What do we do with the Traffic Speed Deflectometer results?

Martin Gribble (NZ Transport Agency) and Dave Stevens (GeoSolve)

NZ Transport Agency & NZIHT

17th ANNUAL CONFERENCE

NZ TRANSPORT AGENCY WAKA KOTAHI & new zealand nz:iht institute of highway technology

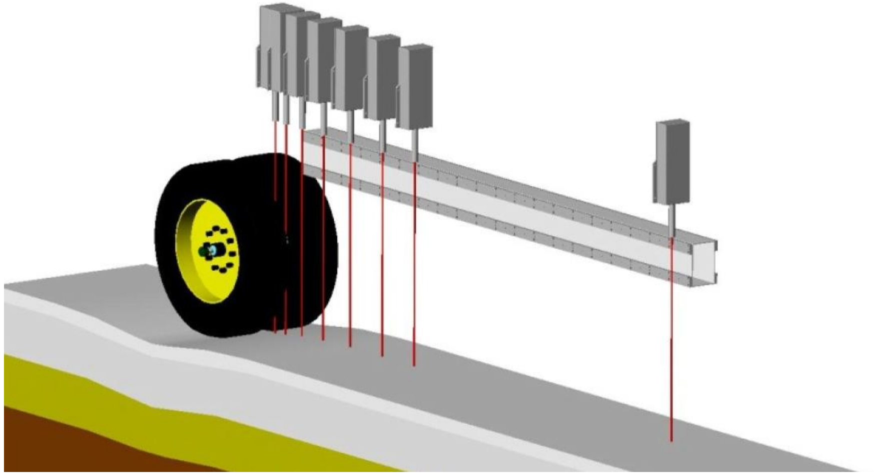
Traffic Speed Deflectometer

What is it?

Traffic Speed Deflectometer

How does it work?

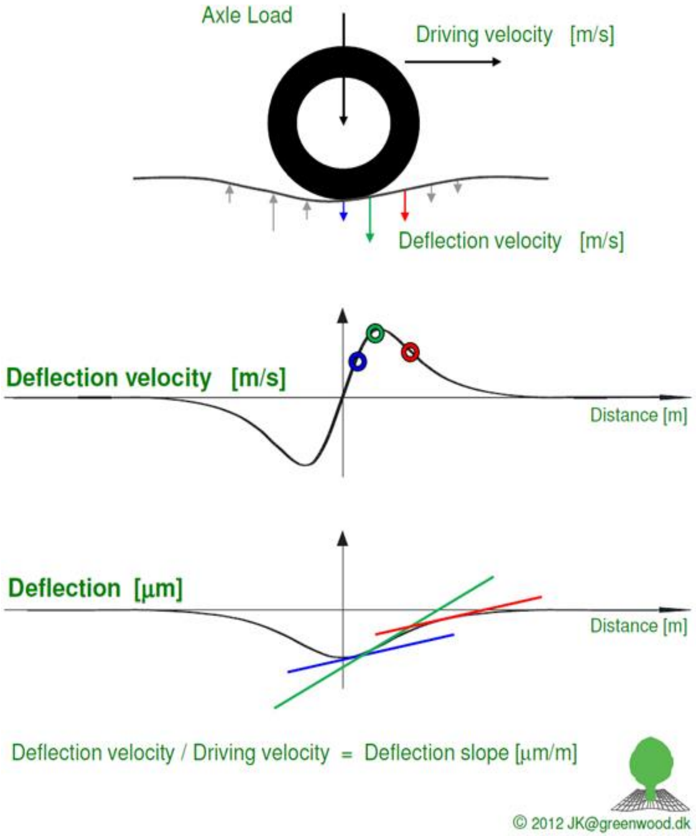
- Dynamic load is highly representative of actual traffic loading
- High speed measurement
- Short measurement intervals
- Crack detection achieved through wavelet analysis of results obtained from rear mounted lasers
- Crack results can be combined with LCMS (requires licence)



Traffic Speed Deflectometer

How does it work?

- Force applied through wheels, and vertical and horizontal vehicle suspension velocities are recorded
- Doppler lasers (mounted at a slight angle) measure vertical pavement deflection velocities
- Deflection bowl slopes are calculated from ratio of pavement vertical velocity to vehicle horizontal velocity
- Deflection bowls are integrated from deflection bowl slopes
- Results are averaged over 10 m sections



Traffic Speed Deflectometer

Limitations?

