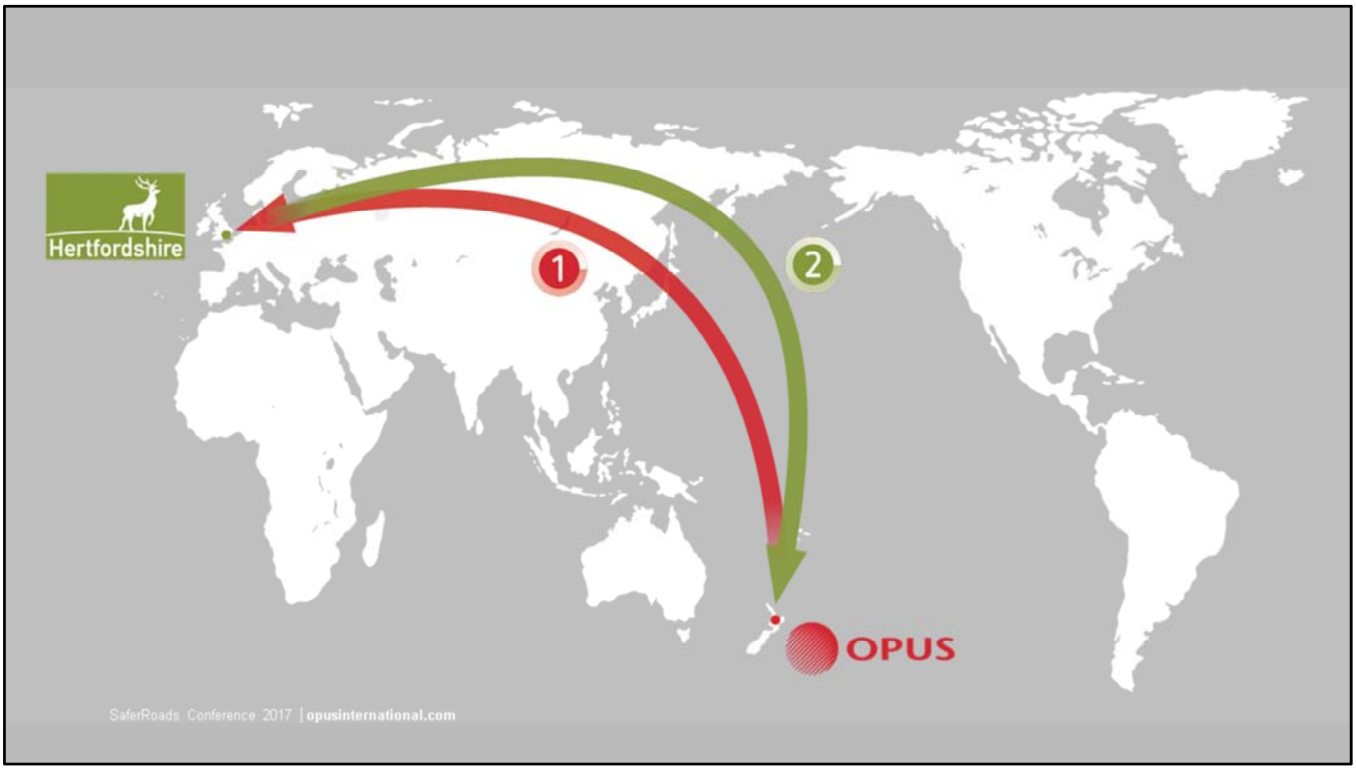
Title slide for use with Transportation work stream



1. Both at some point were sent to work at Hertfordshire County Council in UK
2. Return to NZ. Providing remote assistance from Hamilton

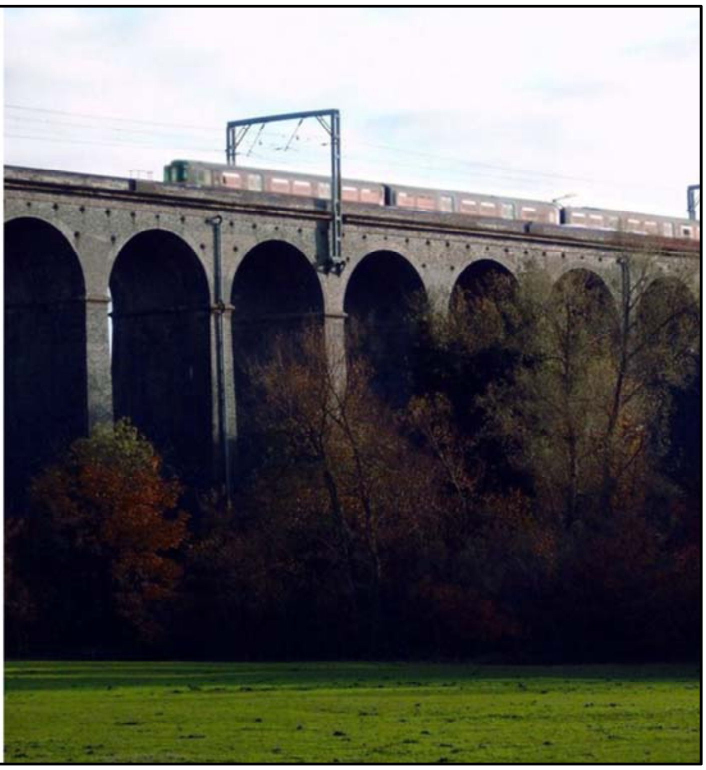
Hertfordshire

- Located immediately north of London
- 5000 km highway network
- Population approx. 1.2 million
- County town = Hertford (pop 26 k)
- Largest city = Watford (pop 96 k)
- 10 districts in County

Some details about Hertfordshire to set the scene.

Hertfordshire (old infrastructure)

- Welwyn Viaduct
- 475 m long and 30 m high
- Opened in 1850 by Queen Victoria who was frightened to travel on it because of its height



Briefly - setting the scene

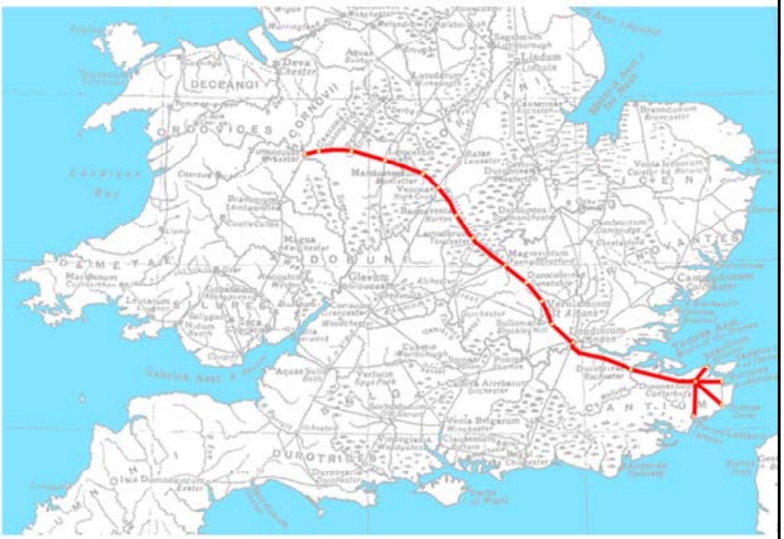
Hertfordshire (really old infrastructure)

- Hatfield House: effectively Queen Elizabeth I was kept under house arrest at Hatfield by Queen Mary until her ascension to the throne in 1558

Briefly - setting the scene

Hertfordshire (really, really old infrastructure)

- Roman Roads. Watling Street, Elstree
- Constructed about 43 - 410 AD
- What is the design life of roads in your jurisdiction?



