Parameterising road construction in route-based road weather models:

Can GPR provide the answer?

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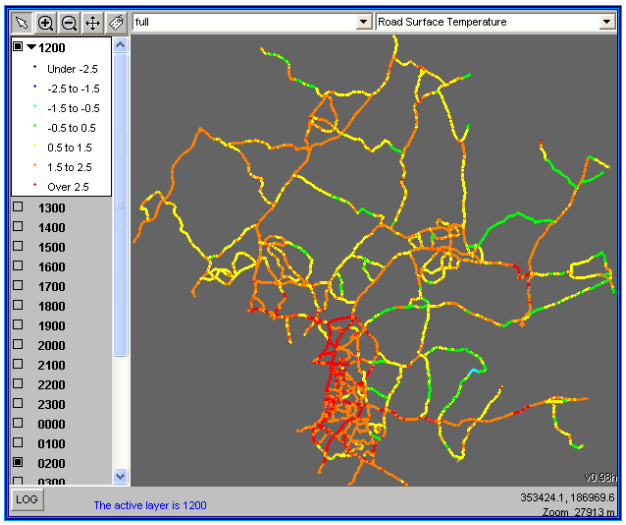
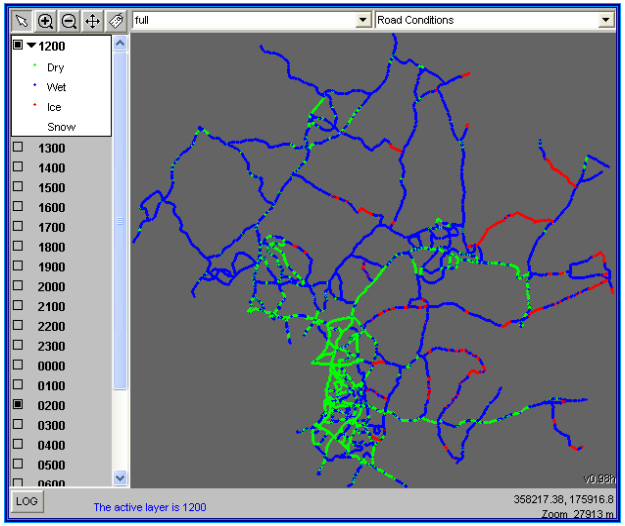
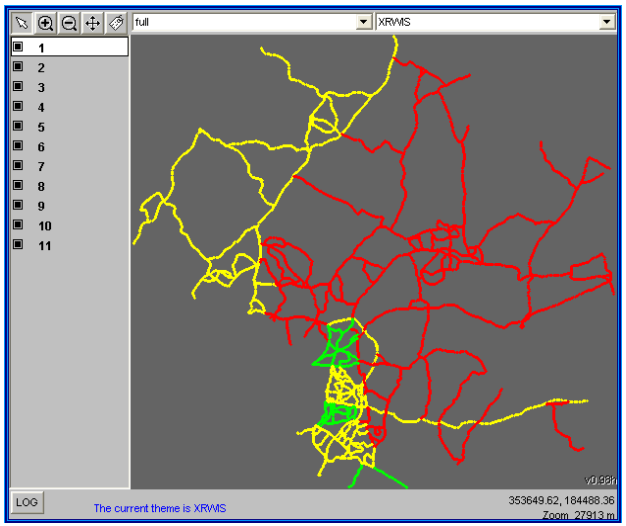
Route-based forecasting

- A new paradigm in winter road maintenance
- Spatial interpolations between ‘point’ outstations no longer reliant on thermal mapping
- Instead, interpolations are made by modelling the influence of geography on the road surface
- Potential exists to leave the warmer routes untreated or eventually utilise selective salting practices such as dynamic routing