- The TSD must be travelling at speeds > 30 kph for data accuracy (otherwise deflections can increase by a factor of 2 or more as speeds tend to 0 kph)
- The speed requirement would make it impractical to test in many urban environments or other built-up areas with considerable traffic, lights, roundabouts and speed bumps
- It is possible to get changes in applied wheel load of up to 10% when cornering, or even when there is a severe crosswind
- The lasers cannot be operated in wet, rainy conditions where there is any surface water
- The Danish Road Directorate indicated difficulties in processing data collected on rough and bumpy roads

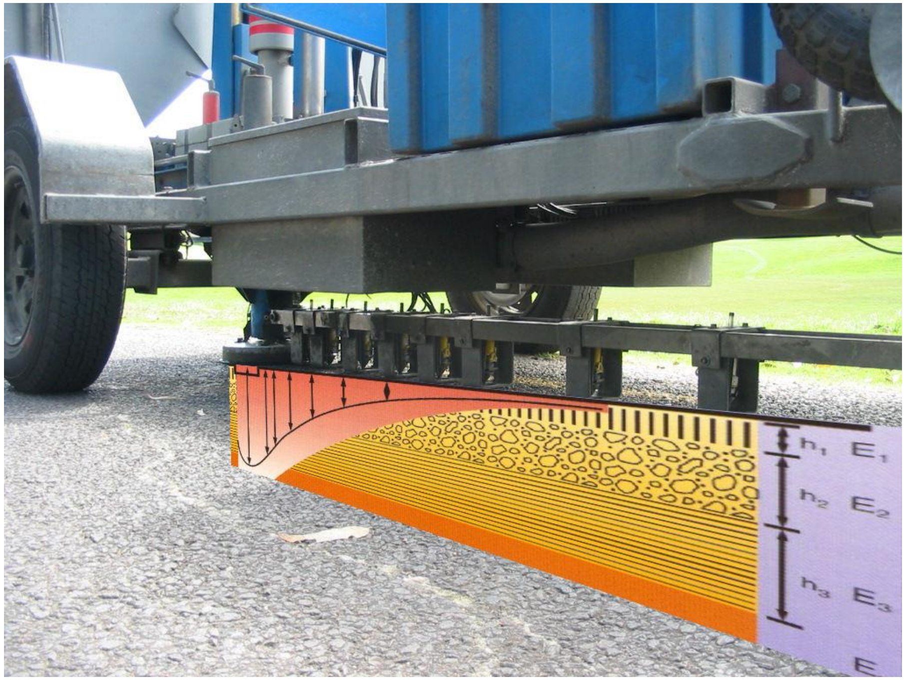
Traffic Speed Deflectometer

What are the benefits for NZ Transport Agency?

- Continuous coverage of pavement structural condition across the State Highway network
- Network surveyed at traffic speed (reduced traffic management, less disruption to the customer)
- Expected that greater data quantity will feed into improved pavement deterioration models
- Better informed pavement management and investment decisions
- Ability to collect comprehensive cracking data
- After transformation, obtain compatibility with existing condition measurement tools – Benkelman Beam or Falling Weight Deflectometer (FWD)

Falling Weight Deflectometer (FWD)

- Force applied through stationary plate (static test)
- Deflection bowl measured with geophones
- FWD data has been collected annually on State Highways since 1998:
  - Network Level FWD: 200 m centres (100 m staggered)
  - AWT/BM/Project Level FWD: usually 20 or 50 m centres in each lane
  - Benchmark (BM) sites used as input to pavement deterioration model



Correlation of TSD with FWD

Existing methods and outputs

- Output deflection bowls at 0, 200, 300, 450, 600, 750, 900, and extrapolate to1200 and 1500mm offsets (as per FWD)
- Interpretation of deflection bowl under TSD moving wheel load currently has three approaches available:
  - Greenwood Integration
  - ARRB Integration (ARRB-12)
  - NZ-16.1 (ARRB bowls calibrated using FWD data)

