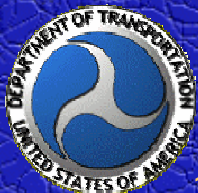


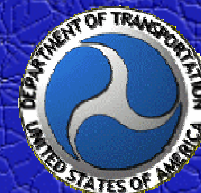
# *Profile Viewer and Analyzer Software*

**Mark Swanlund, P.E.**  
*Federal Highway Administration  
Office of Pavement Technology*

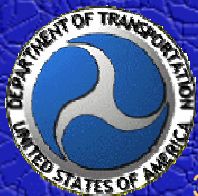


# Presentation Overview

- Introduction
- Purpose
- Fundamentals of Profiles
- Capabilities
- Availability
- Future Enhancements



- QA Tool for LTPP profile data
- Recommended for development by ETG
- Developed new rather than adapted

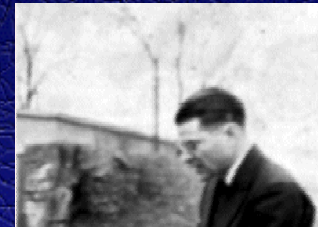


- View and analyze pavement profile data
- File formats
  - .erd
  - .txt
  - .ppf
- Other formats



# Fundamentals - Pavement Profilers

- Profilers have evolved over the years



# Profile Analysis

In order to use the information in a pavement profile, it must be analyzed first.

|           |           |
|-----------|-----------|
| -0.105877 | -0.009103 |
| -0.105854 | -0.008147 |
| -0.106831 | -0.008191 |
| -0.107808 | -0.008235 |
| -0.107785 | -0.008279 |
| -0.107761 | -0.008323 |
| -0.107737 | -0.007368 |
| -0.107713 | -0.006412 |
| -0.107689 | -0.006457 |

|           |           |
|-----------|-----------|
| -0.132440 | -0.014786 |
| -0.132403 | -0.015827 |
| -0.134366 | -0.017866 |
| -0.134328 | -0.017905 |
| -0.136290 | -0.016945 |
| -0.136251 | -0.016984 |
| -0.137212 | -0.017024 |
| -0.138173 | -0.017063 |
| -0.137133 | -0.018102 |
| -0.137093 | -0.018141 |
| -0.137054 | -0.019180 |
| -0.137014 | -0.019218 |
| -0.136974 | -0.019257 |
| -0.137934 | -0.018295 |
| -0.140893 | -0.017334 |
| -0.142851 | -0.017373 |
| -0.143808 | -0.017412 |
| -0.144764 | -0.017452 |
| -0.144720 | -0.015491 |
| -0.144677 | -0.015531 |
| -0.145631 | -0.015571 |
| -0.144587 | -0.015611 |
| -0.144542 | -0.016651 |
| -0.144498 | -0.016691 |
| -0.144454 | -0.015730 |
| -0.145407 | -0.014770 |
| -0.146364 | -0.013811 |
| -0.147318 | -0.012852 |
| -0.148272 | -0.013893 |
| -0.149225 | -0.013933 |
| -0.150177 | -0.013974 |
| -0.151129 | -0.014015 |
| -0.152081 | -0.013056 |
| -0.153032 | -0.013097 |
| -0.153982 | -0.013138 |
| -0.154932 | -0.013179 |
| -0.155881 | -0.013220 |
| -0.157830 | -0.013261 |
| -0.157778 | -0.013302 |

**ProVAL**

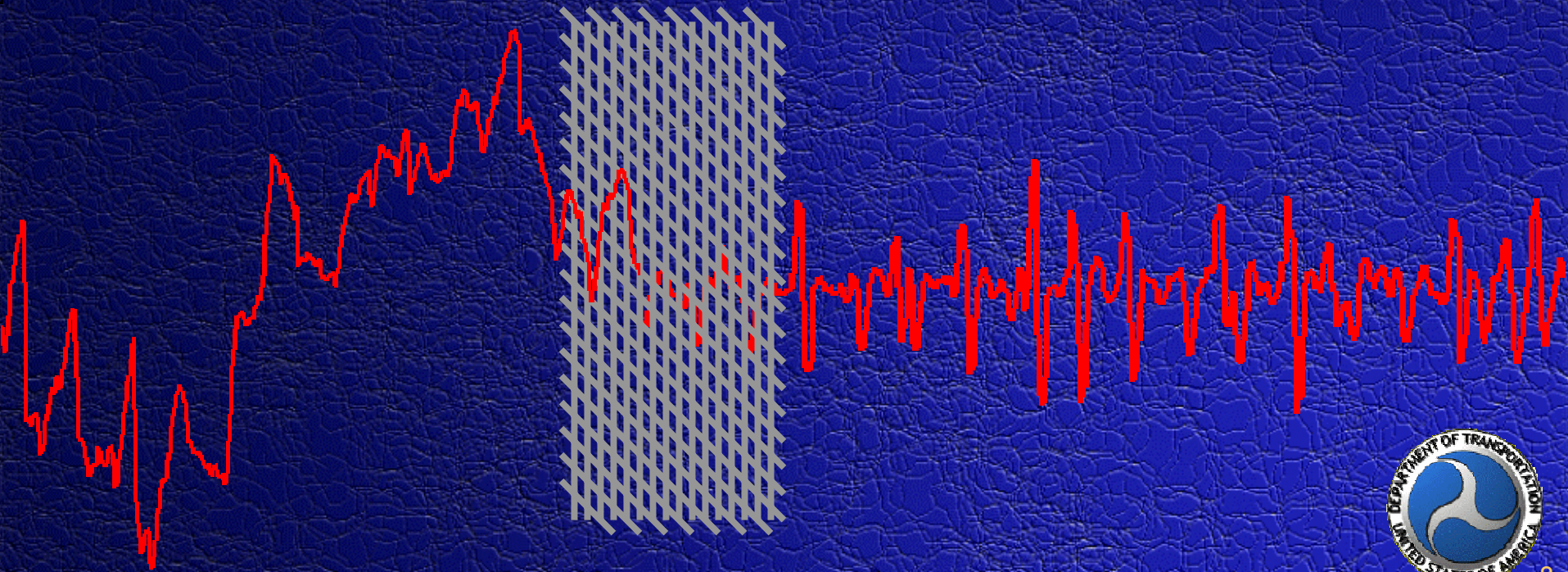
IRI, RN, PI, etc.



