Road scanning V2.0:
Preliminary results from updated TSD and NM-GPR technologies

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Trusted advisor to road agencies

Overview

- **TSD:** Traffic Speed Deflectometer
  - ARRB modifications & analysis method
  - Data display
  - Comparison to FWD
- **NM-GPR:** Noise-Modulated Ground Penetrating Radar
  - Overview of upgraded technology
  - Data examples
  - Multi-offset analysis
- **TSD + NM-GPR**
  - Rapid pavement investigations

Overview & analysis method

TSD analysis method: Muller & Roberts (2013)[1]

- **Plot:** measured road surface velocities in terms of slope v's wheel offset.
- **Assume:** zero slope at wheel & far from wheel.
- **Curve fit:** to determine intermediate values.
- **Numerical integration:** to determine deflection bowl

ARRB-modified TSD:

- **Continuous deflection**

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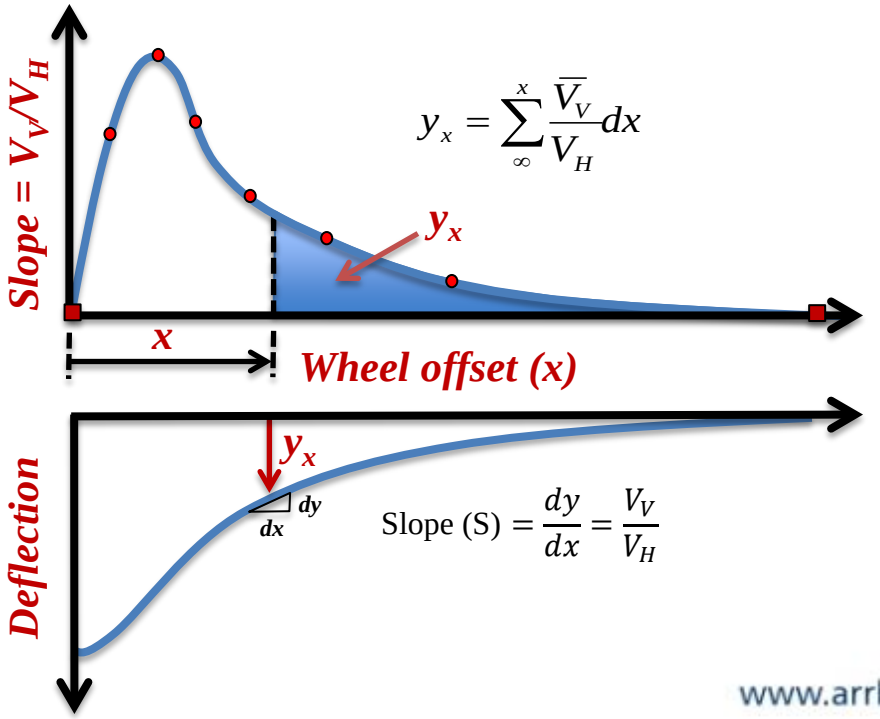
- **Hawkeye sensors:** rutting; roughness; automatic crack detection (ACD); geometry; texture; cameras & DGPS.