Correlation with FWD

- Modifies the ARRB deflection bowl using transfer functions calibrated using FWD (typically across a Route Station)
- Coefficients are optimised when the cumulative distributions show a good correlation
- Transfer functions are unique and need to be generated for every route station
- Historic or future data sets may also require a unique transfer function
- Spreadsheet available

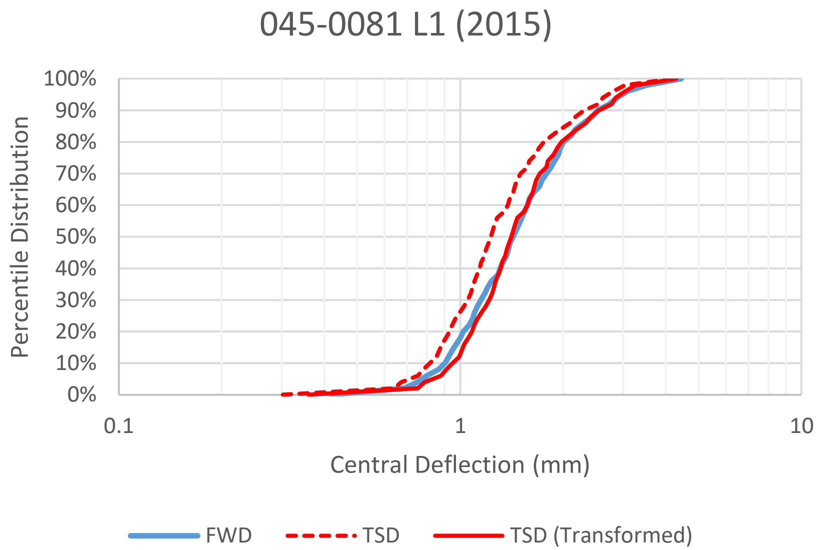
$$CM'_0 = (0.0225 * LN(CM_0) + 0.778) * CM_0$$

$$CM'_{300} = (-0.06 * LN(CM_{300}) + 1.071) * CM_{300}$$

$$CM'_{600} = (-0.11 * LN(CM_{600}) + 1.267) * CM_{600}$$

$$CM'_{900} = \left(1.119 * \frac{CM_{600}}{CM'_{600}}\right) * CM_{900}$$

$$CM'_{1500} = \left(-0.925 * LN\left(\frac{CM_{1500}}{CM_{900}}\right) + 1.239\right) * CM_{1500}$$



