

2023 European Road Profiler Users' Group Conference  
**Profile Measurement Errors**

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October 25, 2023



# Little Book of Profiling

Instructional materials addressing measurement error sources:

- Profiler design  
(sensors, signal processing, etc.)
- System health
- Profiler operation  
(speed, lateral tracking, etc.)
- Surface properties  
(texture, short-term roughness changes)



# Measurement Platform (Baseline System)



nominal sensors

# Measurement Platform (Augmented)

GPS orientation

RTK GPS



longitudinal acceleration

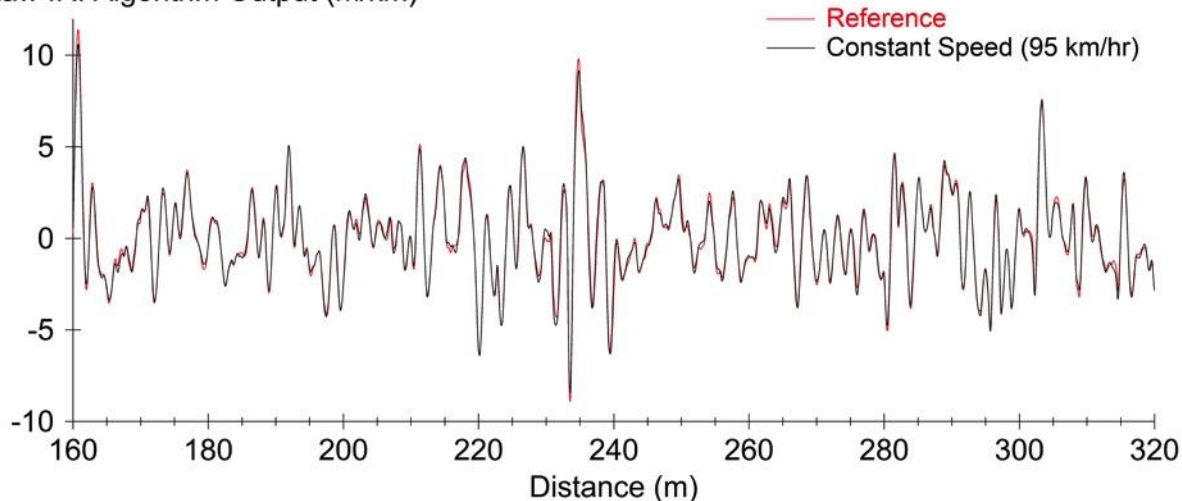
optical fifth wheel

lateral acceleration, pitch and roll rate



# Cross Correlation

Raw IRI Algorithm Output (m/km)



