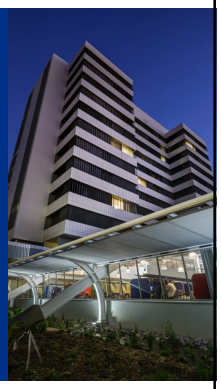
SARF RIDING QUALITY COURSE



5 November 2015

Contents

- 8:00 to 9:00
  Introduction to road riding quality
  Definitions and concepts involved in riding quality
- 9:00 to 10:00
  Measuring riding quality
- **10:30 to 11:30**
  Analysing riding quality data
- 13:30 to 15:00
  Interpreting riding quality data
  Riding quality and Vehicle-Pavement Interaction
- 15:30 to 16:30
  Effects of riding quality on road users and costs

Analysing riding quality data

- Conceptual analysis process
- Proval tool
- What are required for a project

Conceptual analysis process

- Decide on objectives beforehand
  - Response type OK?
  - Detailed analysis required
  - Spectral analysis or IRI or HRI?
- Specifications
- Calibration requirements
- Validation and control testing
- Operational issues
- Verify the data
  - Start with the most basic information (profile or initial riding quality data
- Calculate the appropriate statistic
- Interpret the statistic

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Decide on objectives

Table 3: Network Level Planning Considerations

Frequency of Measurement	Data Uses	Type of Devices	Validation and Calibration Requirements (Notes 1 and 2)
Once-off assessment of network roughness	• Prioritization of maintenance and rehabilitation	• Response type devices • Class 1 and 2 Profilers	• Level 1 Calibration (response type devices) • Level 1 Validation (profilers)
Three-to-five yearly assessment of network roughness	• Prioritization of maintenance and rehabilitation • Monitoring of relative network deterioration	• Response type devices • Class 1 and 2 Profilers	• Level 2 Calibration (response type devices) • Level 2 Validation (profilers)
Annual or biennial assessment of network roughness	• Prioritization of maintenance and rehabilitation • Monitoring of absolute network deterioration • Inputs into planning models	• Class 1 and 2 Profilers	• Level 2 Validation (profilers) • Level 3 Validation (optional) at contract start or when device type is changed (Note 3)

Note 1: Levels of calibration for response type devices are defined and discussed in Section 4. Levels of validation for profilers are discussed in Section 5.

Note 2: In all cases, operational checks and controls as defined in Section 4 (for response type devices) and Section 5 (for profilers) should be strictly implemented.

Note 3: Level 3 validation requires specialist analysis of profile data, and is recommended only where the highest level of precision is needed (for annual surveys, and to be performed at the contract start or when there is a change in device type or major maintenance on the equipment).

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Specifications

- Compile contract specifications
  - lay down criteria for quality and acceptance of survey
- Specifications should cover
  - Equipment specification
  - Calibration or validation
  - Measurement control
  - Survey procedures
  - Contract quality plan
  - Reporting and data reporting format
- Equipment specification should be compatible with survey type and objectives

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B4213 CONSTRUCTION TOLERANCES AND FINISH REQUIREMENTS

- … surface regularity (roughness) of the pavement shall be determined by using a profilometer…
- … capable of producing a Class 1 vertical measurement resolution, and a Class 3 longitudinal sampling distance ...
- … shall have successfully completed a validation trial against the instrument of reference …
- … record the longitudinal profile in both wheel tracks of each traffic lane …
- …two wheel tracks shall be 1,75 m apart…
- … profiles will then be processed using the Quarter-Car simulation model …
- … simulated suspension mentioned will then be linearly accumulated and divided by the length to yield 100 m IRI…

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B4213 BONUS PENALTY SPECIFICATION - Surfacing

TABLE B4213/2: BONUS/PENALTY SPECIFICATION AT COMPLETION OF CONSTRUCTION

Slow Lane and Fast Lane	
Average 100 m IRI (m/km)[1]	Payment Adjustment Factor
Factors	
< 1.01	1.030
1.01 to 1.10	1.020
1.11 to 1.20	1.010
1.21 to 1.30	1.000
1.31 to 1.40	0.990
1.41 to 1.50	0.980
1.51 to 1.6	0.970
> 1.6	Rejected

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B4213 BONUS PENALTY SPECIFICATION - Base

