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MANAGING PAVEMENT ASSETS (ICMPA9)

Latest Development in the Processing of Pavement Macrotexture Measurements of High Speed Laser Devices

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AASHTO THE VOICE OF TRANSPORTATION

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WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE 1909-2009

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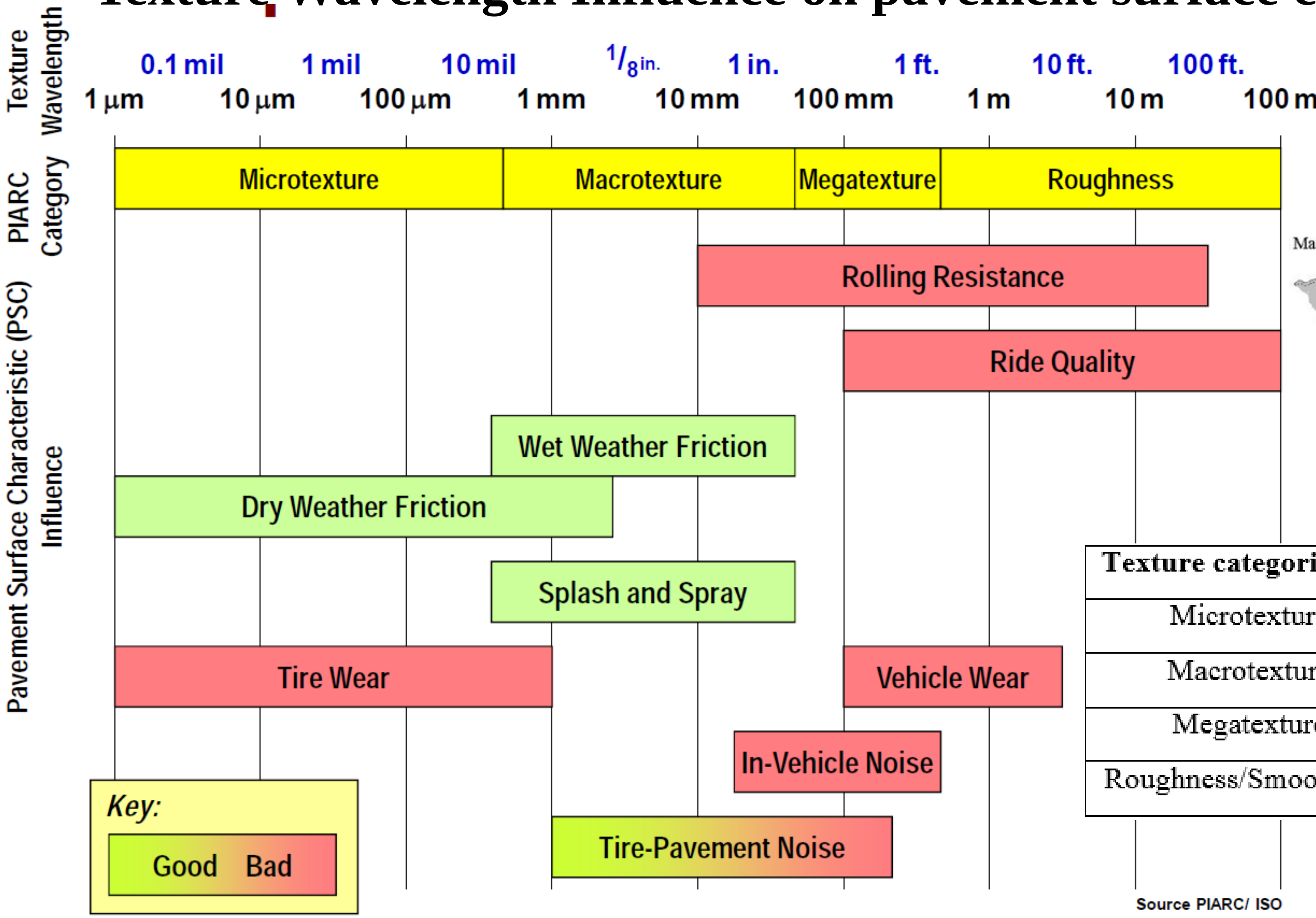
Outline

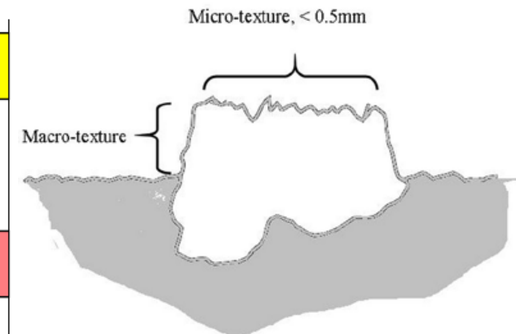
- Background
- Problem statement
- Objective
- Research approach
- Results
- Conclusions

Background

Texture Wavelength Influence on pavement surface characteristics



Source PIARC/ ISO



Source: http://www.mto.gov.on.ca/

Texture categorization	Texture Wavelength (λ)
Microtexture	$\lambda < 0.5$ mm
Macrotexture	0.5 mm $< \lambda <$ 50 mm
Megatexture	50 mm $< \lambda <$ 500 mm
Roughness/Smoothness	0.5 m $< \lambda <$ 50 m

Source: Flintsch, et.al.

Background

- Texture
  - Adequate surface macrotexture of a pavement is essential to:
    - provide good skid resistance,
    - Efficiently drain water out of the contact area,
    - Reduce splash and spray,
    - Mitigate tire-pavement noise, among other properties

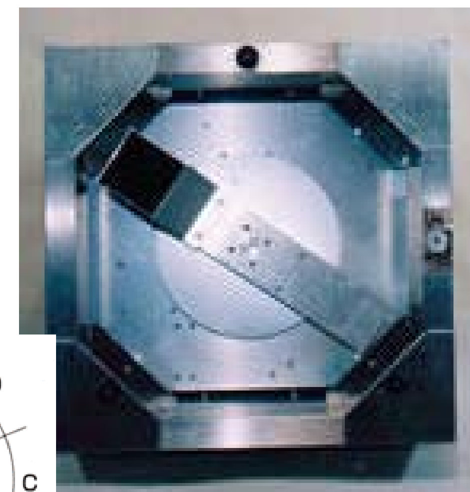
Background

- Methods

  CTmeter

  Mean Profile Depth (MPD), Root Mean Square (RMS)