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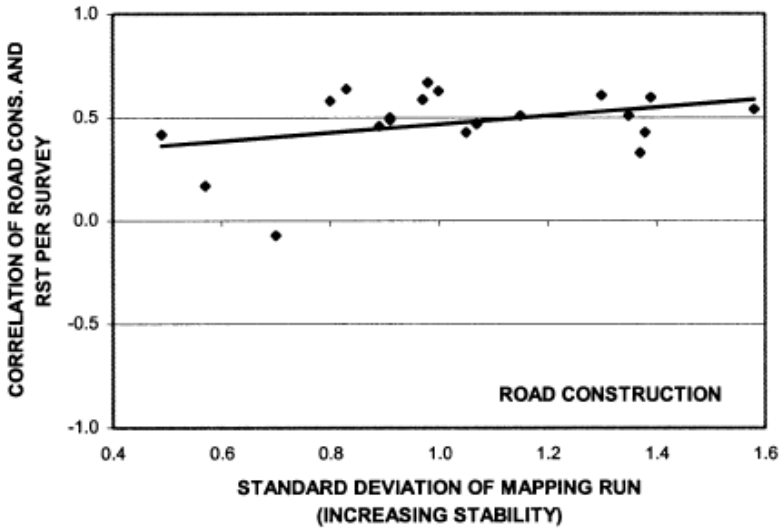
What parameters are included?

Meteorological	Geographical Parameters	Road Parameters
Solar radiation	Latitude	Depth of construction
Terrestrial radiation	Altitude	Thermal conductivity
Air temperature	Topography	Thermal diffusivity
Cloud cover and type	*Screening*	Emissivity
Wind speed	*Sky-View Factor*	Albedo
Humidity / dew-point	Landuse	*Traffic*
Precipitation	Topographic exposure	

- Meteorological parameters are derived from the regional weather forecast
- Geographical parameters are surveyed using geomatic techniques (e.g. GPS, DEM, fisheye imagery)
- Road construction is problematic and is presently not surveyed.
- This presentation looks at a technique which may enable this

Road Construction

- An important factor to consider when predicting road surface temperature.
- Deep construction (e.g. main roads) are warmer and said to have a bigger thermal memory
- Difficulties in surveying mean that road construction is often parameterised in a simple manner



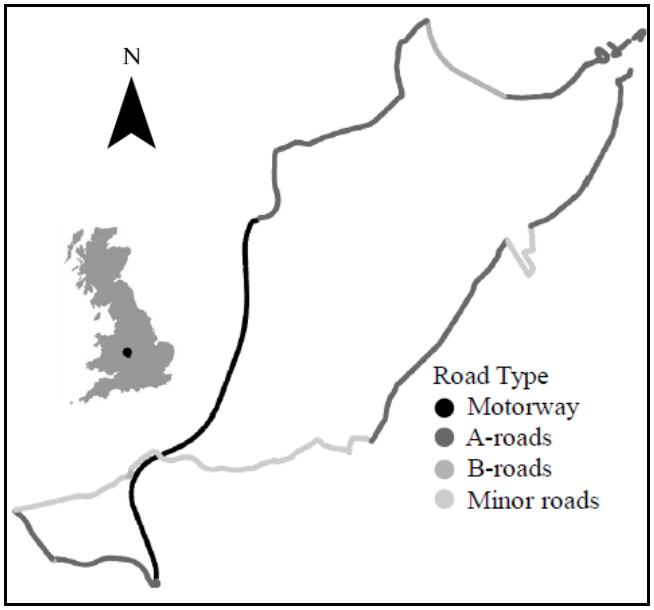
Depth (cm)	Motorway (1)	A-Road (2)	B-Road (3)	C-Road (4)
	Materials			
0 - 4.5	Asphalt	Asphalt	Asphalt	Asphalt
4.5 – 9	Asphalt	Asphalt	Asphalt	Concrete
9 – 18	Asphalt	Asphalt	Concrete	Concrete
18 – 36	Concrete	Concrete	Concrete	Concrete
36 – 72	Concrete	80% Concrete 20% Subgrade/soil	50% Concrete 50% Subgrade/soil	Subgrade/soil
Over 72	Subgrade/soil	Subgrade/soil	Subgrade/soil	Subgrade/soil
	Average thermal conductivity			
	$3.9x10^{-3}$cal cm^{-1} sec^{-1} °C	$3.5x10^{-3}$cal cm^{-1} sec^{-1} °C	$2.9x10^{-3}$cal cm^{-1} sec^{-1} °C	$2.1x10^{-3}$cal cm^{-1} sec^{-1} °C

Bridge Decks

- A big problem for winter road maintenance.
- Shallower construction = lower thermal memory.
- Result is a thermal singularity that requires specialist treatment.