TABLE B3405/1: PAYMENT ADJUSTMENT FOR BASE LAYER

PAYMENT ADJUSTMENT FACTOR	
Average IRI $_{100\ m}$ (m/km)	New Pavement Construction
<1.30	1.050
1.31 to 1.40	1.050
1.41 to 1.50	1.025
1.61 to 1.70	1.010
1.71 to 1.80	1.000
1.81 to 1.90	0.990
1.91 to 2.00	0.975
2.01 to 2.10	0.995
2.11 to 2.20	0.930
2.21 to 2.30	0.900
2.31 to 2.40	0.865
2.41 to 2.50	Reject

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COLTO B3405 CONSTRUCTION TOLERANCES (SANRAL Proforma Part f)

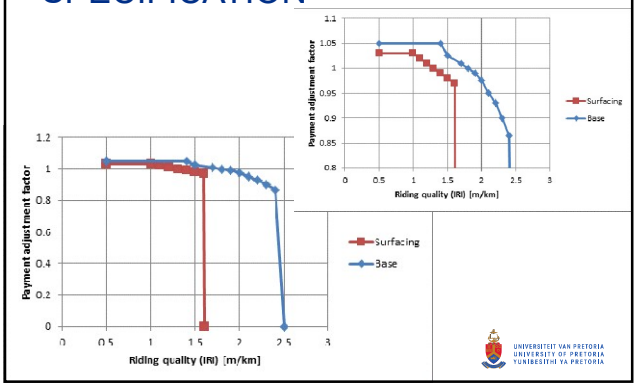
TABLE B3405/1: PAYMENT ADJUSTMENT FOR BASE LAYER

Average IRI $_{100\ m}$ (m/km)	PAYMENT ADJUSTMENT FACTOR		
	Reworked or Recycled Base	Recycle existing layers + New Base Layer	New Pavement Construction
<1.30	1.050	1.050	1.050
1.31 to 1.40	1.050	1.050	1.050
1.41 to 1.50	1.050	1.050	1.025
1.61 to 1.70	1.050	1.050	1.010
1.71 to 1.80	1.050	1.050	1.000
1.81 to 1.90	1.050	1.025	0,990
1.91 to 2.00	1.050	1.010	0,975
2.01 to 2.10	1.050	1.000	0,955
2.11 to 2.20	1.025	0,990	0,930
2.21 to 2.30	1.010	0,975	0,900
2.31 to 2.40	1.000	0,955	0.865
2.41 to 2.50	0,990	0,930	Reject
2.51 to 2.60	0,975	0,900	Reject
2.61 to 2.70	0,955	0.865	Reject
2.71 to 2.80	0,930	Reject	Reject
2.81 to 2.90	0,900	Reject	Reject
2.91 to 3.00	0.865	Reject	Reject
>3.01	Reject	Reject	Reject

Inertial Profiler: Average IRI $_{100m}$ = (Run1 IRI $_{100m\ Ave}$ + Run2 IRI $_{100m\ Ave}$ + Run3 IRI $_{100m\ Ave}$) / 3
Walking Profiler: Average IRI $_{100m}$ = (100m IRI $_{Left\ wheel\ track}$ + 100m IRI $_{Right\ Wheel\ track}$) / 2

ETORIA
ITORIA
ETORIA

B4213 BONUS PENALTY SPECIFICATION



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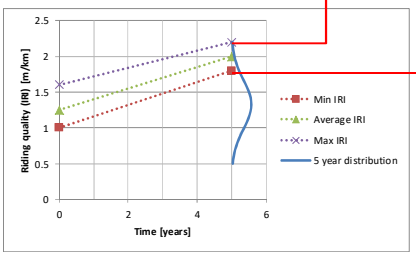
Performance Guarantee specification - Surfacing

At the end of the five year Performance Guarantee Period, as determined in terms of the Specified methodology, the roughness as determined shall not exceed the values as specified in Table 8504/4.