  - ASTM E2157-09
  - Static, Profile



http://www.tics.hu/CTMeter.htm

Background

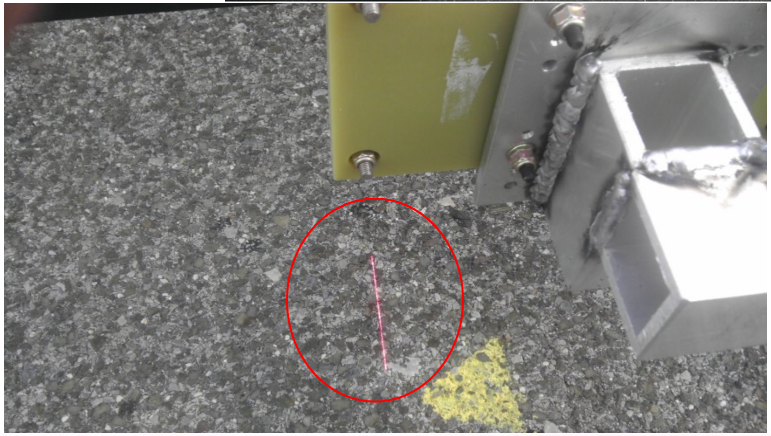
- Methods

  High frequency laser devices

    MPD, RMS

    ROLINE, AMES, etc.

www.amesengineering.com



Problem Statement

- A drawback of laser devices is the presence of "spikes" in the collected data. These spikes make measurements inaccurate and cause erroneous calculated texture (mean profile depth) values. Therefore, identifying and removing these spikes is essential to obtaining accurate MPD measurements.

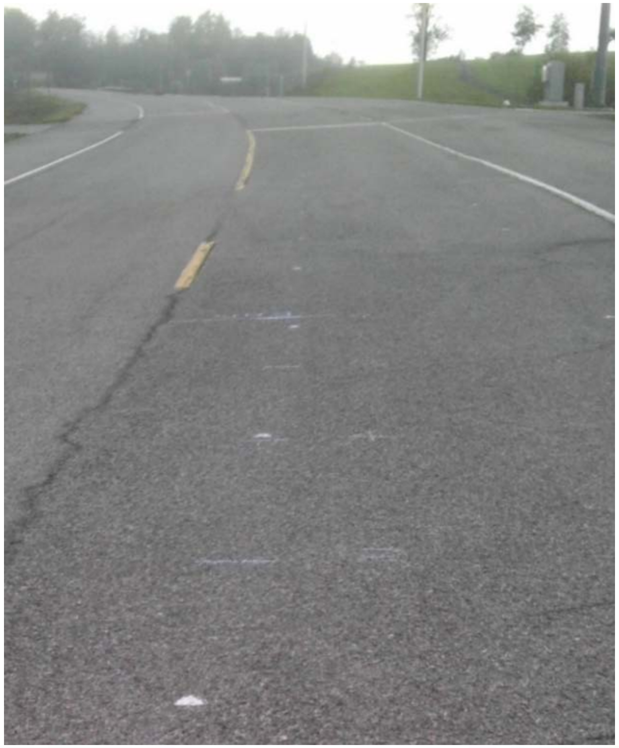
Objective

- (a) Develop a method that can objectively identify and remove the spikes
- (b) Compare the results of the calculated MPD with and without spikes
- (c) Validate the method with MPD measurements obtained with a Circular Texture Meter (CTMeter) taken at the same locations.

Research approach

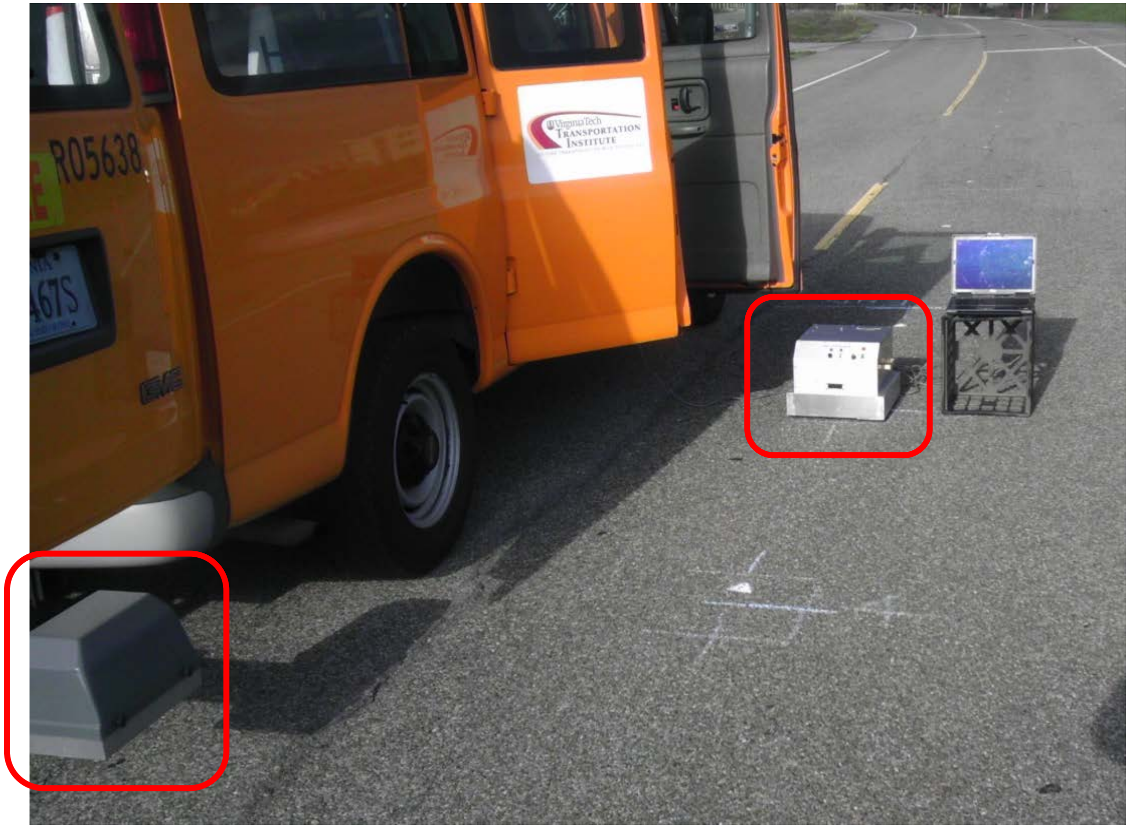
- Test site: Section B on VA Smart road, SM9.5D