$$r_{pq}(iDx) = \frac{1}{S_p S_q} \sum_{k=1}^N \hat{p}(x_k) \hat{q}(x_{k+i})$$

$r$  — cross correlation

$\hat{p}$  — filtered reference profile

$\hat{q}$  — filtered candidate profile

$$g = \frac{\min(S_p, S_q)}{\max(S_p, S_q)}$$

$$\text{Agreement score} = r_{\max} \times g$$

Example above: 0.98

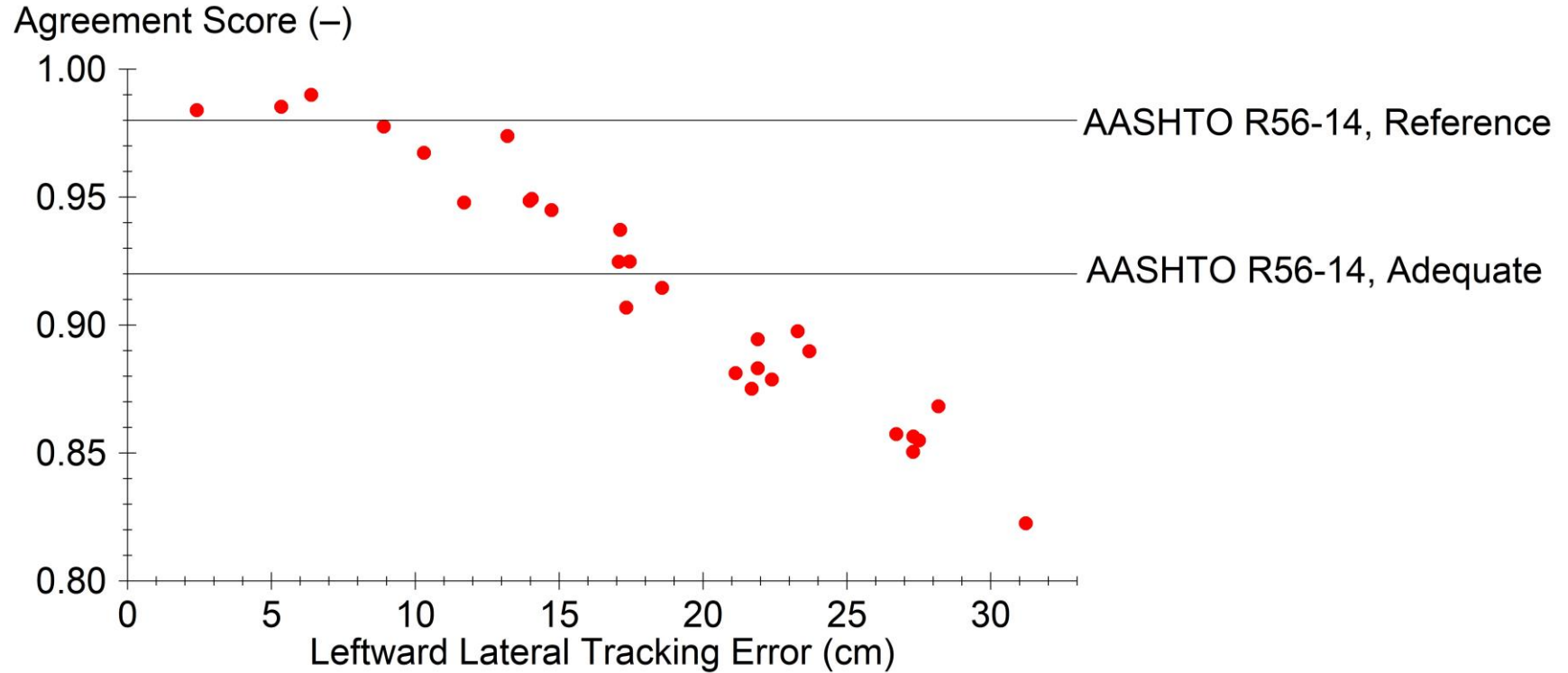
AASHTO R56-14

Acceptable: 0.92

Reference Quality: 0.98



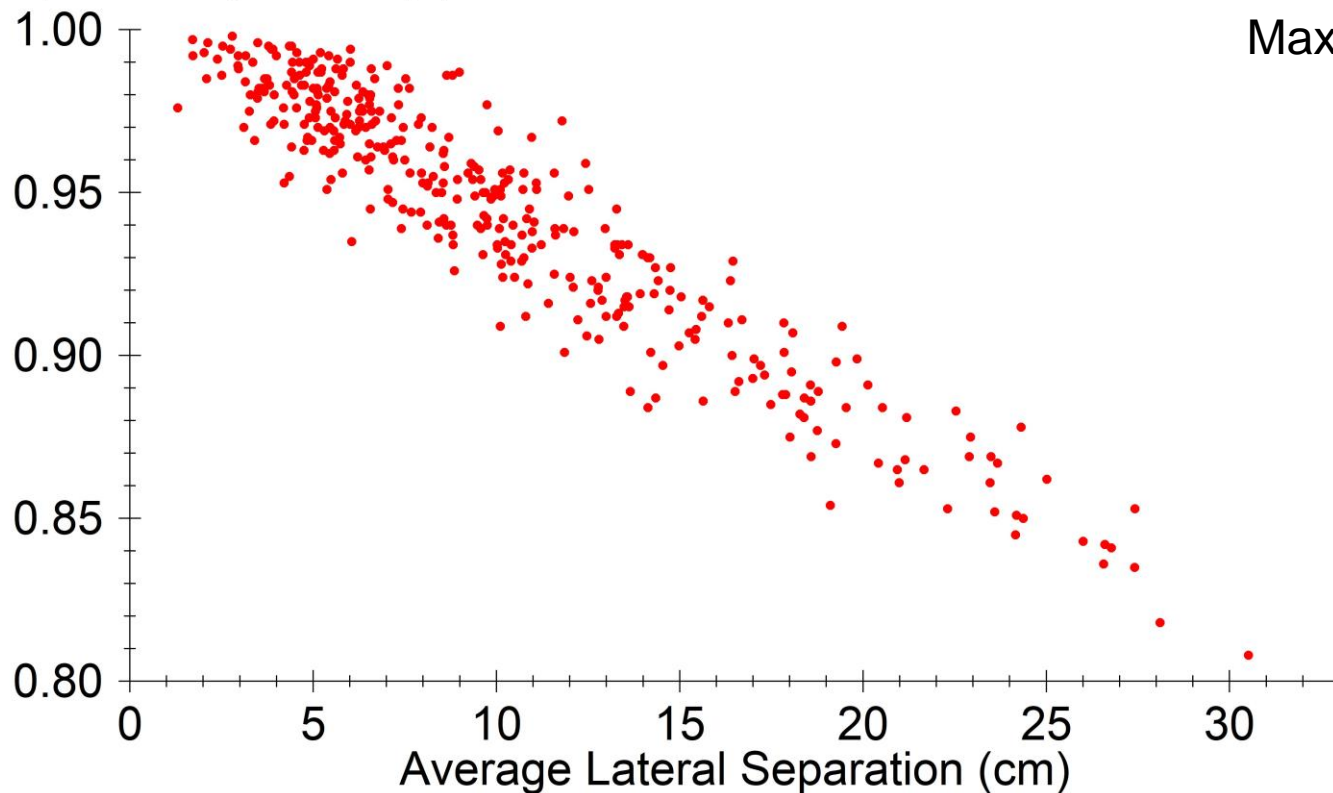
# Accuracy Scores versus Tracking Error



# Repeatability Scores versus Tracking

Repeatability Score (-)

