2020

WEBINAR SERIES

RPUG
Road Profile Users' Group

Roughness Considerations Related to Roadway Design

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Outline

- Roughness of basic shapes
- Preliminary examples
- Practical example, design profile
- Practical example, signal processing considerations

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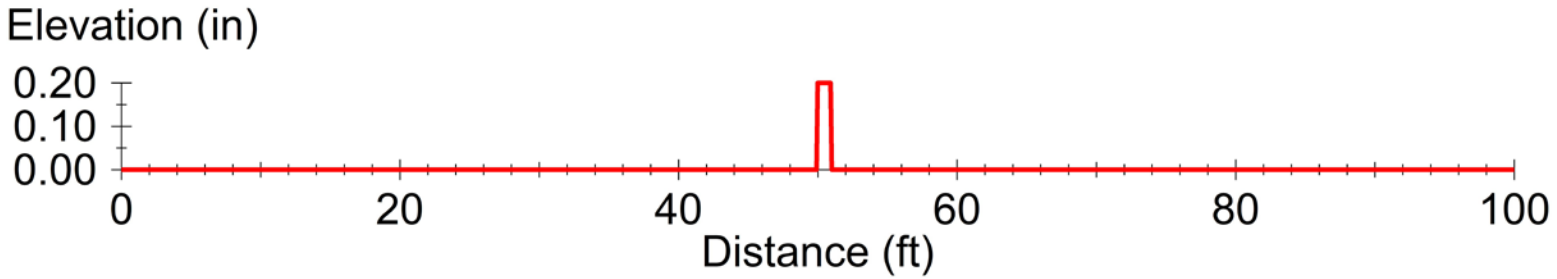
Basic Shapes

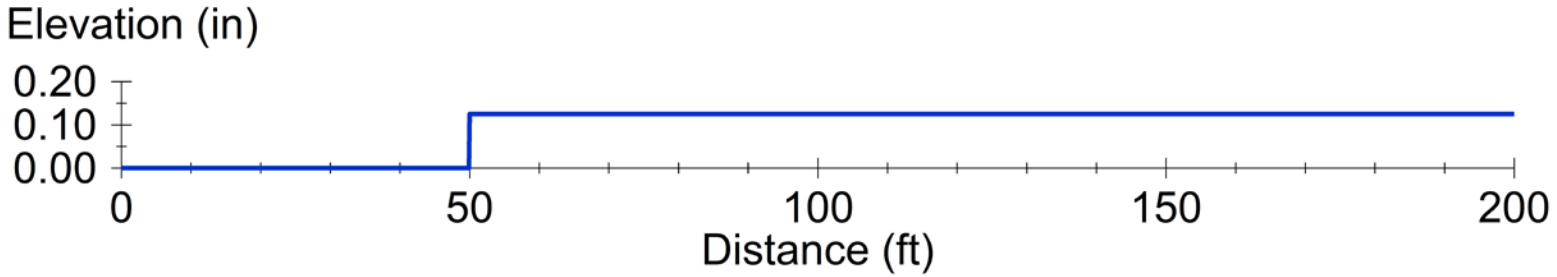
Cleat
0.2”x1’
3.83 in/mi (0.060 m/km)

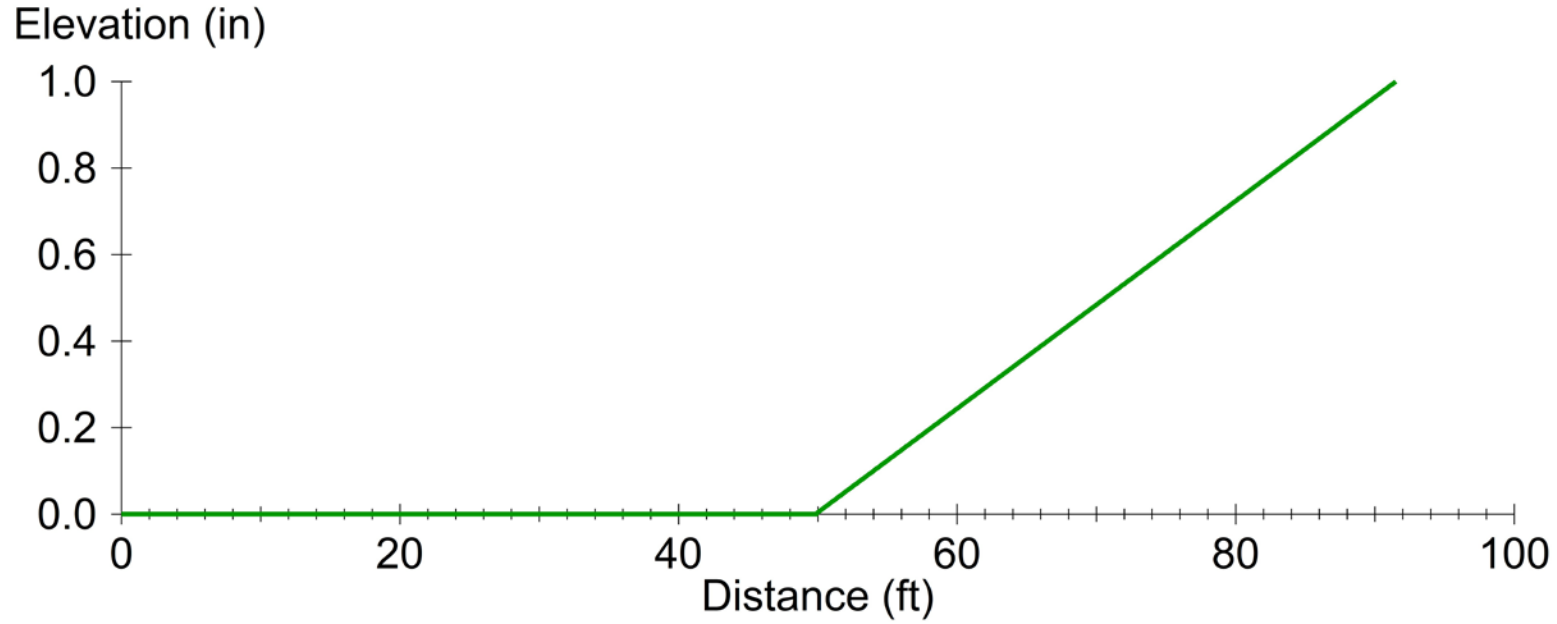
Step
0.125”
4.30 in/mi (0.68 m/km)

Ramp
0.2%
4.21 in/mi (0.66 m/km)

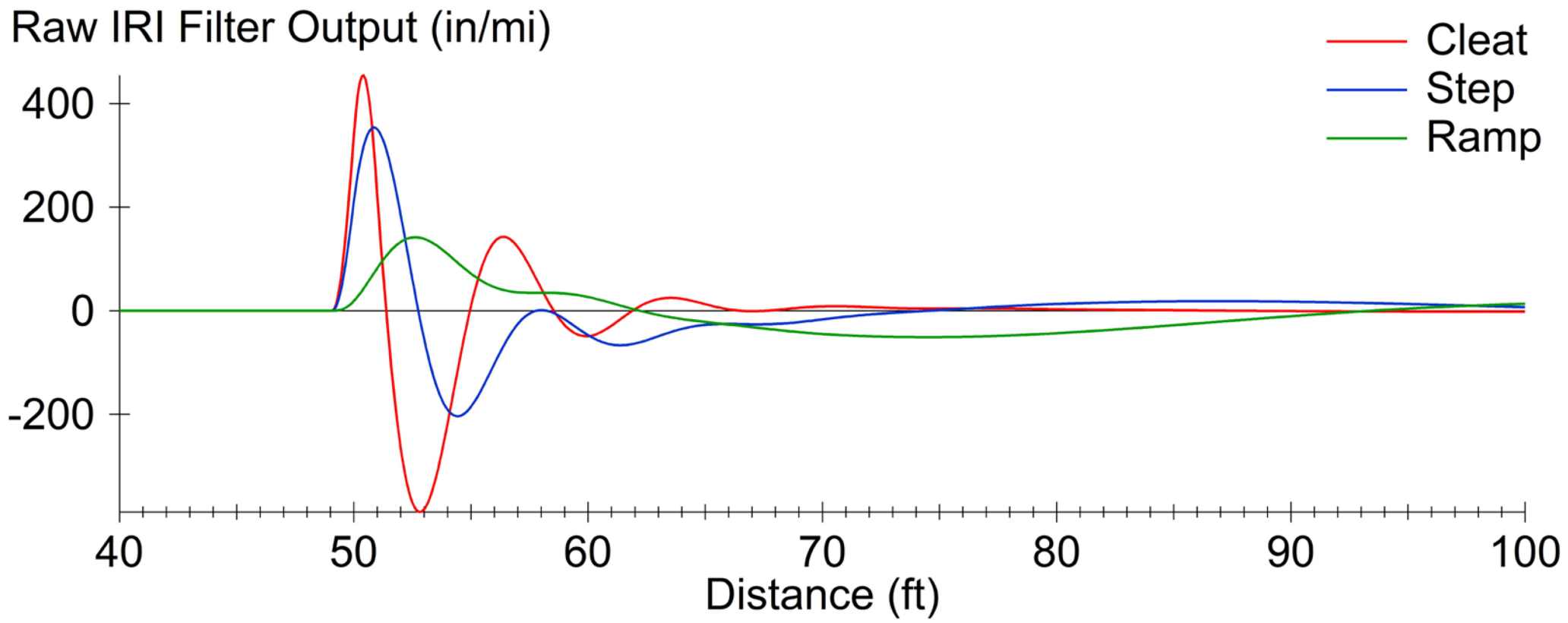
Roughness is per 0.1 mi (160.9 m)





