility B Car 96010 L3 (TOR)



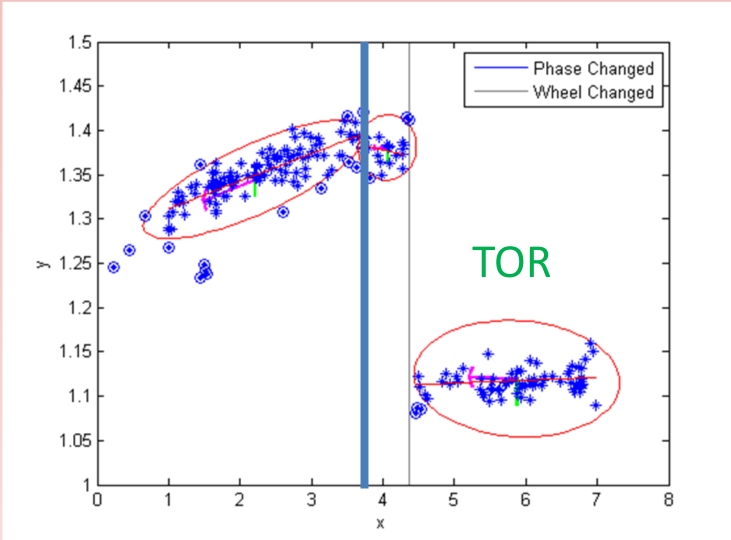
Utility B Car 96010 R3 (TOR)



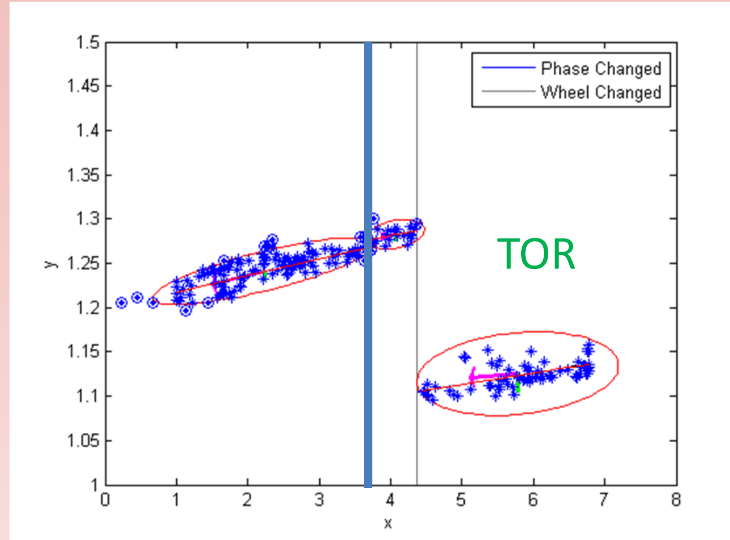
Utility A Car 25136 L1 (non -TOR)



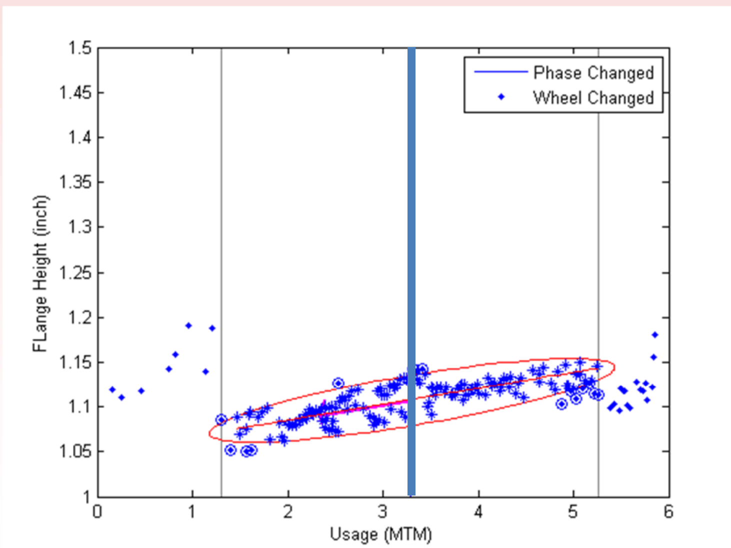
Utility A Car 25136 R1 (non -TOR)