- A digital filter is a calculation procedure that transforms a series of numbers (a signal) into a new series of numbers



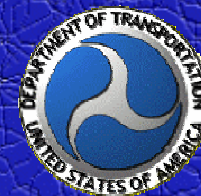
- Electronic filters remove unwanted “noise” and produce a “clean” signal





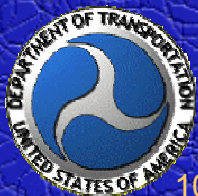
# Passenger Discomfort

- Resonance of the abdominal cavity is at about 5 Hz (for vertical acceleration)
- Minimum tolerance for horizontal acceleration is at about 1 Hz



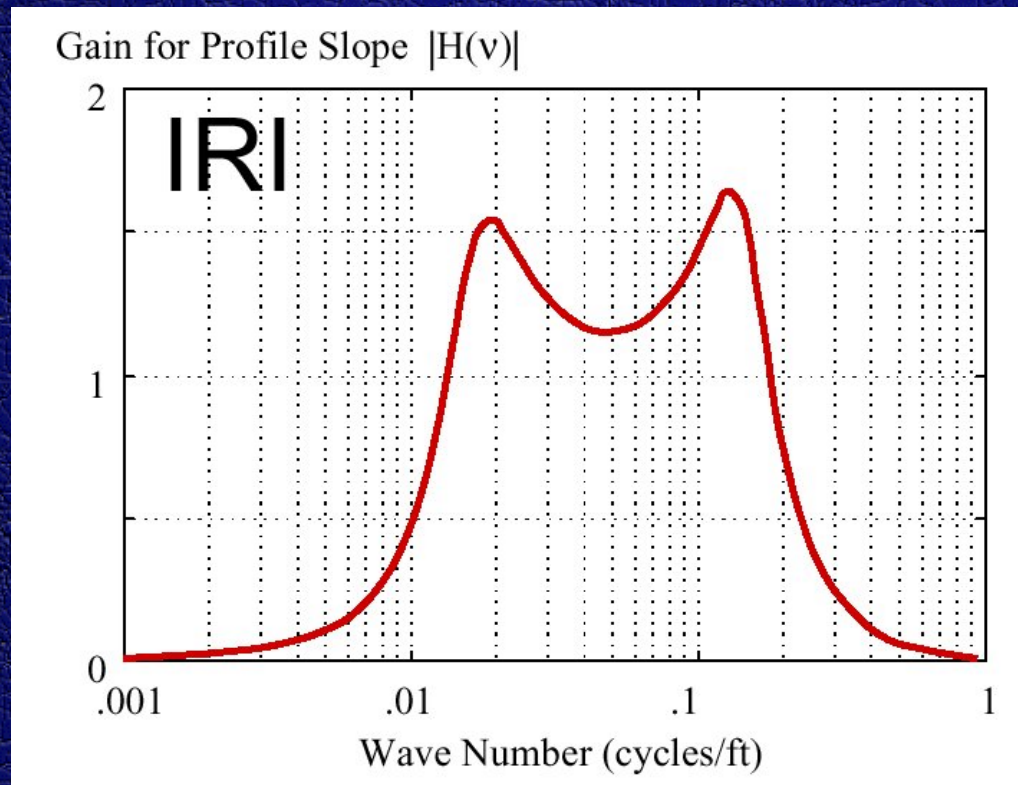
Many types of road roughness measures are available:

- International Roughness Index (IRI)
- Ride Number (RN)
- Profile Index (PI)

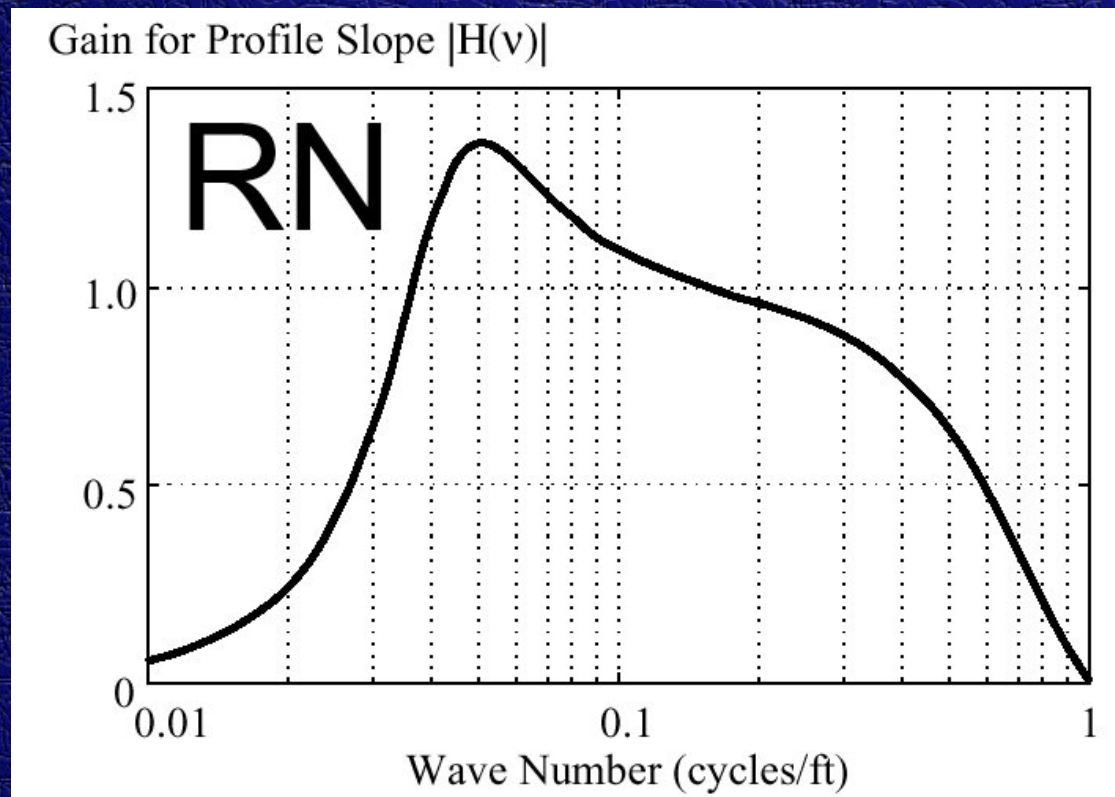


# International Roughness Index

IRI is influenced by wavelengths ranging from 4 to 100 ft.