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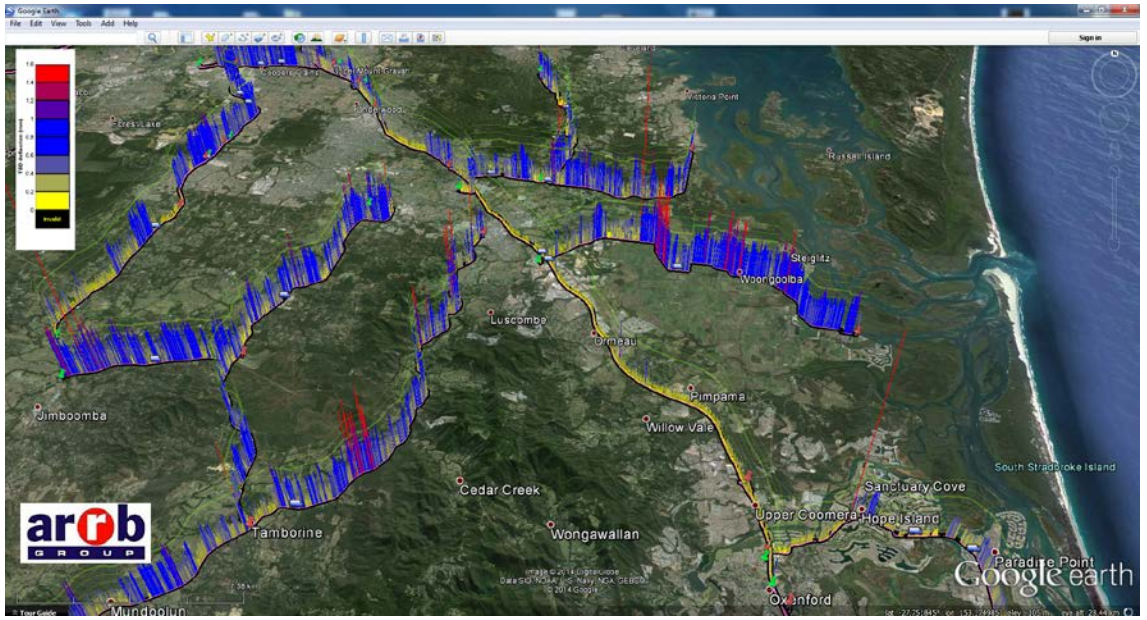
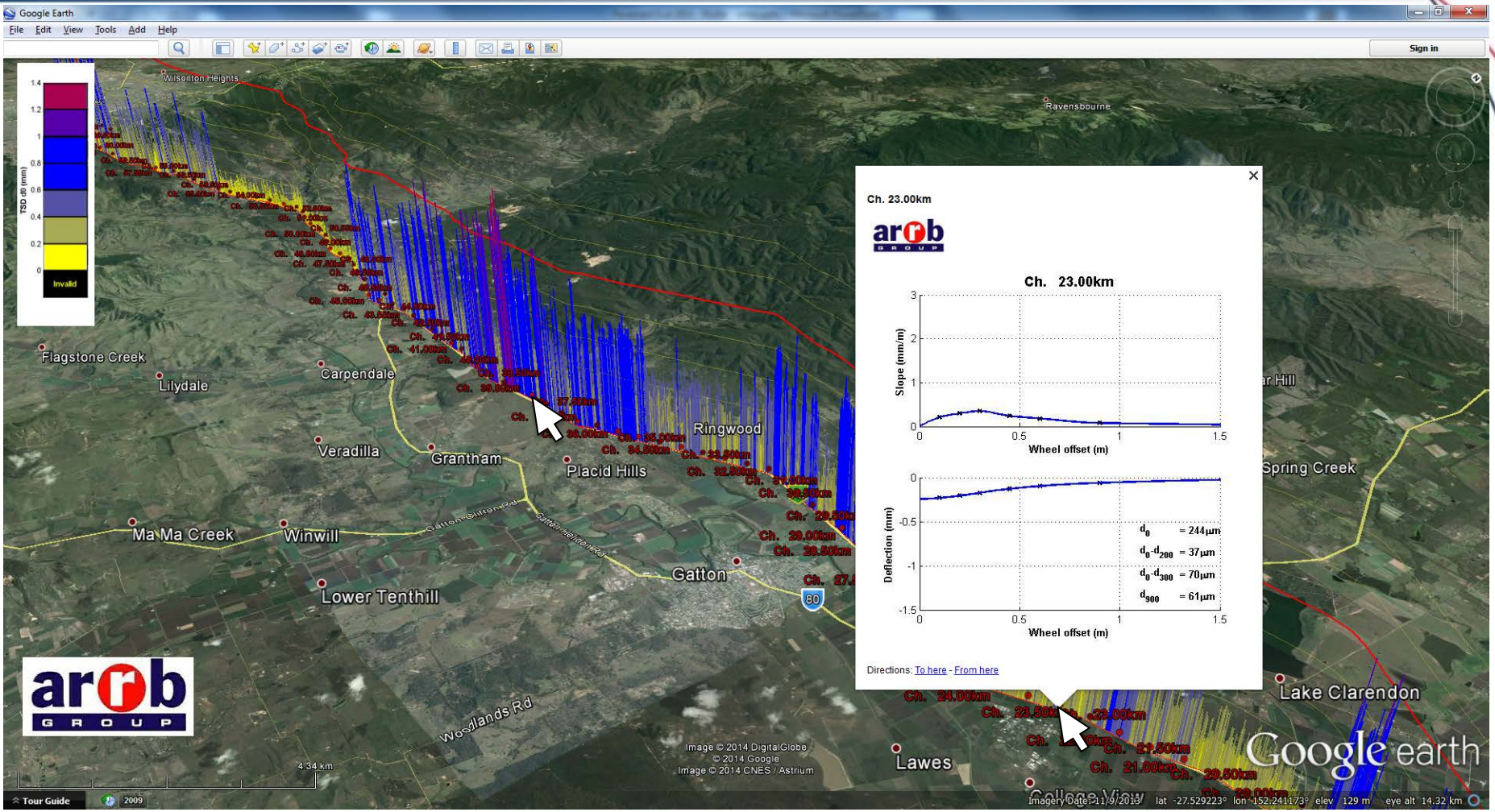
TSD scanning in QLD & NSW

- >13,300km (8,200 miles) collected (April-September 2014)
- Geospatial views of data generated
- Comparisons with FWD in selected locations