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Briefly - setting the scene.
Interesting the infrastructure design life.

Hertfordshire (really, really “old” infrastructure)

- Roman Roads.
  Watling Street, Elstree
- A5183

Briefly - setting the scene.
Example of what the Roman Road looks like today.

Overview

- Why bother?
- Engineering
- GIS
- Quite a few slides, but survivable

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Now let's get down to business

Key messages

- Skid resistance is an important road safety measure
- One size does not fit all, have a skid resistance strategy that fits your network
- Creating and applying a bespoke skid resistance strategy takes a bit of effort, but it is achievable

Why bother?

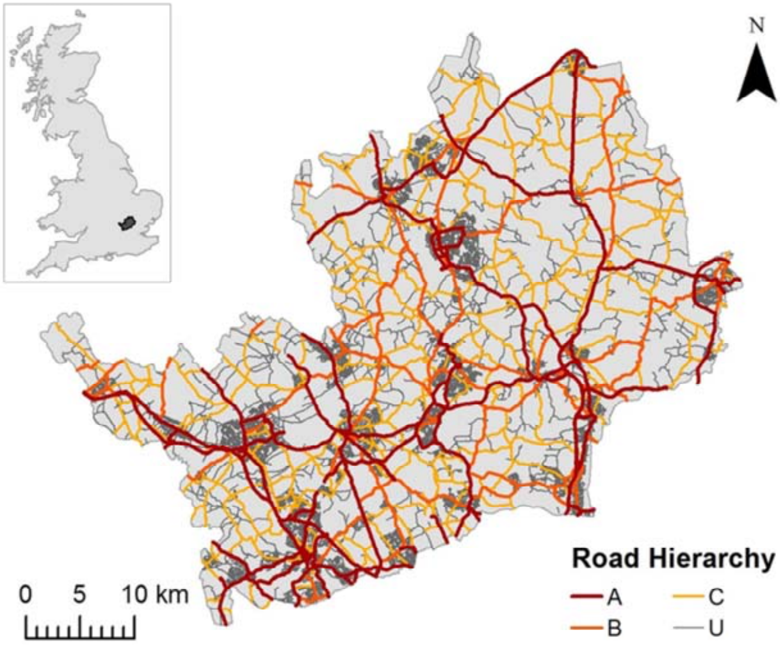
- Hertfordshire already has a relatively safe road network:
  - United Kingdom one of safest road networks
  - Hertfordshire performs better than average in UK for KSI
- Skid resistance an important road safety measure
- Are road deaths and serious injuries acceptable?
- We've got all this data, now what?
- Hertfordshire network compared with Highways England
  - Skid resistance strategy can be flexible and fit for purpose

Fundamental aims

- Engineering components of strategy address:
  - What is skid resistance?
  - How to measure skid resistance
  - Approach used in Hertfordshire

Budgets

- Always budget limitations
- Prioritise spending
  - Road hierarchy A, B, C, and U
  - Higher risk
- Road users know the road hierarchy



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Map done by Renee Schicker (Opus)

Road hierarchy
A-Roads

- A10, north of Ware

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Example of an A Road

Road hierarchy
A-Roads

- A505, Hitchin

Another A road example

Road hierarchy
B-Roads

- B656, Baldock

Example of a B road

Road hierarchy
B-Roads

- B1000, near Hertford

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Another B road example

Road hierarchy
C-Roads

- C21, Arlesey Road, Ickleford

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Example of a C road

- **Road hierarchy**
  U-Roads
  - 5U562, Woolgrove Road, Hitchin

U road example

Basis for event categories

- Event categories based on Highways England standard
- HE has 10 site categories
- HCC has 16 site categories, including:
  - variation by speed limit
  - controlled versus uncontrolled approaches
  - lower curve radii than trunk roads
  - inclusion of U-roads

Points of difference and important considerations leading into the geospatial analysis.

Event categories

- Familiar, but different
- Ticked cells are the default IL values used in the GIS process

	SITE CATEGORY AND DEFINITION		INVESTIGATORY LEVEL 0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
	A	Motorway class	Not Applicable							
Non-Event	B	Dual carriageway non-event		✓						
Non-Event	C	Single carriageway non-event, speed limit >30 mph			✓					
Non-Event	D	Single carriageway non-event, speed limit ≤30 mph		✓						
Junctions	QU	Across all junctions and uncontrolled approaches to junctions				✓				
Junctions	QC	Controlled approaches to junctions, including approaches to roundabouts (refer endnote)					✓			
Junctions	R	Roundabout circulatory carriageway				✓				
Ped Xings	K	Approaches to controlled pedestrian crossings					✓			
Gradient	G1	Gradient 5-10% longer than 50 m				✓				
Gradient	G2	Gradient ≥10% longer than 50 m					✓			
Curves	S1	Bend radius ≤500 m – dual carriageway				✓				
Curves	S2	Bend radius ≥250 m and <500 m - single carriageway					✓			
Curves	S3	Bend radius <250 m - single carriageway						✓		
Non-Event	U1	Unclassified road with speed limit ≤30 mph	0.35 for all locations except where site categories QC, K, and/or US apply							
Non-Event	U2	Unclassified road with speed limit >30 mph	0.40 for all locations except where site categories QC, K, and/or US apply							
	US	Unclassified Specific; IL site on unclassified road for which specific intervention level has been set	IL will be determined from risk analysis for site, based on site categories above.							

✓ VALUE APPLIED IN MODEL

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This table from the Hertfordshire County Council Skid Resistance Strategy has been central to what the automated spatial analysis is to achieve. The site categories and their criteria in defining them as well as what IL value to apply based on site category identified. The coloured boxes Indicate the separate model streams before everything is compiled together.

Length of demand

- Stopping distance varies based on speed
- But, most standards have "standard" length of about 50 m
- HCC lengths vary from 25 m (30 mph) to 130 m (70 mph)

Source: Cenek and Brown

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Stopping distance, important to cover this as lengths based on speed limit are a factor in the approach to junctions and pedestrian crossings.

Curves

- “Safer Roads" more important to road users than any other transport services
- Road users need appropriate skid resistance
- Road users don't know curve radii
- Allow for variation in measured radius for assigning curve IL
- Contiguous varying curves treated as a complete curve