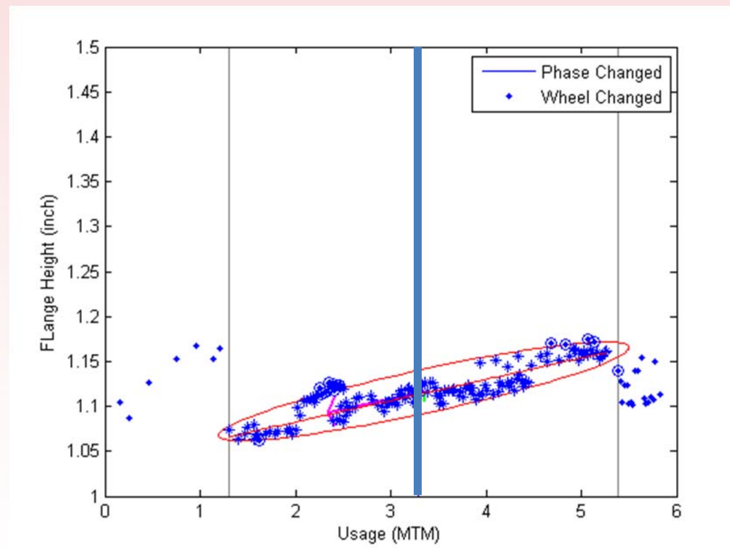
Utility B Car 26214 L4 (TOR)



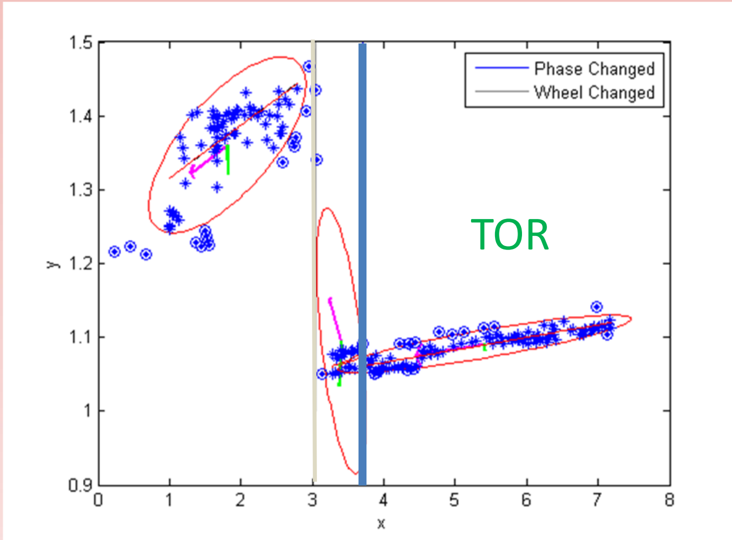
Utility B Car 26214 R4 (TOR)



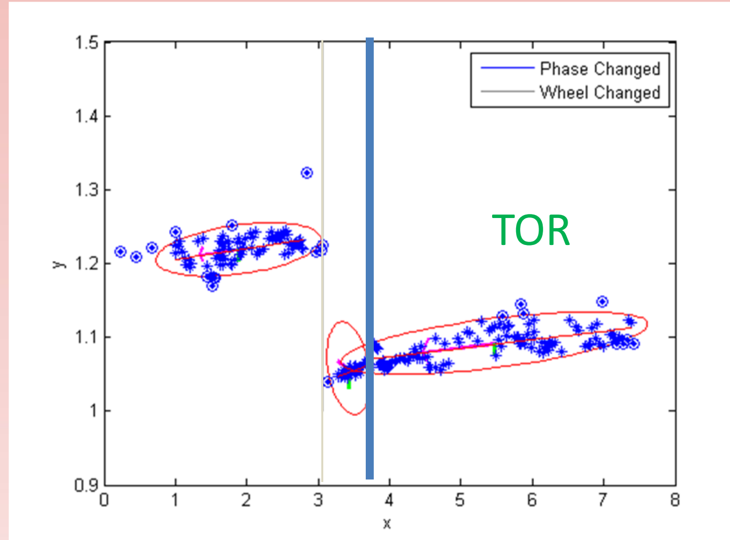
Utility A   Car 24161 L3 (non -TOR)