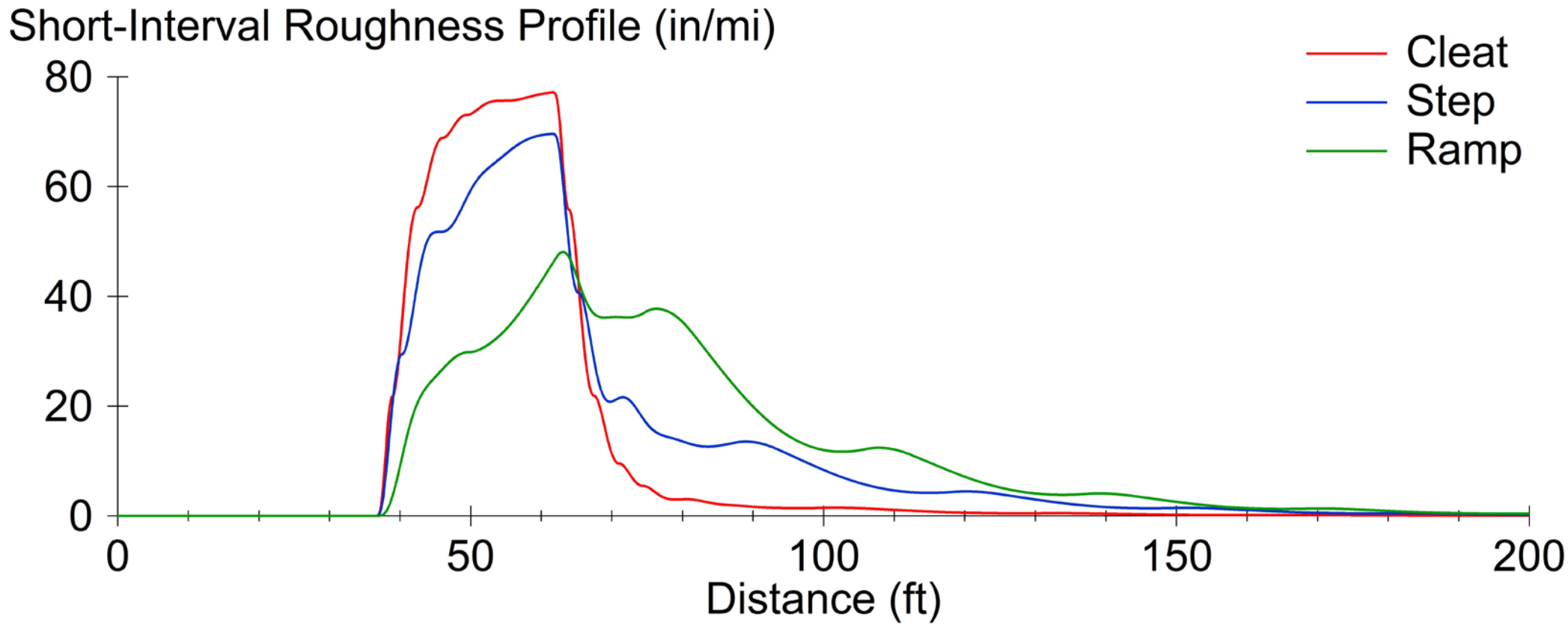


Basic Shapes, IRI Filter Response



Response to the cleat is more isolated.
Response to the (slope break at the start of the) ramp is more spread out.

Basic Shapes, Short-Interval Roughness Profile



Base length of 25 ft (7.62 m).

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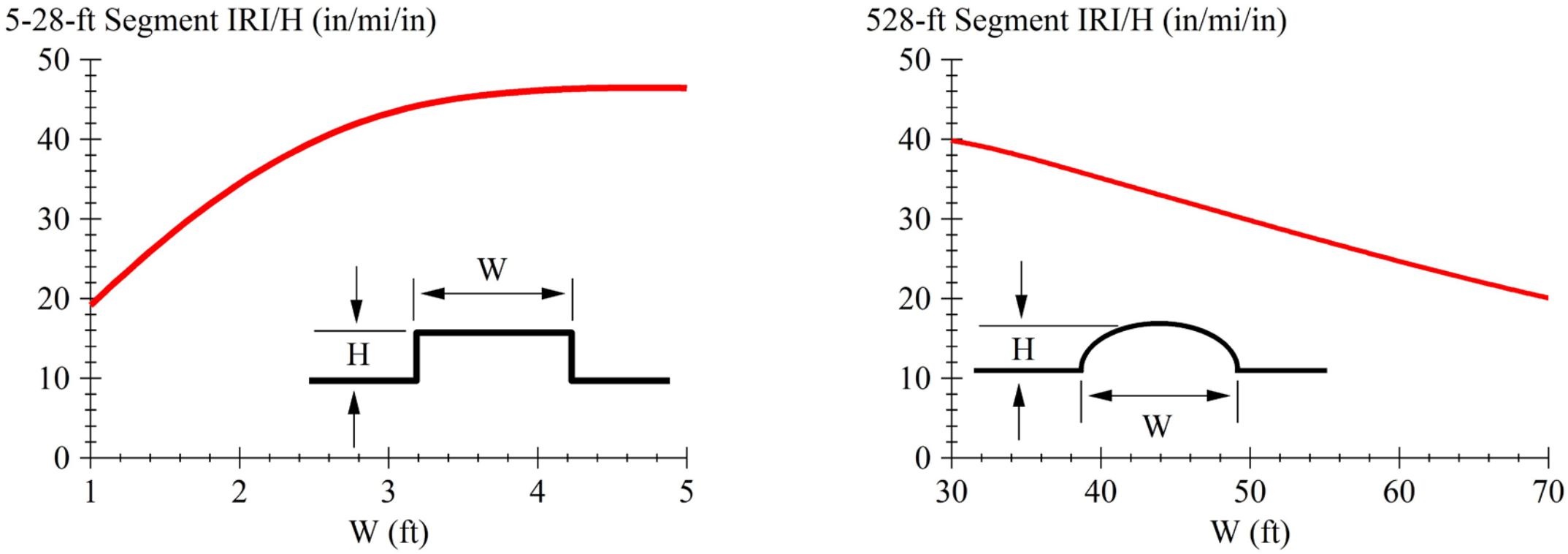
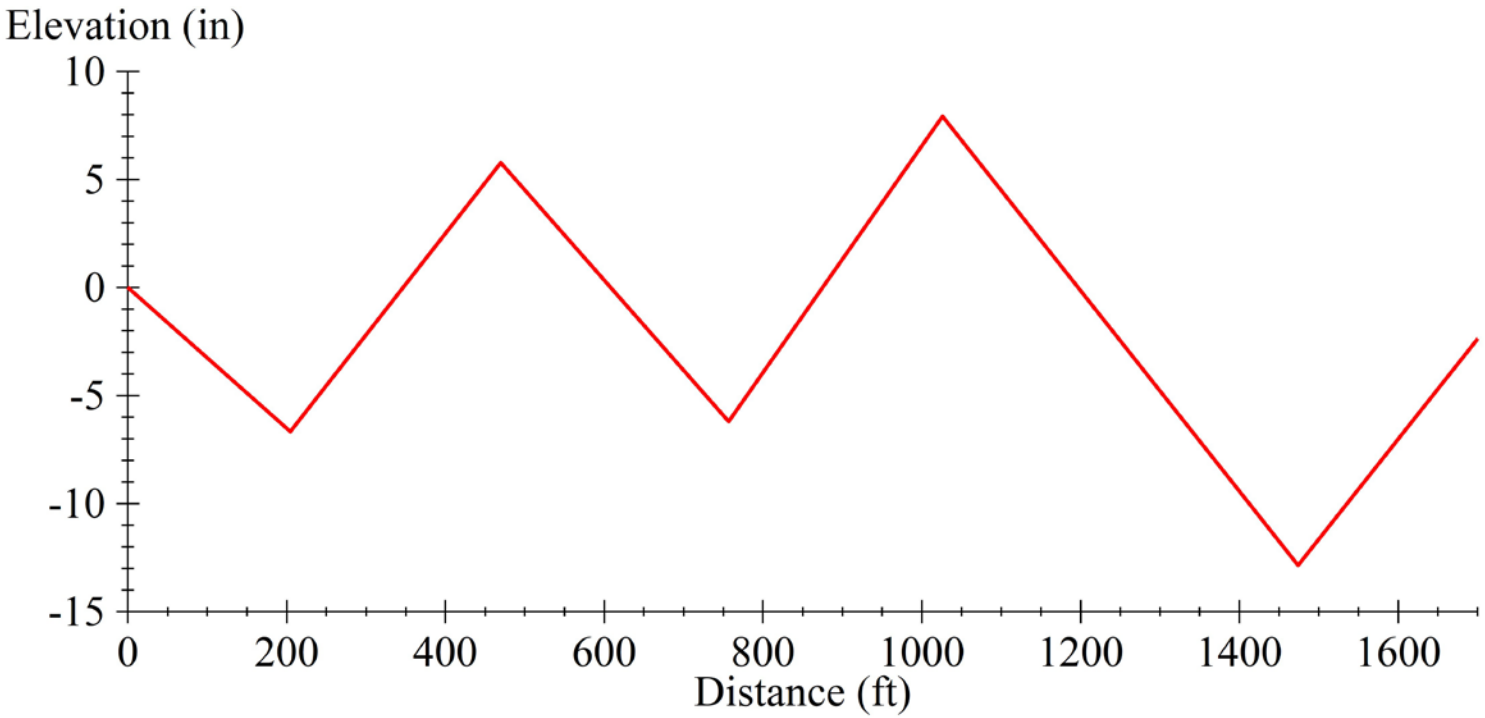
Roughness of Idealized Shapes



Karamihas, S. M., et al.. "Measuring, Characterizing, and Reporting Pavement Roughness of Low-Speed and Urban Roads." National Cooperative Highway Research Program Report 914 (2019).