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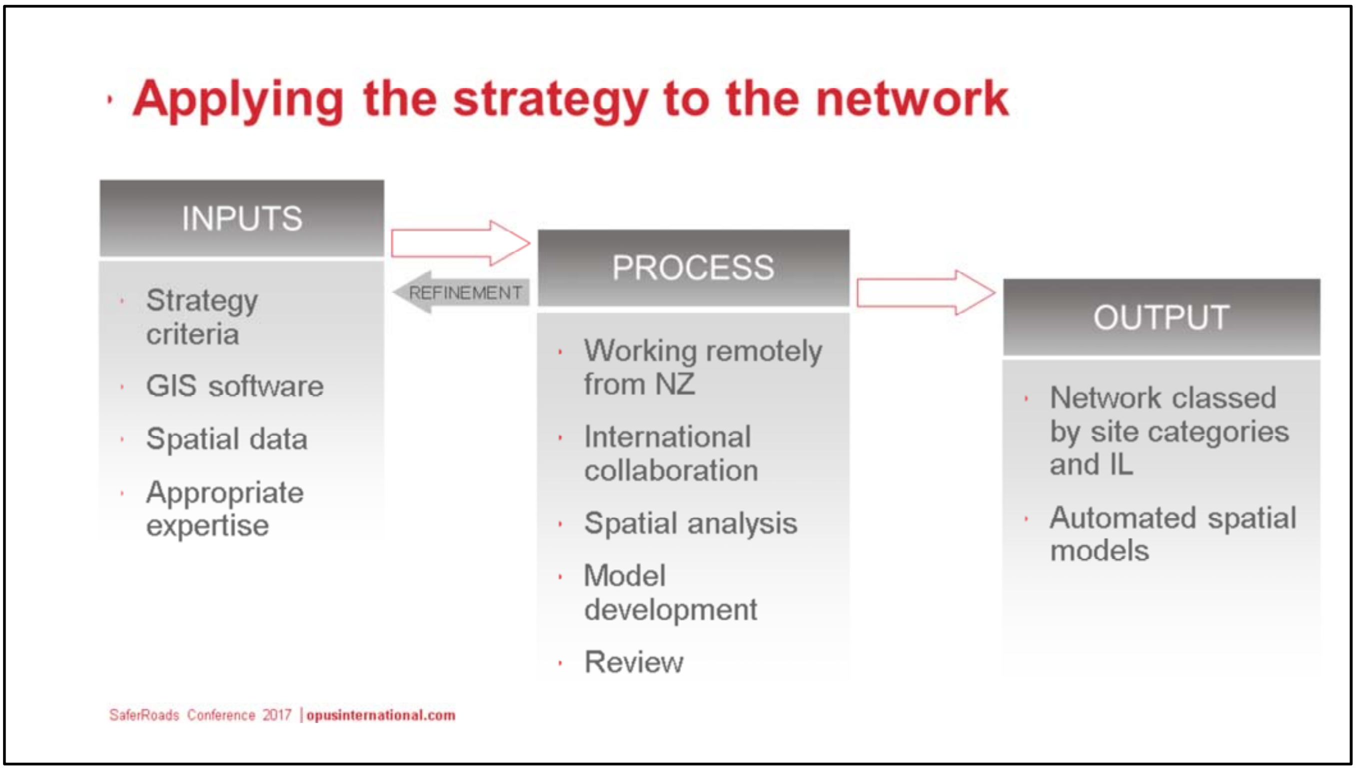
Road users don’t know the curve radii and generally wouldn’t care.
Not much signage for curves unless really problematic.

Prioritisation: the next chapter

- Prioritisation process (to be tested):
  - Amount skid resistance below IL
  - Personal injury collision (PIC) history
  - Highway classification
  - Speed limit
  - Normalised by length

Engineering summary

- Strategy to identify risk and prioritise spending
- Skid resistance fit for County's purposes
- Skid resistance to meet road user demand
- Rely on GIS magic to make it work



Segway from strategy into applying it in GIS.

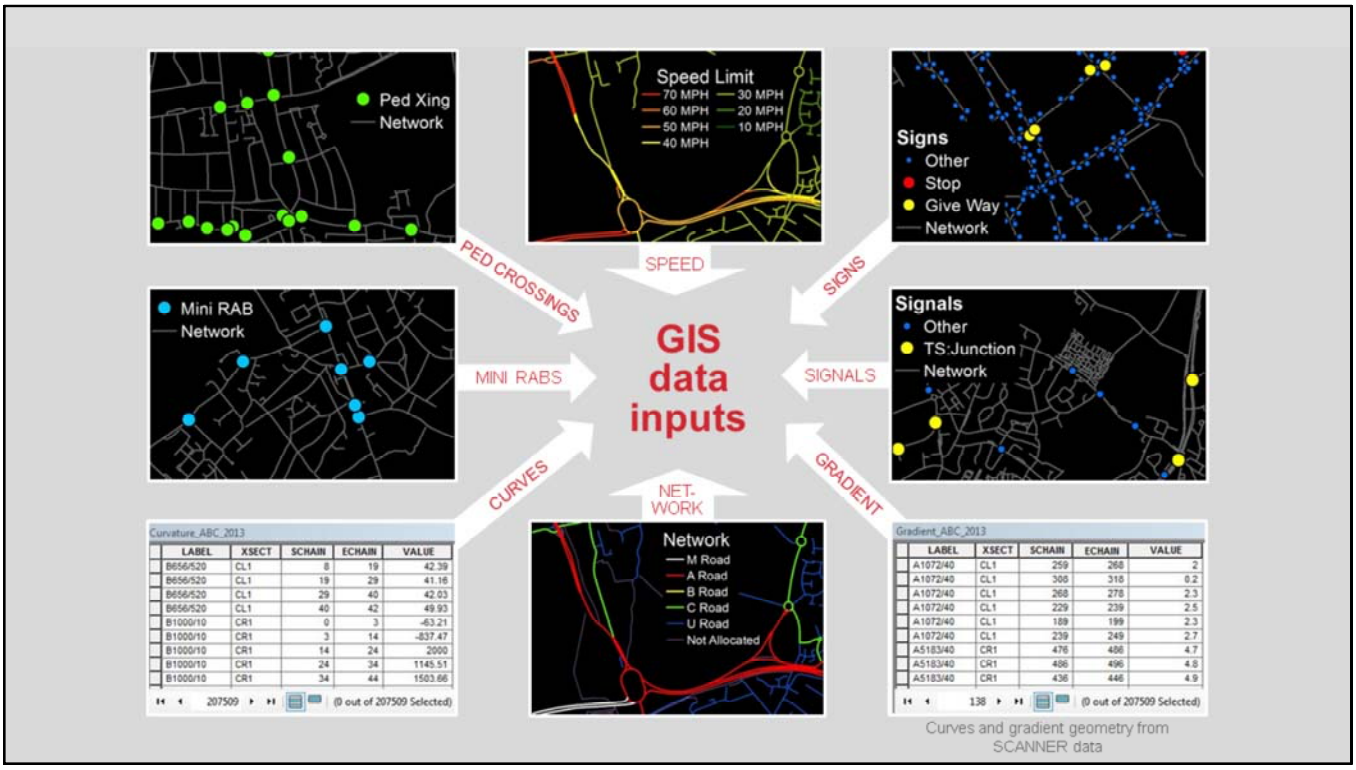
Combine GIS knowledge, software, and data to develop a process that will generate an output of a classified network.

Why develop models? Record process, easier to review process, can re-run, hit play and walk away.

Refinement: covers issues with the input data where it needs improving; learning through multiple failures and gradual successes with each hurdle and identifying where else this can be applied or a change in the order of operations; where criteria in the strategy doesn't cover all cases (i.e. the model output has raised some odd trends which can be explained based on the process and data) and it raises a point of what do we do in this case? Prompting discussion & brainstorming and documentation in the strategy to cover those instances.

Resulting output should assist in identifying which sites have higher or lower ILs and where measured skid resistance is below IL.

This project has been 100% remote GIS input, working from NZ but in collaboration and discussion with Rob and the guys in the UK team.



Raw input data as provided by HCC (UK).

<u>Additional (more detailed) info:</u>

- **Network** dataset: base network with a range of information about the individual roads. Includes FEATURE_ID (unique road name e.g. A1000/100), ROADTYPE (e.g. Single 2 lane carriageway, Roundabout, Dual Carriageway, etc.), CUSTOMER (i.e. who is responsible for maintaining that road), and various others

- **Speed** dataset: no useful attributes other than speed limit. Makes it a bit more tricky to identify which road ID has what speed limit, but can be done.