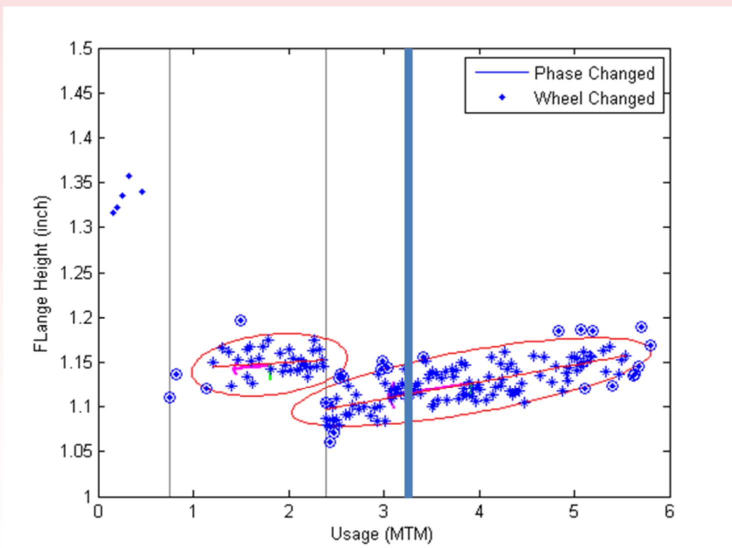
Utility A Car 24161 R3 (non -TOR)



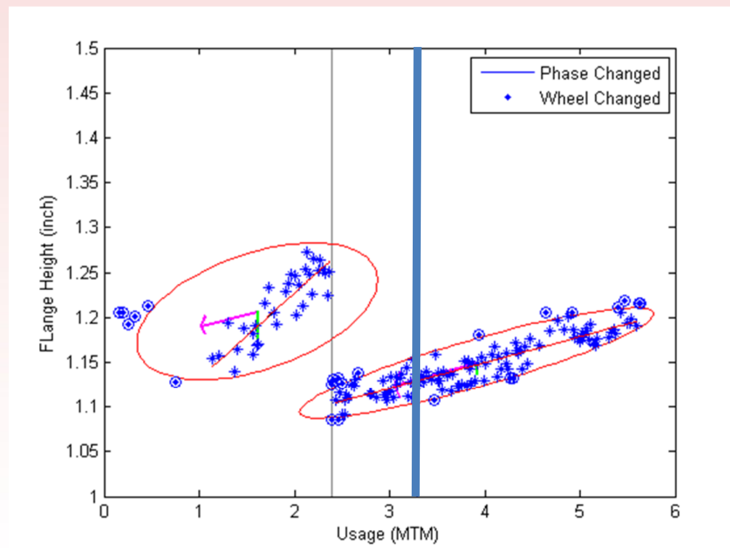
Utility B Car 26214 L2 (TOR)



Utility B Car 26214 R2 (TOR)