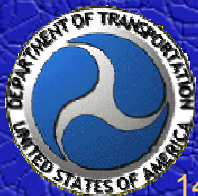
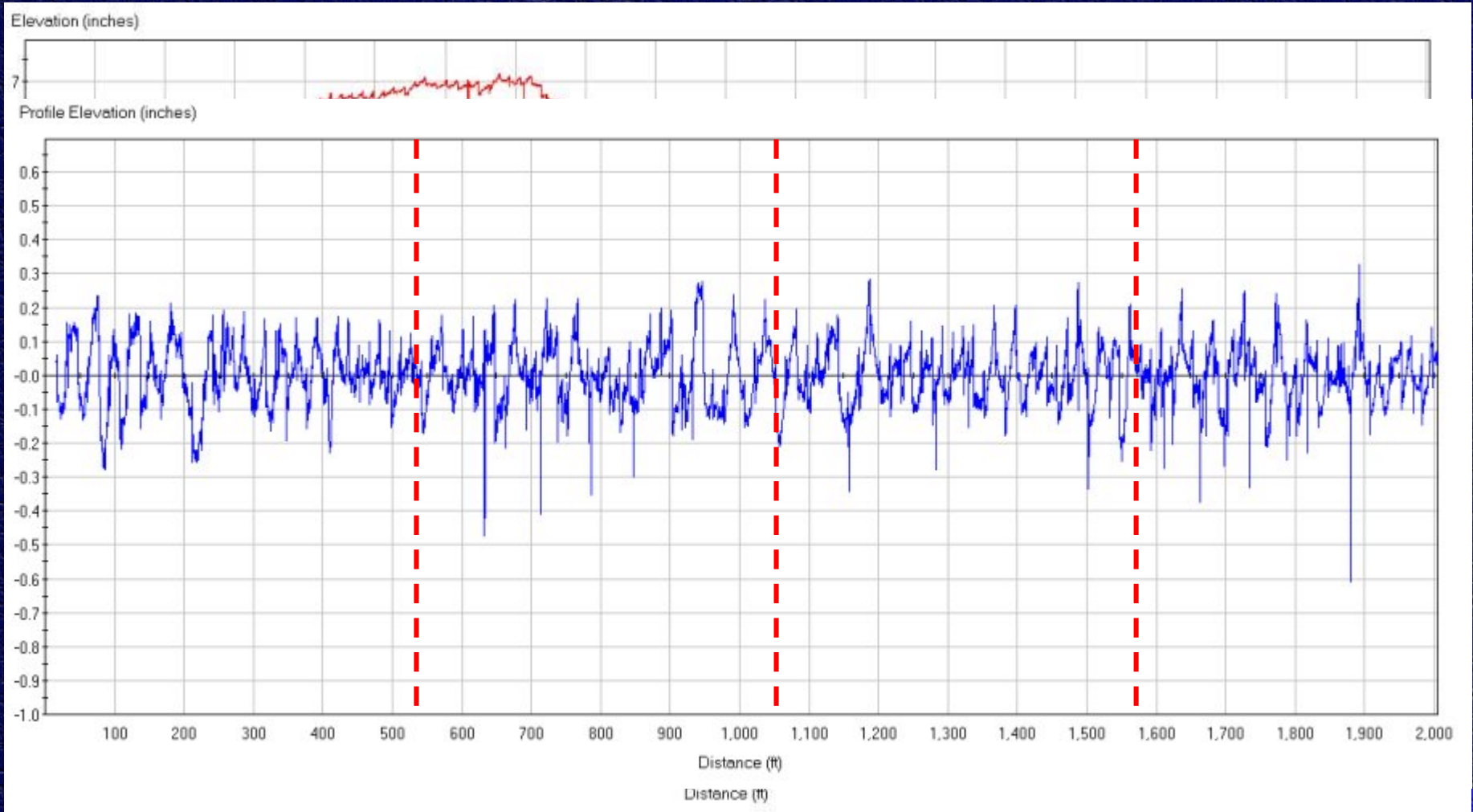
RN is influenced by wavelengths ranging from about 2 to 33 ft.