Max Score = 0.9978



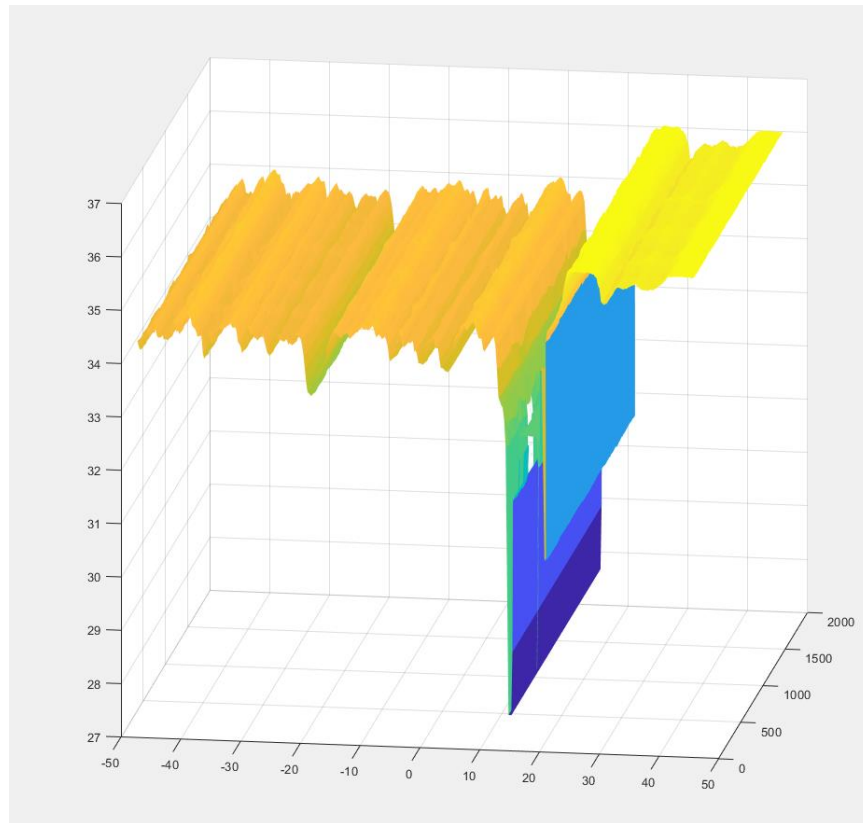
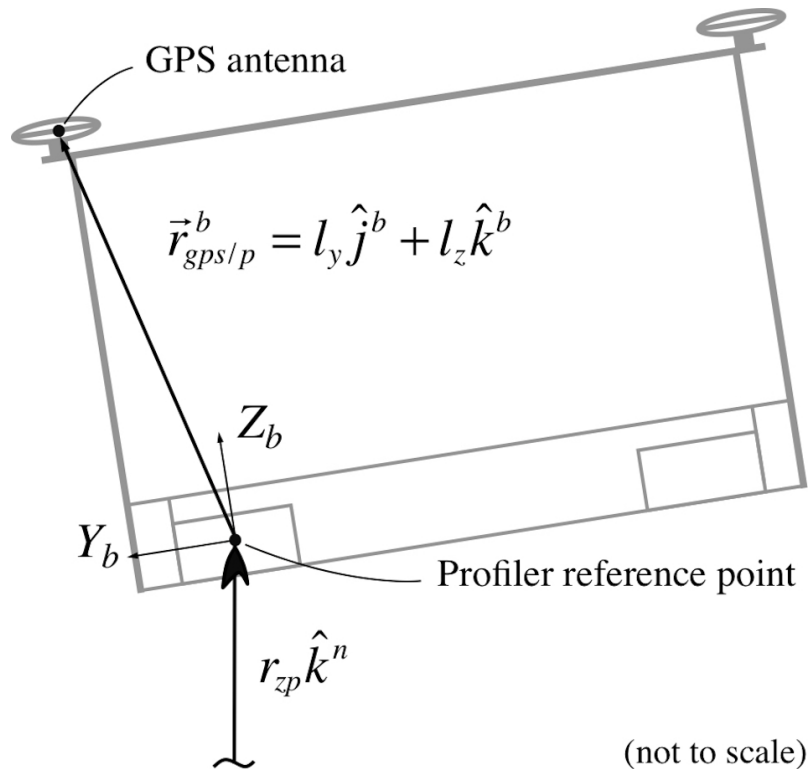