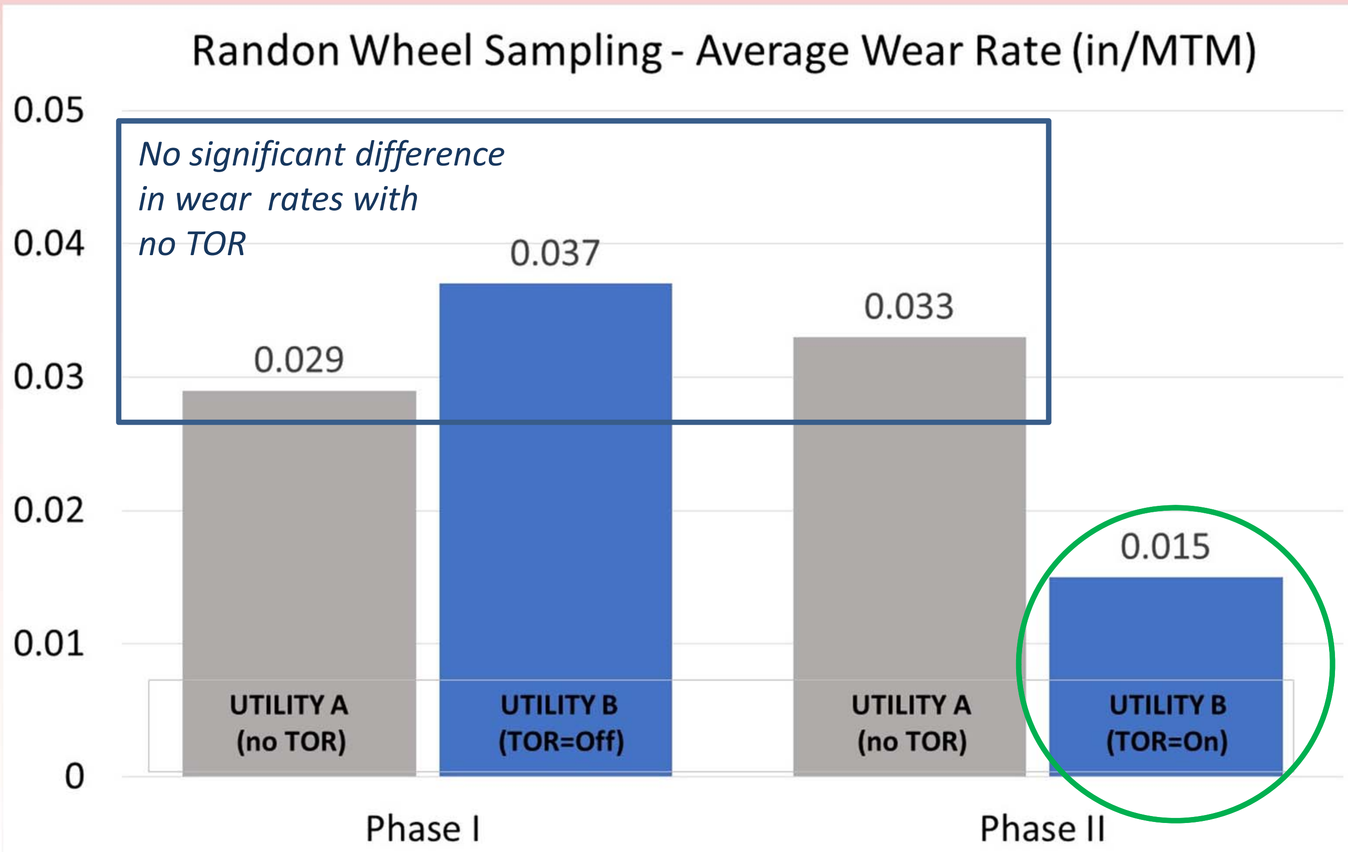


Utility A   Car 25100 L2 (non -TOR)