Grades to Support Drainage



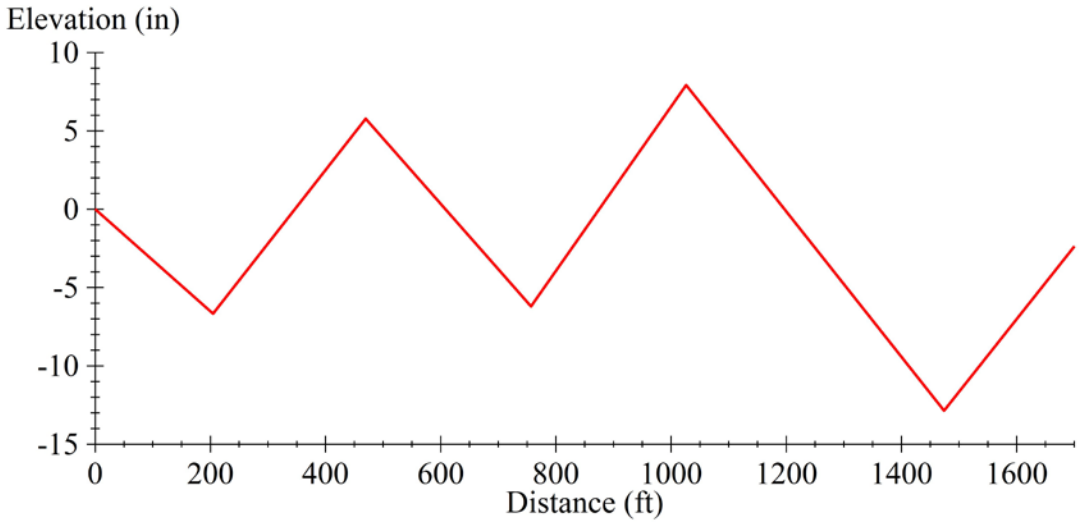
Grade Breaks (%)

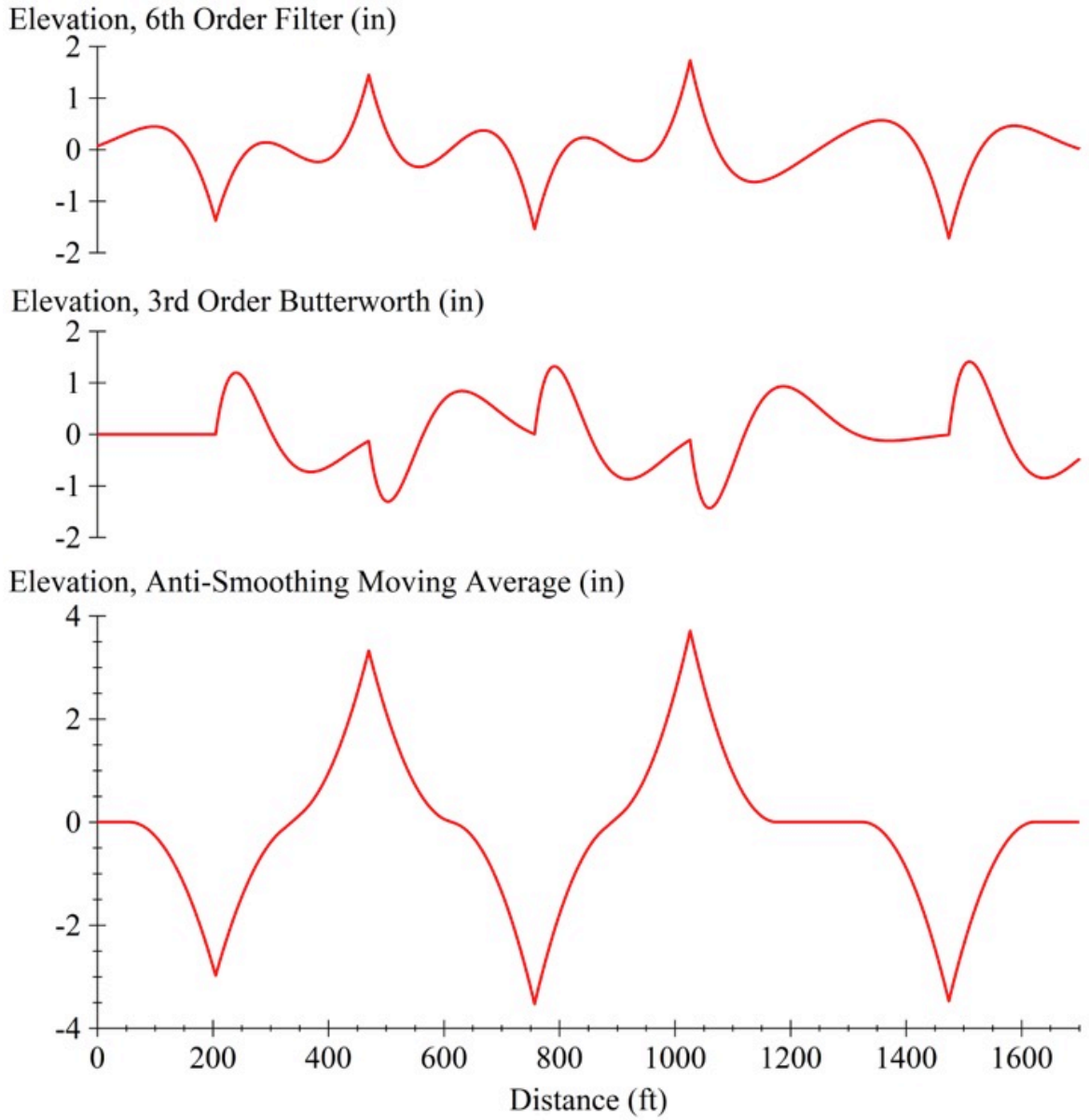
+0.67
-0.75
+0.79
-0.83
+0.78

Average IRI = 24.70 in/mi (0.390 m/km)
The grade breaks do not interact.

Reggin, A, et al.. 2008. “Urban considerations for Using Road Roughness To Manage Road Networks.” 7th International Conference on Managing Pavement Assets, Calgary, Alberta.

Filtering

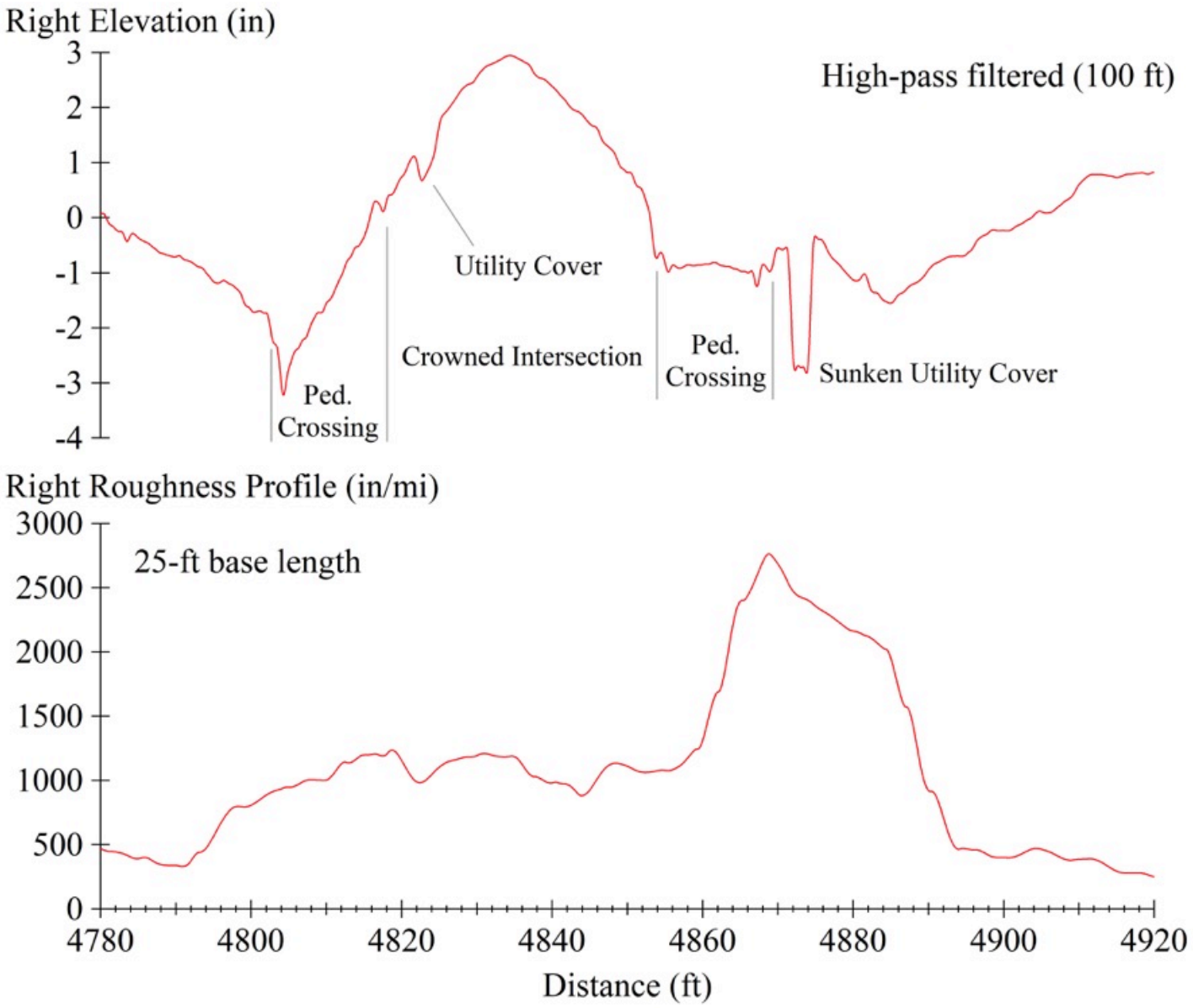




High-pass filtering will distort the geometry.