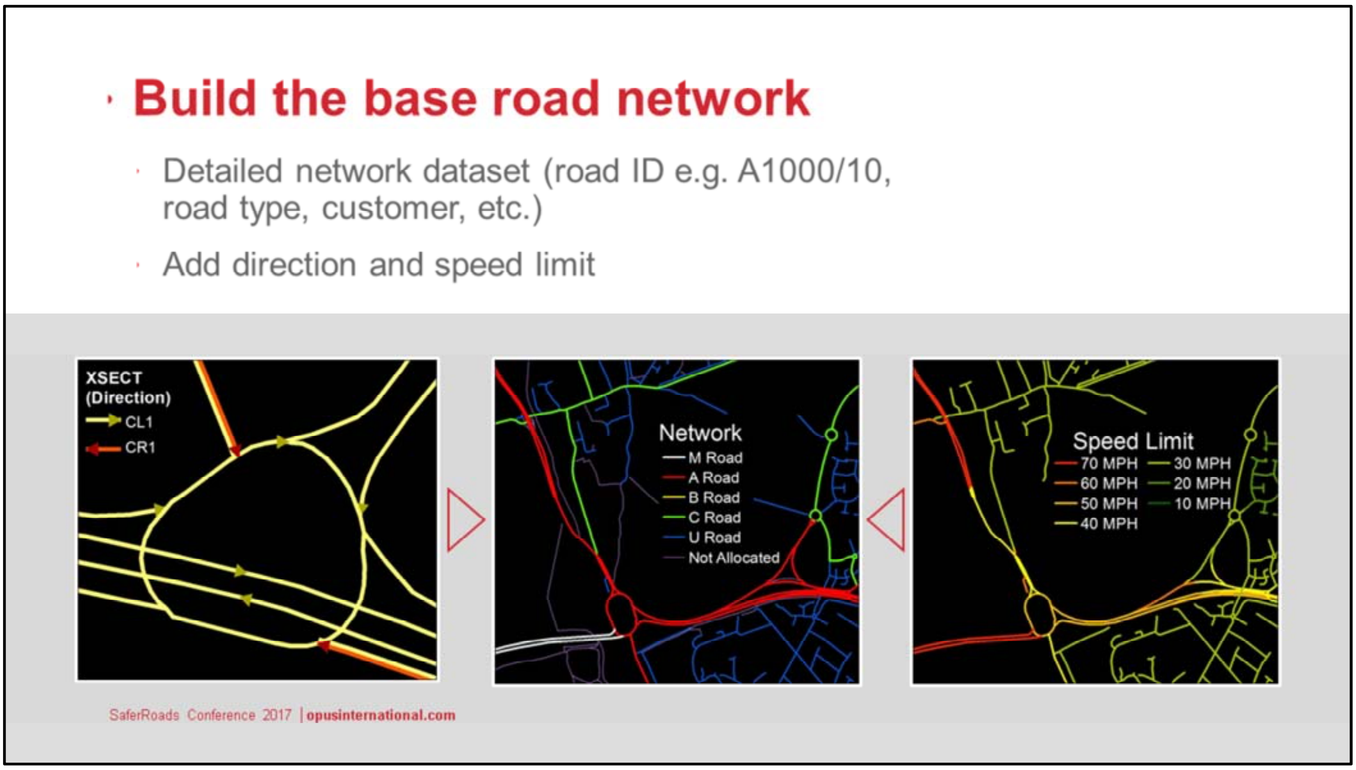
- **Curve** and **Gradient** tables – contain geometry data captured in the SCANNER data. LABEL matches the FEATURE_ID field in the Network dataset (so can linear reference by matching ID); XSECT (direction increasing/decreasing or in this case CL1/CR1); SCHAIN (starting route position/chainage in metres. Used in linear referencing to define start of extent along the route ID); ECHAIN (end route position/chainage in metres, used in linear referencing to define end of extent along the route ID); VALUE (curve radius for curve, gradient value for gradient).

- **Mini RAB** – point locations of the mini roundabouts on the network (and some outside the network). Factor involved in junctions modelling.

- **Signals** – all signal types across the network represented as points. Traffic signals (TS: Junction) are just a subset of this data which feeds into the junctions modelling. One point represents a set of signals at or near a location, not individual signals.

- **Signs** – all signs on the network. Subset of Stop and Give Way priority control related signs were extracted as a subset for use in the junctions modelling. Signs dataset includes a FEATURE_ID which matches that in the Network dataset so can identify which road the sign belongs to.

- **Pedestrian crossing** – point locations of where pedestrian crossings are. Includes some information about the type.



Bringing together the information that is required in the base network which will essentially be the skeleton of the modelling process. Important to ensure the base network is set up first and has the required information for the automated spatial analysis.

While the Network dataset has most the information required, direction and speed limit are required in a number of modelling stages.

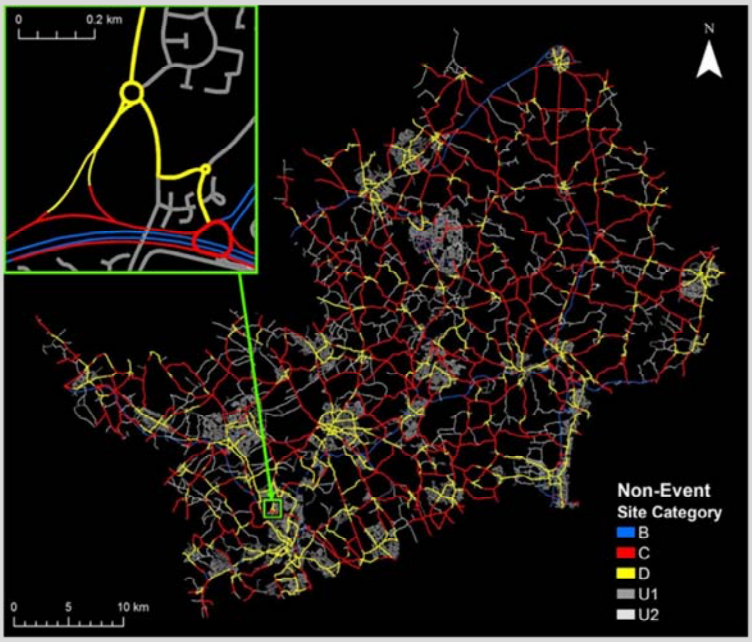
- Direction is required to differentiate between records of differing direction where these share the same centreline and as a result will result in two stacked features of differing information sharing the same exact space. The need to identify between these is crucial to avoid information from one being inadvertently added to the other through the spatial relationships. So it is a means of ensuring the data added by spatial means is done so correctly..

- Speed limit – this is used to define some site categories (i.e. non-event categories), and also approach lengths in the junctions and pedestrian crossing analyses.