- Asphalt section,
- SM: Surface Mix
- H= 38 mm
- MSA: 9.5mm
- D: 70-22



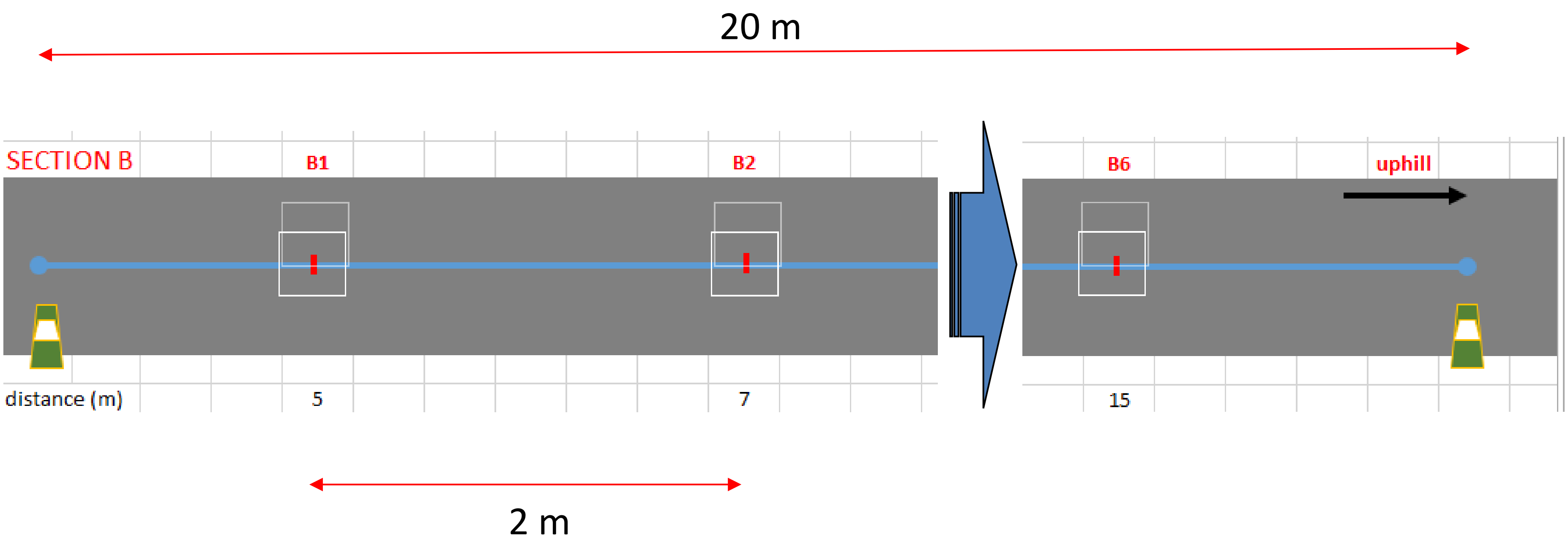
Research approach

- Equipment: CTMeter, HSLD



Research approach

- Measurements setup:



Research approach

- Static Measurements (CTmeter)

6 measurements wheel path, 6 measurements offset, for each location (B1 – B6), i.e. below: B6