TSD data visualisations



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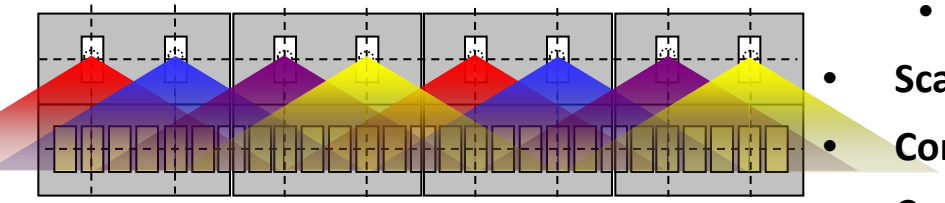
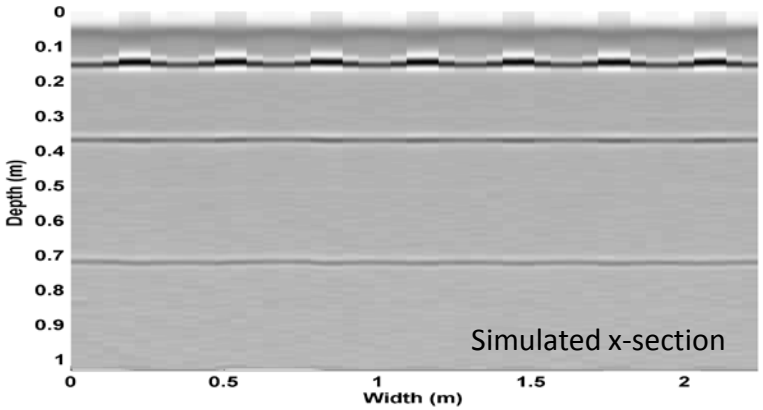
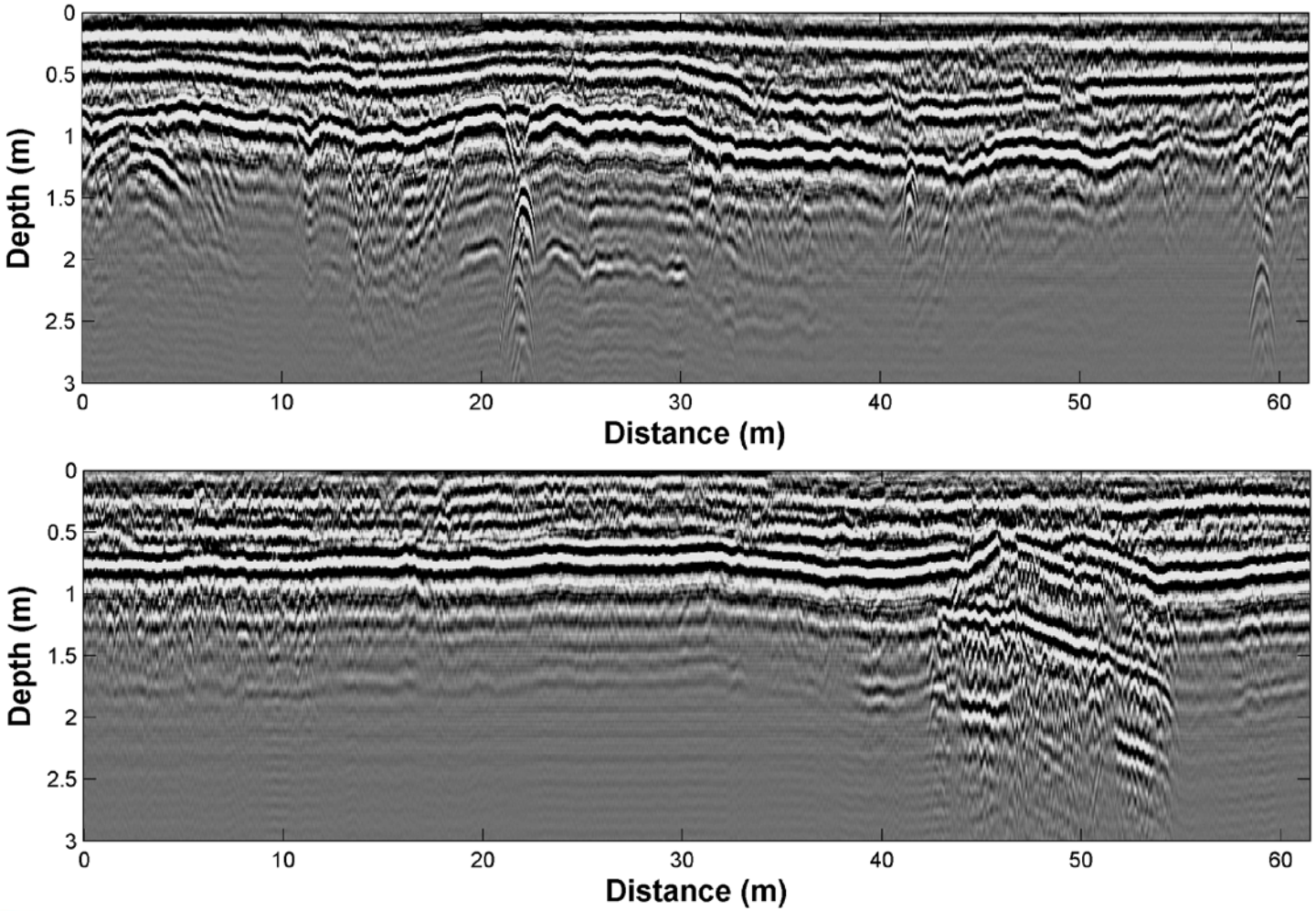
Noise-Modulated Ground Penetrating Radar





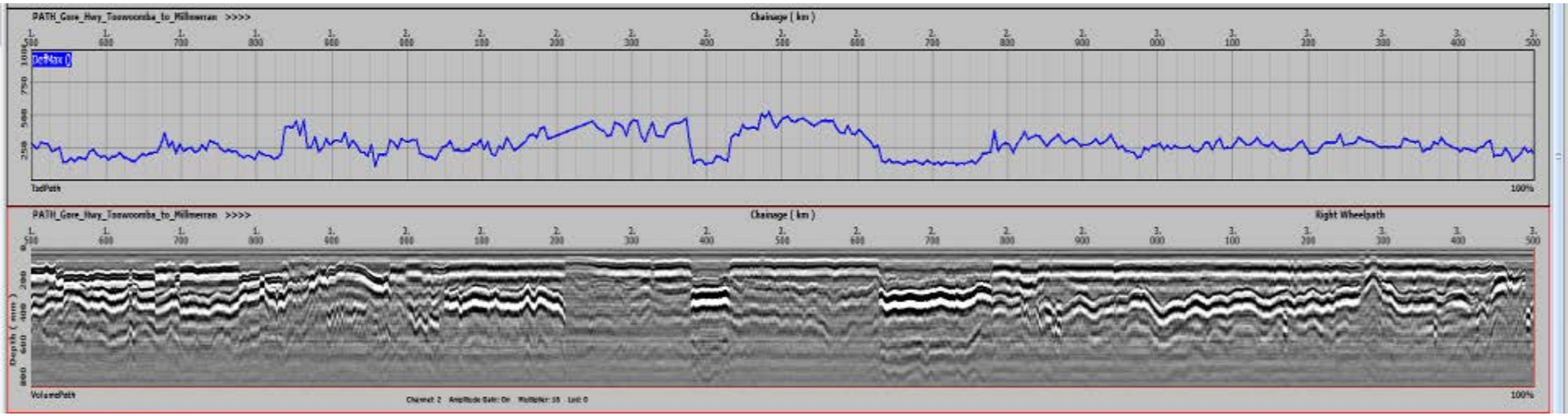
- **Development:**
  - 1st generation: extensive field use since 2008[2-3].
  - 2nd generation: recently completed.
- **Performance:**
  - Uses coded signals for much cleaner data & better penetration compared to existing GPR equipment.
  - Rugged; highway speed operation (100km/hr).
- **Scalable:** 1 or 2 pods or full trailer for 3D.
- **Compliance:** Expected to meet FCC limits (TBC).
- **Cost:** similar to existing GPR alternatives.
- **Multi-offset operation (full trailer):**
  - Non-destructive calibration of EM wave velocities for accurate layer depths.
  - Avoids key limitations of surface reflection methods.
  - Semi-automated analysis methods being developed[4,6]
  - Quantitative pavement moisture mapping[4-6]