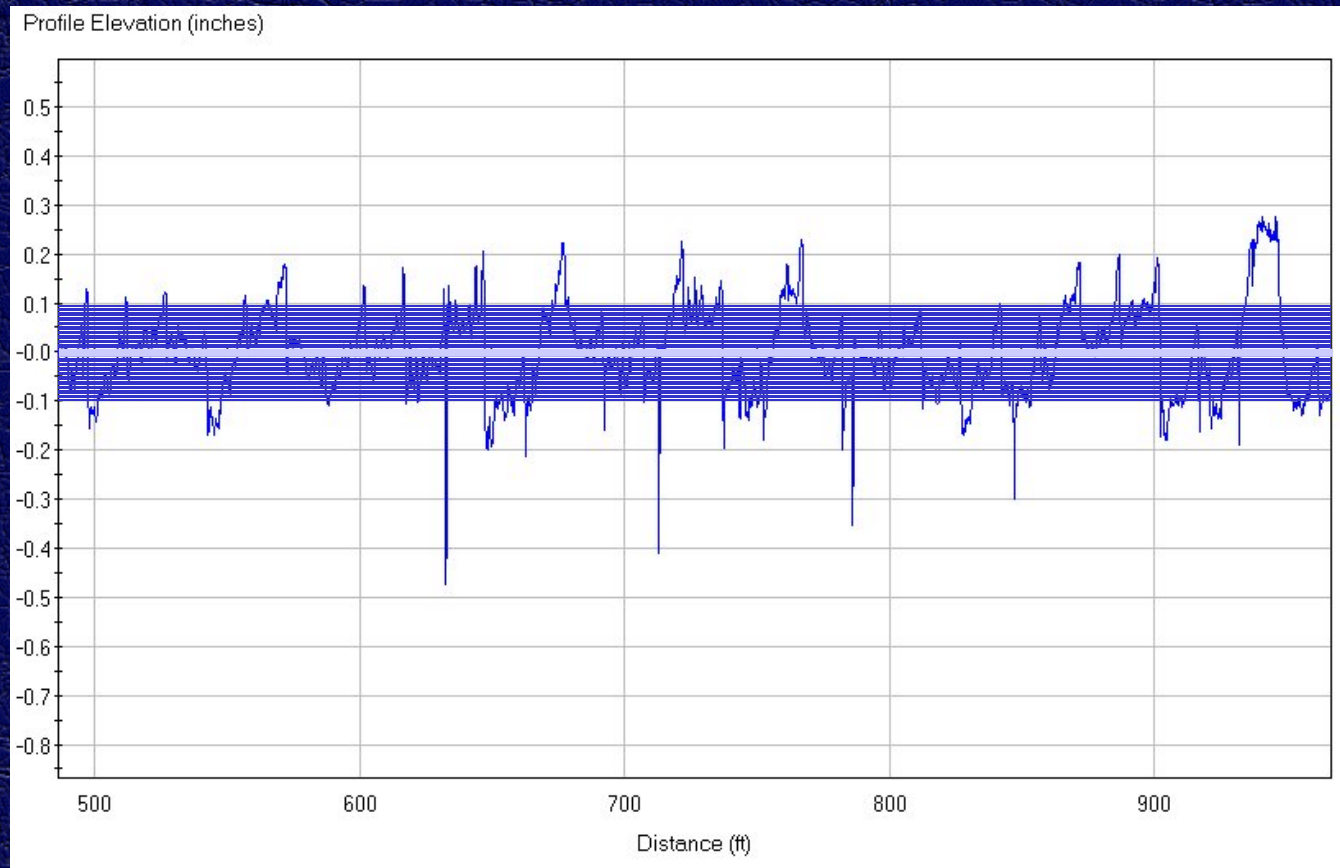
# California Profilograph



# Before and After



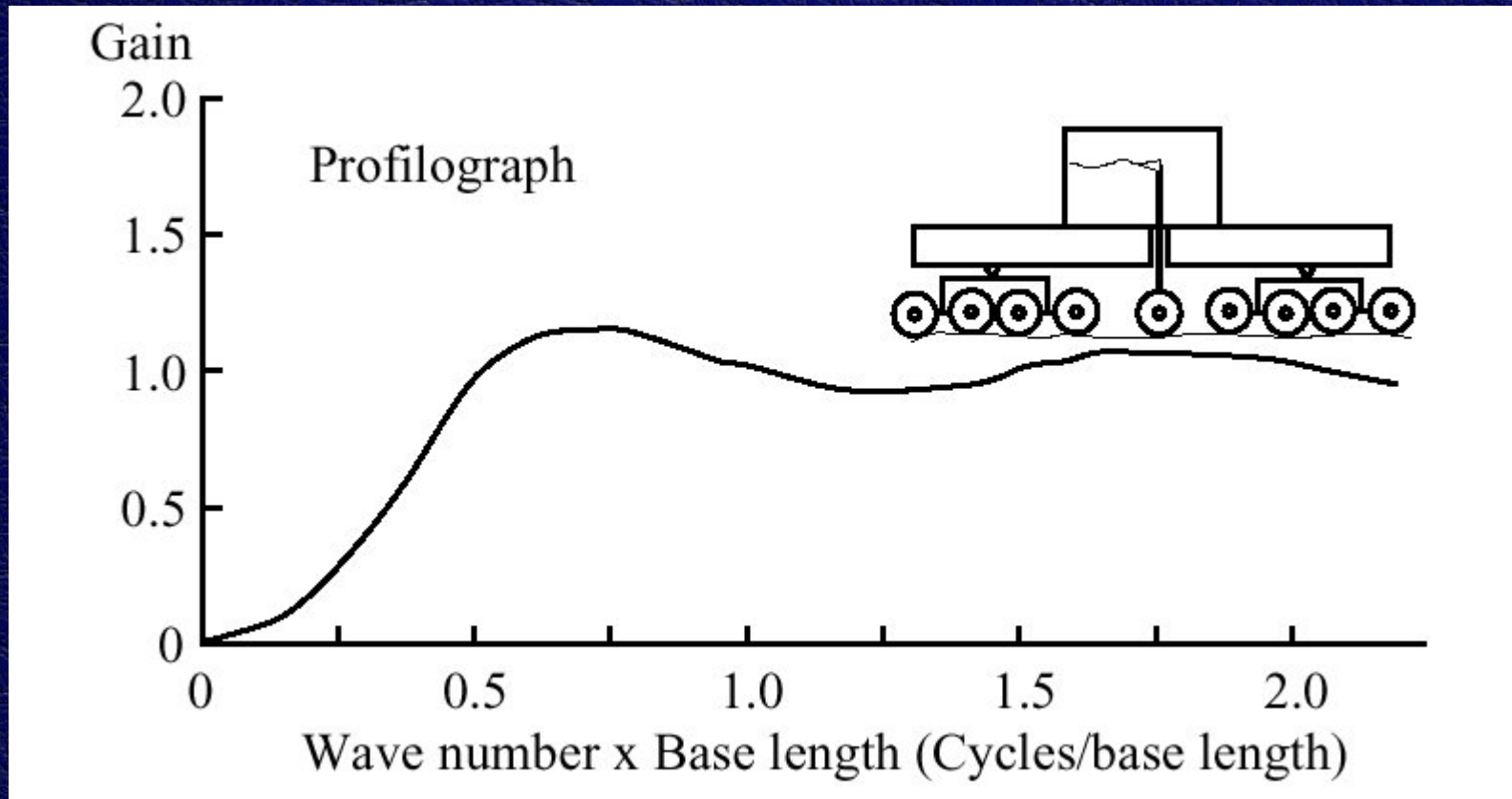
# Add Blanking Band



Different Blanking Band Widths are Used - 0.10 inches

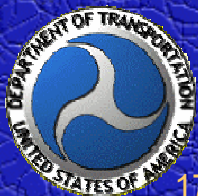


# Frequency Response of Profilograph





- ASTM E-950
- Cross Correlation
- Power Spectral Density



- ASTM E 950 defines precision and bias of longitudinal profiles



- Requires 10 runs of the same profile
- Profile must be 320 m (1056 ft) sampled at 0.30 m (1 ft) interval
- Total of 1057 elevations