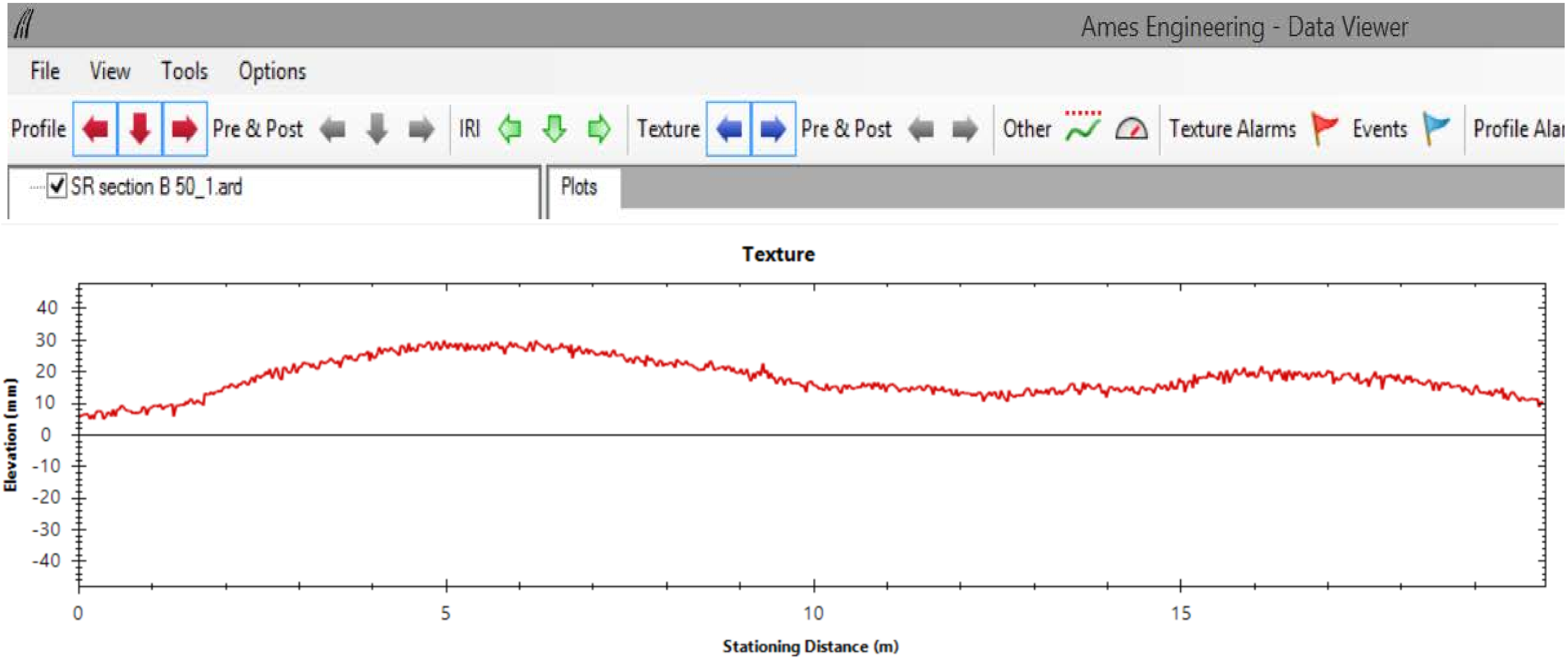
	wheel path							
[1]	A: 1.60(1%)[1.10]	B: 1.12(1%)[0.88]	C: 1.53(0%)[1.97]	D: 1.41(0%)[1.01]	E: 1.01(0%)[0.87]	F: 1.47(3%)[0.90]	G: 1.66(4%)[0.95]	H: 1.41(2%)[0.80]
[2]	A: 1.63(0%)[1.07]	B: 1.13(2%)[0.89]	C: 1.32(0%)[0.70]	D: 1.46(0%)[1.02]	E: 1.01(2%)[0.86]	F: 1.44(5%)[0.89]	G: 1.69(3%)[0.95]	H: 1.47(2%)[0.81]
[3]	A: 1.61(1%)[1.08]	B: 1.17(2%)[0.88]	C: 1.38(0%)[1.00]	D: 1.50(0%)[1.02]	E: 1.02(4%)[0.86]	F: 1.42(4%)[0.86]	G: 1.70(2%)[0.96]	H: 1.40(2%)[0.80]
[4]	A: 1.63(2%)[1.10]	B: 1.15(2%)[0.86]	C: 1.30(0%)[0.71]	D: 1.45(0%)[1.01]	E: 0.99(0%)[0.86]	F: 1.42(4%)[0.87]	G: 1.65(2%)[0.95]	H: 1.45(2%)[0.80]
[5]	A: 1.66(0%)[1.09]	B: 1.14(2%)[0.84]	C: 1.26(0%)[0.69]	D: 1.46(0%)[1.02]	E: 1.05(3%)[0.88]	F: 1.45(3%)[0.86]	G: 1.62(2%)[0.93]	H: 1.22(2%)[0.79]
[6]	A: 1.63(1%)[1.07]	B: 1.10(2%)[0.85]	C: 1.28(0%)[0.70]	D: 1.47(0%)[1.02]	E: 1.01(0%)[0.87]	F: 1.45(4%)[0.89]	G: 1.68(3%)[0.95]	H: 1.22(1%)[0.80]
	offset							
[1]	A: 1.47(0%)[1.02]	B: 1.59(2%)[1.14]	C: 1.52(1%)[1.89]	D: 2.05(0%)[1.47]	E: 1.22(2%)[0.91]	F: 0.88(1%)[1.21]	G: 1.84(0%)[1.36]	H: 1.51(0%)[1.52]
[2]	A: 1.44(0%)[1.01]	B: 1.60(2%)[1.12]	C: 1.55(1%)[1.88]	D: 2.07(0%)[1.47]	E: 1.26(2%)[0.92]	F: 0.91(0%)[1.21]	G: 1.83(1%)[1.36]	H: 1.51(0%)[1.51]
[3]	A: 1.47(0%)[1.02]	B: 1.60(1%)[1.13]	C: 1.57(1%)[1.88]	D: 2.04(0%)[1.47]	E: 1.27(2%)[0.90]	F: 0.89(0%)[1.20]	G: 1.74(2%)[1.33]	H: 1.49(0%)[1.51]
[4]	A: 1.46(1%)[1.02]	B: 1.58(1%)[1.16]	C: 1.48(1%)[1.88]	D: 2.07(0%)[1.48]	E: 1.29(5%)[0.91]	F: 0.86(1%)[1.18]	G: 1.85(0%)[1.36]	H: 1.48(0%)[1.50]
[5]	A: 1.49(0%)[1.02]	B: 1.59(1%)[1.11]	C: 1.52(1%)[1.87]	D: 2.01(0%)[1.47]	E: 1.22(2%)[0.89]	F: 0.90(0%)[1.21]	G: 1.74(2%)[1.32]	H: 1.53(0%)[1.52]
[6]	A: 1.44(1%)[1.03]	B: 1.56(2%)[1.11]	C: 1.47(1%)[1.86]	D: 2.04(0%)[1.45]	E: 1.27(3%)[0.90]	F: 0.97(0%)[1.21]	G: 1.80(1%)[1.34]	H: 1.53(0%)[1.52]

576 calculated MPD measurements (100 mm)

Research approach

- Measurements

5 measurements wheel path 50 mph along 20 m., i.e. below: run 1 at 50 mph



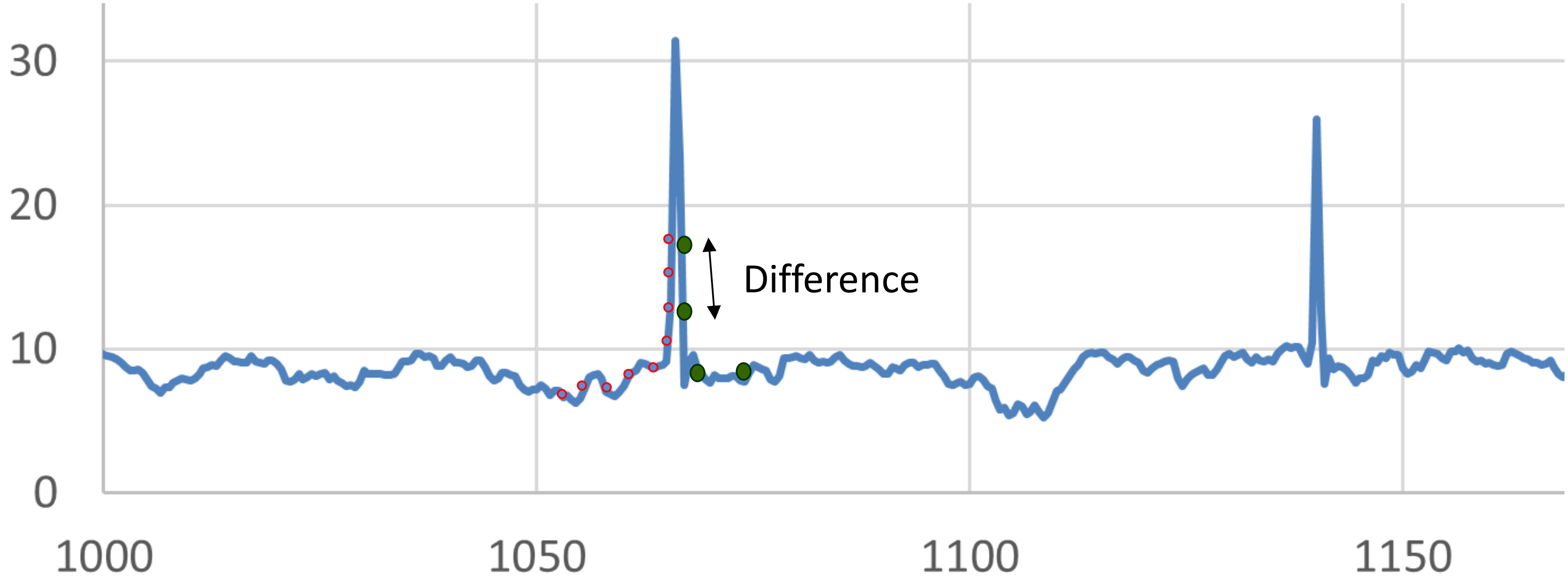
1,000 calculated MPD Measurements (100 mm)