# Lane Tracking

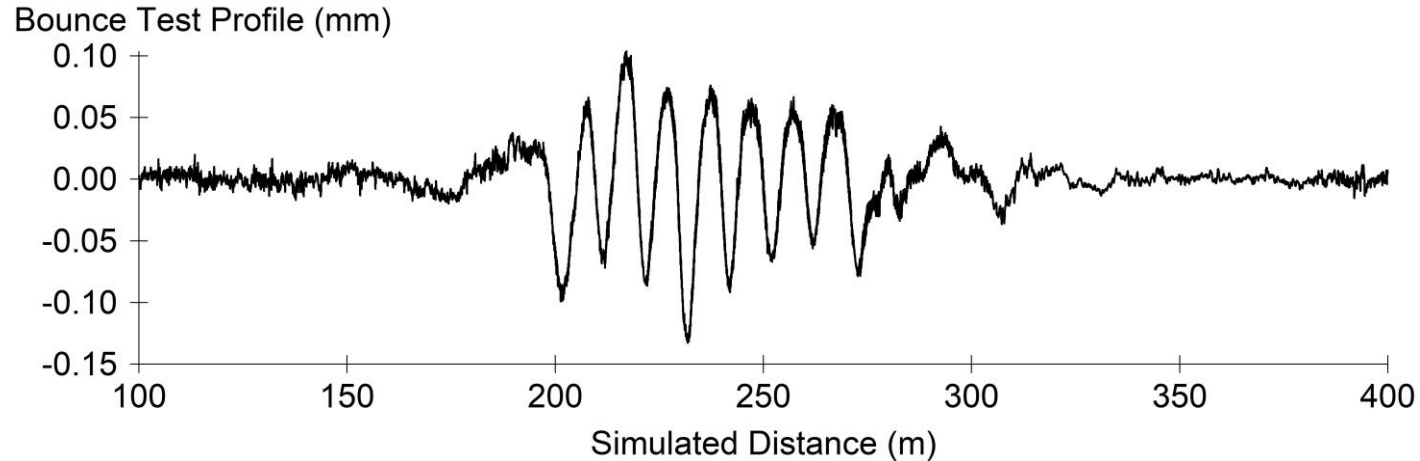
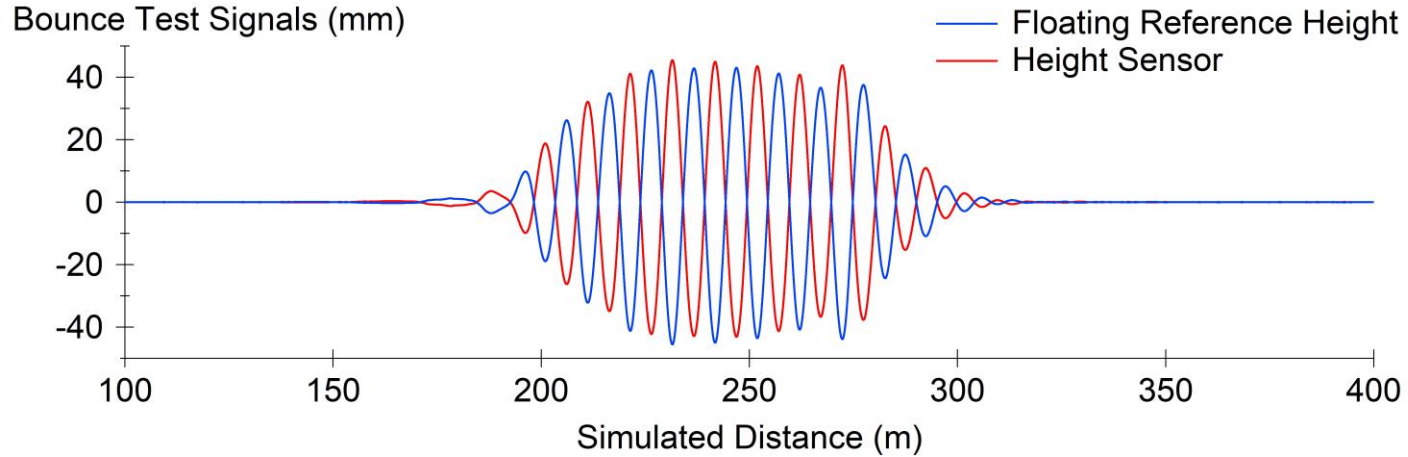