NM-GPR: Data examples (fixed offset)

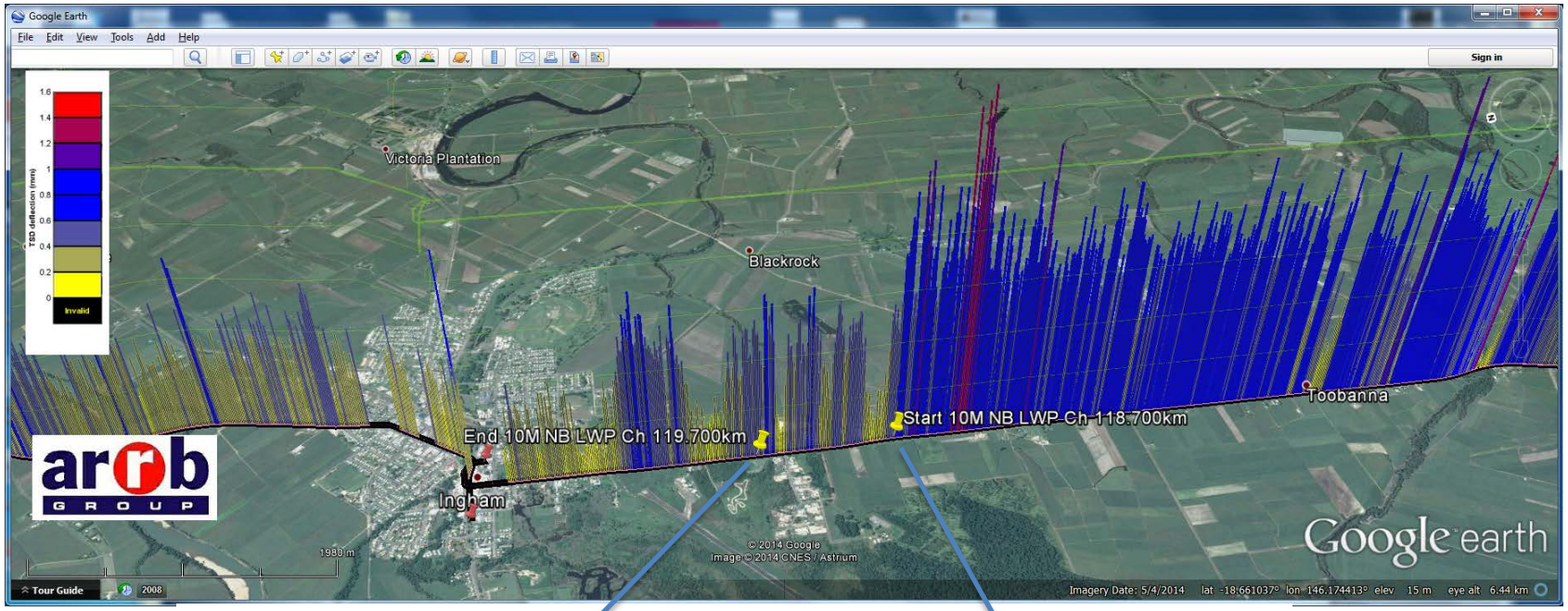


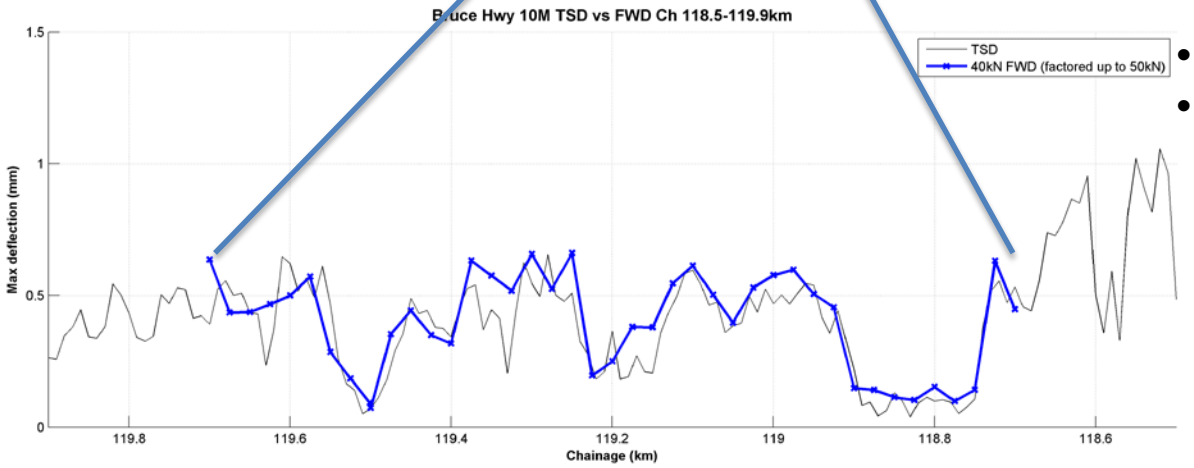
TSD + NM-GPR

- **Prelim. work in 2010 comparing TSD and NM-GPR:**
  - **Clear correlation observed between TSD d_0 and NM-GPR data.**
  - **Complementary methods, greater than either method alone.**