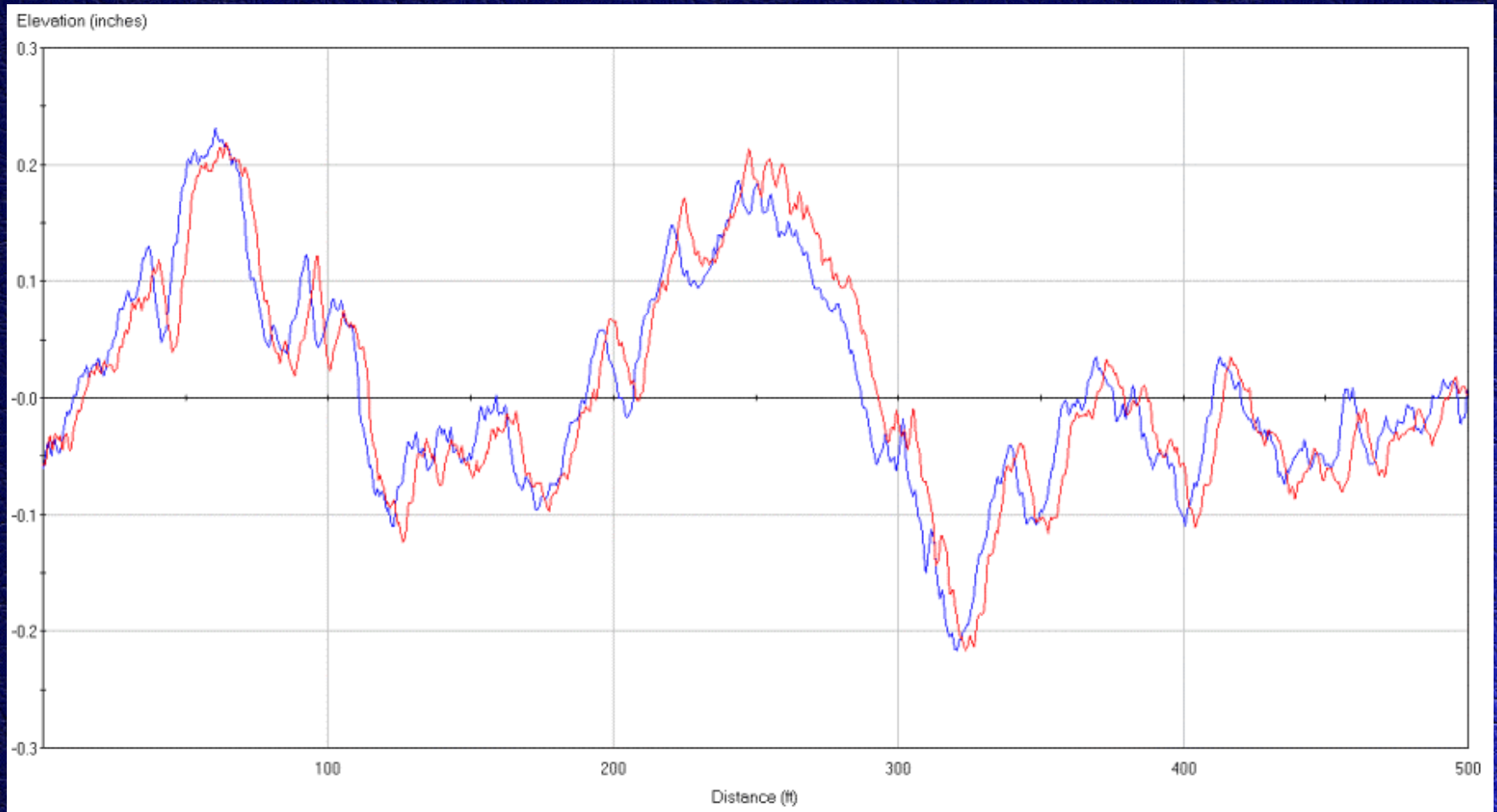


# Cross Correlation

- For road profile applications, correlation coefficient it is used to synchronize repeat measurements
- Most common difference is variations in start location on repeat profiles



# Cross Correlation



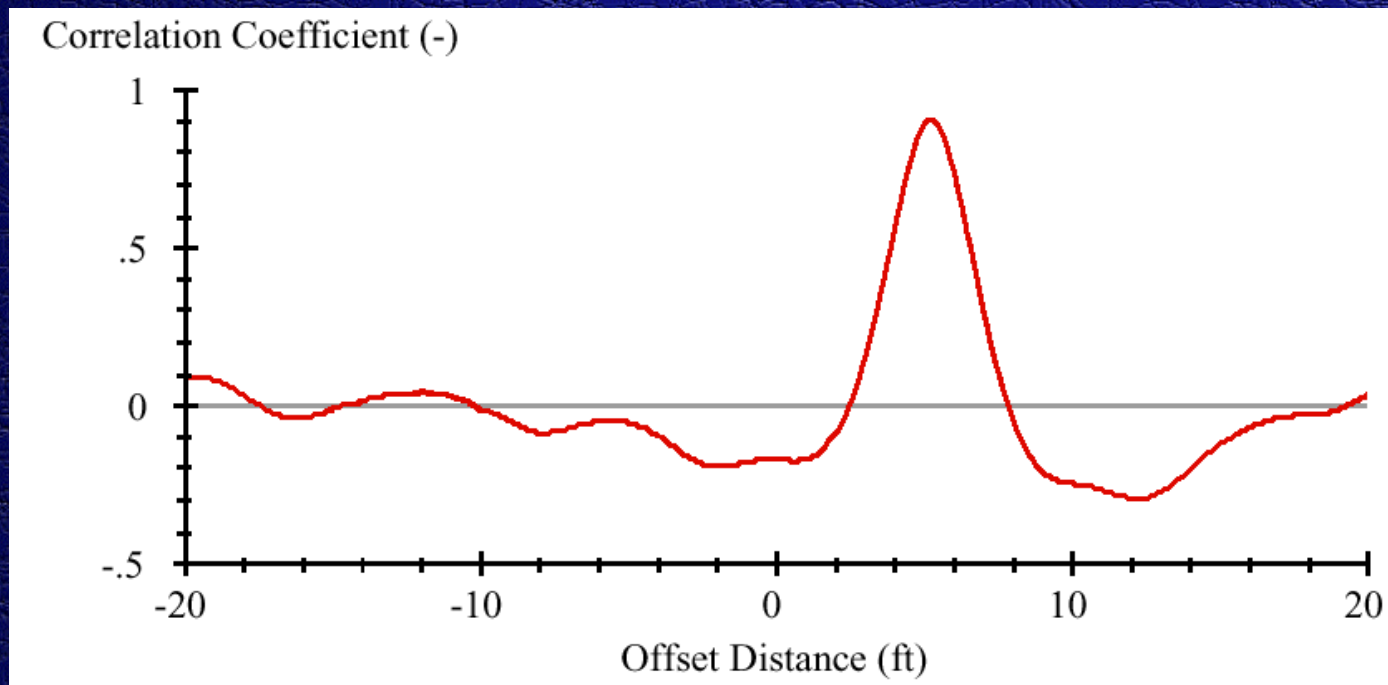
# Cross Correlation

- Cross correlation analysis determines the optimum horizontal offset to maximize agreement between the two profiles
- A plot of horizontal offset vs correlation coefficient is obtained by calculating the coefficient for each possible offset (each step in the data) within a reasonable range



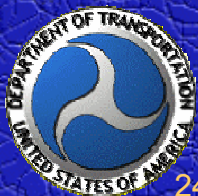
# Cross Correlation

The maximum correlation coefficient achieved is 0.9, by offsetting the blue profile +4.5 feet