TABLE B8504/4 – SPECIFICATION FOR ROUGHNESS DEPTH CRITERIA

Profilometer measurements Limiting Roughness (IRI)	Maximum length (%) of segment with roughness depth worse than limiting value
1,8	10%
2,0	5%
2,2	0%



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Calibration requirements

- Component calibration
  - calibration of individual components of system
    - lasers / accelerometers / distance measuring transducers
- System calibration or validation
  - checks to ensure accuracy of measurement system as a whole

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Calibration requirements

- Component calibration
  - contractor produce calibration certificates
  - rules or conditions of recalibration
  - specify components for which proof of calibration is required
- System calibration or validation
  - number and type of calibration sites
  - length of calibration sections
  - calibration methodology and criteria
  - details of calibration procedure
    - demarcation of sections, measurement speeds, data to be gathered

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Validation and control testing

- Determine if all components in profiler system work correctly
- Validate that all individual components are correctly calibrated
- Confirm that measurement approach adopted can provide consistent results in required format
- Accepted as valid if measured IRI values over different parts of each validation section have acceptable levels of
  - bias - error between reference and measured IRI is acceptable
  - precision - variation amongst repeated measurements is acceptable

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Operational issues - Response type

- Vehicle load
- Tyre inflation pressure
- Linkages
- Tyre condition
- Temperature effects
- Water and dirt
- Speed control
- Suspension condition

Operational issues - Profiles

- Warm-up
- Electronic equipment checks
- Output and data collection
- Bounce test
- Height sensor accuracy

Verify the data

- Logic check of the data
- Collected data
  - Operator details
  - Section details
  - Location (GPS)
  - km position
  - Left and right wheelpath data
  - Measurement speed
- Validation process
  - Profiler
  - Distance measurements

Verify the data

- Check vehicle - ensure same as used in validation exercise
- Ensure that driver is same as for validation exercise
- Request and inspect daily checklist - meets quality control plan format
- Inspect vehicle - ensure that height sensors are free of excessive dirt, mud, etc
- Request operator to perform height check
- Request operator to perform bounce check
- Confirm correct operation of GPS

Pavement and environmental influences

- Pavement
  - Cracking
  - Texture
  - Potholes and patching
  - Daily variations (mainly concrete)
  - Seasonal variations
- Environment
  - Wind
  - Temperature and humidity
  - Surface moisture
  - Contaminants

Calculate appropriate statistic

- Which statistic is being used
  - Network level
  - Project level
- How to calculate
  - Service provider?
  - Raw profile data?

Interpret the statistic

- Relative to specification
  - Network level
  - Project level
- Relative to V-PI effects
- Best that can be delivered?

PROVAL

PROVAL

- Purpose of PROVAL
- Availability of PROVAL
- What is required to run PROVAL

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PROVAL screenshots

- Initial screen
- Data input
- Data / project save
- Types of data analysis
- Interpretation of output

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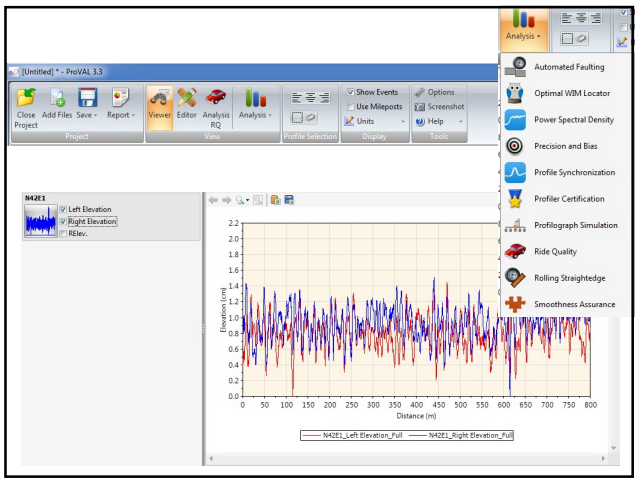
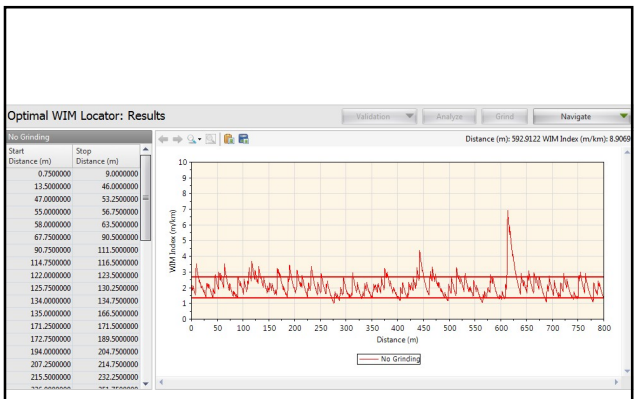
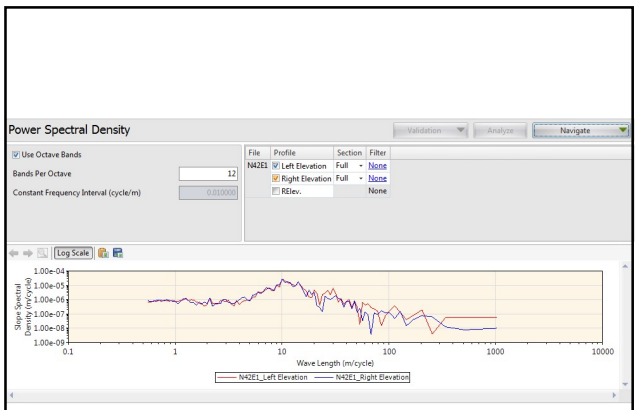
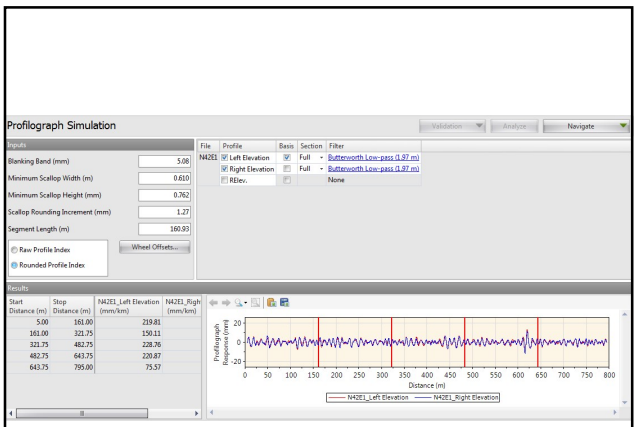