- Also difficult to survey.
- Included in route-based forecast models by interrogation of maps.
- GIS can automate this to some extent, but is there a better way?

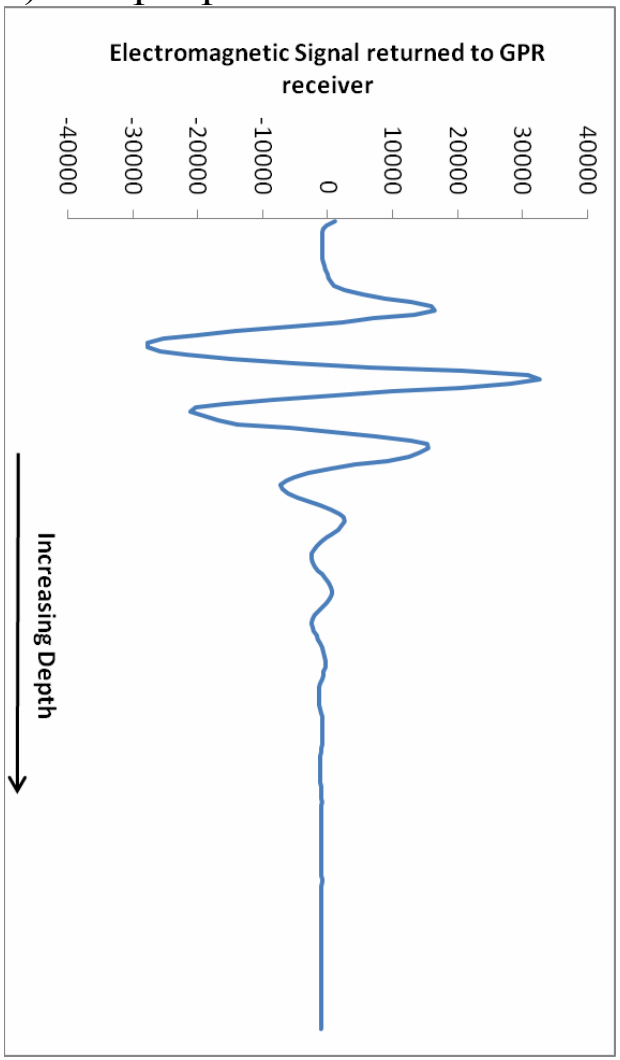
Ground Penetrating Radar



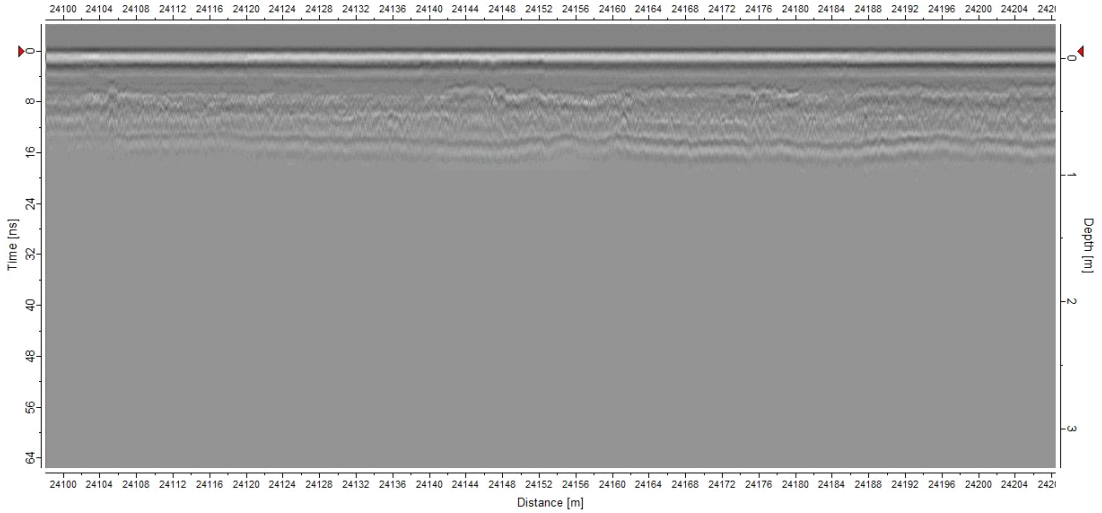
- A non-invasive geophysical technique
- Used to detect electrical discontinuities in the sub-section
- An electromagnetic pulse identifies differences in electric properties below the surface.
- Where a difference is identified, it can be assumed that the surface material has changed.