Non-events

- Classify full ABCU network based on hierarchy and speed limit

	Site Category	
Road	Speed ≤30 mph	Speed >30 mph
A, B, C	D	C
U	U1	U2



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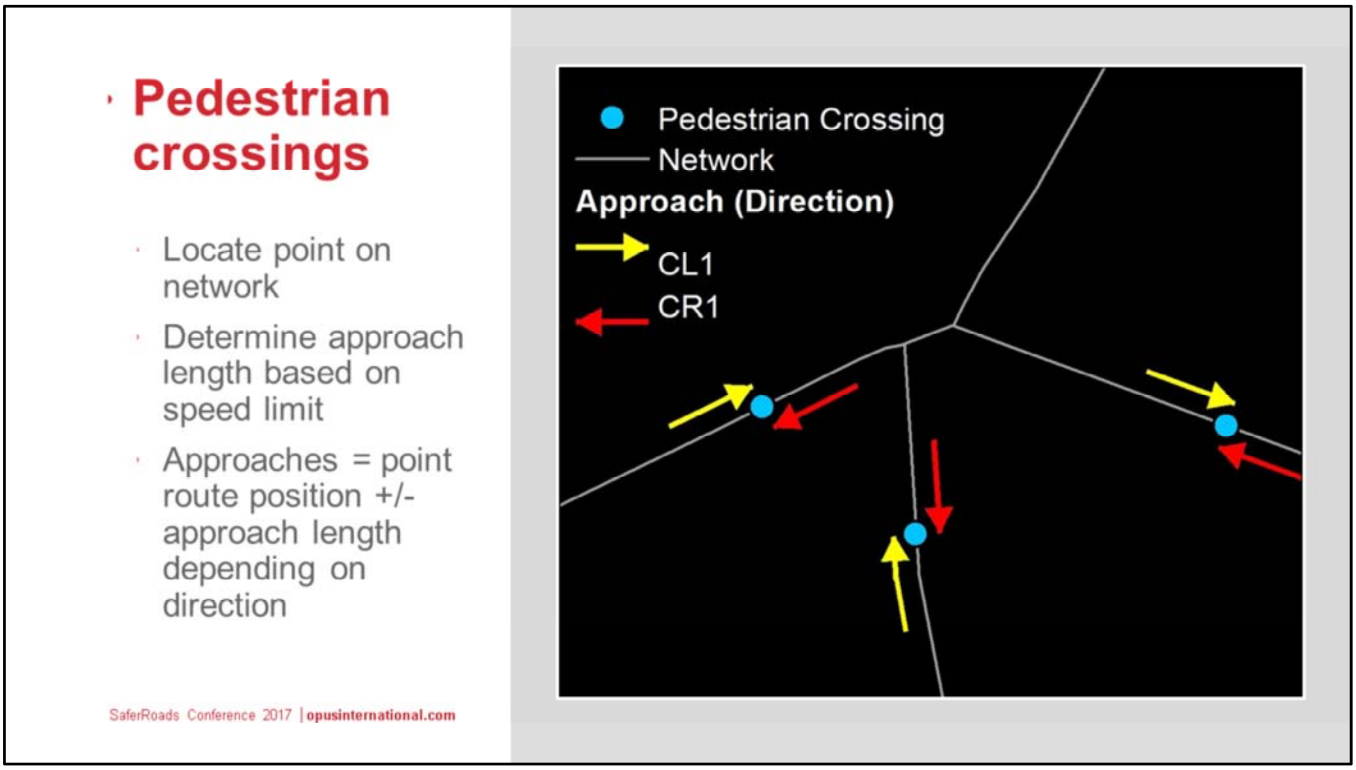
Non-Event – classify the whole network depending on whether the road is and A,B,C or U road in conjunction with what speed limit is for that road.



Locate the pedestrian crossing points on the network, obtaining route id and route position, use this information with the approach length based on speed limit, and direction to differentiate between approach and departure.

Pedestrian crossings

- Approach based on direction
- Approach length based on speed limit

Speed Limit	Approach Distance
70 mph	130 m
60 mph	95 m
50 mph	70 m
40 mph	45 m
30 mph	25 m
20 mph	25 m