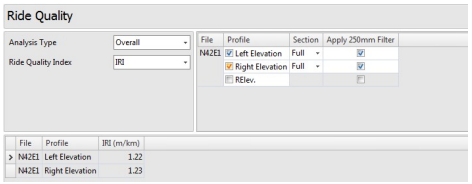



Power Spectral Density
Validation
Analyze
Navigate
Use Octave Bands
Bands Per Octave
12
Constant Frequency Interval (cycle/m)
0.010000
File
Profile
Section
Filter
N42E1
Left Elevation
Full
None
Right Elevation
Full
None
RElev.
None
Log Scale
Slope Spectral Density (m/cycle)
1.00e-04
1.00e-05
1.00e-06
1.00e-07
1.00e-08
1.00e-09
0.1
1
10
100
1000
10000
Wave Length (m/cycle)
N42E1_Left Elevation
N42E1_Right Elevation

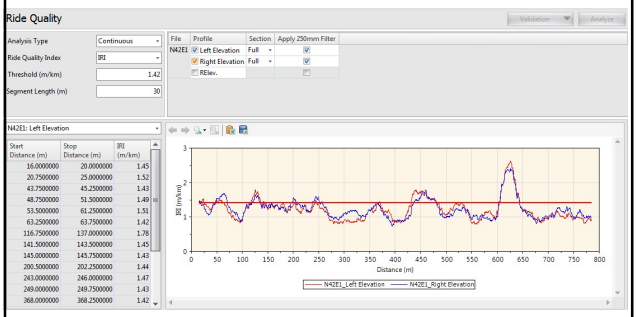
29


Profilograph Simulation
Validation
Analyze
Navigate
Inputs
Blanking Band (mm)
5.08
Minimum Scallop Width (m)
0.610
Minimum Scallop Height (mm)
0.762
Scallop Rounding Increment (mm)
1.27
Segment Length (m)
160.93
Raw Profile Index
Rounded Profile Index
Wheel Offsets...
File
Profile
Basis
Section
Filter
N42E1
Left Elevation
Full
Butterworth Low-pass (1.97 m)
Right Elevation
Full
Butterworth Low-pass (1.97 m)
RElev.
None
Results
Start Distance (m)
Stop Distance (m)
N42E1_Left Elevation (mm/km)
N42E1_Right (mm/km)
5.00
161.00
219.81
161.00
321.75
150.11
321.75
482.75
228.76
482.75
643.75
220.87
643.75
795.00
75.57
Profilograph Response (mm)
Distance (m)
N42E1_Left Elevation
N42E1_Right Elevation

30


Ride Quality
Analysis Type
Overall
Ride Quality Index
IRI
File
Profile
Section
Apply 250mm Filter
N42E1
Left Elevation
Full
Right Elevation
Full
RElev.
File
Profile
IRI (m/km)
N42E1
Left Elevation
1.22
N42E1
Right Elevation
1.23