Radargrams

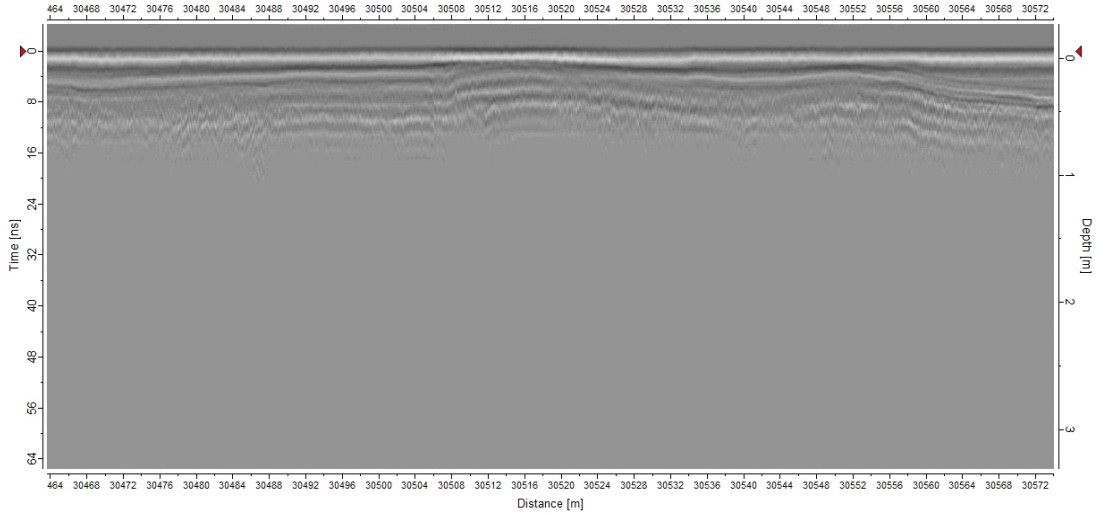
a) Sample pulse



b) Motorway



c) Minor Road



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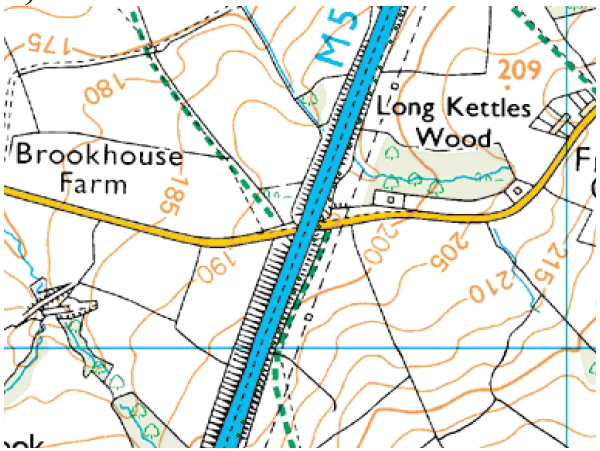
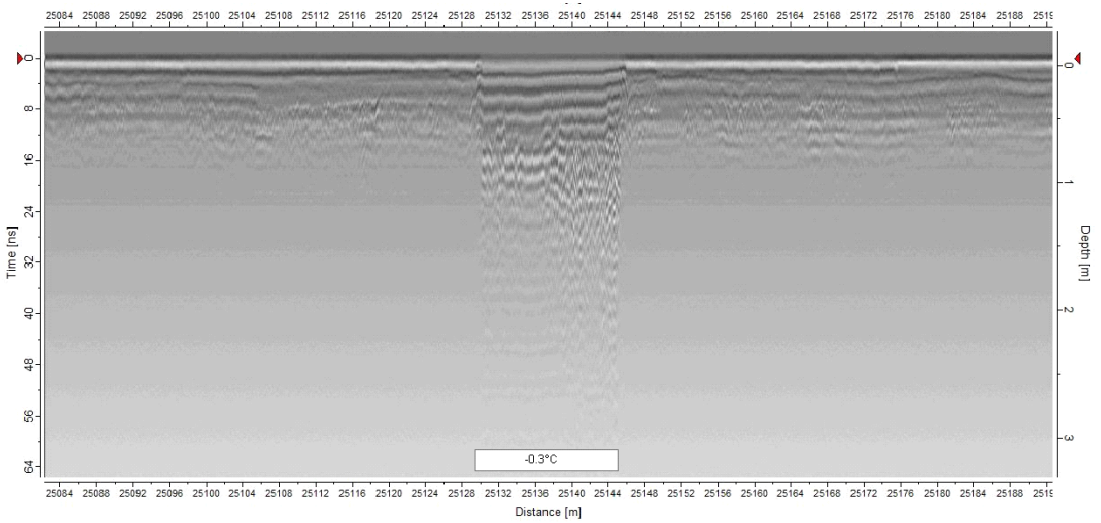
Identification of Bridge Decks