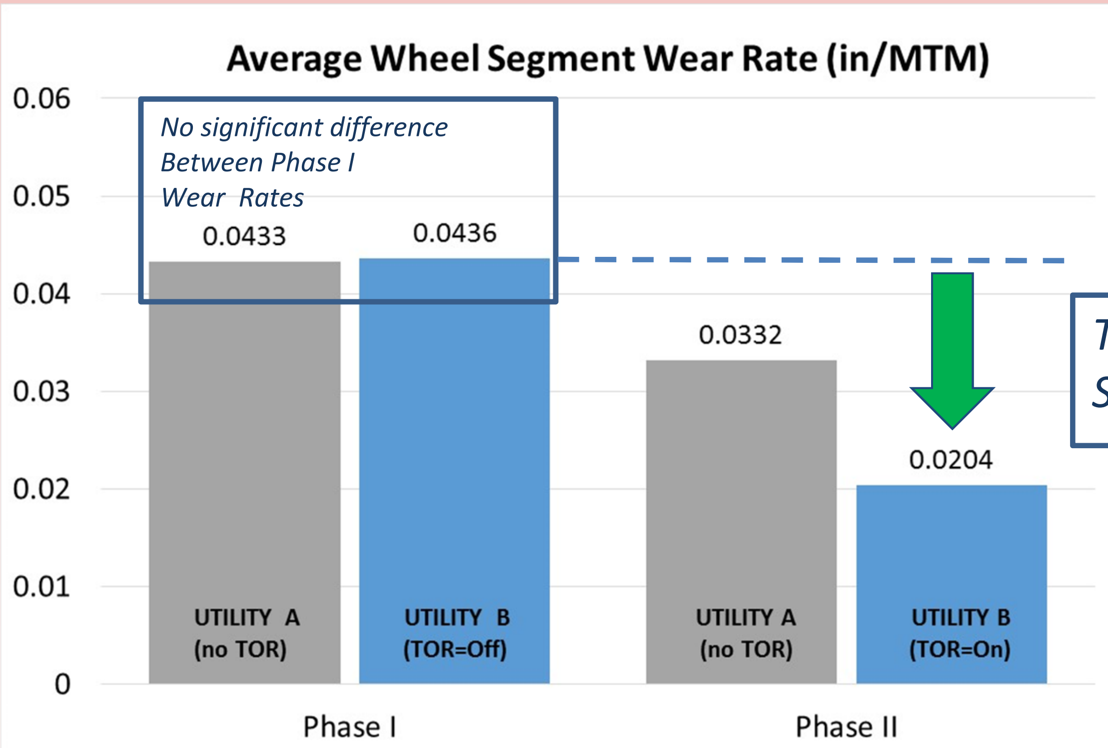


Utility A Car 25100 R2 (non -TOR)

- Small random wheel sample size showed 50% wheel wear reduction with TOR



All Car Pool Wheels – TOR Reduced Wear



TOR reduced wear rates Significantly in Phase II

- Utility A (no TOR): 23%
- Utility B (TOR): 53%

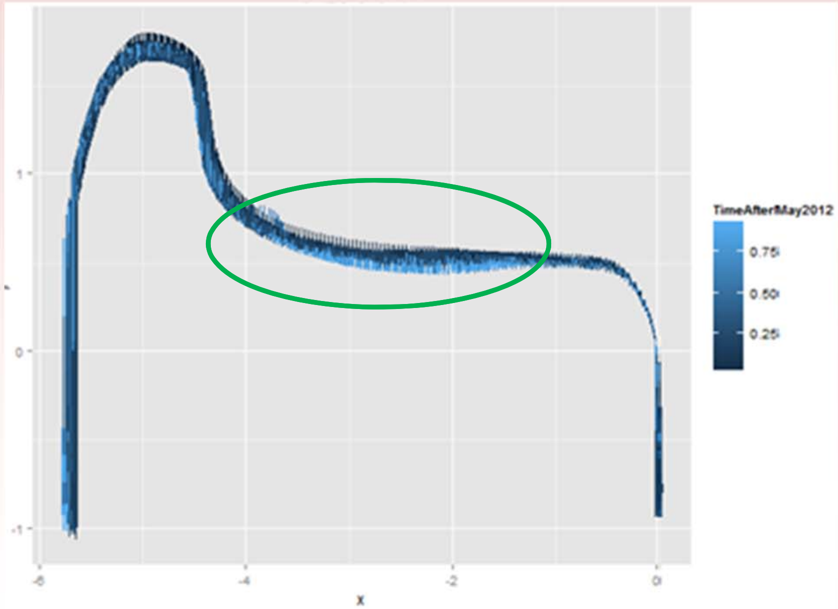
```
                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level                         -----+---------+---------+---------+----
Utility A Ph I (no TOR)                                (---*---)
Utility A Ph II (no TOR)                      (---*----)
Utility B Ph I (TOR=Off)                               (----*-----)
Utility B Ph II (TOR=On)      (----*-----)
                              -----+---------+---------+---------+----
                                 0.020     0.030     0.040     0.050
```