Karamihas, S. M., et al.. “Measuring, Characterizing, and Reporting Pavement Roughness of Low-Speed and Urban Roads.” National Cooperative Highway Research Program Report 914 (2019).

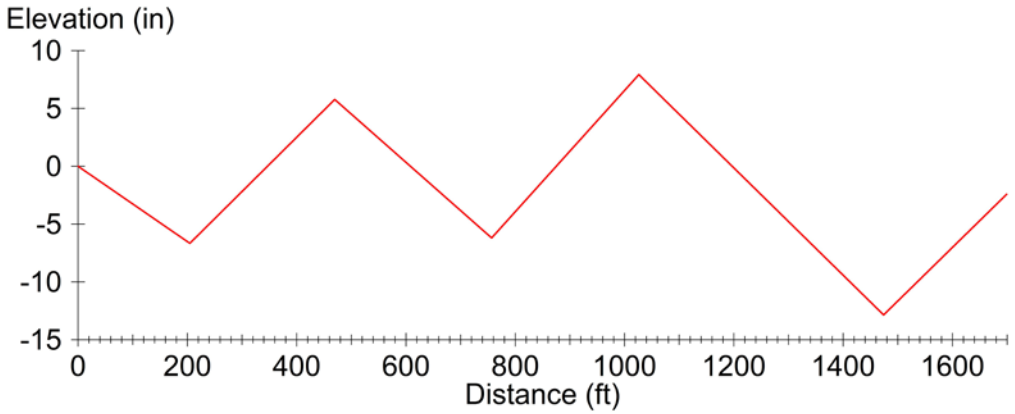
Urban Intersection



Built in items often interact.

Karamihas, S. M., et al.. “Measuring, Characterizing, and Reporting Pavement Roughness of Low-Speed and Urban Roads.” National Cooperative Highway Research Program Report 914 (2019).

Design Profile Plus Construction Defects



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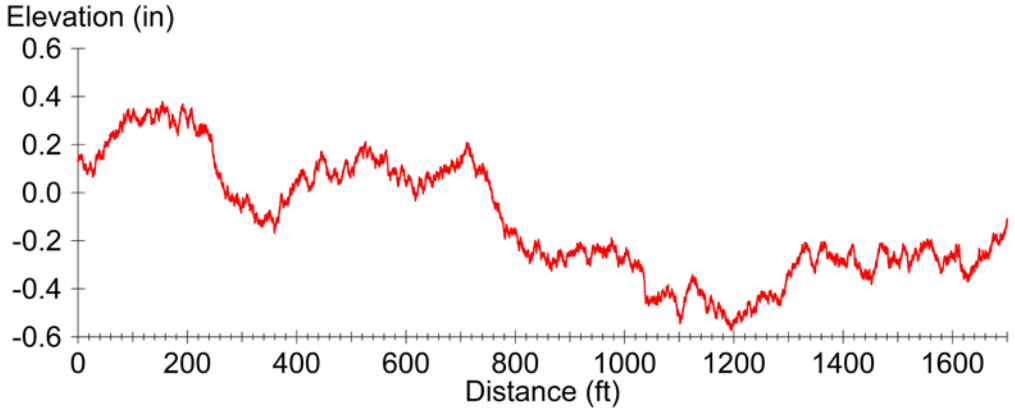

Design Profile IRI = 24.70 in/mi (0.390 m/km)
Background Roughness IRI = 50.00 in/mi (0.789 m/km)

Combined Profile IRI = 64.58 in/mi (1.019 m/km)

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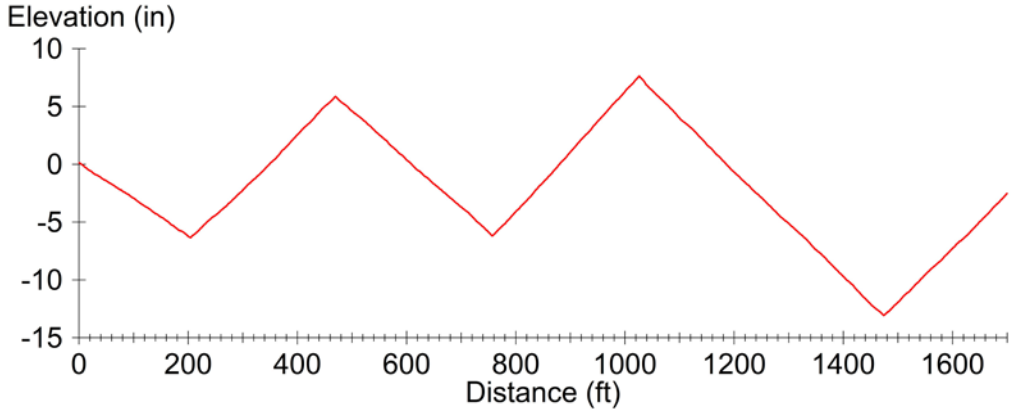

The total roughness is not the sum of the components.

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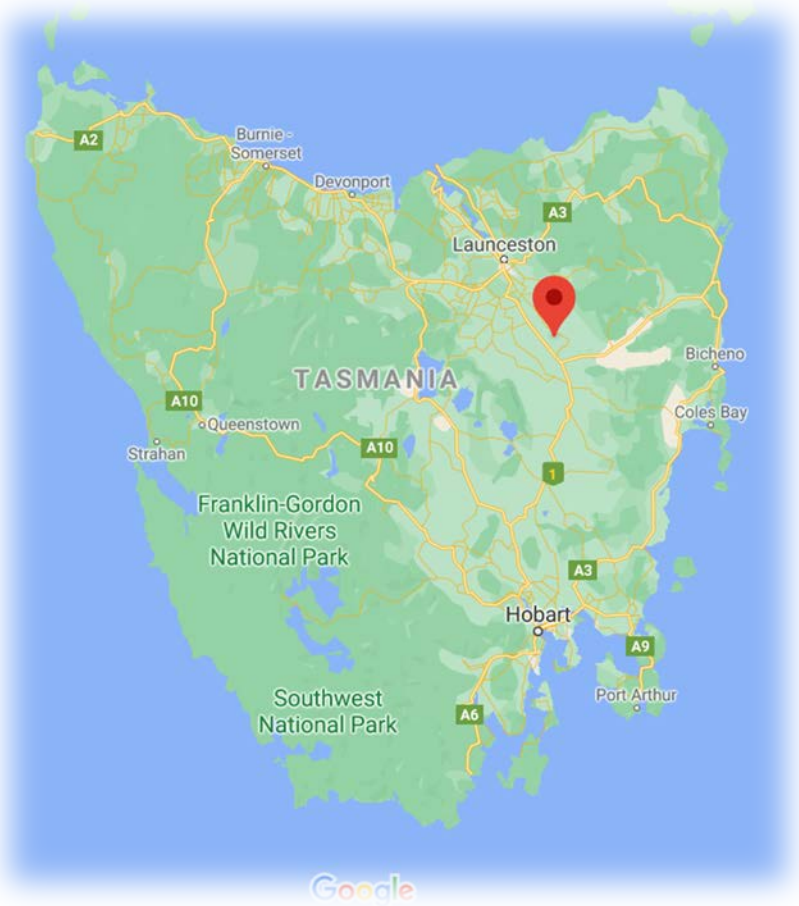
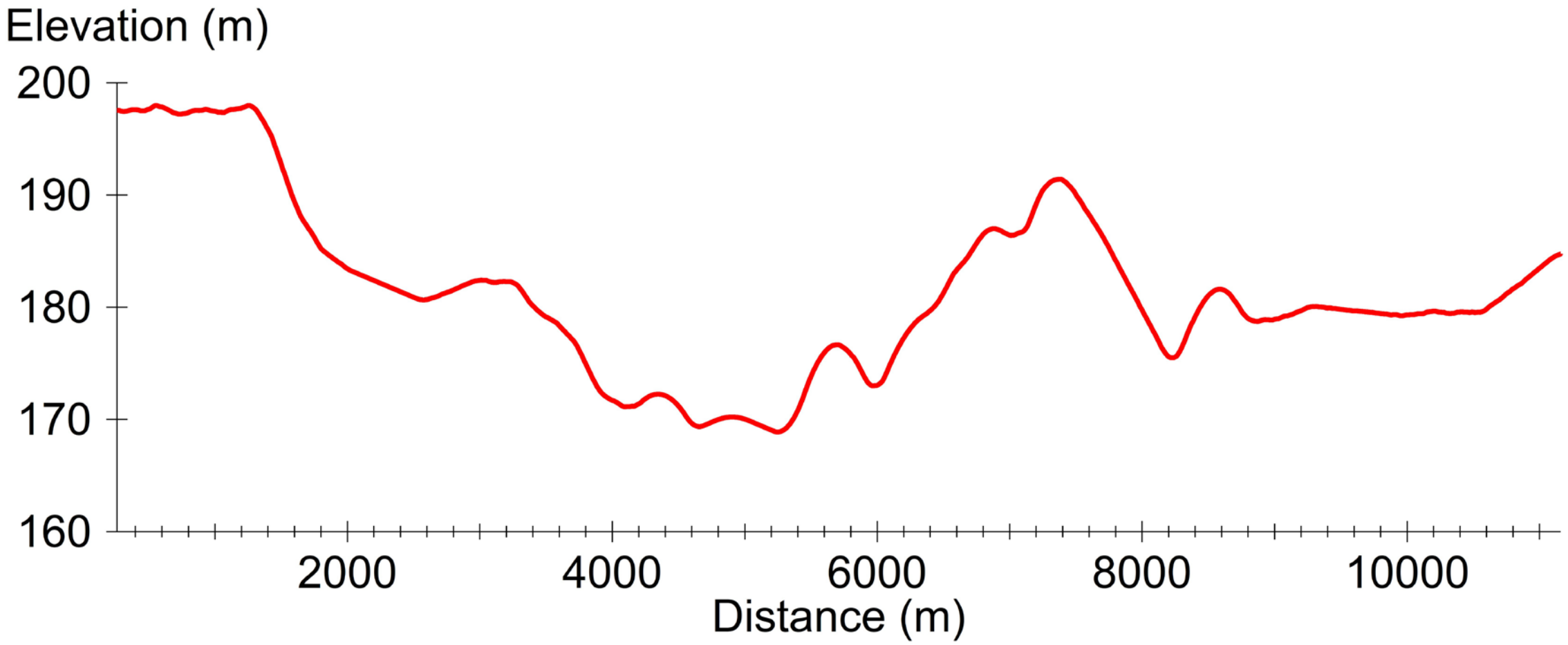
Midland Highway Segment Design