31


Ride Quality
Validation
Analyze
Analysis Type
Continuous
Ride Quality Index
IRI
Threshold (m/km)
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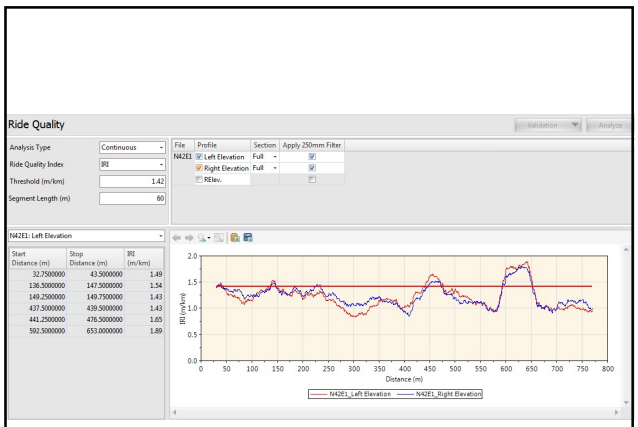
Segment Length (m)
30
File
Profile
Section
Apply 250mm Filter
N42E1
Left Elevation
Full
Right Elevation
Full
RElev.
N42E1: Left Elevation
Start Distance (m)
Stop Distance (m)
IRI (m/km)
16.0000000
20.0000000
1.45
20.7500000
25.0000000
1.52
43.7500000
45.2500000
1.43
48.7500000
51.5000000
1.49
53.5000000
61.2500000
1.51
63.2500000
63.7500000
1.42
116.7500000
137.0000000
1.78
141.5000000
143.5000000
1.45
145.0000000
145.7500000
1.43
200.5000000
202.2500000
1.44
243.0000000
246.0000000
1.47
249.0000000
249.7500000
1.43
368.0000000
368.2500000
1.42
IRI (m/km)
Distance (m)
N42E1_Left Elevation
N42E1_Right Elevation

32



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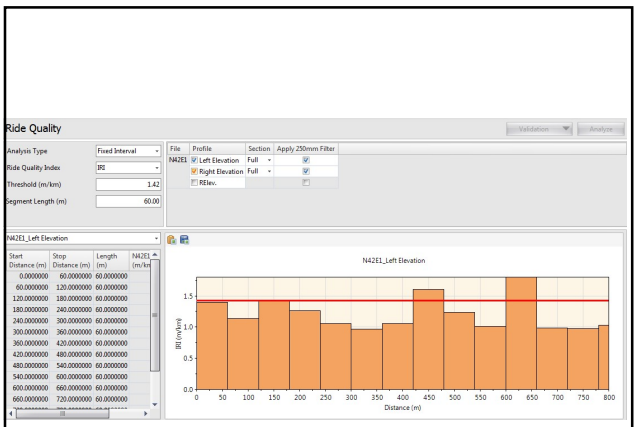

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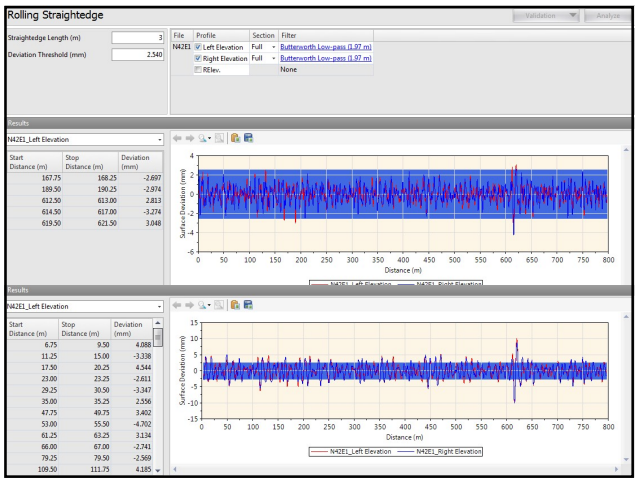