Analysis of Variance Testing
Utility and Phase Comparison

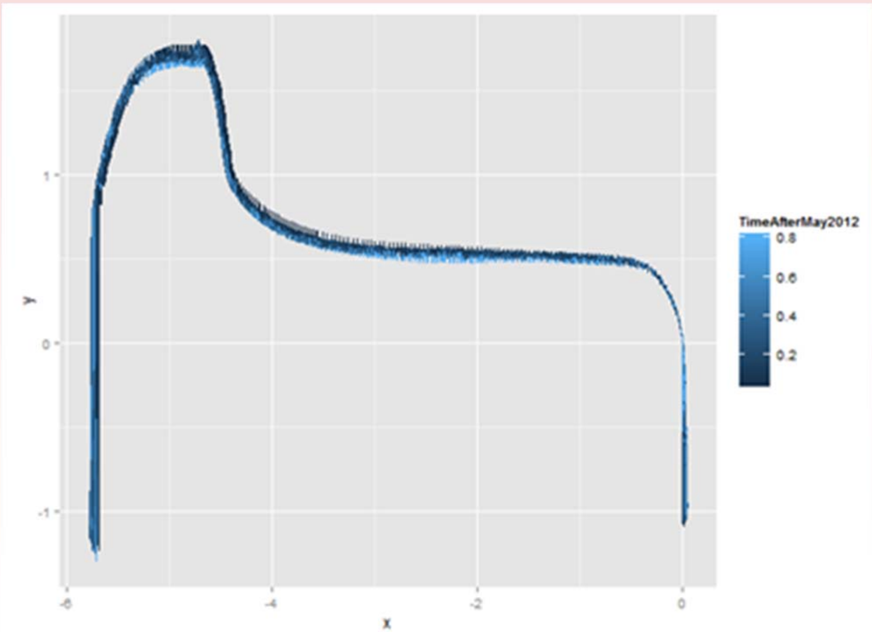
Typical Wheel Profile Progression for TOR and non-TOR Wheels

- Equivalent MTMs for both wheels during Phase II

UTILITY A
No TOR



UTILITY B
TOR



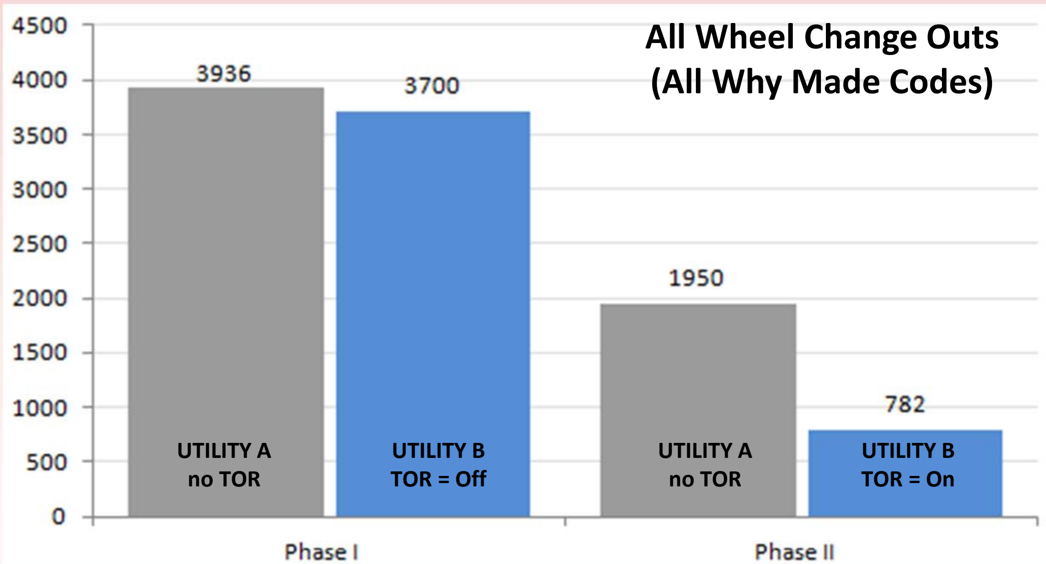
UP Car Repair Billing - CRB

- Wheel Wear and WILD data analysis is leading indicator for further UP CRB analysis
- Provides specific change out billing dates for comparing back to Wheel Wear and WILD analysis
- Ability to drill down for specific wheel change removal reasons (Why Made Codes)