	Chainage	Elevation	Height change (m)	Approach gradient	Departure gradient	Grade Change
VPOB	260	197.538	0		0.10%	
VPI	270	197.549	0.0001	0.10%	-0.21%	-0.32%
VPI	280	197.527	-0.0001	-0.21%	-0.54%	-0.33%
VPI	290	197.474	-0.0003	-0.54%	-0.23%	0.31%
VPI	300	197.451	-0.0001	-0.23%	-0.08%	0.15%
VPI	310	197.443	0.0000	-0.08%	0.05%	0.13%
VPI	320	197.448	0.0000	0.05%	0.08%	0.03%
VPI	330	197.456	0.0000	0.08%	0.33%	0.26%
VPI	340	197.489	0.0002	0.33%	0.37%	0.04%
VPI	350	197.526	0.0002	0.37%	0.37%	0.00%
VPI	360	197.563	0.0002	0.37%	0.36%	-0.01%
VPI	370	197.592	0.0001	0.29%	0.09%	-0.20%
VPI	380	197.601	0.0000	0.09%	0.02%	-0.07%
VPI	390	197.602	0.0000	0.02%	0.00%	-0.02%
VPI	400	197.602	0.0000	0.00%	-0.07%	-0.07%
VPI	410	197.596	0.0000	-0.07%	-0.14%	-0.07%
VPI	420	197.582	-0.0001	-0.14%	-0.39%	-0.25%
VPI	430	197.542	-0.0002	-0.42%	-0.41%	0.01%
VPI	440	197.502	-0.0002	-0.41%	-0.08%	0.33%
VPI	450	197.493	0.0000	-0.08%	0.05%	0.13%
VPI	460	197.498	0.0000	0.05%	0.08%	0.03%
VPI	470	197.506	0.0000	0.08%	0.49%	0.41%
VPI	480	197.555	0.0002	0.49%	0.66%	0.17%
VPI	490	197.62	0.0003	0.66%	0.20%	-0.45%

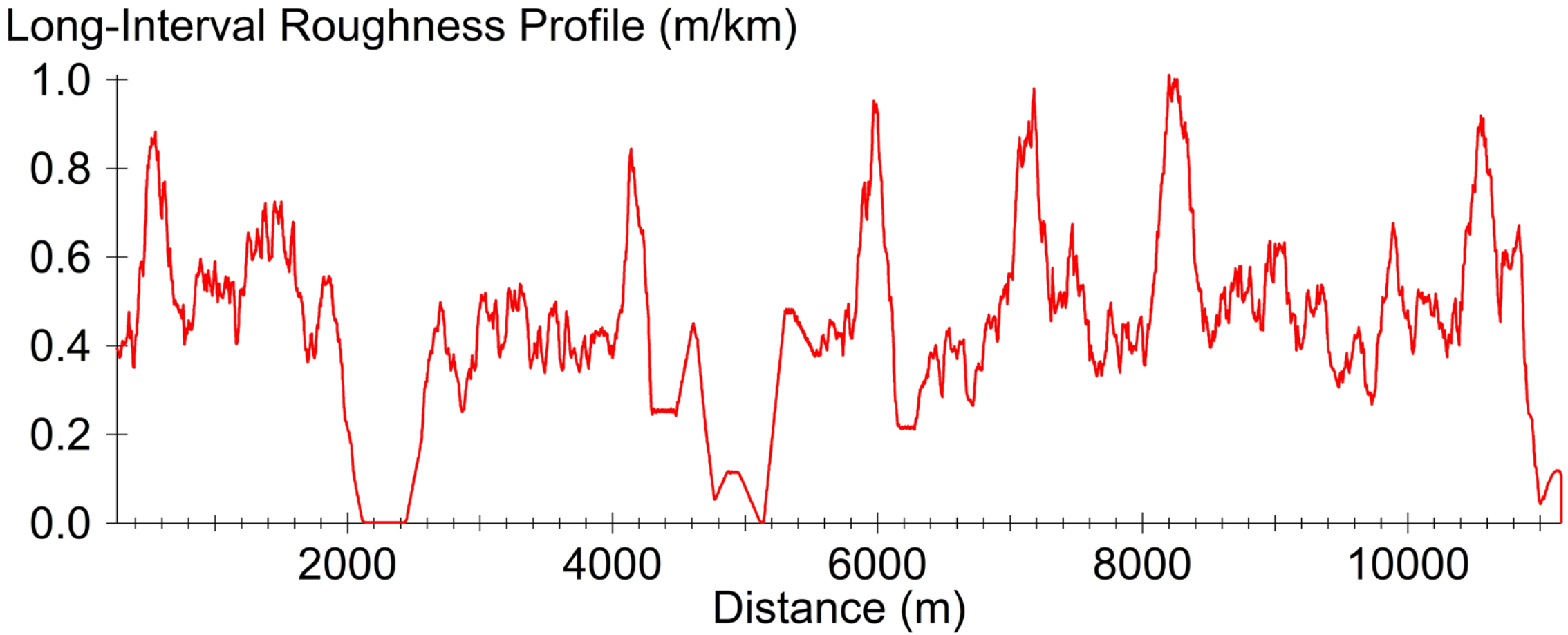


Midland Highway Segment Design Profile



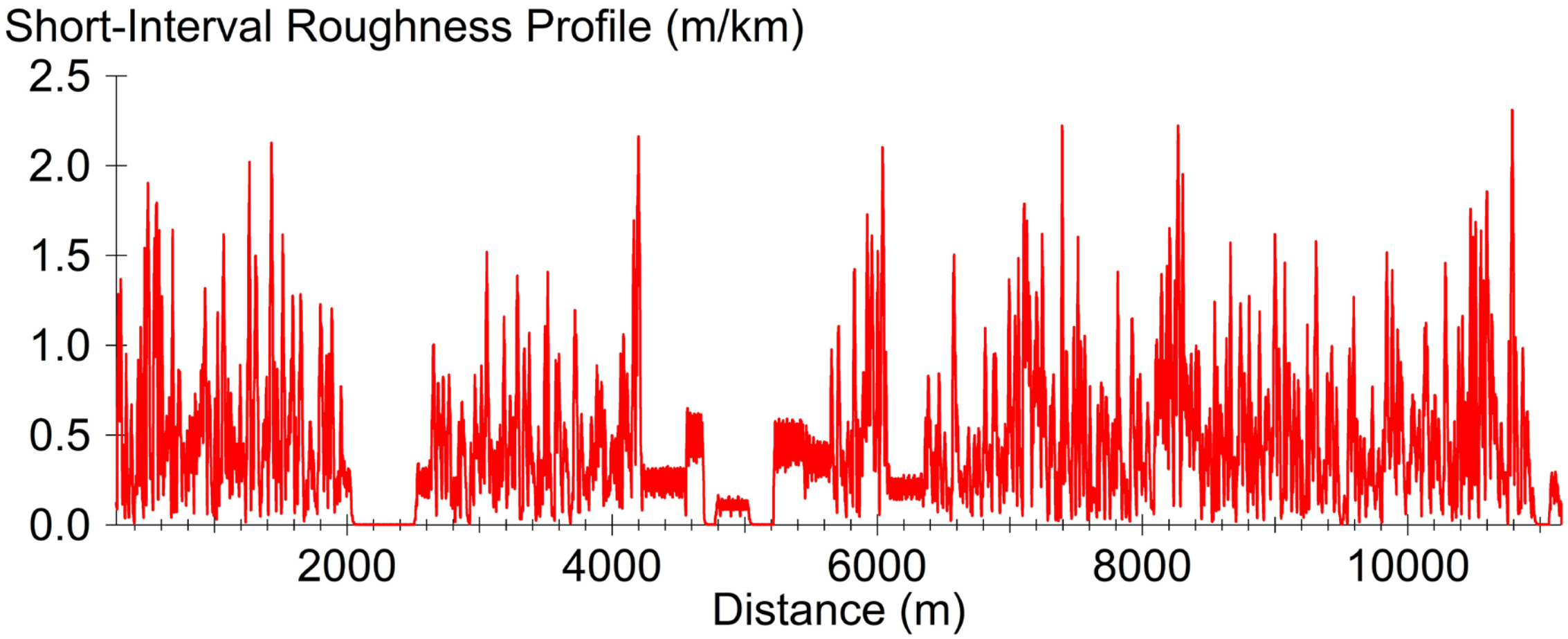
Average IRI = 0.443 m/km (28.1 in/mi)