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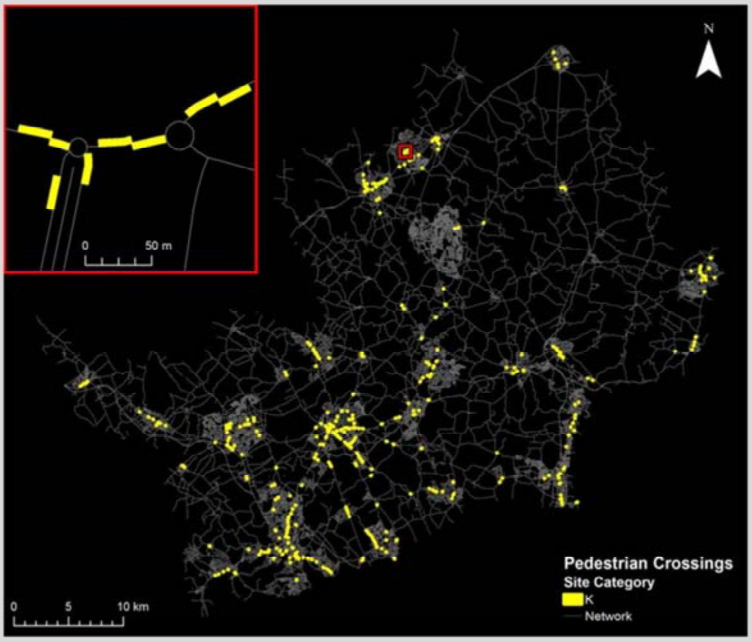
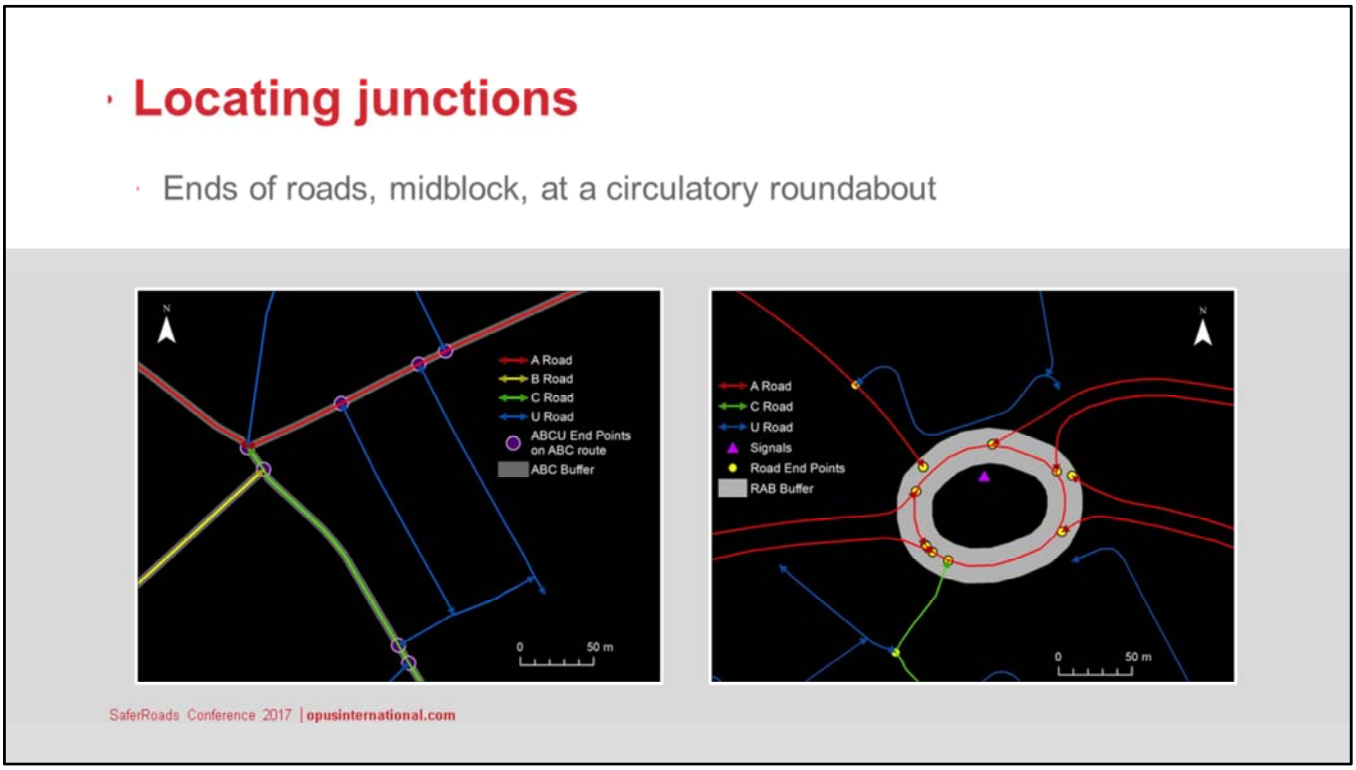
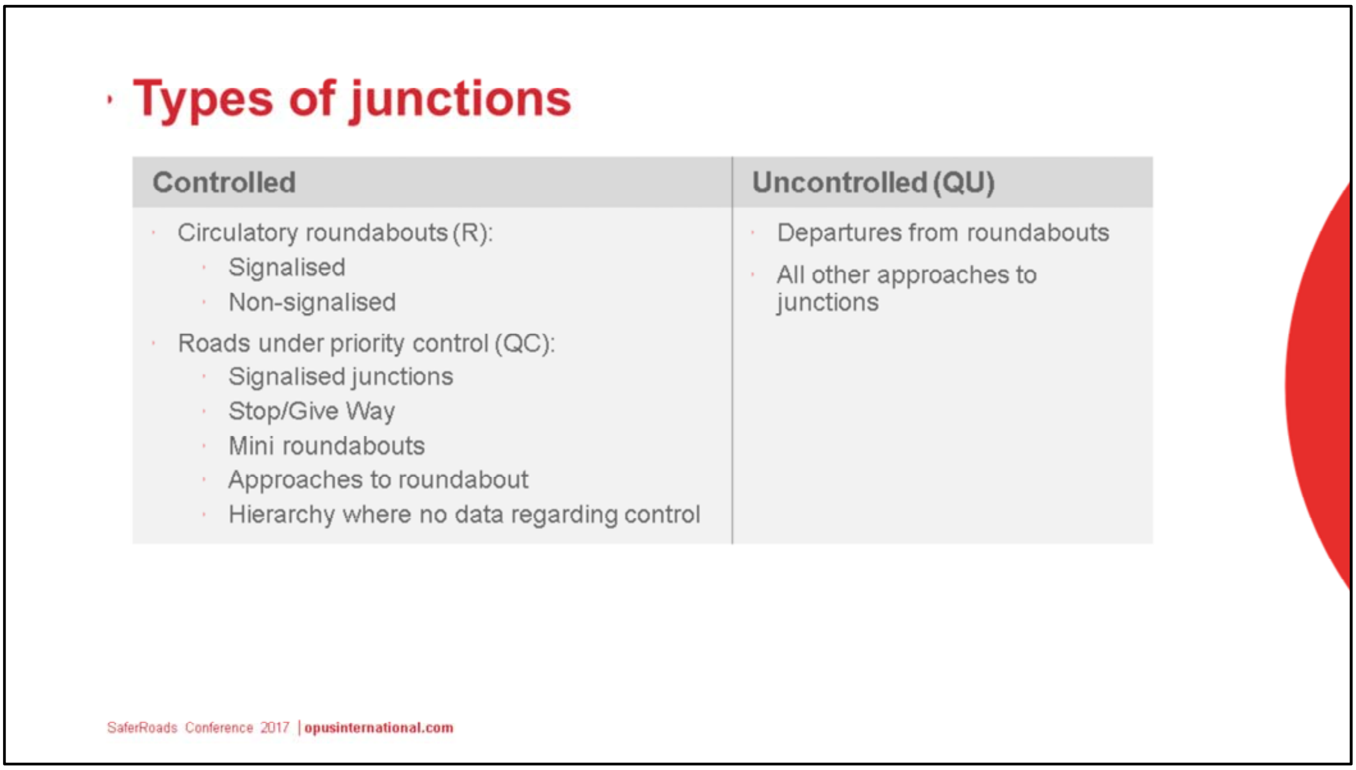


Some extents are shorter than they should be as a result of being located near the end of the Road ID (Feature_ID) extent. The Road ID (Feature ID) dictates which road the approach is to be drawn along, it only knows to look for the one the pedestrian crossing point was located on not the adjoining road or roads within the approach distance. So the approach doesn't extend around side roads where pedestrian crossings are near junctions.



- Similar approach to pedestrian crossings, but far more complex.
- Road "end points" based on start/end locations
- Points within ABC buffered route (did not look at junction of U roads with U roads)
- Define the junction area and identify the points and number of points within this junction area
- Exclude change in A/B/C section (presence of 2 ABCU end points of same road name e.g. A100 – if we disregard the /XXX)
- Approaches to roundabouts – identify road end points which fall within a defined zone around the roundabout centreline
- Generate points for the ABC network to represent the ABC road where a roads joins at midblock (otherwise the midblock approaches to junction are not represented).

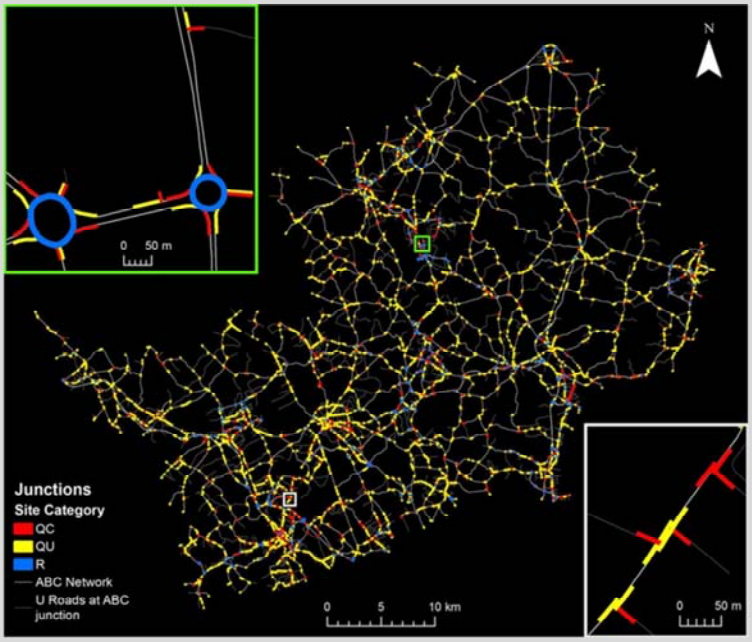


- Stop, give way, rotate priority, signs taken from dataset of all signs.
- Traffic signals taken as a subset of the dataset of all signals.
- Traffic signals – a single feature represent a set of traffic signals not individual traffic signals. So signalised RABs were a bit trickier as the point can be anywhere near the roundabout or located in the RAB island.
- Hierarchy: A road > B road > C road > U road

Categories R, QC, QU defined in earlier slide (22) and next slide (36).