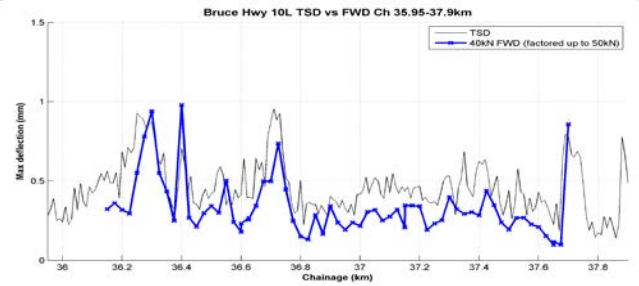
Comparing TSD and FWD d_0 values

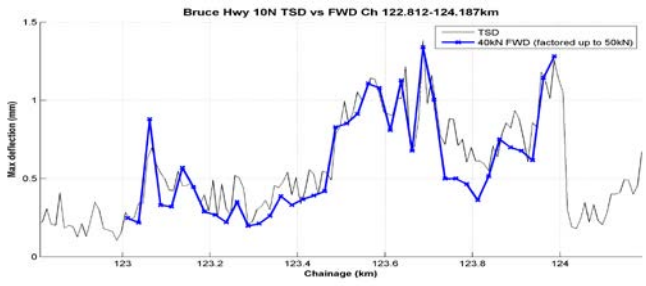


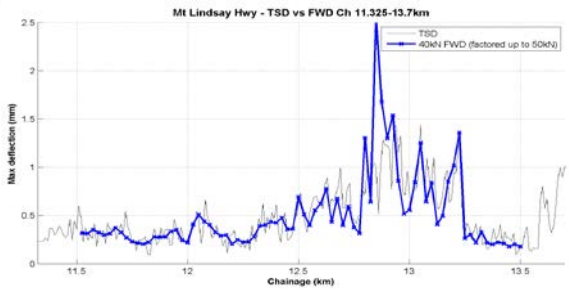


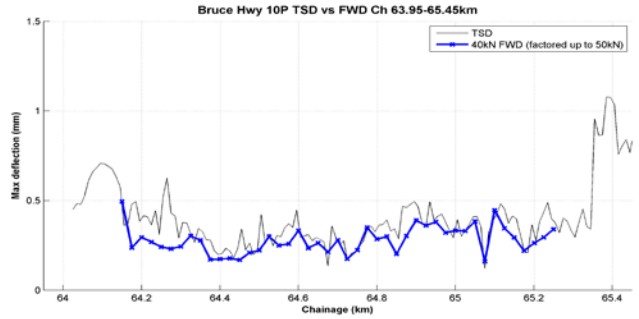
- **TSD: 2 July 2014**
- **FWD: 28 May 2014**
  (40kN scaled to 50kN)