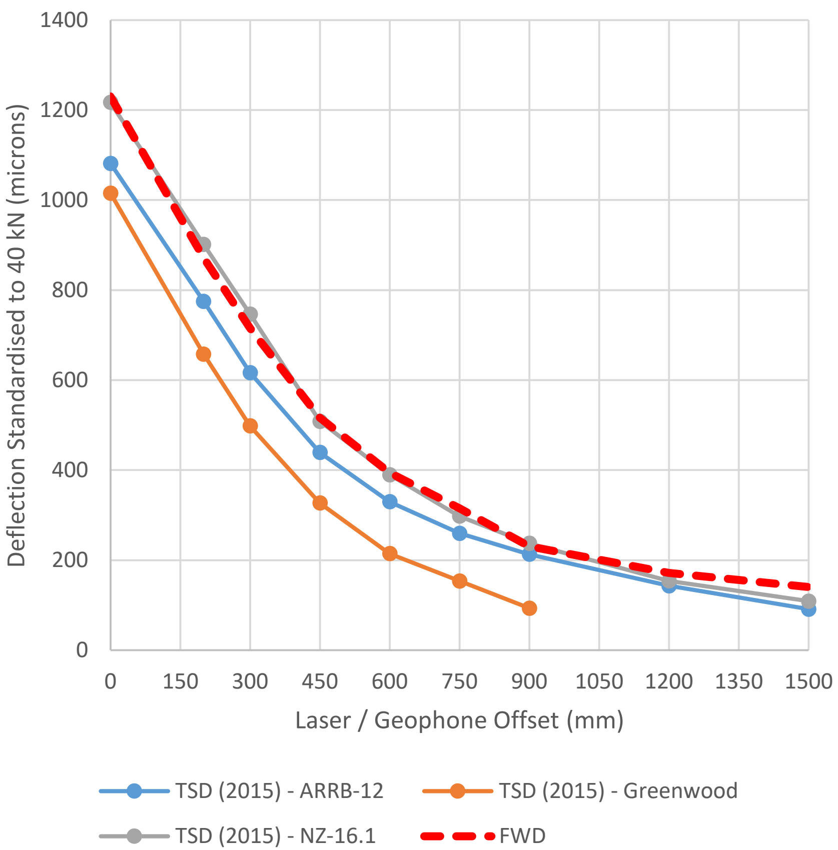
Correlation with FWD

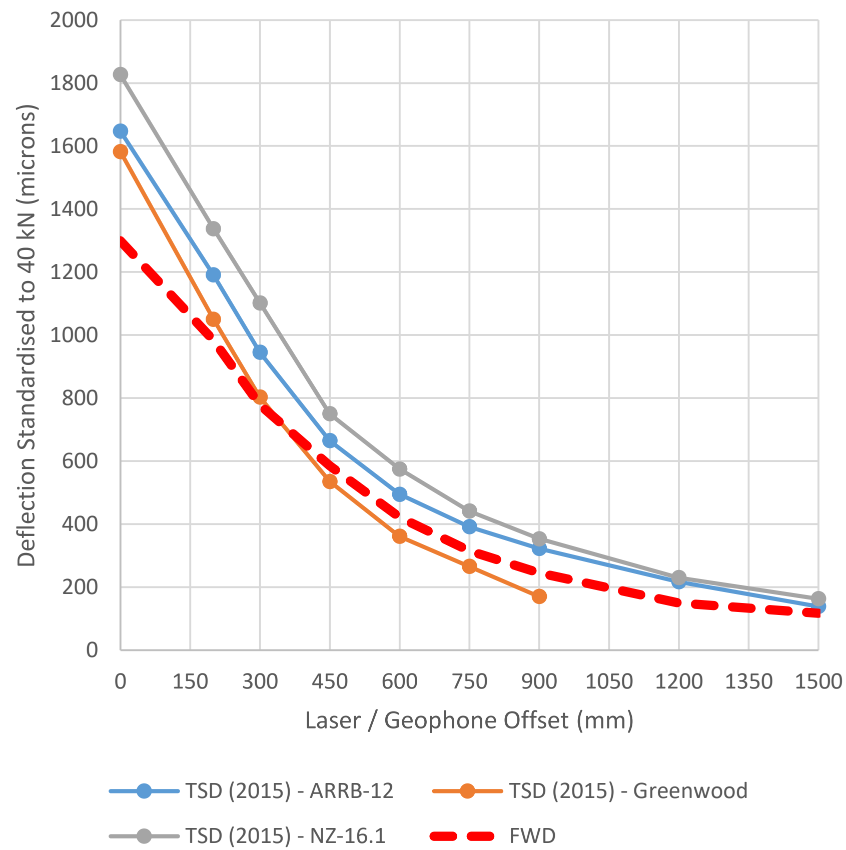
Issues with Existing Methods

- TSD data supplied in RAMM is <u>not standardised</u> (therefore one cannot simply use TSD Central Deflection and Curvature for empirical design purposes)
- There is a significant difference in the calculated deflection bowls across all methods when compared with FWD, and each method shows good and bad correlations for individual points