Junction events

Site Category	Description	IL
R	Circulatory roundabout	0.45
QC	Controlled junctions, including approaches to roundabouts	0.5
QU	Across all junctions and uncontrolled approach to junctions	0.45



Top inset demonstrates RAB junctions and junction on a dual carriageway. Bottom inset is an example of junction site categories for a single carriage way with a signalised junction (all approaches in red), give way (middle right red) and hierarchy based (lower 2).

Curves - another challenge

- SCANNER geometric data for ABC roads
- 10 m extents recorded
- Evaluation based on ≥50 m extents
- Evaluate over sections of the same road where the road ID changes
  - e.g. A4147/120 and A4147/122

	Single Carriageway	Dual Carriageway
Directions sharing the same Centreline	2 (Increasing AND decreasing)	1 (Increasing OR decreasing)
Classes	3 (S2, S3, Unclassed)	2 (S1, Unclassed)
Complexity	High	Moderate

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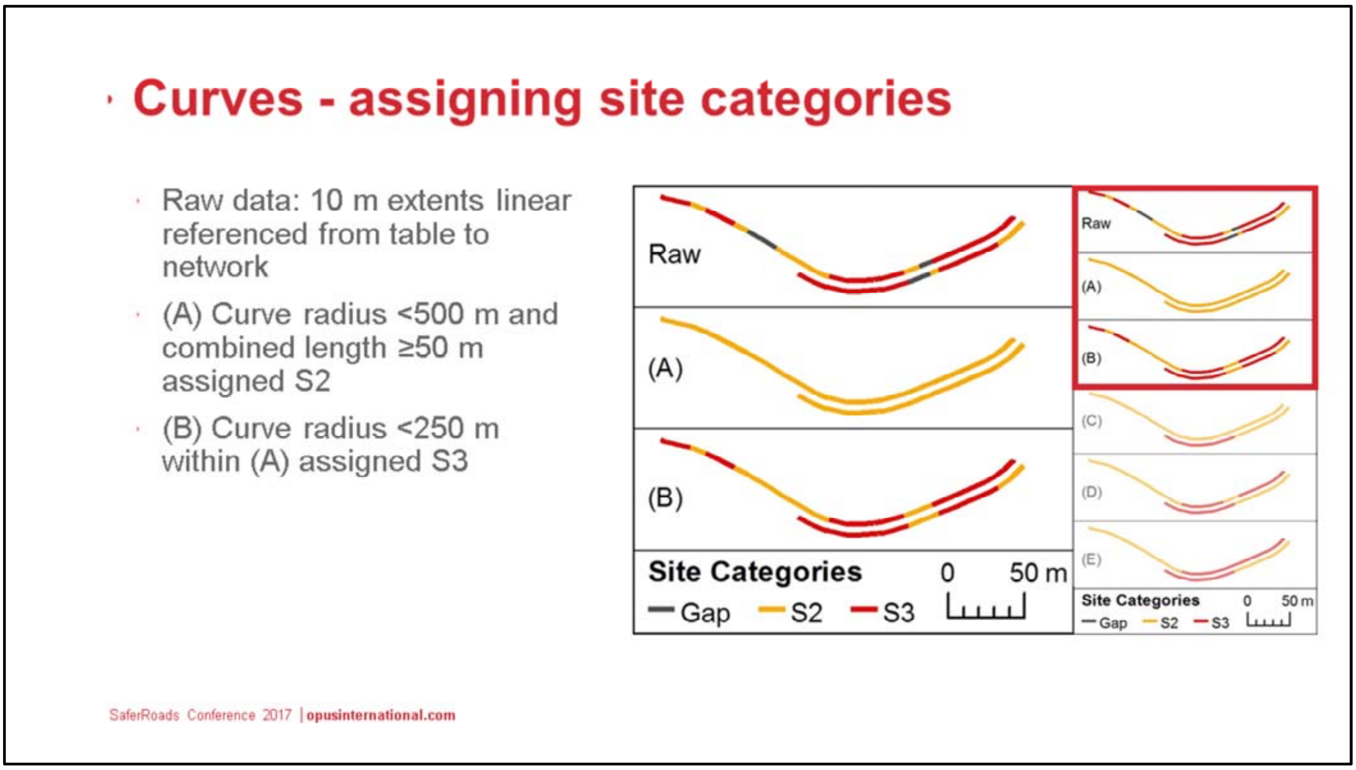
Had to analyse single carriageway and dual carriageway separately then bring back together. Single carriageway one to many spatial joins required a check that joined features matched the Road ID (Feature_ID) and Direction (XSECT) to ensure correct matches are analysed and not just any that happen to be nearby. One to Many spatial join used as a one to one may join the incorrect direction and/or road ID, using a one to many give the option to select a subset of data.

Having more categories meant having more steps and more criteria to determine how to class a 10m section in the scheme of a longer extent that could be various sections of interchanging S2/S2/gap, or S1/gap.

No curve (or gradient) data for U roads = no analysis possible for U roads



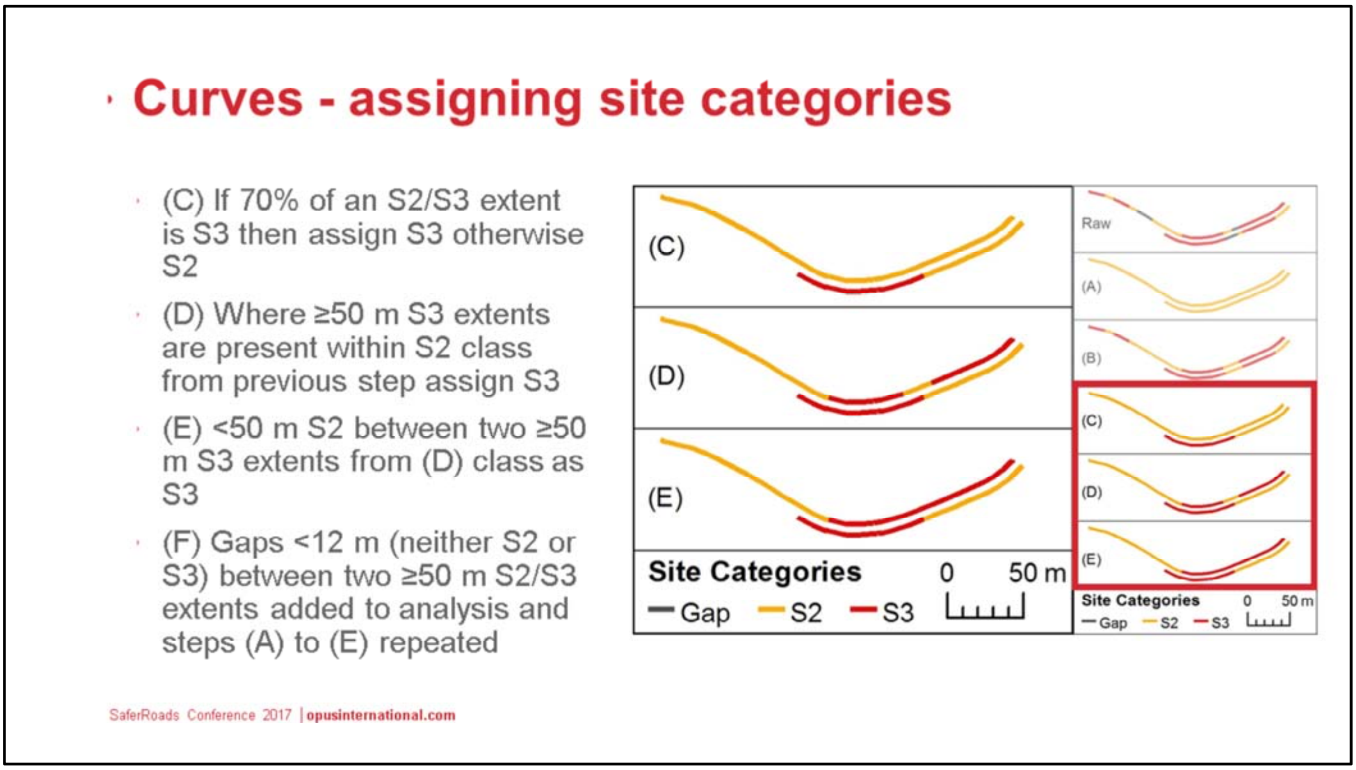
Single Carriageway example (the more complex one)…

- **Raw**: The raw data plotted and themed purely on the curve radius values red/S3 <250 m; orange/S2 >250 m and ≤500 m; grey/gap >500 m

- **(A)**: class full contiguous extents as S2

- **(B)**: identify extents of S3 based on curve radius criteria (<250 m) alone.