Long-Interval Roughness Profile



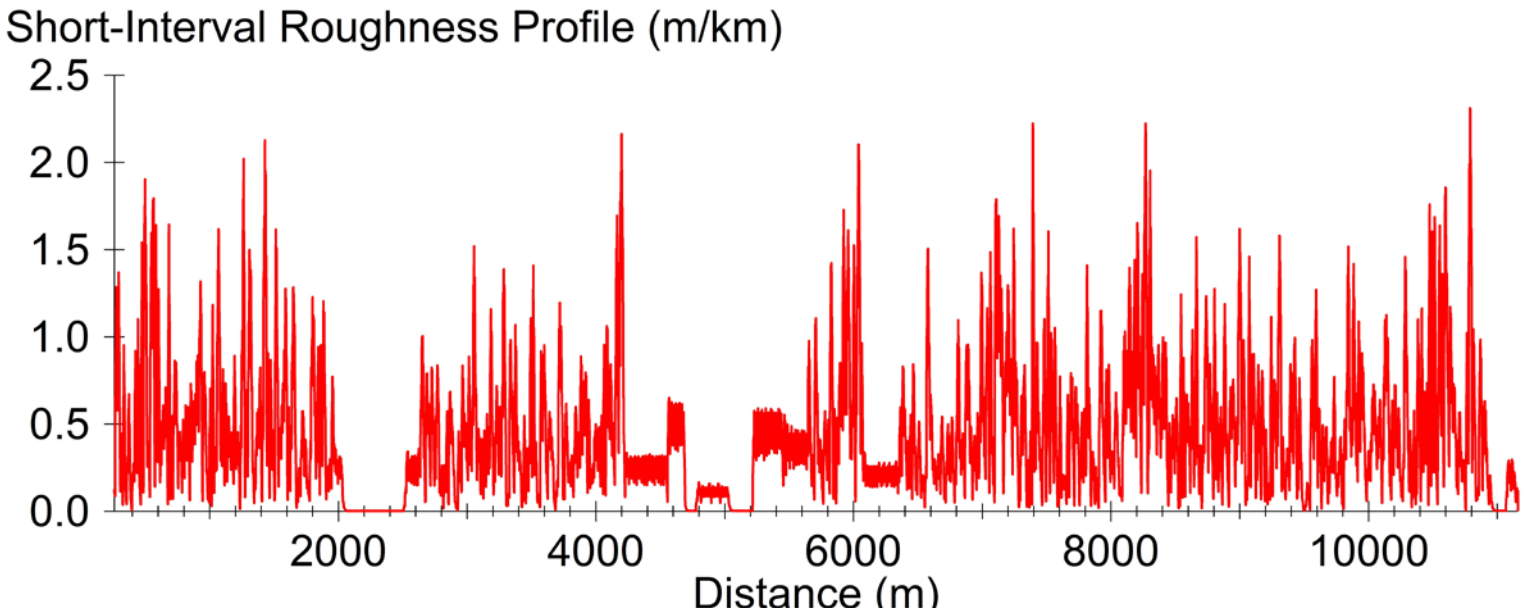
Base length 160.9 m (528 ft)

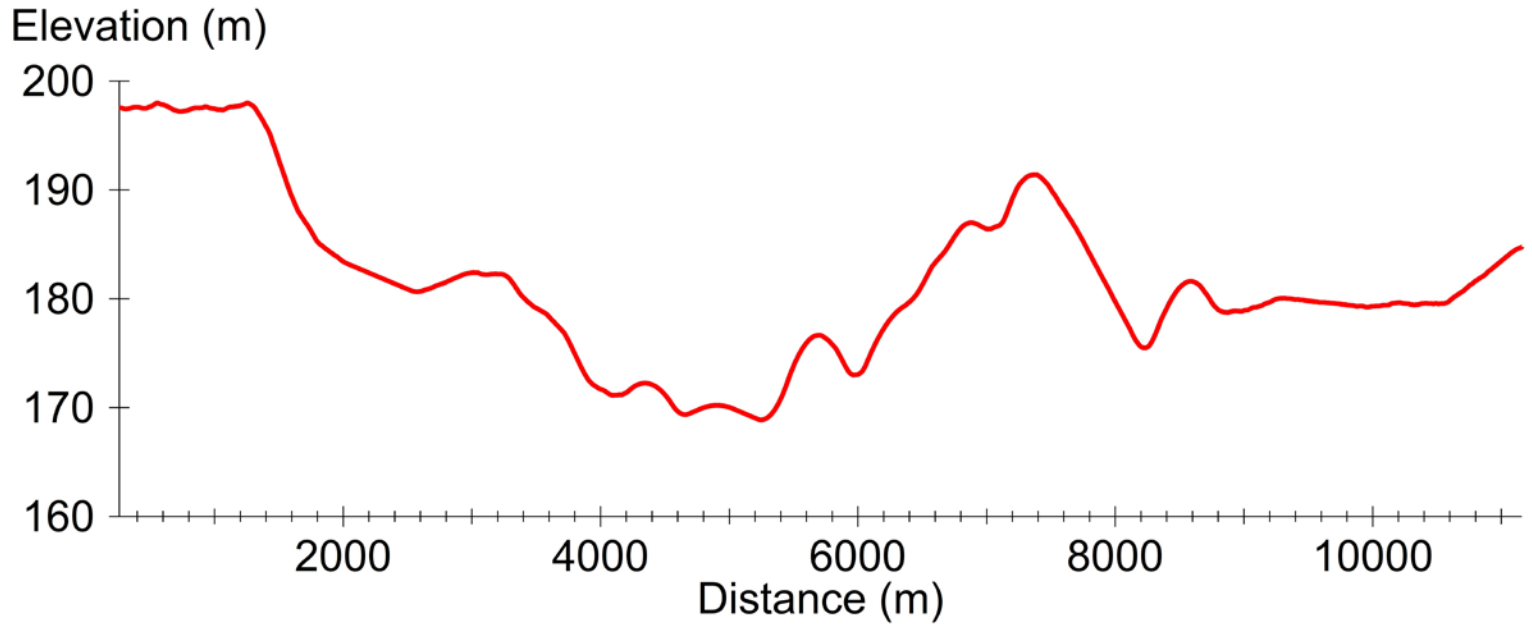
Short-Interval Roughness Profile



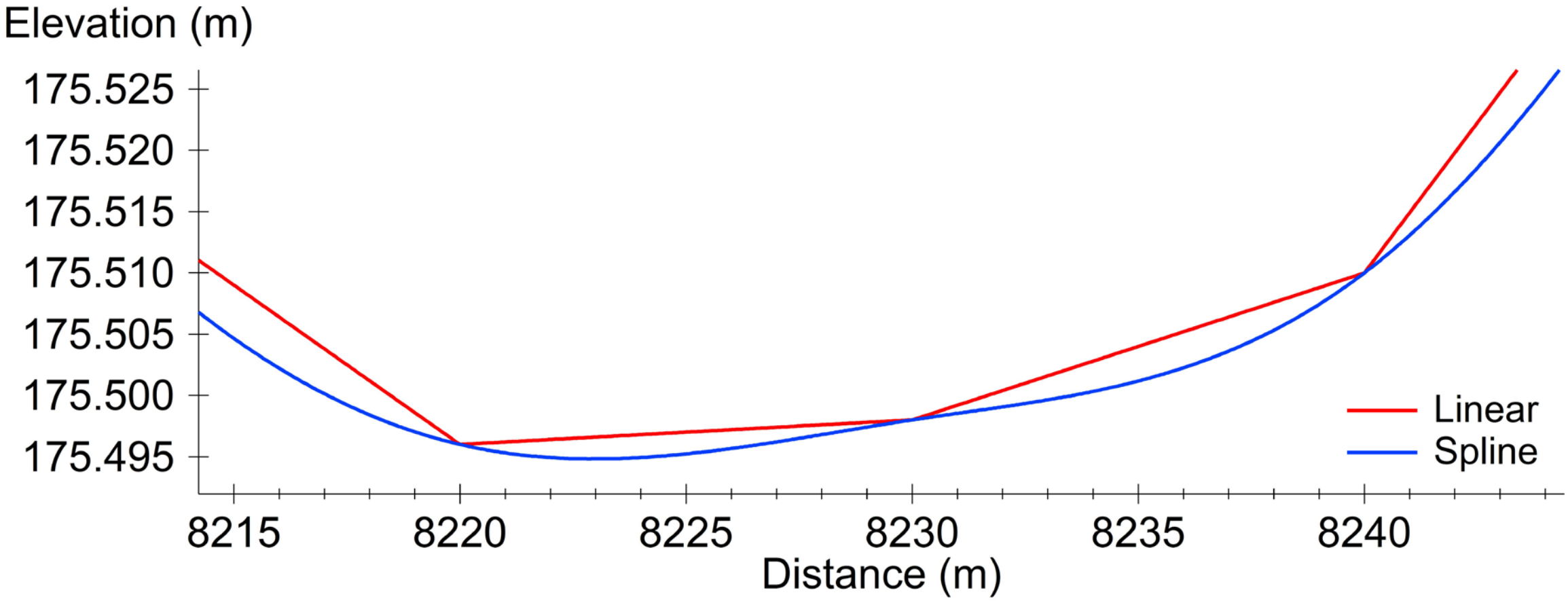
Base length 7.62 m (25 ft)