Determine Impacts to the Railroad

UP Car Repair Billing - CRB

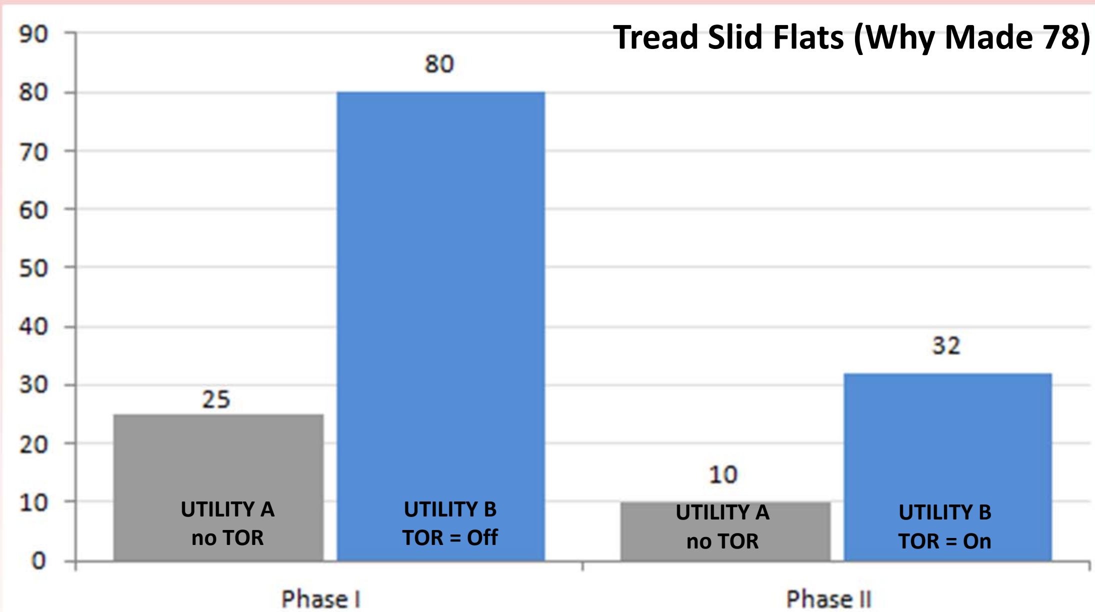
- UP change out data only (does not include private repairs)
  - All Cars (898 Non TOR Utility Cars and 883 TOR Utility Cars)
- Same relative wheel change outs compared to WPD determined changes



UP changed 30-60% of the wheels
Therefore: CRB failure stats apply to entire fleet

UP Car Repair Billing - CRB

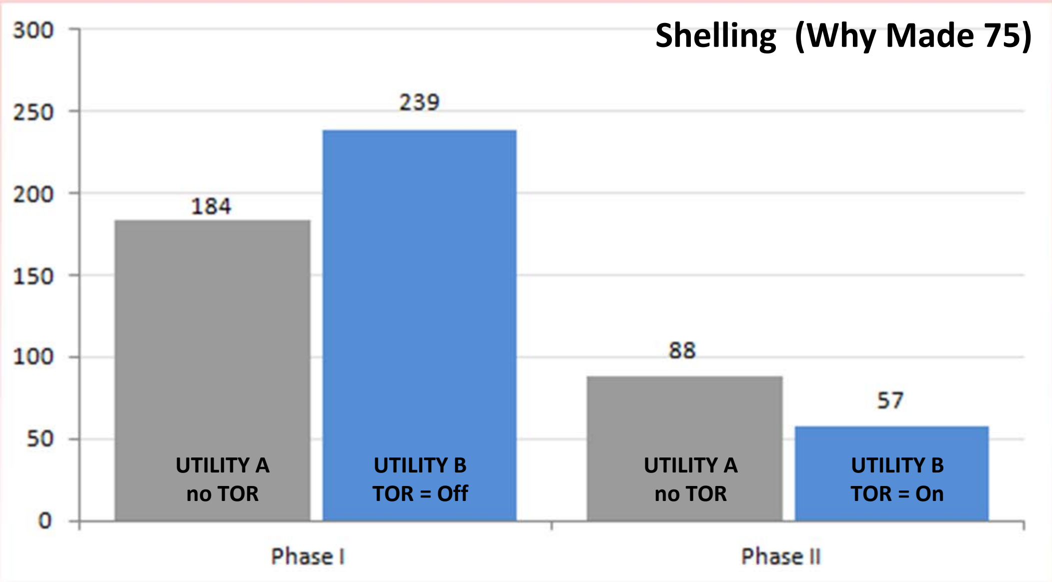
- No accelerated slid flats observed by applying a water based product to the rail