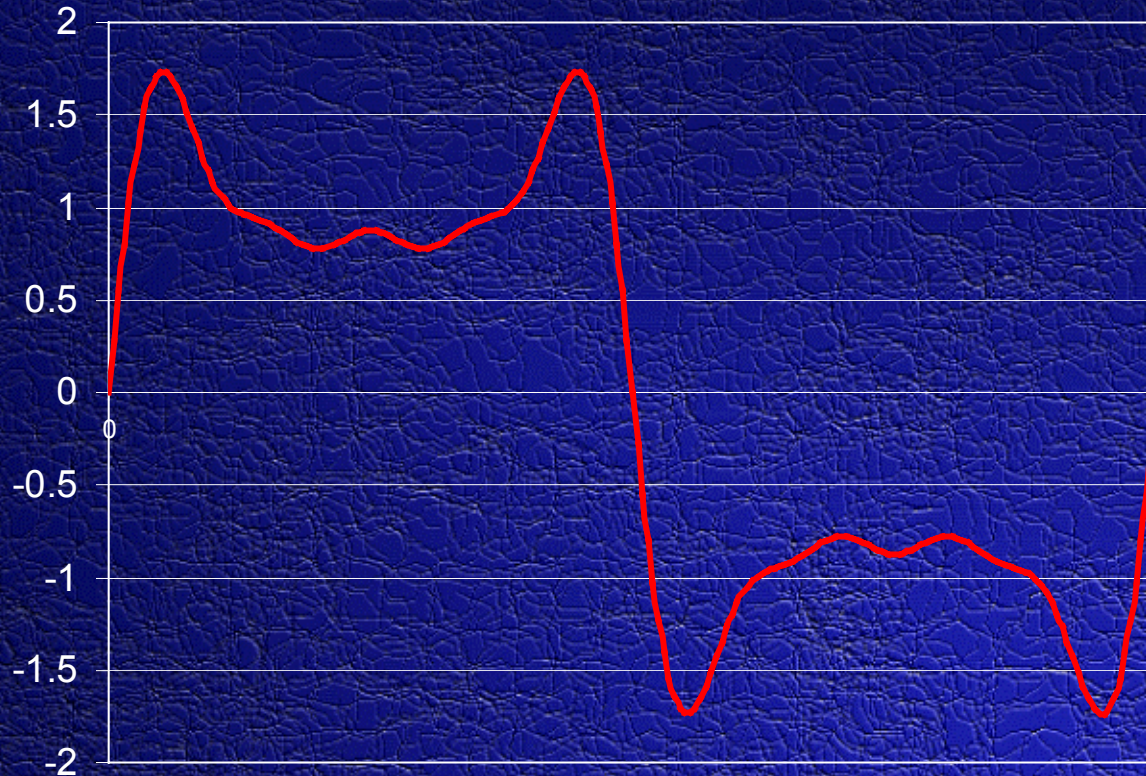
# Power Spectral Density

- A PSD is a set of wavelengths, amplitudes, and phases that describe the individual sinusoids that make up the profile
- For pavements, the PSD highlights predominant wavelengths in the road profile