Correlation with FWD

Comparisons of Deflection Bowls





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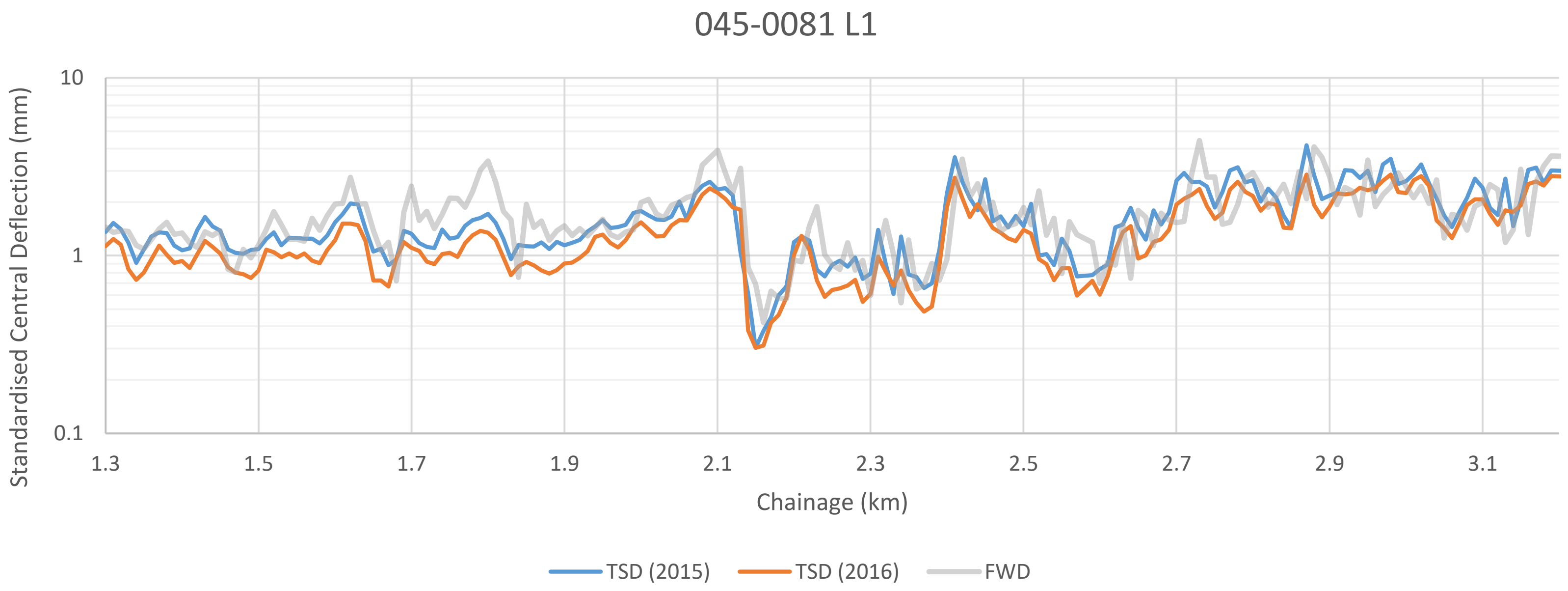
Correlation with FWD

Positive Aspects

- Aside from the difficulties in generating an equivalent FWD deflection bowl from TSD data, the *shape* of the deflection profile is highly repeatable, thus allowing weak spots to be easily identified and targeted for localised project level FWD testing