# Lane Tracking

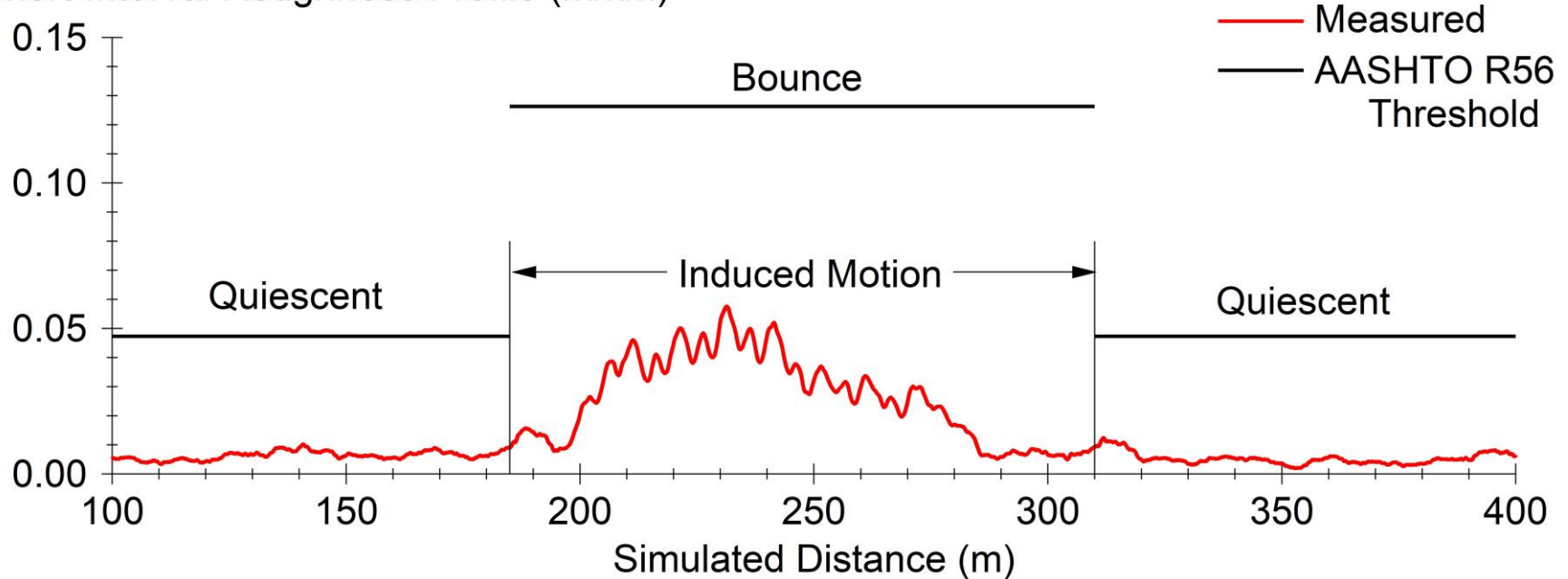


# Bounce Test



# Bounce Test, Short-Interval Roughness Profile

Short-Interval Roughness Profile (m/km)

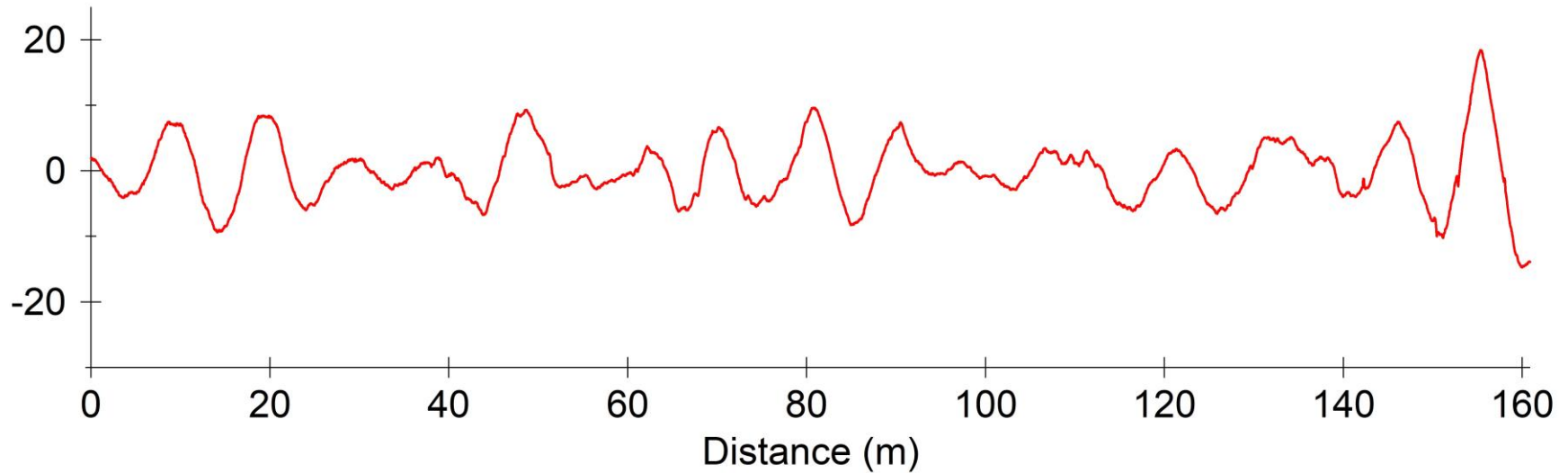


IRI: Induced Motion 0.026 m/km (< 0.126 required)  
Quiescent 0.006 m/km (< 0.047 required)