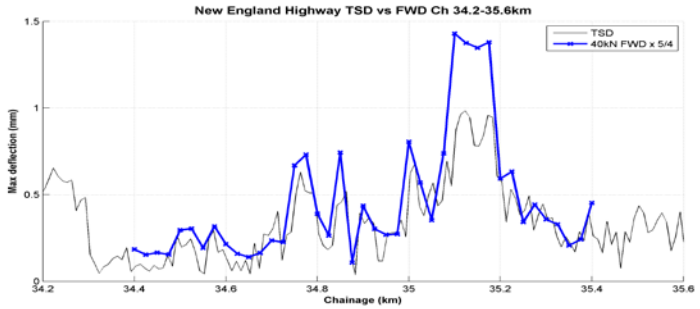
TSD v's FWD in Queensland…

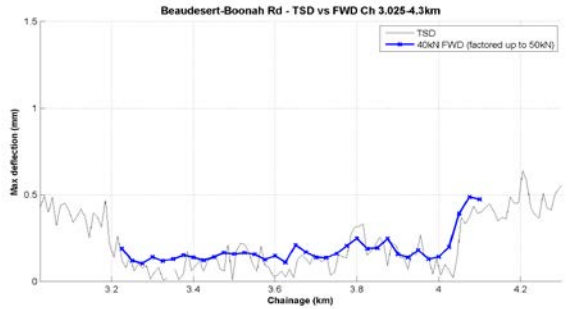


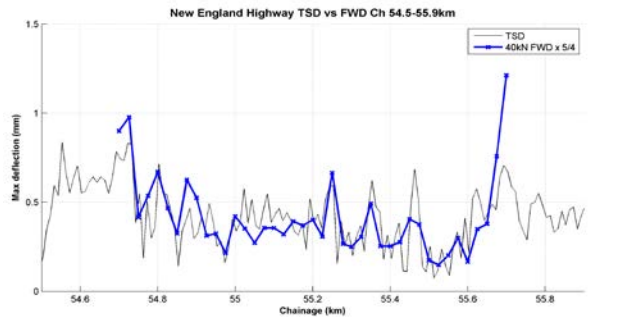


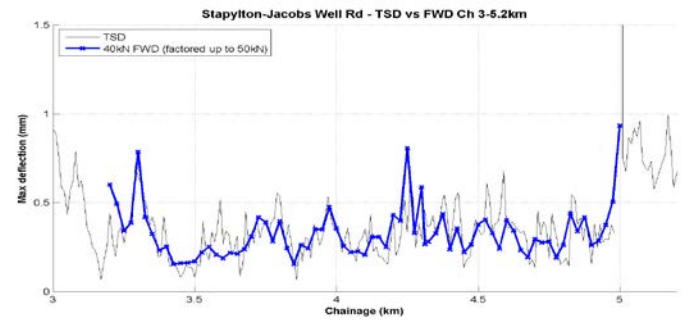


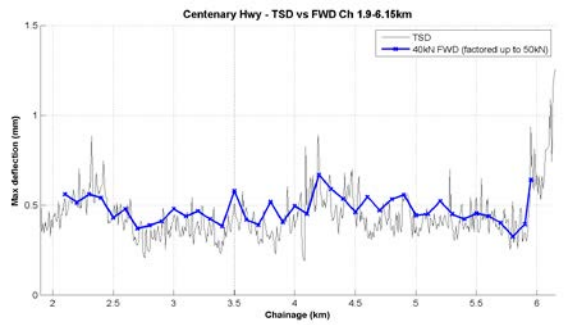






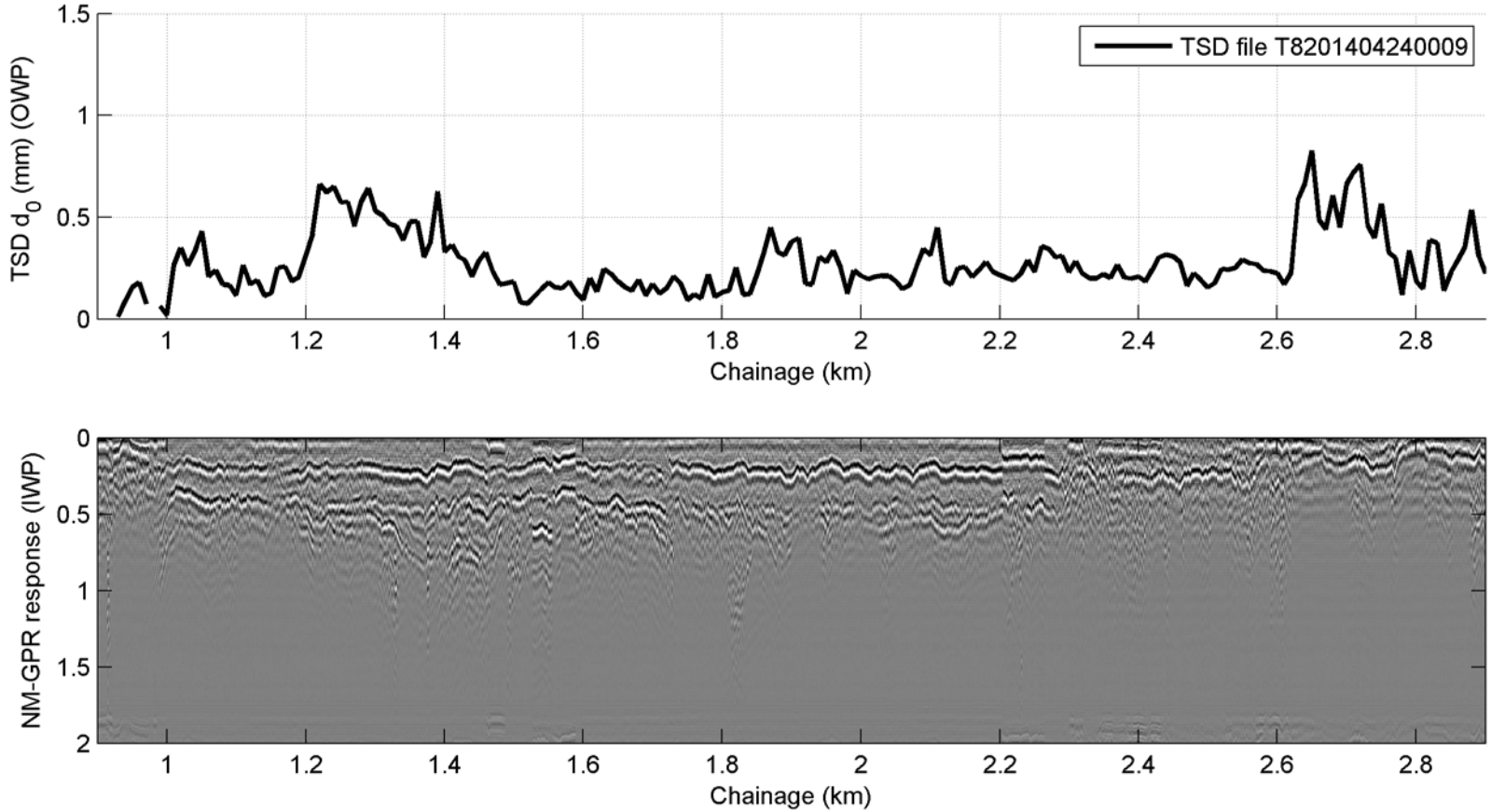






- **A few differences, but overall very encouraging comparisons.**
- **Deflection bowl <u>shapes</u> also compare well, not just d_0 plots!**