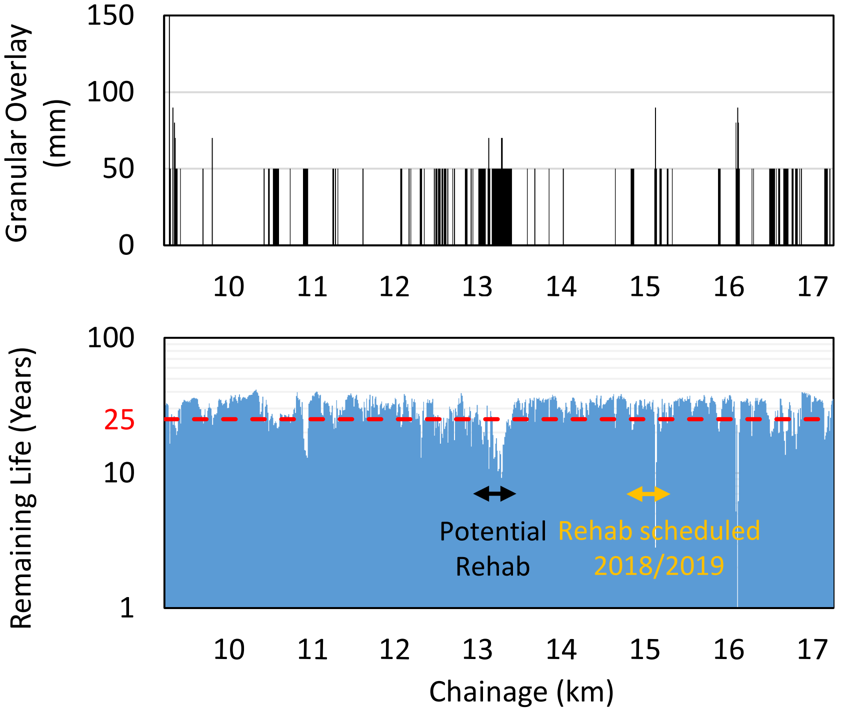
Using TSD Data

Conventional Approach

- Visual inspection and evaluation by Asset Manager
  - Requires extensive knowledge of the network
  - Only surface inspection easily possible without destructive testing etc.
  - Latest resurfacing of road could potentially hide road distresses (especially from new staff)
- Example road
  - Visually equally distressed (prioritisation decision is best supplemented by deflections)

Using TSD Data

- Same as FWD output
- Mechanistic evaluation gives insight into pavement structure (as opposed to just superficial)
- Roads with similar distress shown on the surface should be classified by subsurface structural distress
- Informed decisions enabled for:
(1) will resurfacing suffice or is rehabilitation essential
(2) prioritising: which interval is working harder and hence is likely to have greater future maintenance costs (objective not subjective indicator)



TSD – The Way Forward

How we see the data from the TSD being used

- Better resolution will allow weak areas of pavement to be identified and renewals prioritised
- Optimised treatment lengths with well defined extents
- The TSD with 10 m average spacing will allow close definition of the limits (start and end) of each individual treatment length
- TSD data transformed to equivalent FWD bowls allow existing proven evaluation methods to be adopted, provided some calibration check is done
- Rehabilitation design using precedent performance (NZ Supplement to Austroads) can also be used, as this method uses relative characteristics, rather than absolute

TSD – The Way Forward

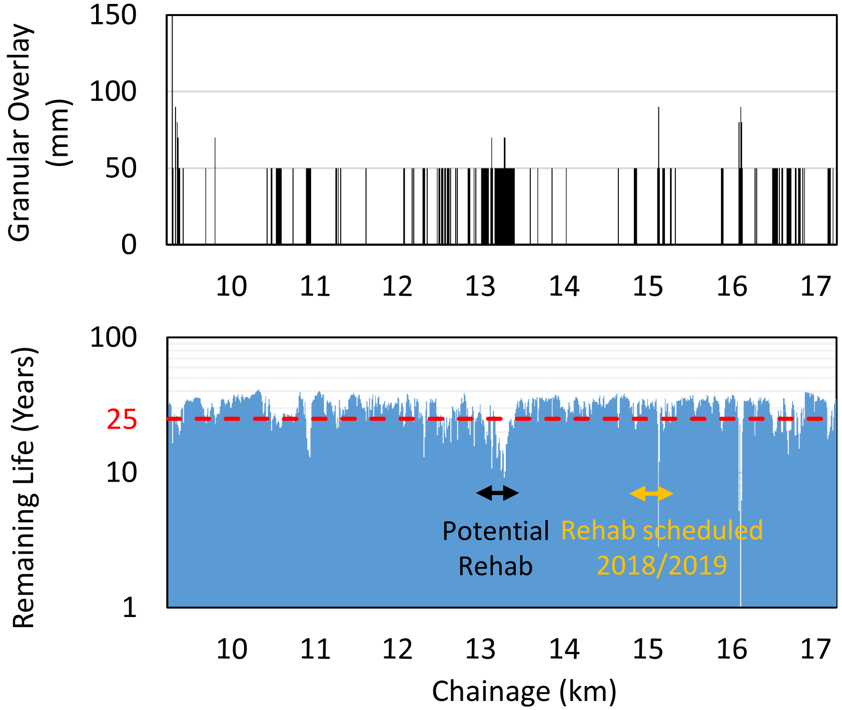
Has significant promise!