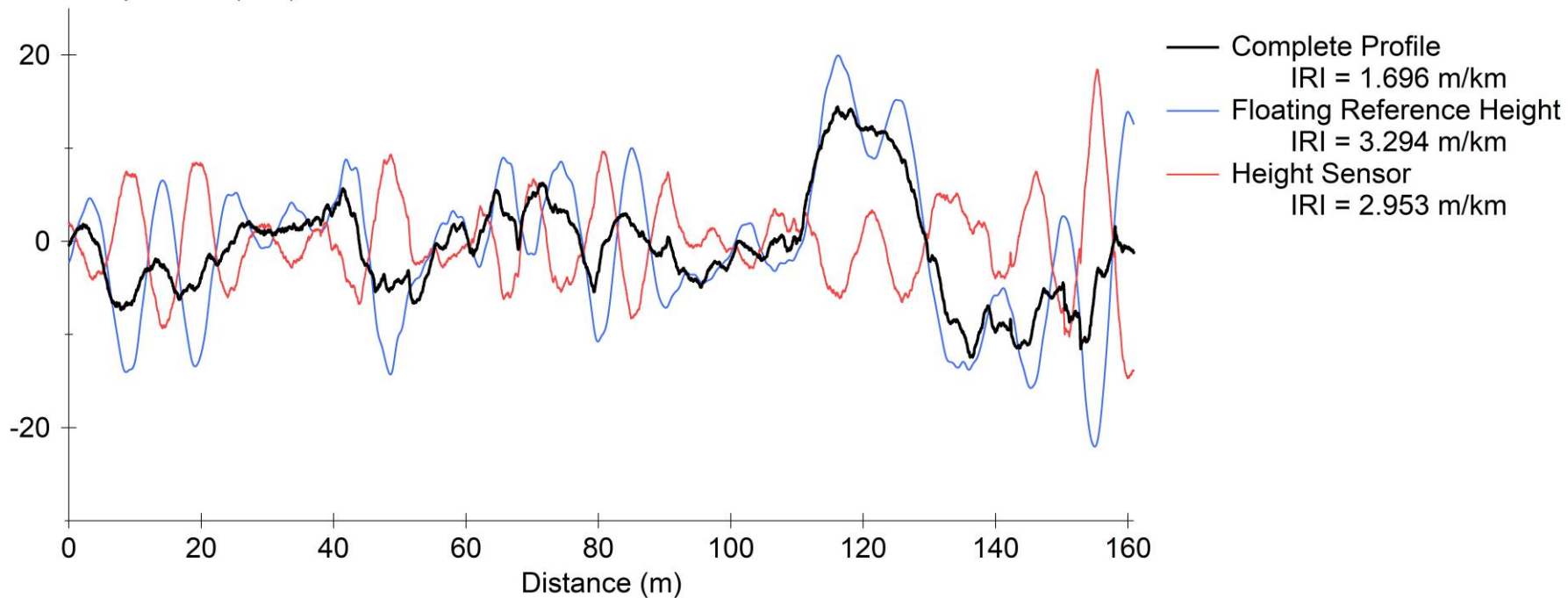
# Test Section Profile (Not!)

Elevation (mm)