a)





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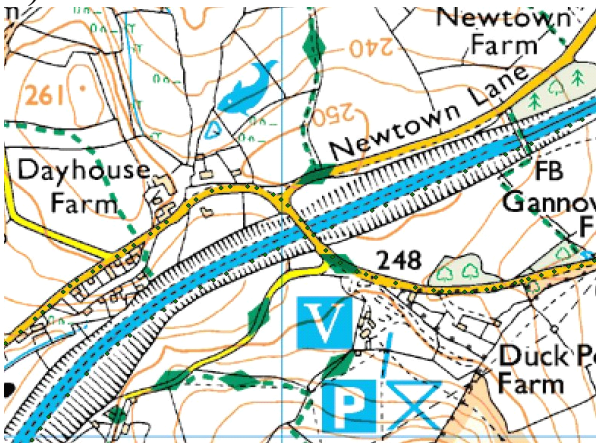

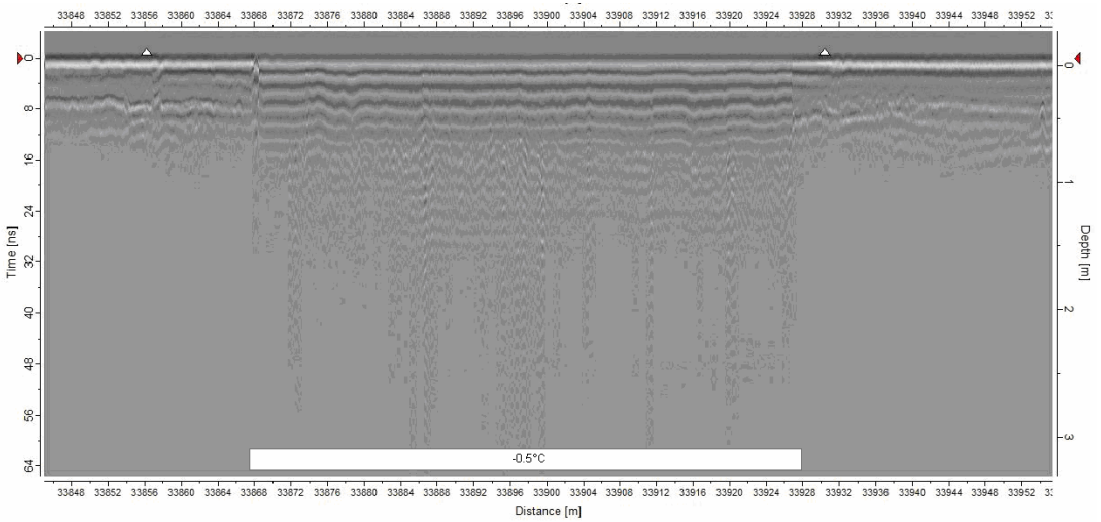

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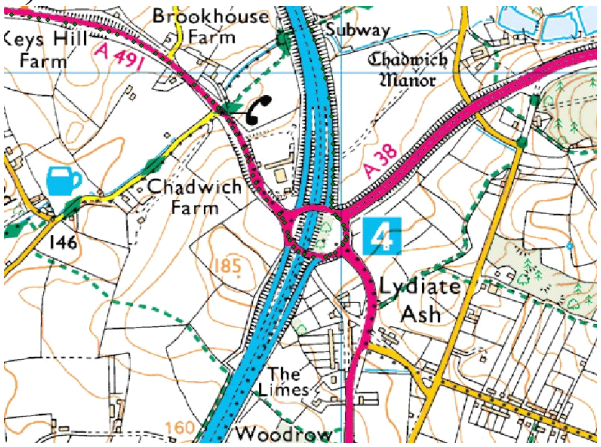
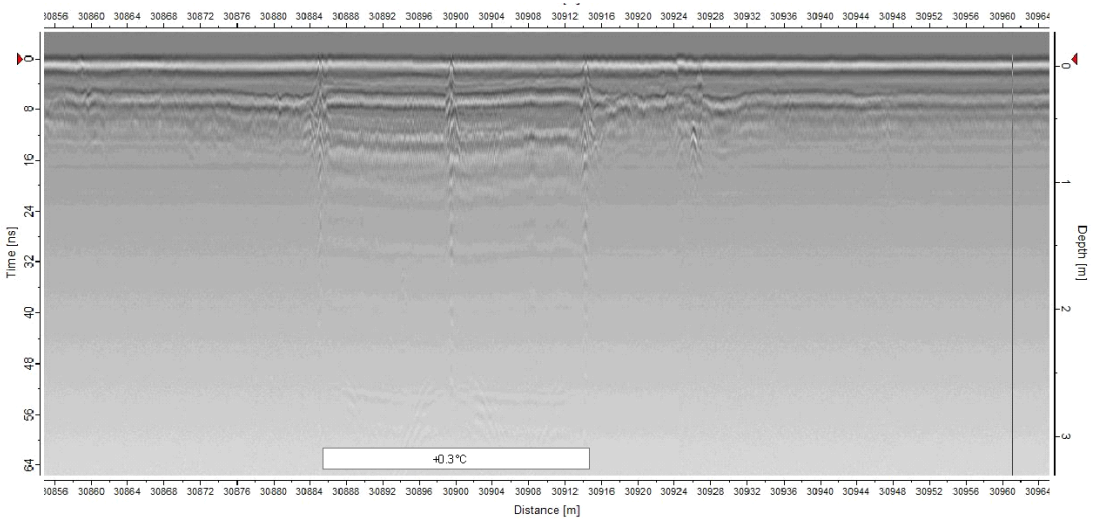
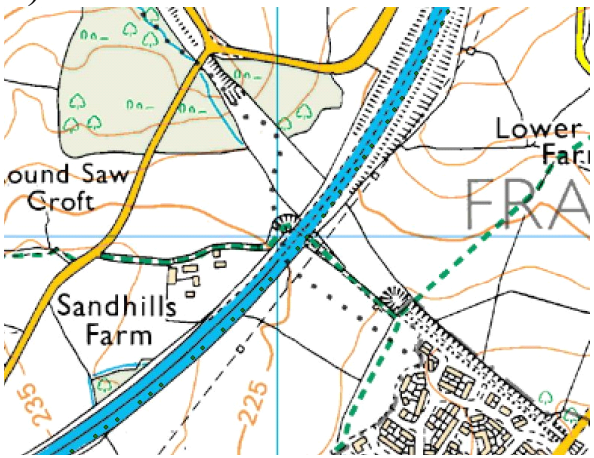
Identification of Bridge Decks