Slid Flats – Same relative performance

UP Car Repair Billing - CRB

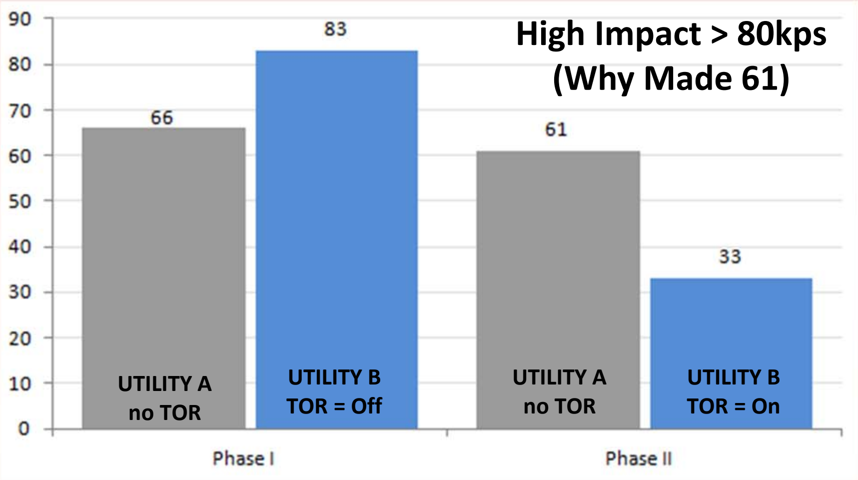
- Numerous Wheel Change outs are due to wheels shelling / spalling
- Notable reduction to wheel change outs for both Utility groups – more pronounced for TOR Utility

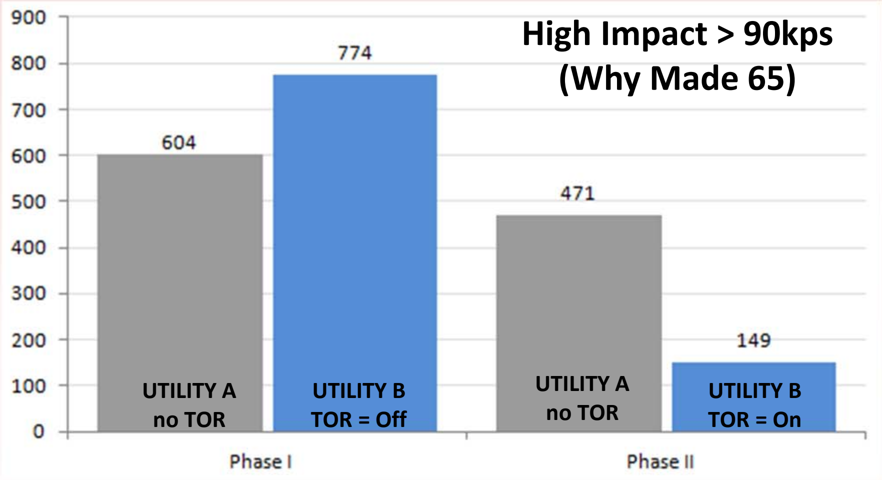


Shelling – same relative performance

UP Car Repair Billing – CRB

- Effects of wheel shelling/spalling can increase high impact forces
- Wheel Change outs due to high forces lead to wheel change outs
- Slight reduction of wheel change outs from high impact forces for Non TOR Utility
- Significant reduction of wheel change outs from high impact forces for TOR Utility





Non-TOR improved very little – TOR improvement was comparably much better

CONCLUSIONS – Train Mounted TOR-FM

- TOR-FM on unit coal trains showed:
  - Significant reduction in wheel wear rate based on flange height measurements
  - Significant reduction in incidence of wheel high impact loads > 90 kips
  - Reduced wheel replacements
- Measured wheel results agreed with UP CRB database findings
- Similar unit coal trains without TOR-FM saw reductions, but to lesser degree

Future Work

- Continued analysis to determine if TOR-FM trends continue with current wheels (2015)
- Further analysis to determine if reductions observed with non TOR trains are due to product retentive benefits

Thank-you

Acknowledgements

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- Ming Du, L.B. Foster Company