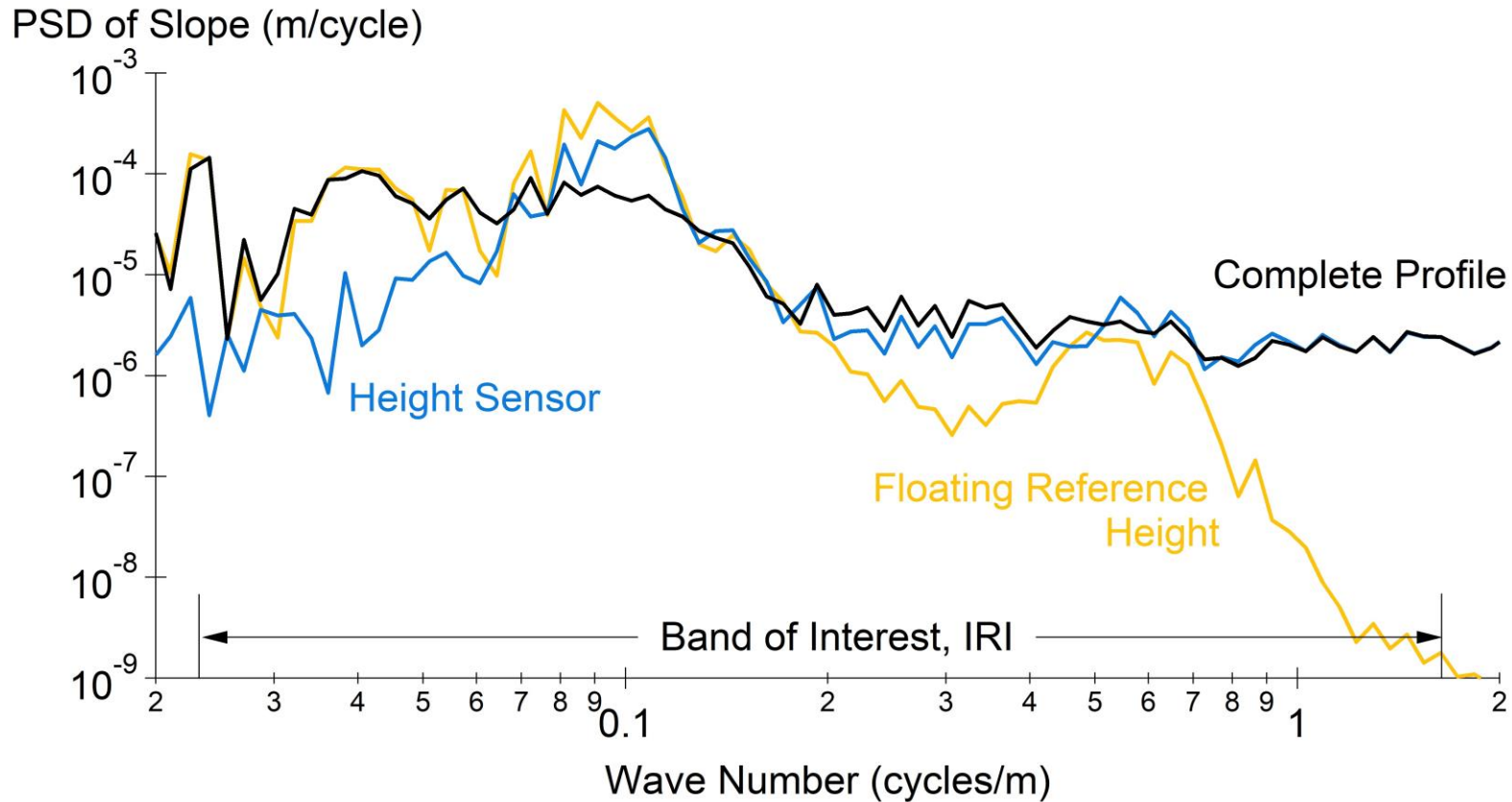


# Profile Components

Profile Components (mm)

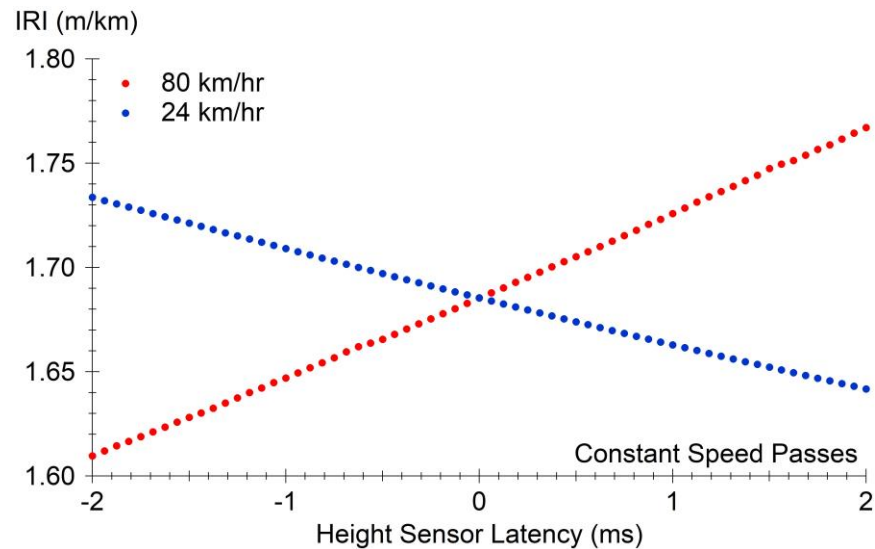
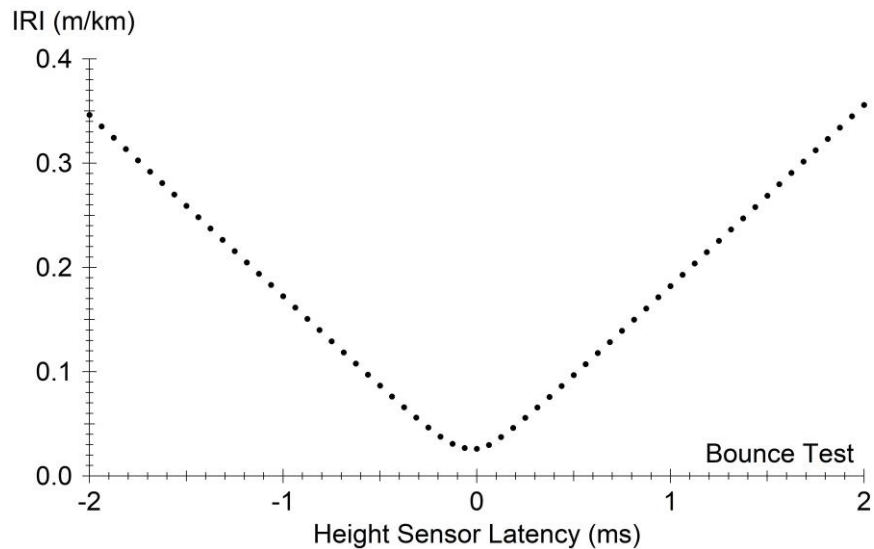