Elevation profile versus roughness profile



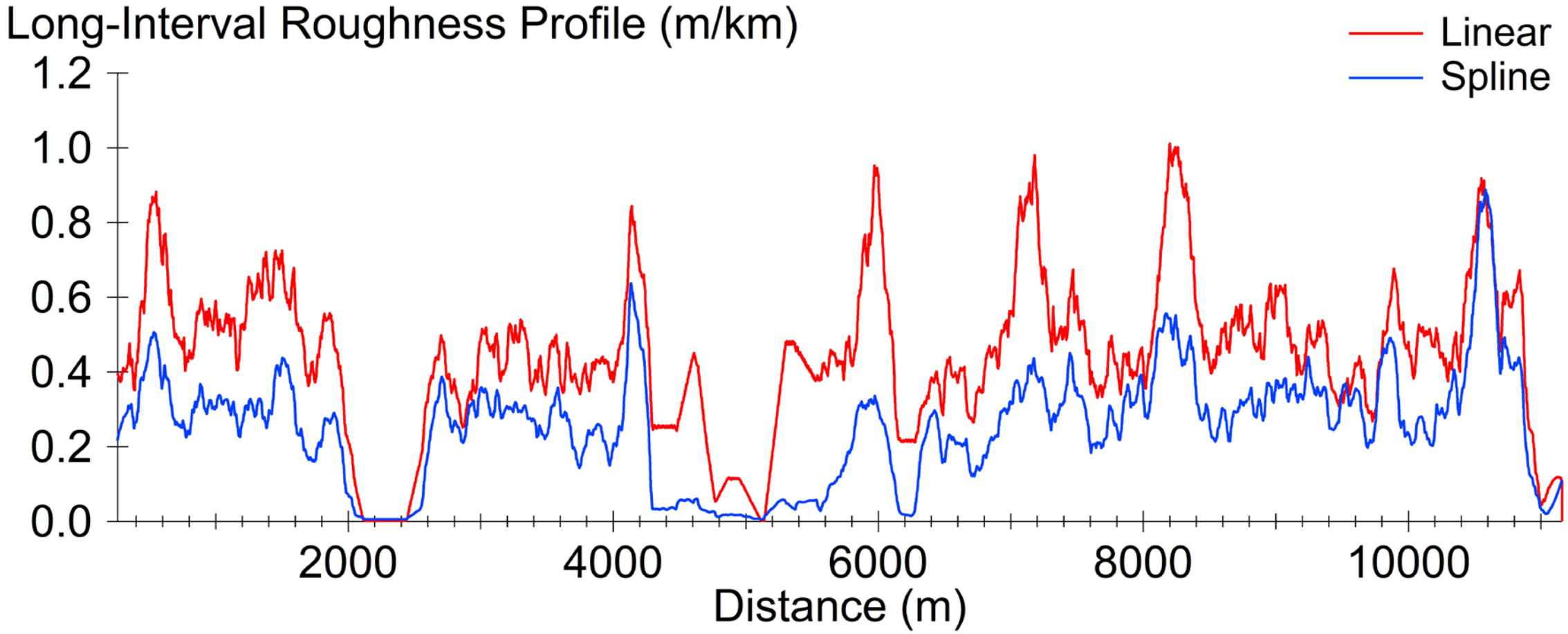


Spline versus Linear Interpolation



Linear Profile IRI = 0.443 m/km (28.1 in/mi)
Spline Profile IRI = 0.253 m/km (16.0 in/mi)

Linear and Spline, Long-Interval Roughness Profile



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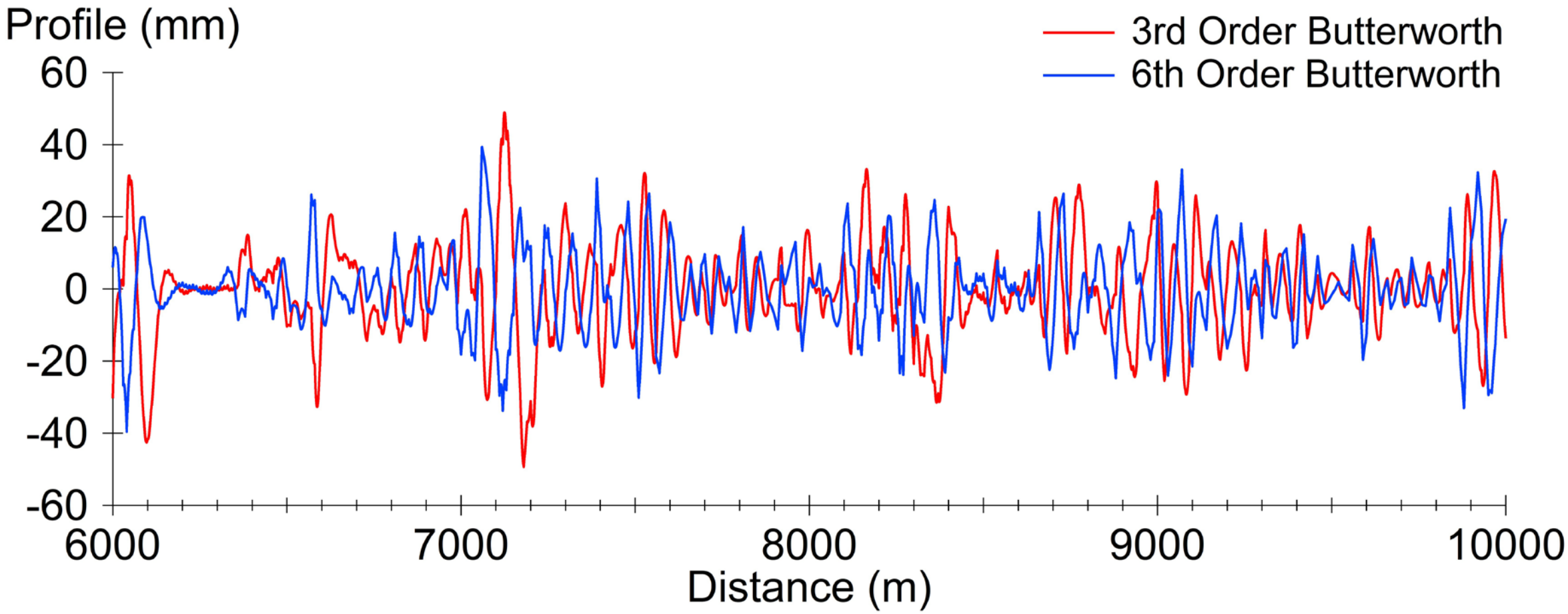
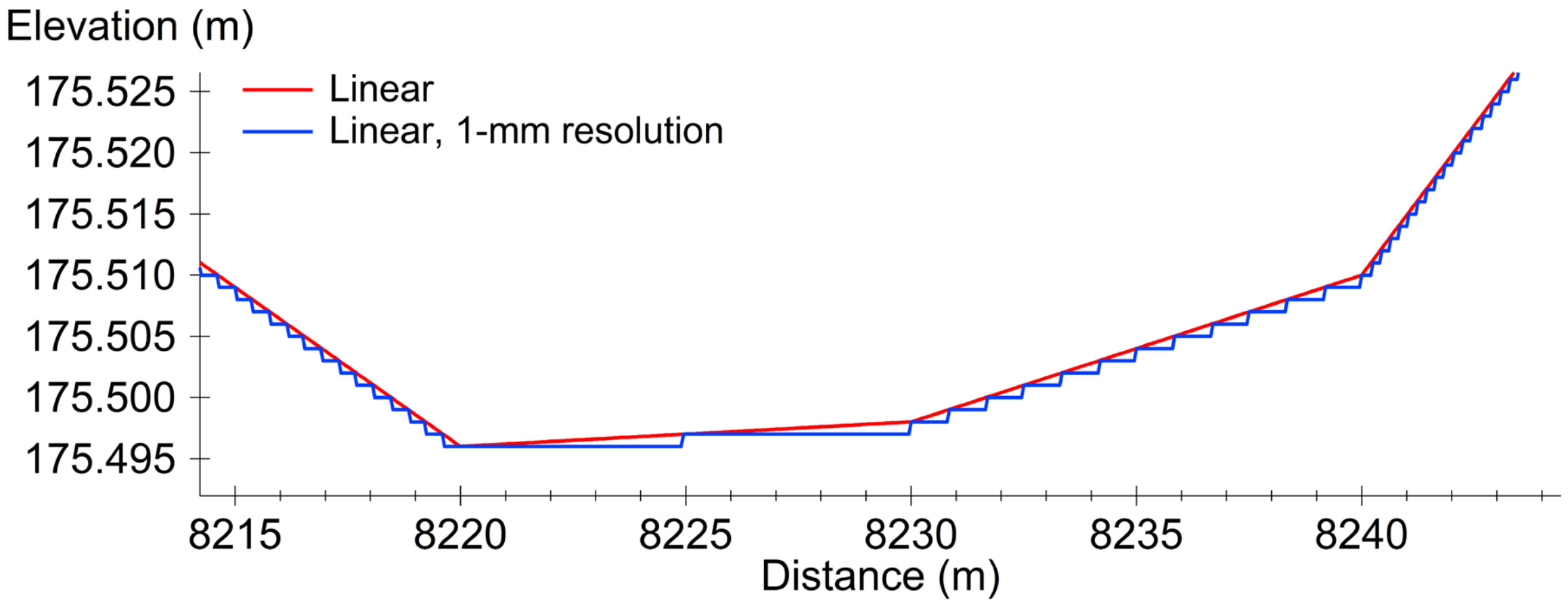
High-Pass Filtering, Linear Profile



After high-pass filtering, the profiles will look nothing like the design.