Research approach

- Spikes' identification
  - Discrete Wavelet transform
    - Transform the signal into another representation which presents the signal information in a more useful form
    - DWT "decompose" the signal, using discrete values of the dilation and translation
    - Discrete Wavelet Transform type Haar, allows to look for 'differences' between adjacent data points at different levels

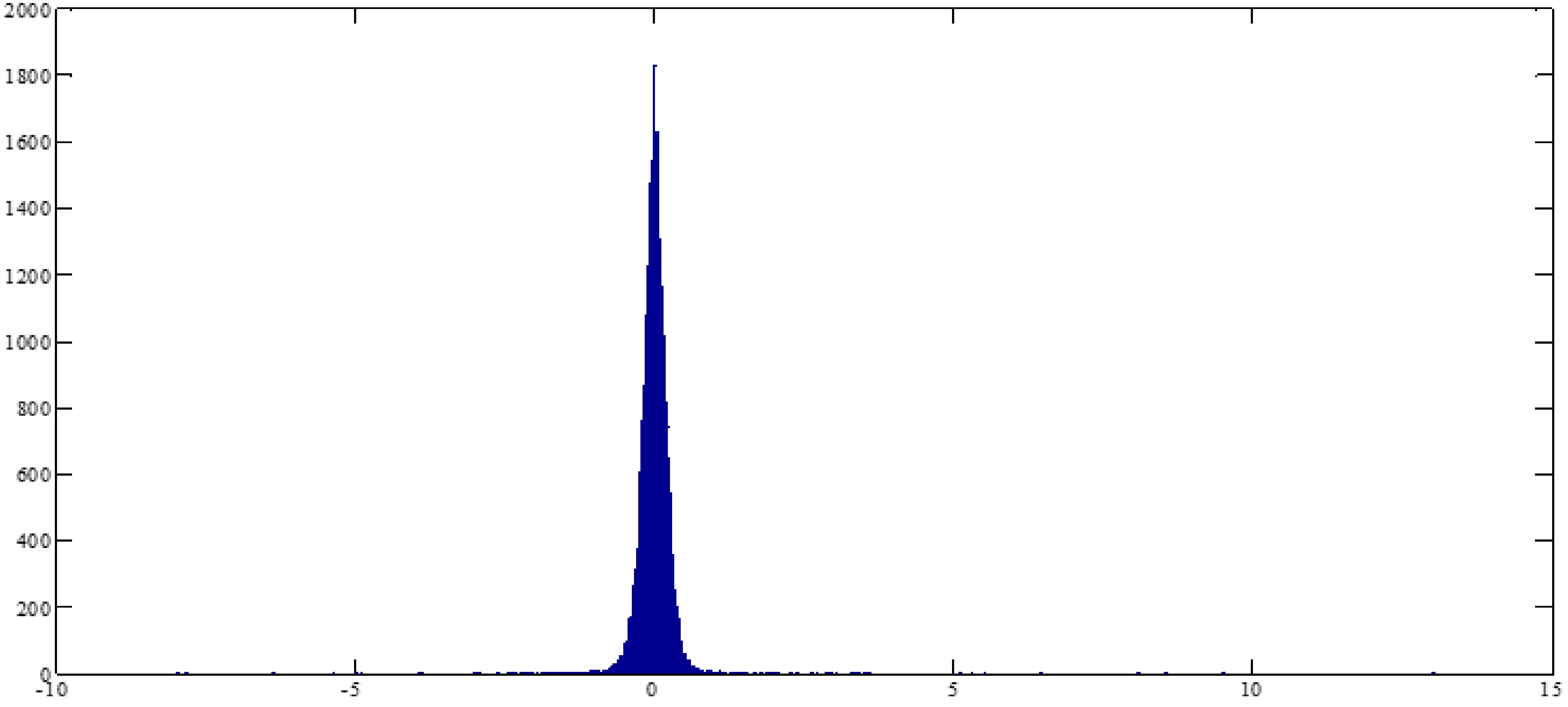
Research approach

- Spikes' identification



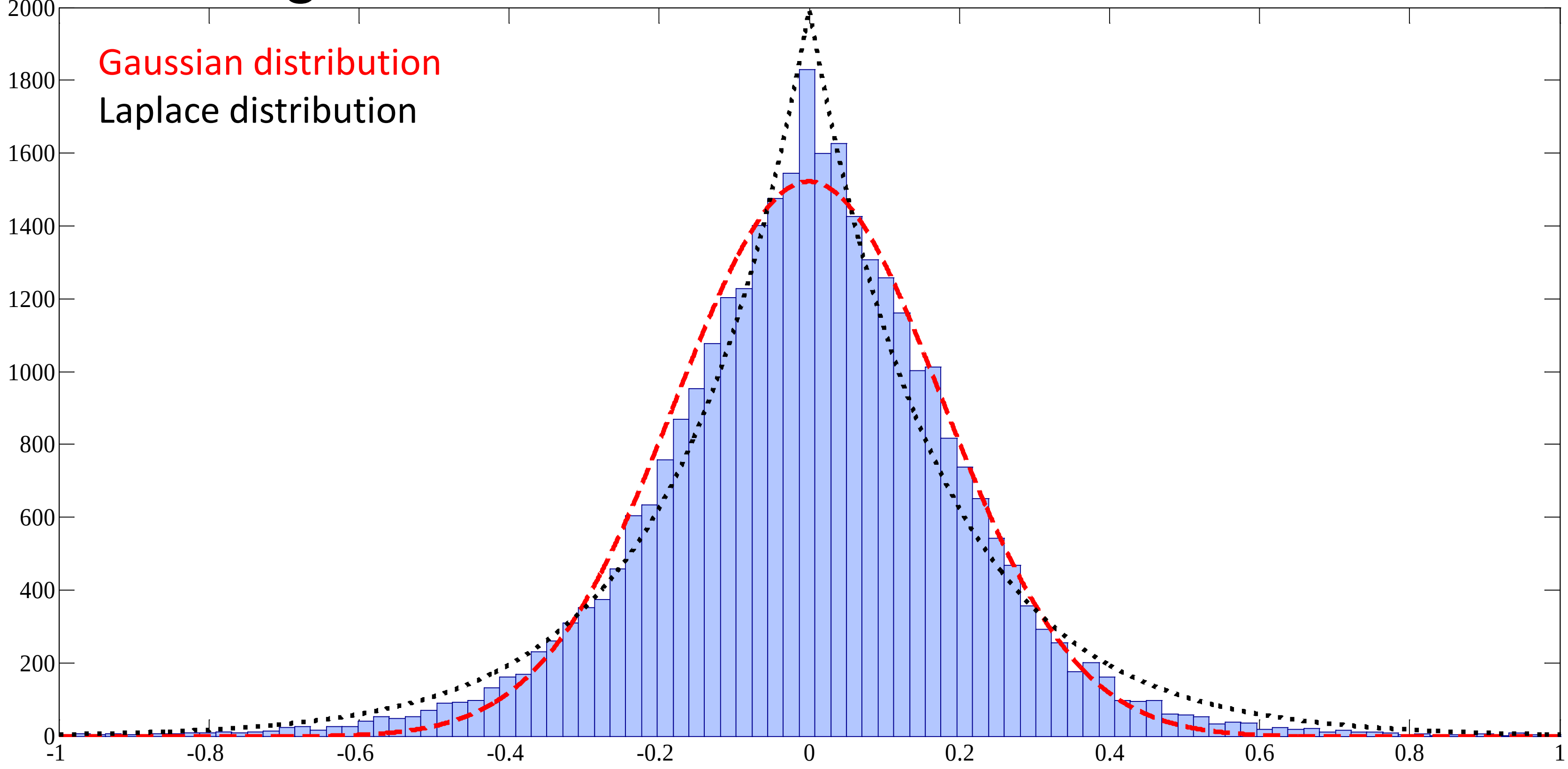
Research approach

- Spikes removal
  - Histogram for the differences (finest scale)