TSD + NM-GPR: Recent examples



NOTE: TSD and NM-GPR on opposite wheelpaths in this example

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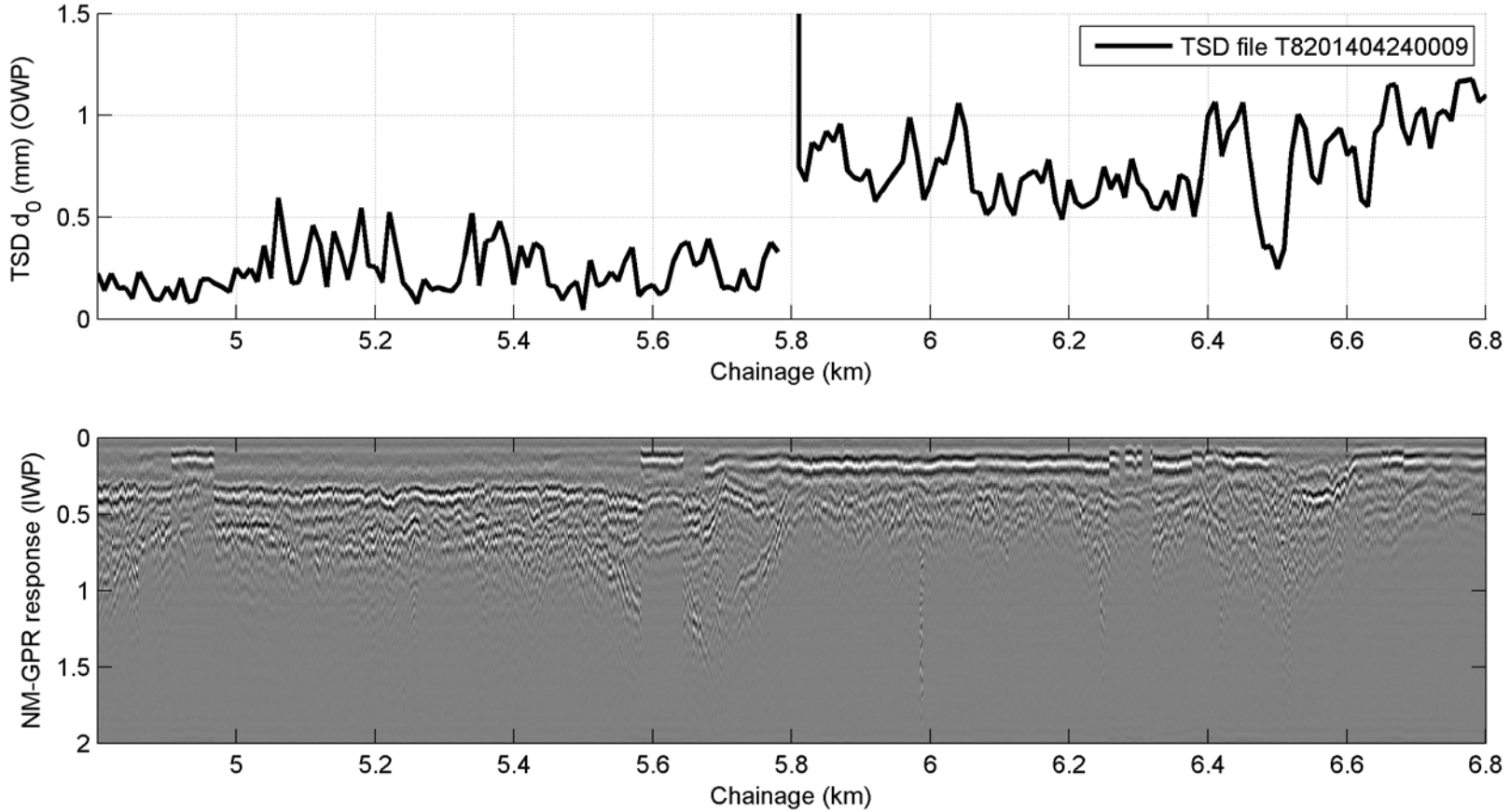