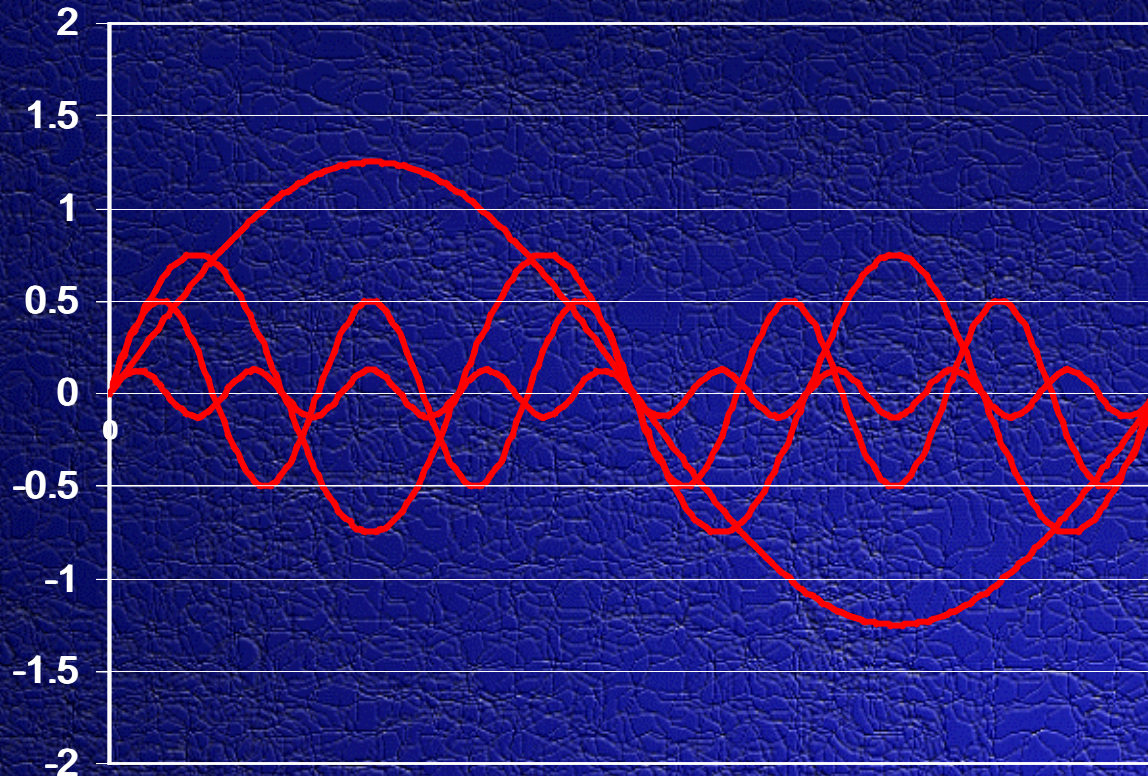




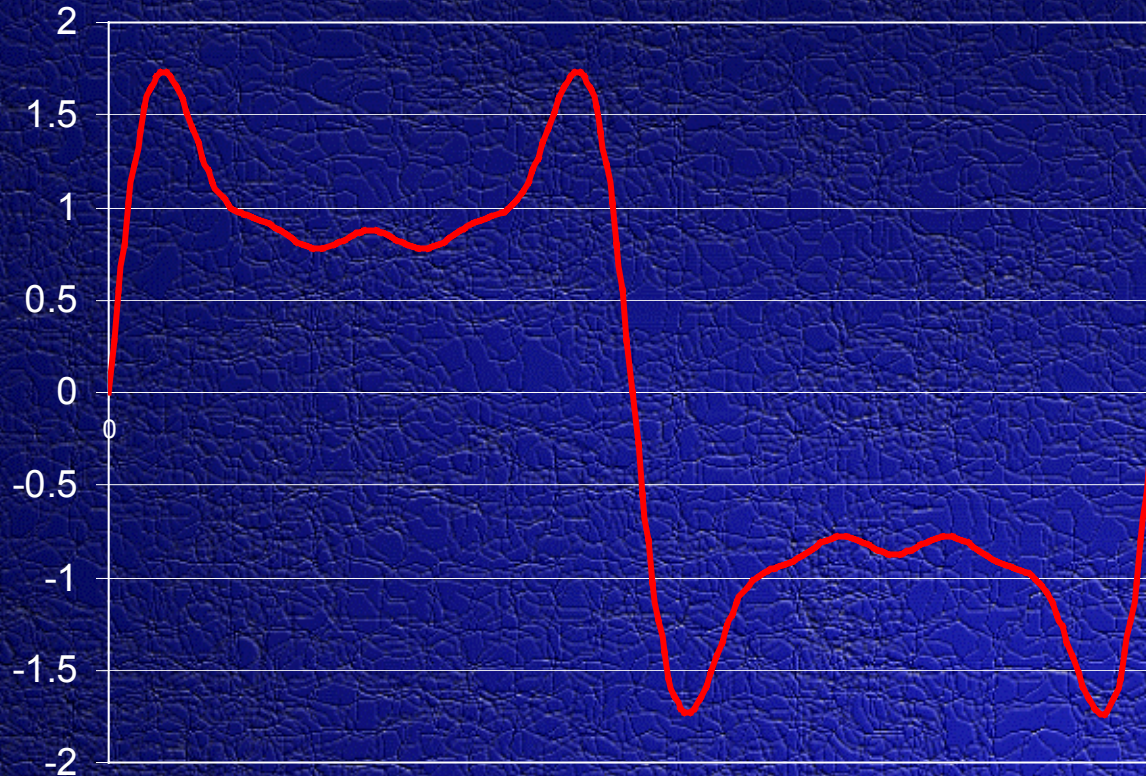
# Power Spectral Density



# Power Spectral Density



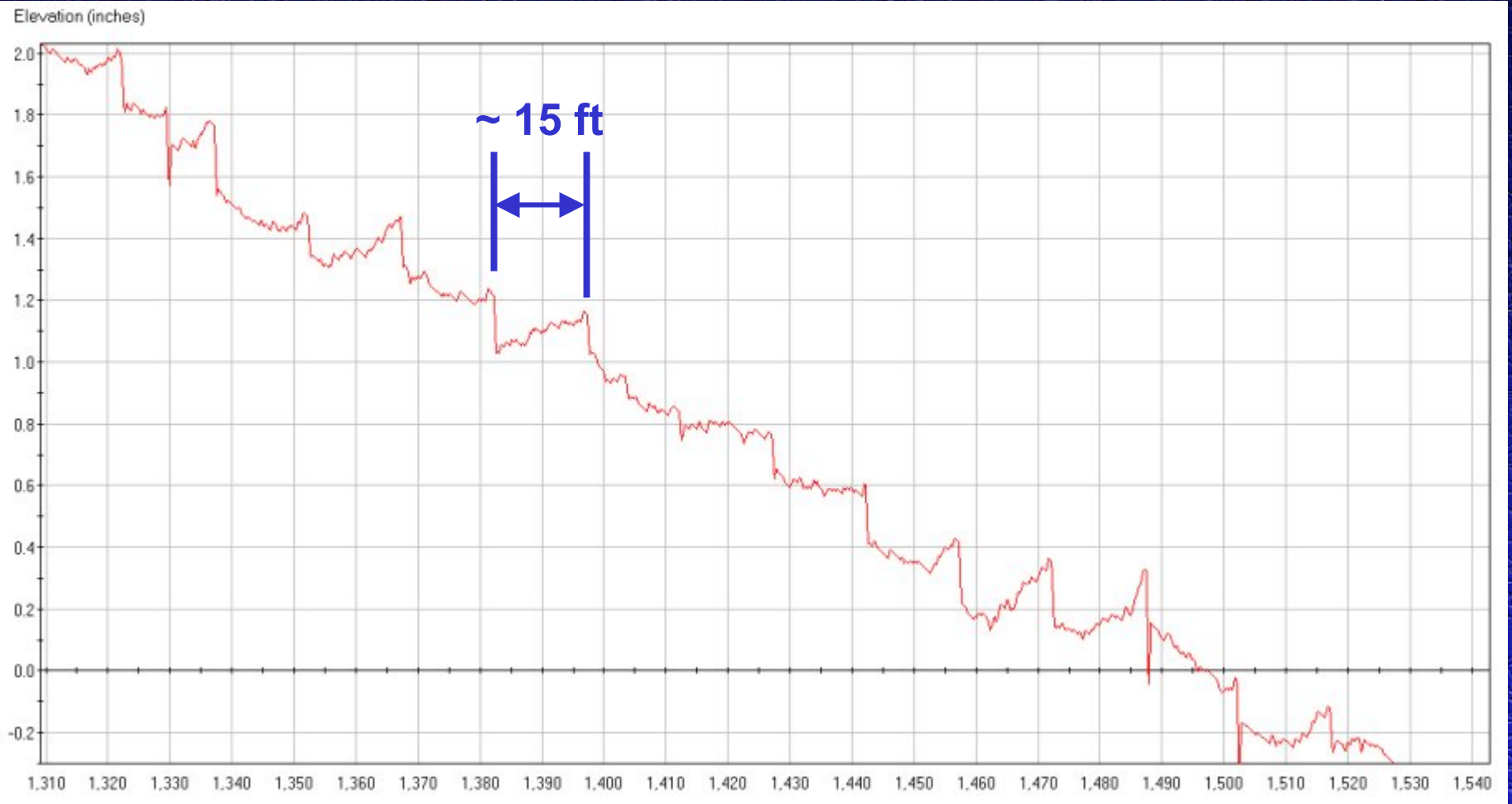
# Power Spectral Density



# Power Spectral Density

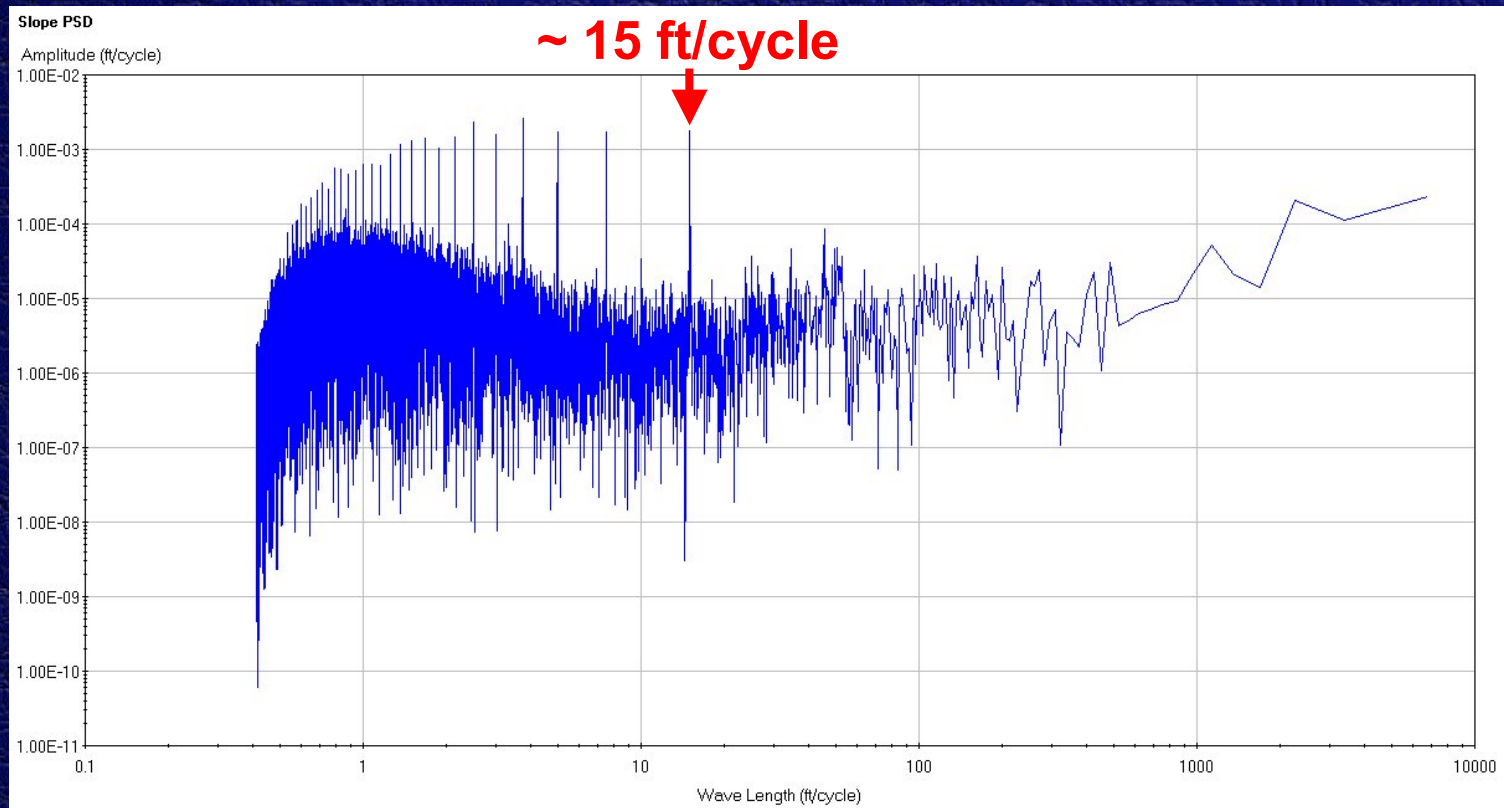


# Power Spectral Density



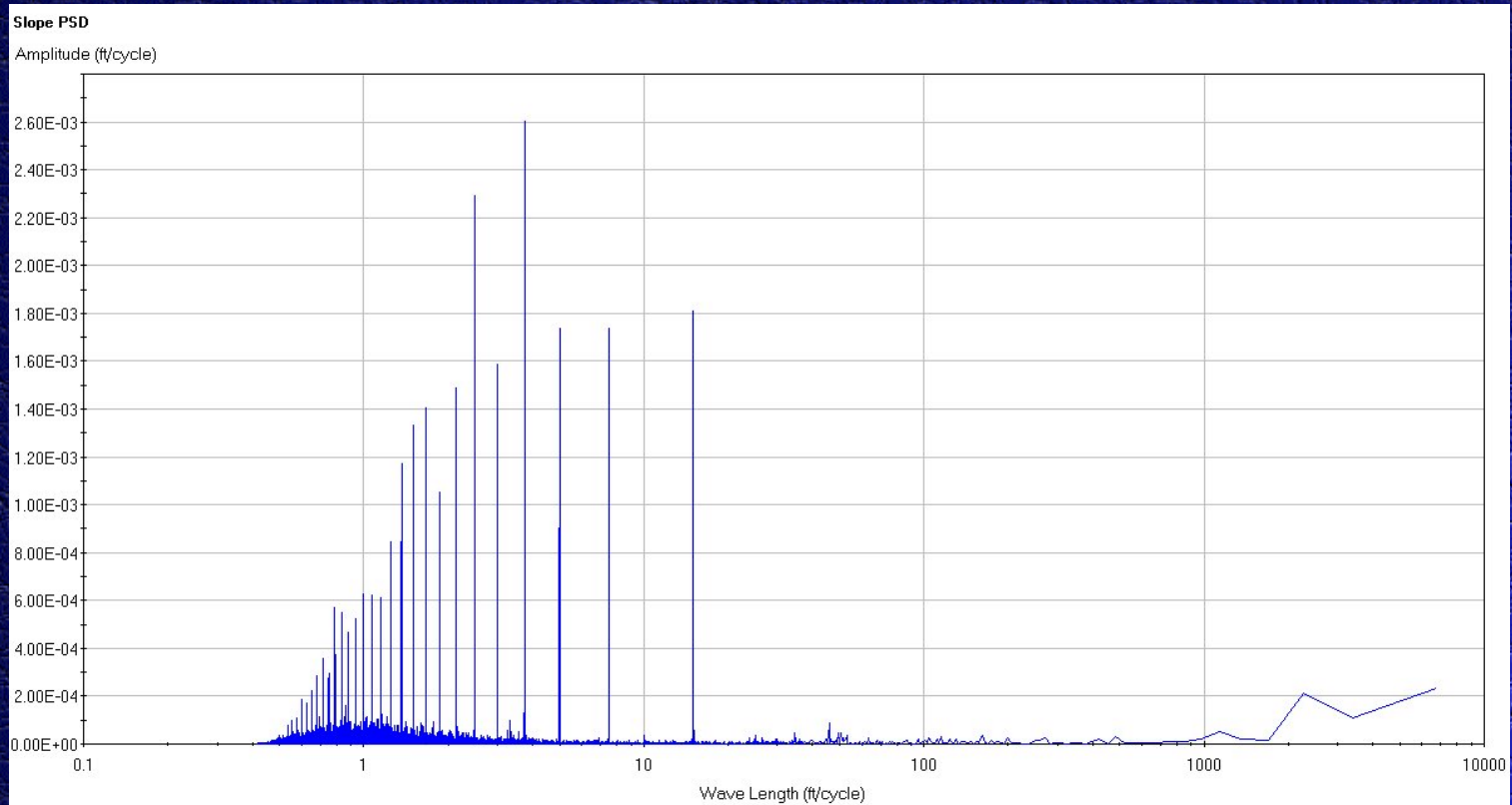
# Power Spectral Density

## Slope PSD - Log Y Scale

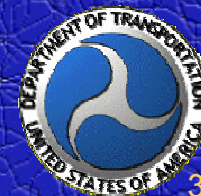


# Power Spectral Density

## Slope PSD - Normal Y Scale



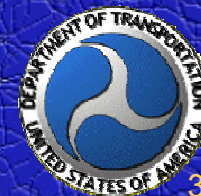
- Profile Viewer (ProVal)1.0 currently available
- Contact:
  - Resource Center Pavement Engineer
  - LTPP Products Engineer





# Future Development/Enhancements

- Profile Viewer (ProVal) 2.0 under development soon
- Enhancements:
  - continuously reported ride statistics
  - HHT
  - Band-pass filtered analysis
  - localized roughness ID techniques
  - grinding simulations



# QUESTIONS?

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