- The correlation between FWD and TSD is excellent from a relativity point of view, but the absolute deflections from the TSD between successive years (2015 versus 2016) can be anomalous in many cases. Further validation is required but meanwhile users should expect absolute repeatability in successive years may be about 10% if climate has been similar.
- Improvements with integration methods (currently in development) are in progress to improve the translation of dynamic to pseudo-static bowls, as is the development of more detailed dynamic analysis methods that require no intermediate step

Using TSD Data

Comparison – Visual Inspection, versus

- Visual plus Structural Evaluation



(More case histories available)

THE END

For more information, please contact

martin.gribble@nzta.govt.nz

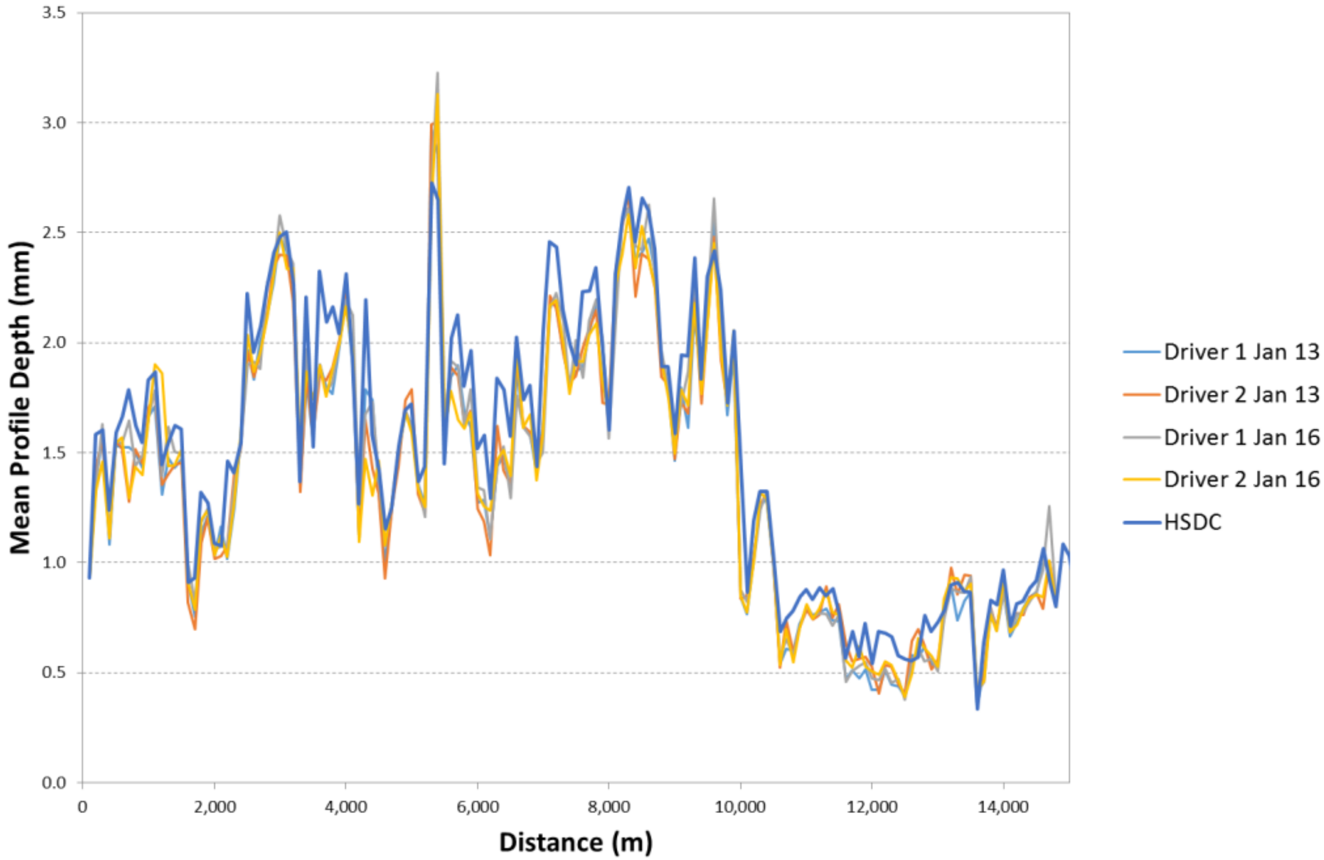
021 842 667

Traffic Speed Deflectometer

Validation and Correlation with HSD/FWD

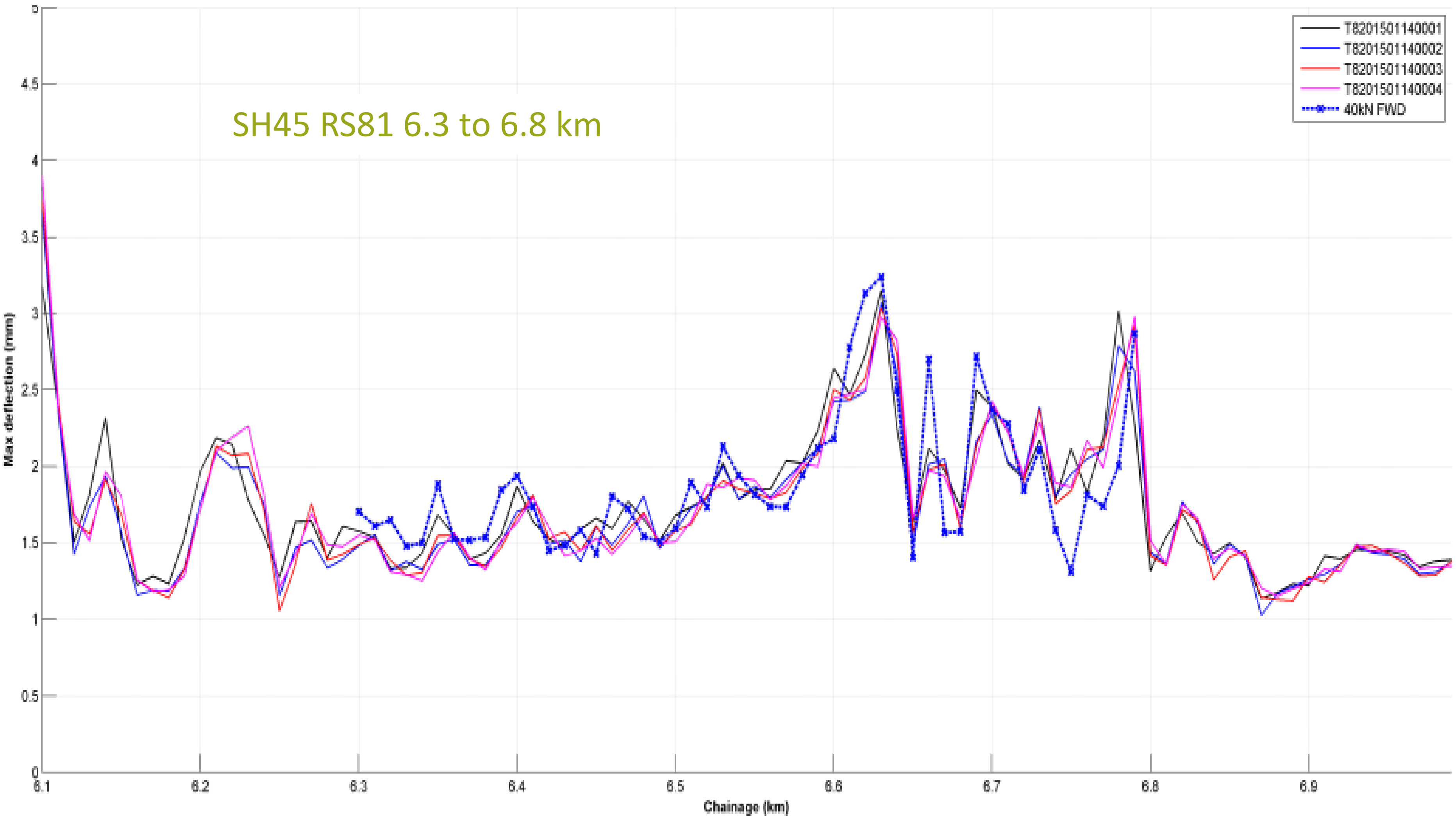
- Validation Sites – SH58 (approx 30km return)
- Used to check for any bias and precision limits, namely repeatability and reproducibility
- Also used for validation of NZTA HSD annual survey
- Provided opportunity to assess TSD against HSD for rutting/texture/roughness etc
- Validation Sites – SH45 (5 sites between 400 -1000m long)
- Chosen for variable pavement strength to assess repeatability of TSD and correlation with FWD

Repeatability – SH58 Texture



SH58 - Left wheel path Mean Profile Depth

Correlation with FWD data – SH45



Corrections for crosswind and cornering…