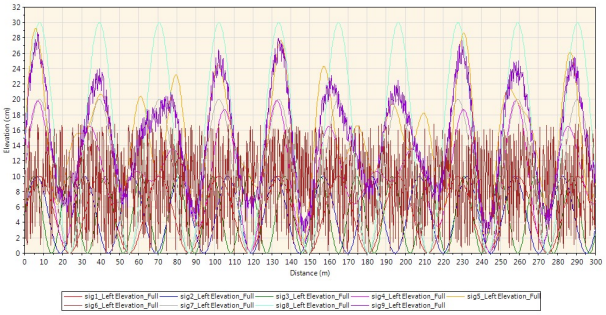
Analysis demonstrating concepts

- 9 Generated profiles
- Combinations of sinusoidal functions

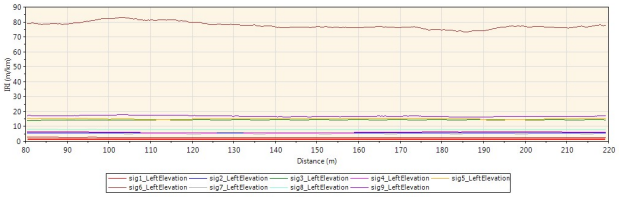
Sig1	=SIN(x/5)+1
Sig2	=SIN(x/4)+1
Sig3	=SIN(x/3)+1
Sig4 (12)	=Sig1 + Sig2
Sig5 (1234)	=SUM(Sig1 to Sig4)
Sig6 (random)	=SIN(RAND())
Sig7 (Amp1)	=Sig1*2
Sig8 (Amp2)	=Sig1*4
Sig9 All	=SUM(Sig1 to Sig8)

36

Profiles



Continuous IRI



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Overall IRI

File	Profile	IRI (m/km)
sig1	Left Elevation	2.64
sig2	Left Elevation	5.73
sig3	Left Elevation	14.23
sig4	Left Elevation	6.31
sig5	Left Elevation	15.12
sig6	Left Elevation	78.64
sig7	Left Elevation	5.27
sig8	Left Elevation	7.90
sig9	Left Elevation	17.13

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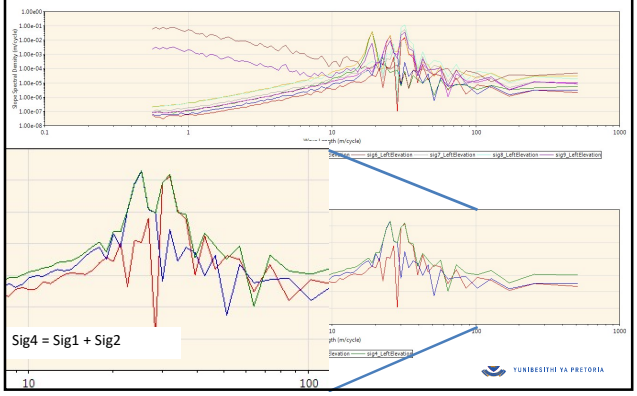
Slope PSD



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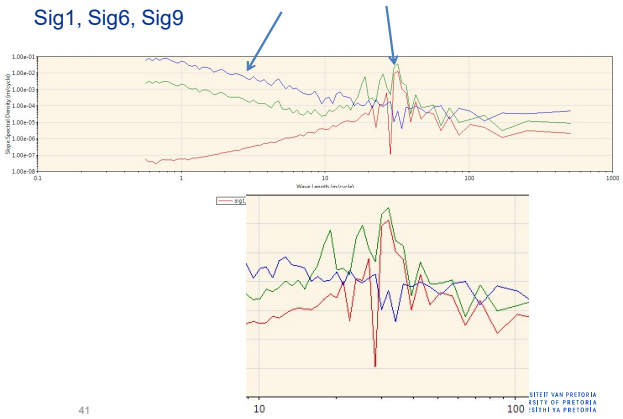
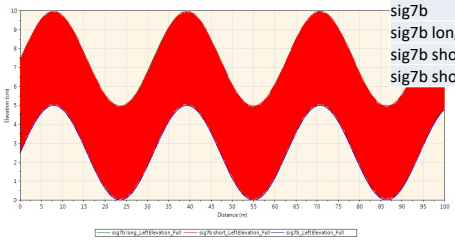
Sig1, Sig6, Sig9



Short and long wavelength effects

- IRI affected by 1.2 to 30 m wavelengths (mainly)
- Analysis of profile

Description	IRI (m/km)
longlong	0.02
shortshort	0.34
sig7b	1.40
sig7b long	1.40
sig7b short	1.41
sig7b short long	1.41



Proval demonstration

- Open M roads and run through analyses
  - Riding quality
  - PSD
  - Rolling straight-edge