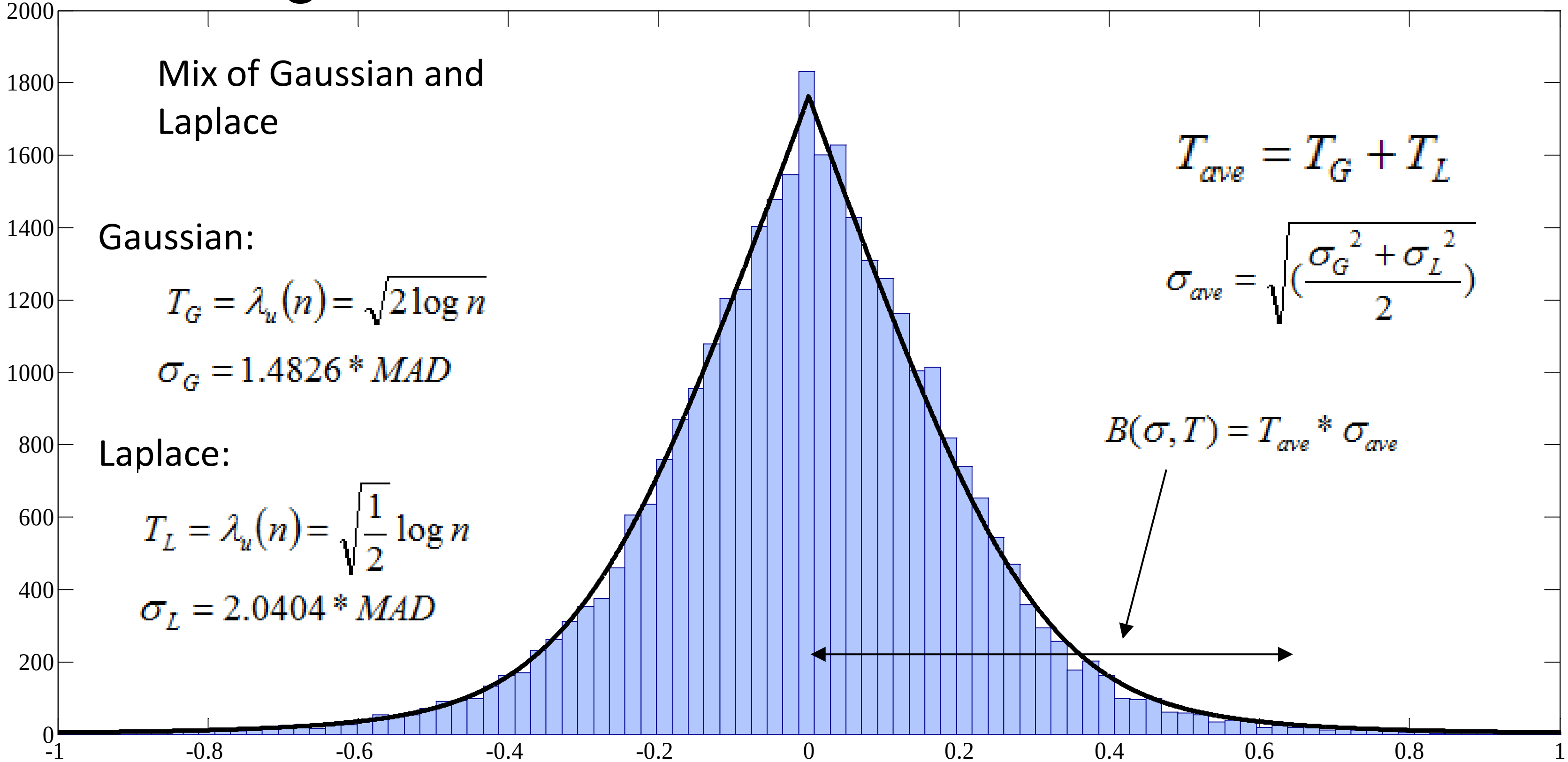
Research approach

- Spikes removal
  - Histogram for the differences



Research approach

- Spikes removal
  - Histogram for the differences



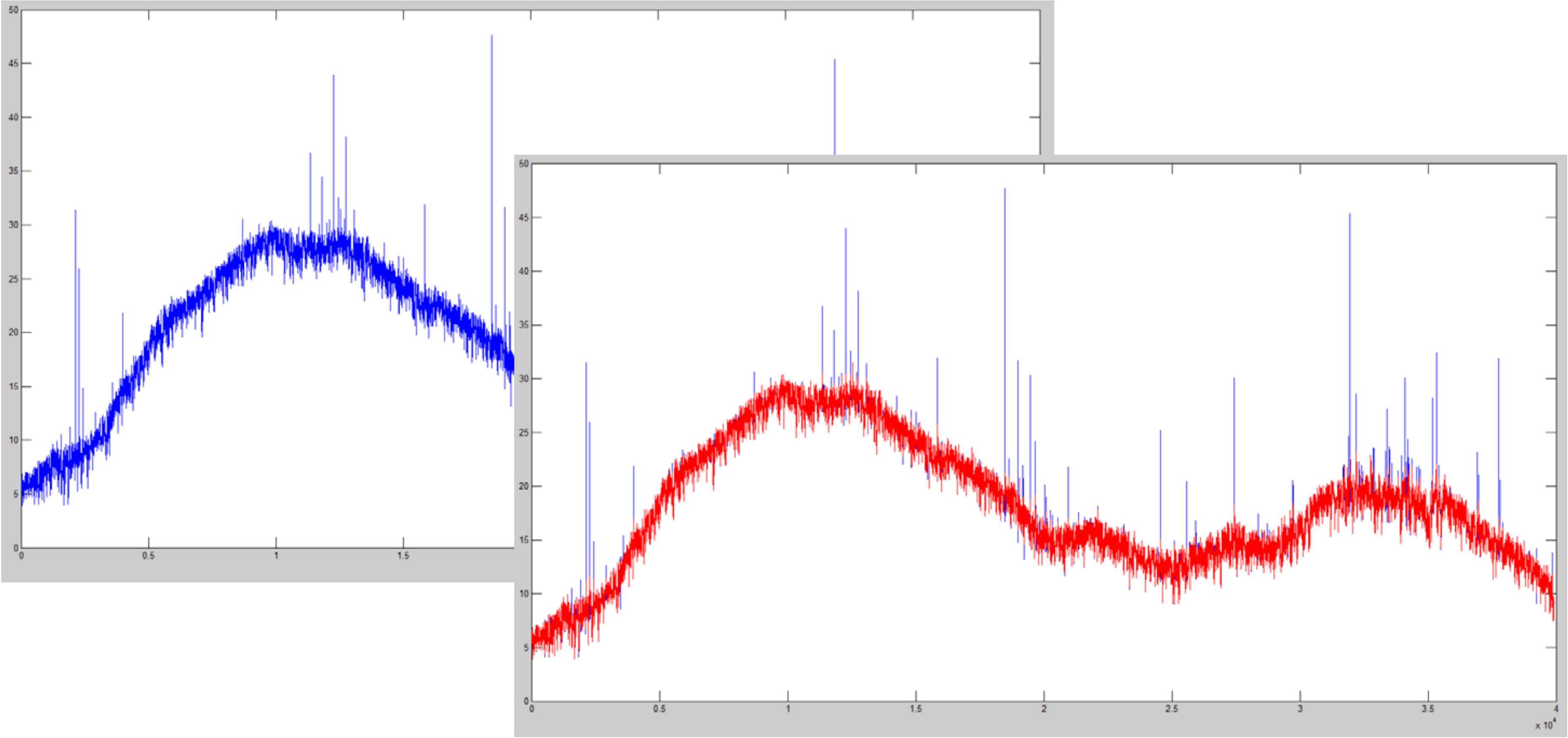
Research approach

- After spikes removal and re-composition of the original data (now without spikes):

- MPD calculation