# Profile Components, PSD

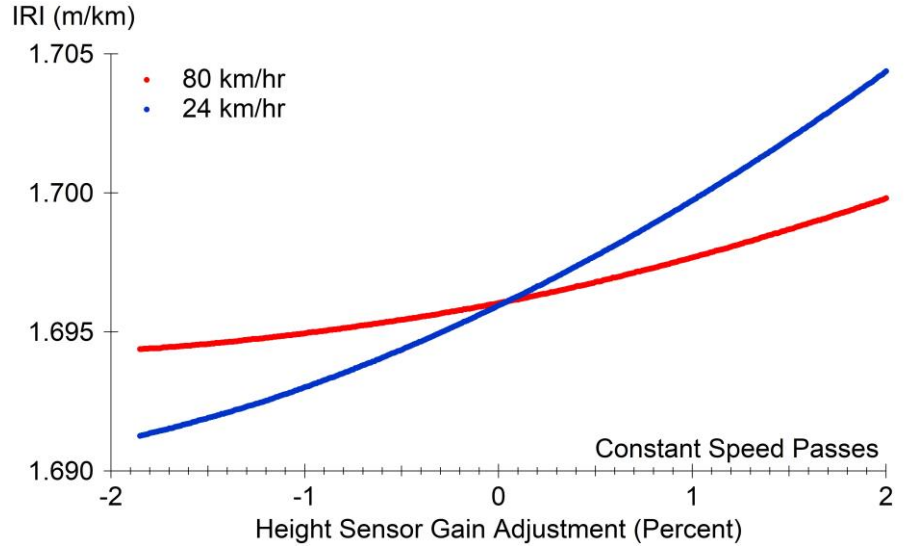
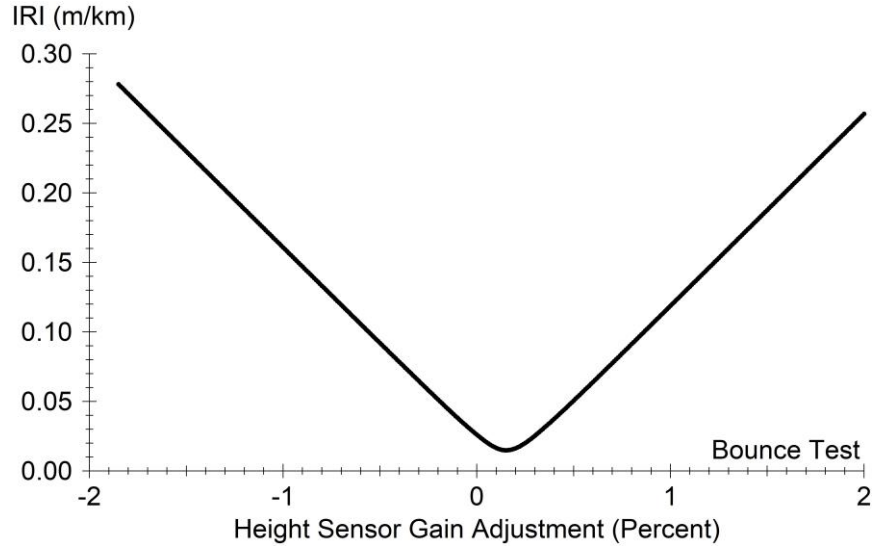




# Height Sensor Latency



# Height Sensor Gain



# Other Modeling Possibilities

- Sensor specifications  
(waveband, range, resolution, noise)
- Processing algorithms  
(filtering, sampling)
- Height sensor footprint  
(averaging and bridging algorithms)

# Thanks!

## Little Book of Profiling:

<https://deepblue.lib.umich.edu/bitstream/handle/2027.42/21605/90151.pdf>