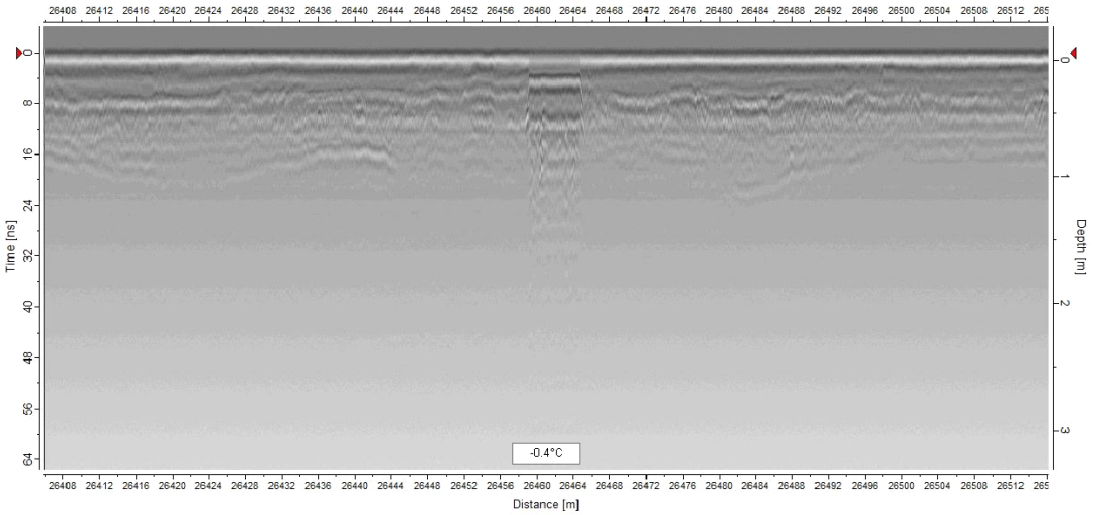
c)





d)