  - According to the ASTM E1845-09
  - A moving average 2.5 mm low-pass filter was applied before the finding of the MPD
  - The relative slope was also removed before

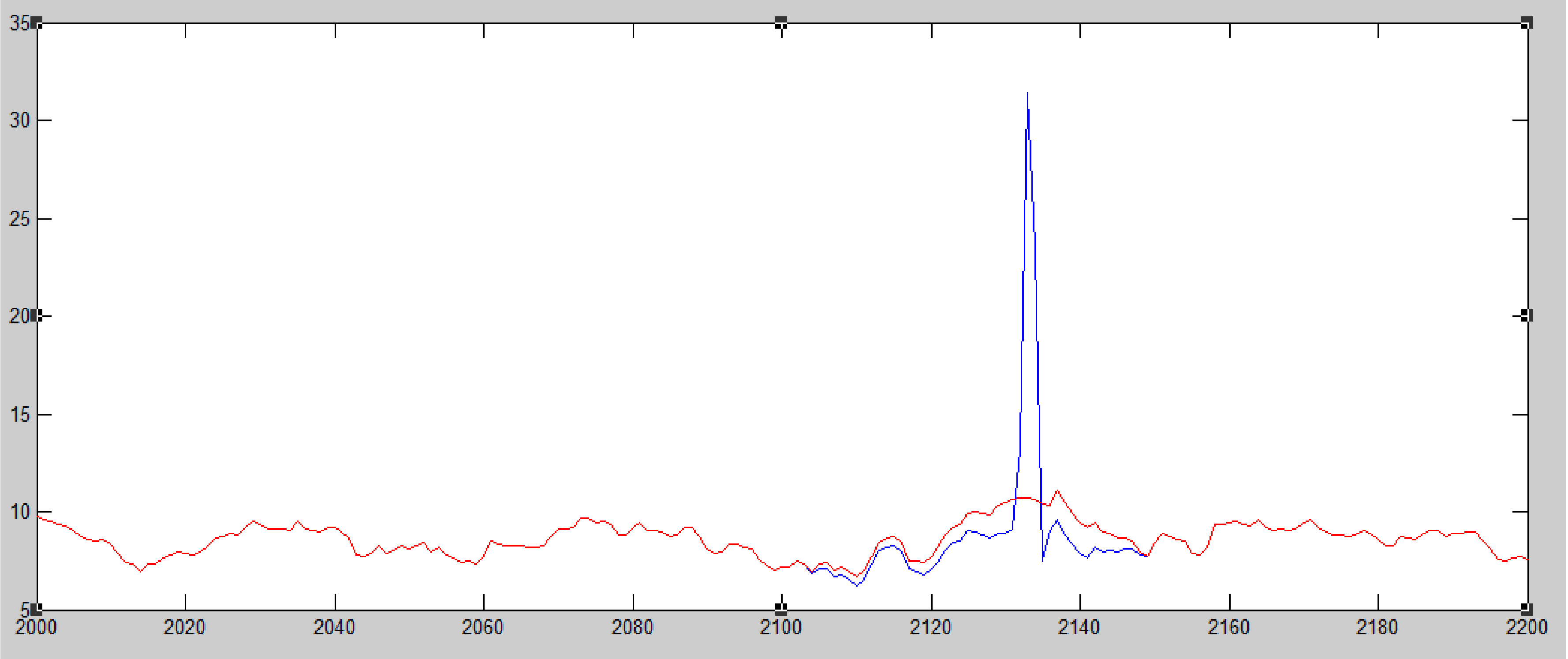
Results

- Spikes removal



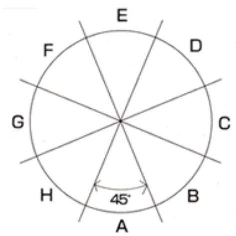
Results

- Spikes removal
  - Data points every 0.5 mm (100mm of data)