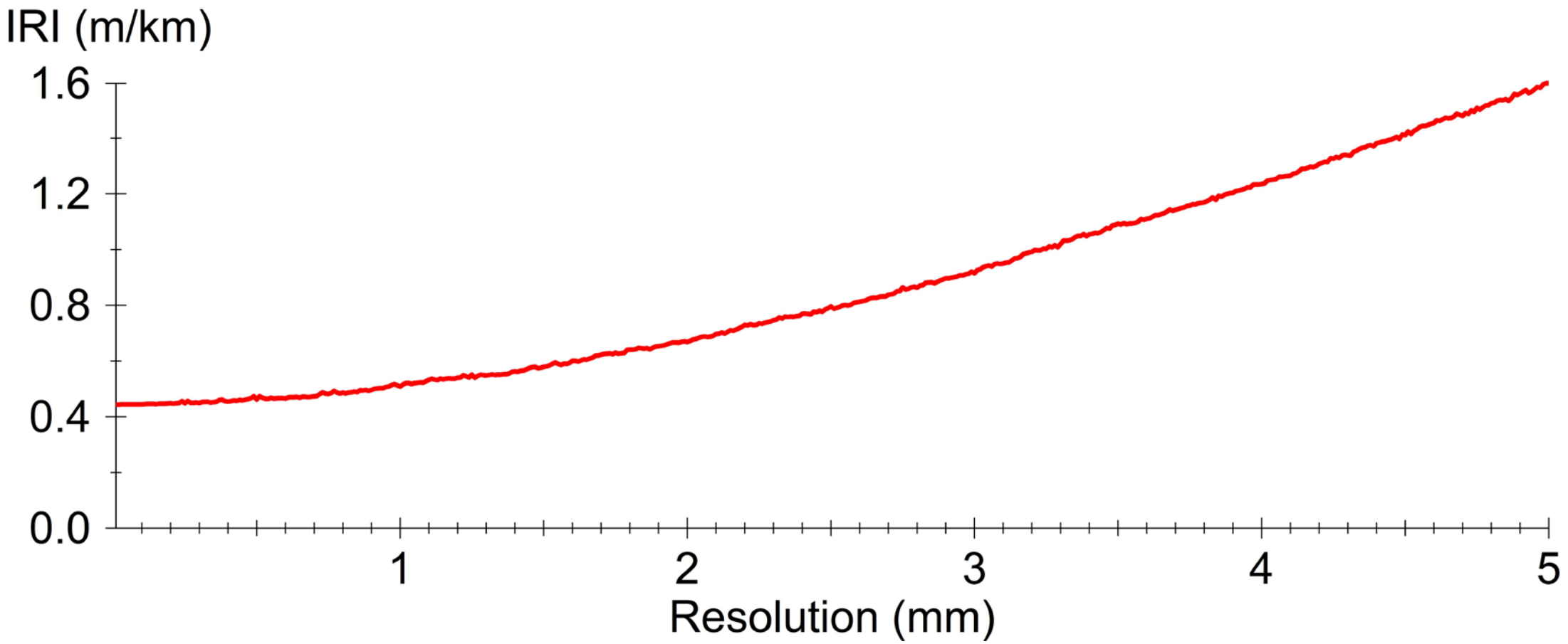
Resolution



IRI = 0.443 m/km (28.1 in/mi)

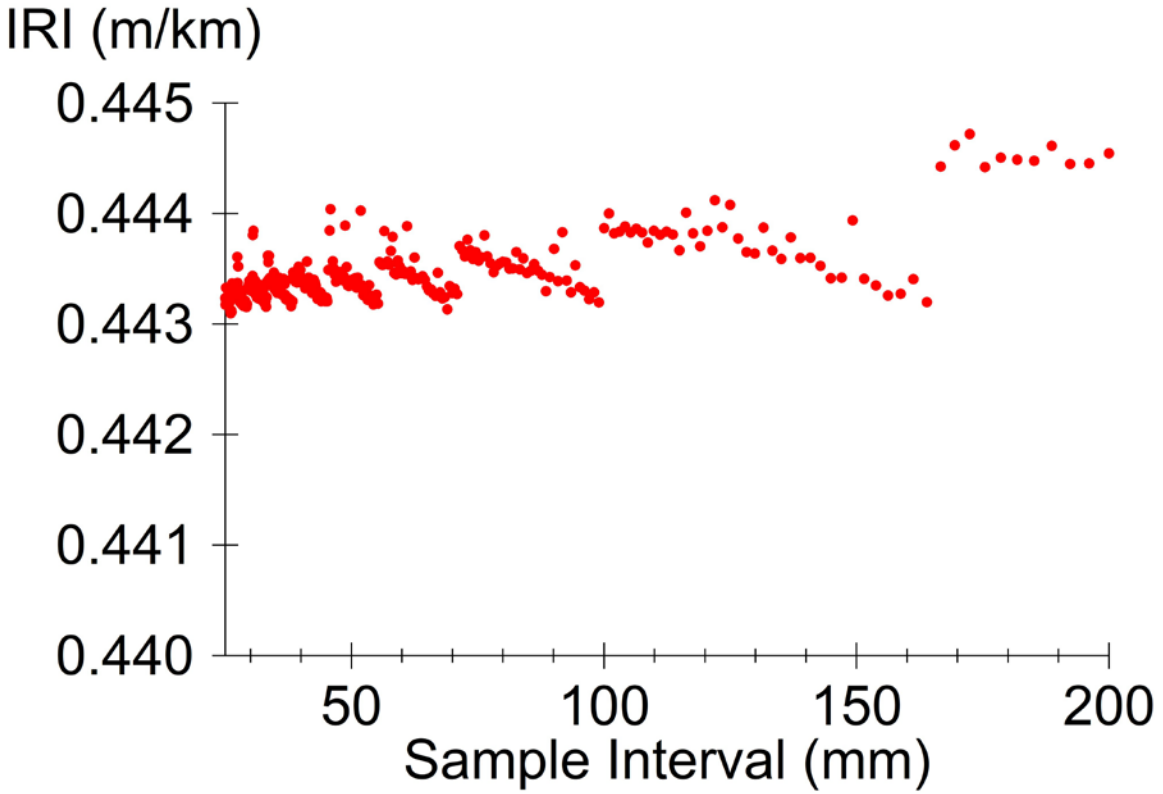
1 mm resolution, IRI = 0.508 m/km (32.2 in/mi)

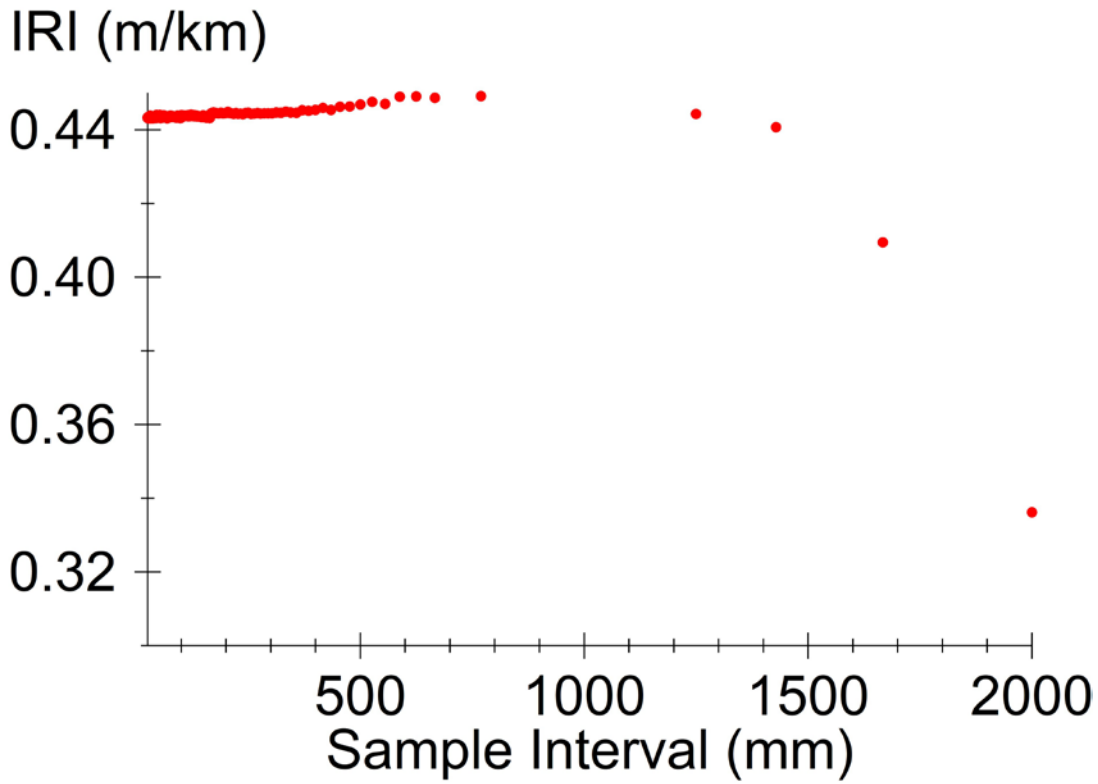
IRI versus Resolution



Round to the nearest 0.1 mm or smaller.
Round to the nearest 0.0003 ft or smaller.
(Just use 1/10,000 ft or 1/1,000 in.)

IRI versus Sample Interval





The Golden-Car algorithm is affected when sample interval > 250 mm.
The moving average is affected when sample interval > 50 mm.
Use 25 mm (1 inch) or less.

Key Points

- Write the profile for roughness analysis using the appropriate resolution, sample interval.
- High-pass filtering will distort the shape of the design.
- An inertial profiler is unlikely to capture true vertical grades.
- The design profile and and profile we measure to get roughness are not the same thing.
  - Designers and ride experts should work together to bridge the disconnect.
  - Data/experience is needed to understand how the design constrains and affects roughness.