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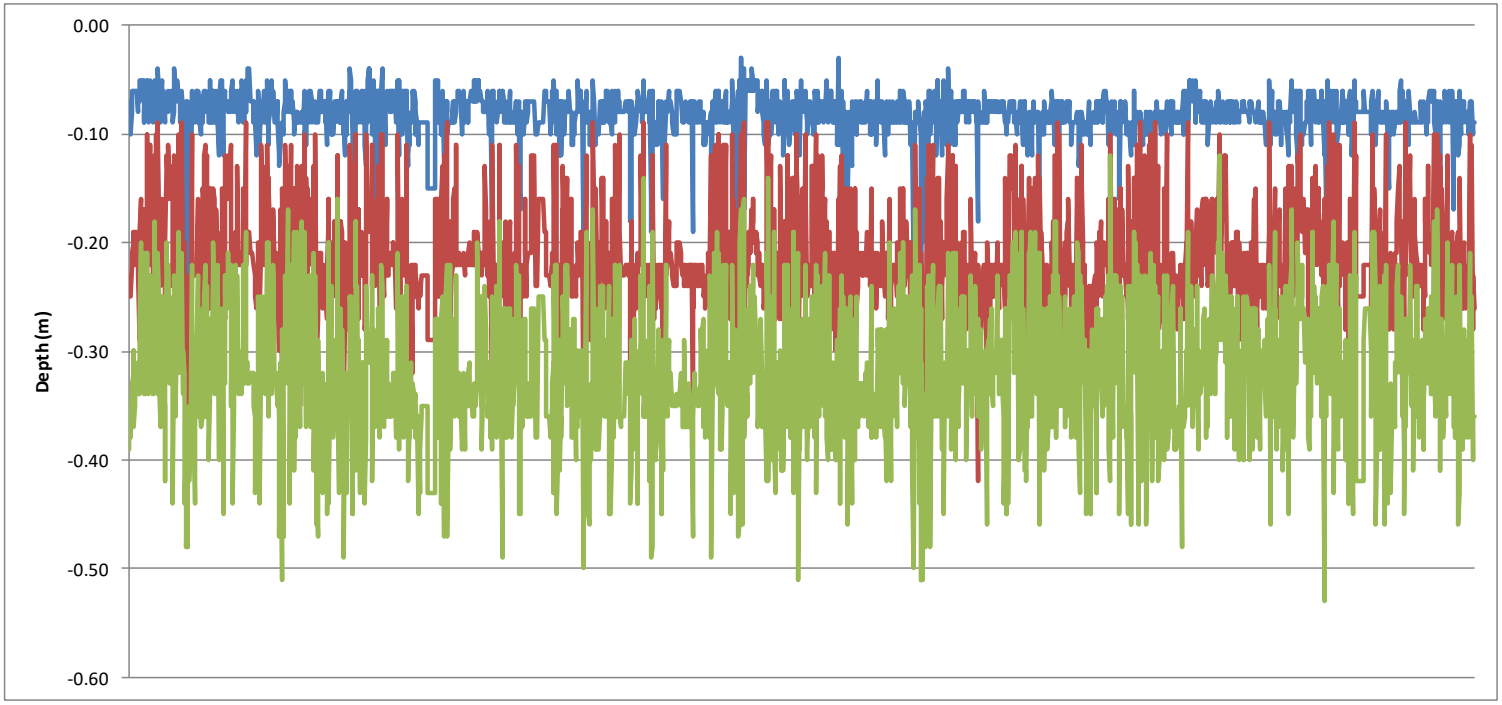
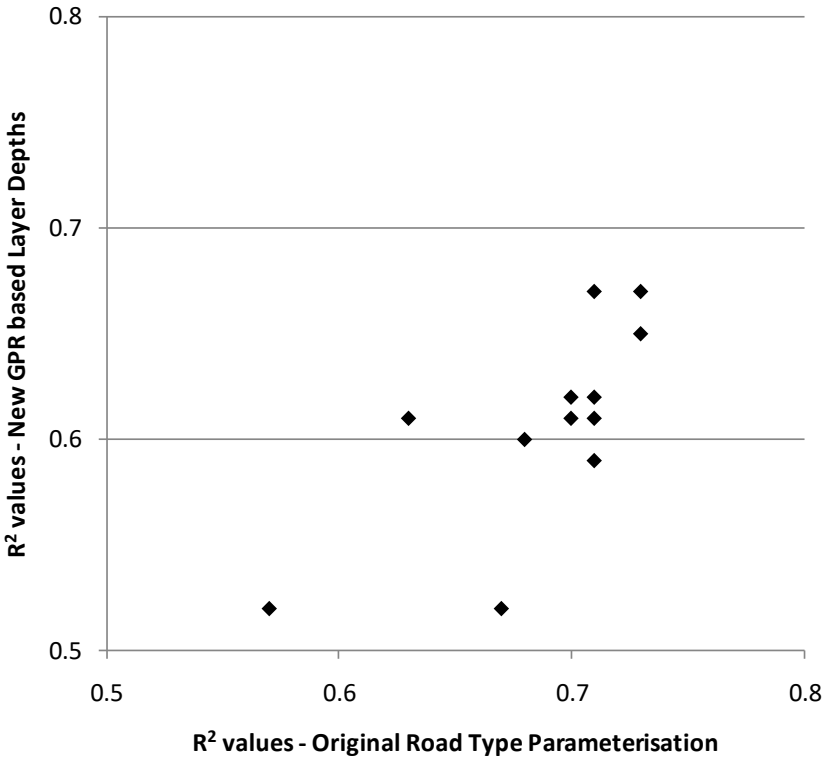
Variations in Road Construction

- Can GPR identify the variations in construction around the route as effectively as it can detect bridge-decks?
- An algorithm was developed in MATLAB to automatically detect the top 3 discontinuities of the road surface (i.e. down to the interface where asphalt becomes concrete).
- The theory is that bigger roads with a larger thermal memory will have a deeper asphalt layer.



Variations in Road Construction

- Results are disappointing.
- When the new horizons are used in the route-based forecast, there is reduced model performance.
- This could be a result of noisy data…
- …or a result of an overly-simplistic assumption (a standard value of 6.5 was assumed for the dielectric constant)
- There was also limited ground truth data (i.e. road cores)



Conclusions

- We think GPR still has a lot of potential!
- Very useful for objectively identifying bridge decks often missed by manual techniques.
- Produces sensible looking data pertaining to the variation of road construction across a network.
- A constant value of the dielectric constant is too simplistic: In reality it will vary around the route depending on materials, air voids and moisture.
- Ground truth data (road cores) would help…
- … but are expensive to obtain

- More research needed!