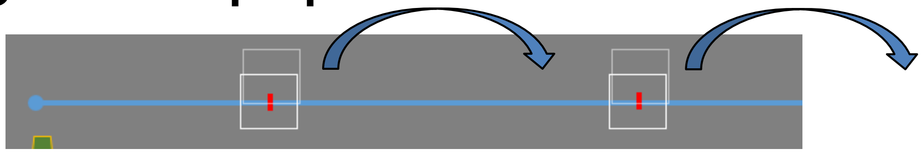


Results

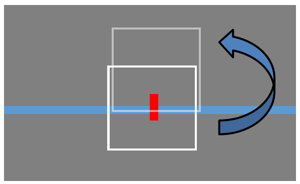
- N-way ANOVA test → to see the influence of all variables involved on the CTmeter measurements:
  - the influence of the measurements for different sectors



  - the influence of moving the equipment longitudinally, and



  - the influence of moving the equipment transversally along the wheel path.



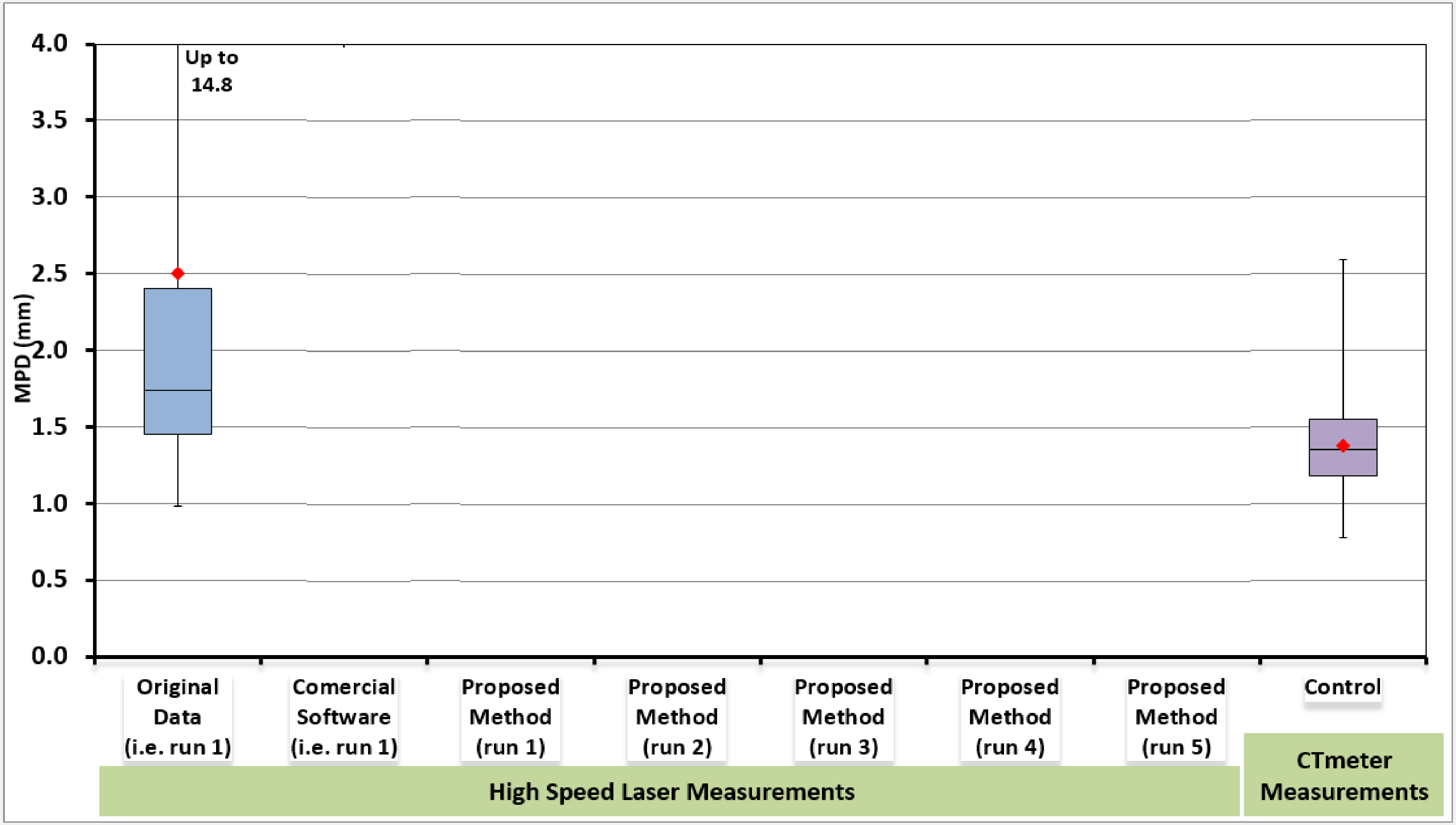
Results

Analysis of Variance

Source	Sum Sq.	d.f.	Mean Sq.	F	Prob>F
X1	0.03974	1	0.03974	0.46	0.5016
X2	0.4261	5	0.08522	0.98	0.437
X3	0.74054	7	0.10579	1.21	0.3053
Error	7.15424	82	0.08725		
Total	8.36063	95			

- all p-values for the three analyzed variables are far from being small (p-values → 0 are significant),
- Indicating that none of the variables are significant in the results for a 95% confidence,
- → the analysis was made considering all the 576 values as individual MPD values for the validation

Results



4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
MPD (mm)
Up to 14.8
Original Data (i.e. run 1)
Comercial Software (i.e. run 1)
Proposed Method (run 1)
Proposed Method (run 2)
Proposed Method (run 3)
Proposed Method (run 4)
Proposed Method (run 5)
Control
High Speed Laser Measurements
CTmeter Measurements

Conclusions

- **The <u>CTmeter sectors, spatial location</u> (longitudinally, transversally) <u>did not have an effect</u> on the MPD. →This <u>allowed us to confidently compare</u> measurement from the high speed device and the CTmeter without having to worry about exactly matching the location of measurements.**
- **<u>Spikes</u> in the measurements collected with the HSLD resulted in <u>MPD values that were about 50% higher</u> than those provided by the CTmeter. Removing the spikes with the proposed method <u>resulted in mean MPD</u> calculated from the high-speed device that were <u>essentially the same</u> as the one calculated from the CTmeter.**

Thank you for your attention