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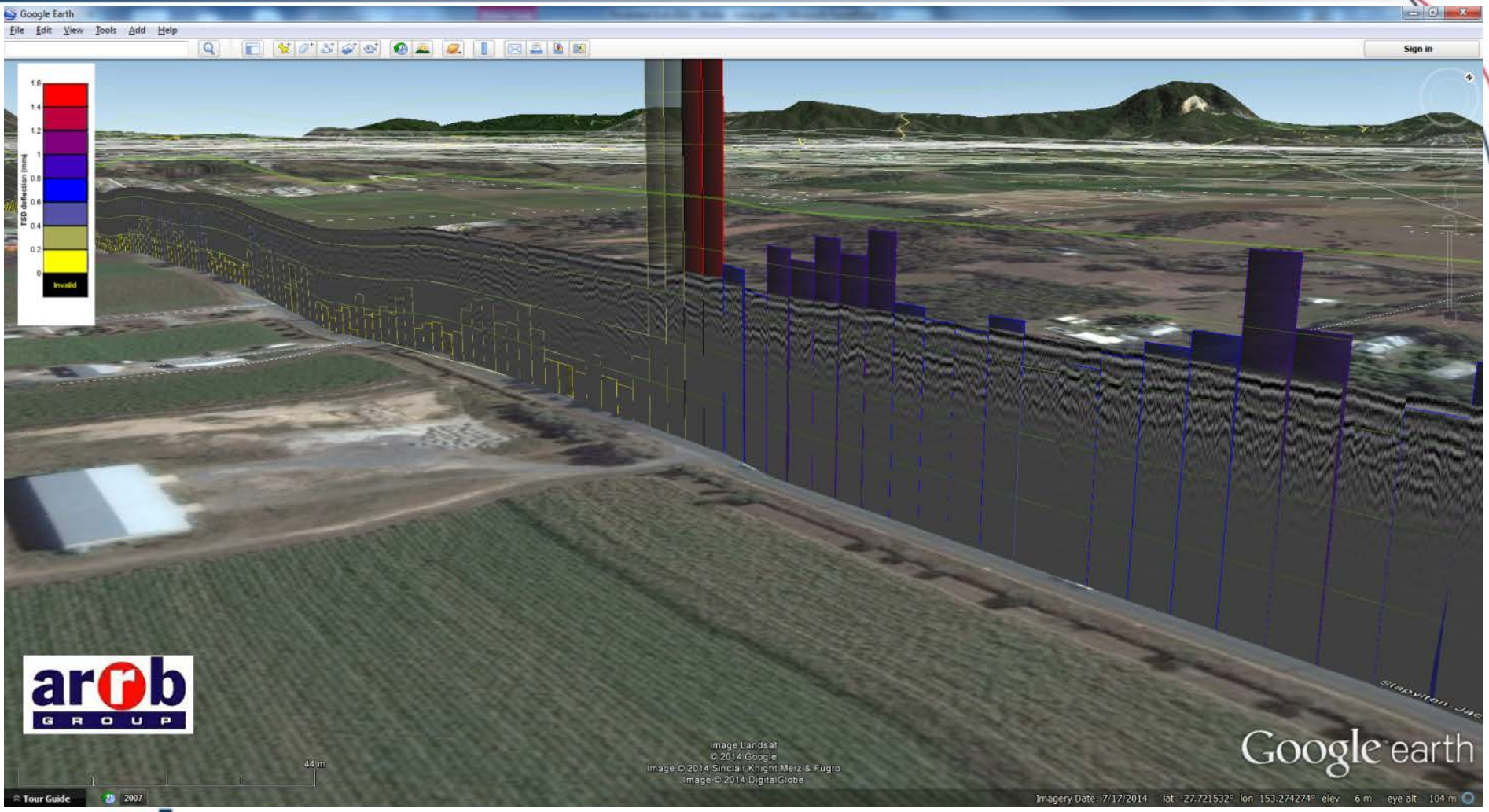
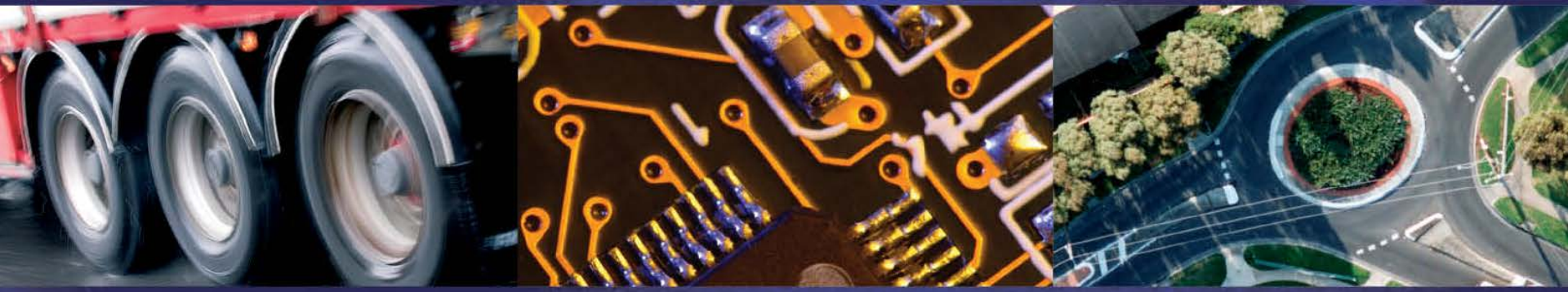


Conclusions

- **ARRB TSD:**
  - Overview of capability & preliminary use.
  - Visualisations of TSD deflection data.
  - TSD v's FWD: encouraging comparisons so far… more to be done.
- **NM-GPR**
  - Overview of updated traffic speed 3D GPR technology
  - Data examples.
- **GPR + TSD**
  - Complementary methods that enable rapid road investigations.
  - Example comparisons.

References

1. Muller W.B. & Roberts J. *'Revised approach to assessing traffic speed deflectometer data and field validation of deflection bowl predictions'*, International Journal of Pavement Engineering, Vol. 14 Issue 4, pp. 388-402, 2013.
2. *Muller W.B., 'A network level road investigation trial using Australian-made 3D Ground Penetrating Radar (GPR) technology', in 25th Annual ARRB Conference, Perth, Australia, 2012.*
3. *Muller W. & Reeves B.A., 'Comparing traffic speed deflectometer and noise-modulated ground penetrating radar data for rapid road pavement investigations', in 14th International Conference on Ground Penetrating Radar (GPR-2012), 4-8 June 2012, Shanghai, China, pp. 502-509, IEEE, DOI: 10.1109/ICGPR.2012.6254917.*
4. *Muller W.B., 'Self-correcting pavement layer depth estimates using 3D multi-offset Ground Penetrating Radar (GPR)', 15th International Conference on Ground Penetrating Radar, Brussels, Belgium, July 2014.*
5. *Muller W. & Dèrobert X., 'A comparison of phase-shift and one-port coaxial cell permittivity measurements for GPR applications', 7th International Workshop of Advanced Ground Penetrating Radar (IWAGPR-2013), Nantes, France, 2-5 July 2013.*
6. *Muller W., Scheuerman A. & Reeves B., 'Quantitative moisture measurement of road pavements using 3D noise-modulated GPR', in 14th International Conference on Ground Penetrating Radar (GPR-2012), 4-8 June 2012, Shanghai, China, pp. 517-523, IEEE, DOI: 10.1109/ICGPR.2012.6254919.*



Thank you

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