<u>Additional detail</u>
Defining contiguous lengths – take extents of S2 and S3 (based on curve radii alone), single these out, apply 6m buffer to pick up any singular ~10m gap features which may be present between initial S2/S3 10m extents.
Dissolve all adjoining features to determine contiguous lengths and identify length of the contiguous length.



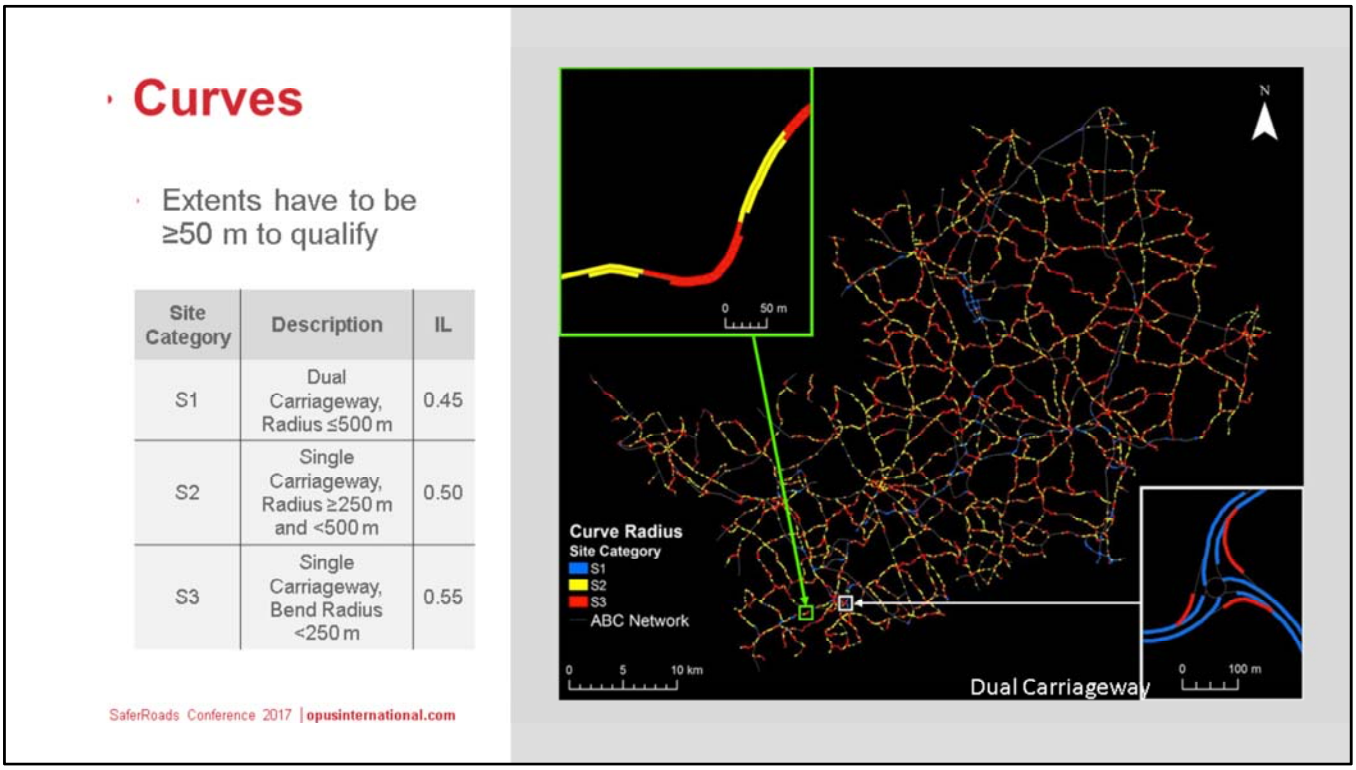
Single Carriageway example (the more complex one)… (continued)

- **(C)**: Identify proportion of S2 and S3 per contiguous extent. An arbitrary value of 70% to be met for classification of S3 otherwise default to S2

- **(D)**: If contiguous extents of 50 m or more are present within an extent classed as S2 from step (C), class these as S3.

- **(E)**: Following step (D), if a S2 extent of <50 m falls between two S3 extents class this and the S3 extents as S3

- **(F)**: if sections of curve radius >500m ("gap" sections that are neither S2 or S3) with a length <12 m are present between two ≥50 m contiguous S2/S3 extents include these in the analysis and repeats steps (A) to (E).



Curve site categories defined for the network.

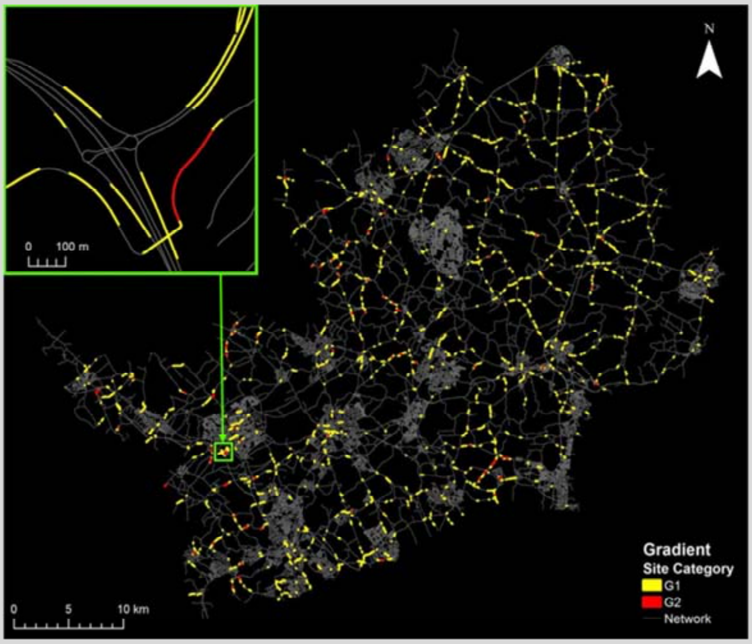
Top Inset: Single carriageway – top/left polygon extents relate to CL1, bottom/right extents relate to CR1. Note: despite both directions sharing the same centreline the site category extents for each vary.

Bottom Inset: Dual carriageway

Gradient

- Similar approach to single carriageway curves
- Extents also have to be ≥50 m in length to qualify

Site Category	Description	IL
G1	Gradient 5-10%	0.45
G2	Gradient ≥10%	0.50



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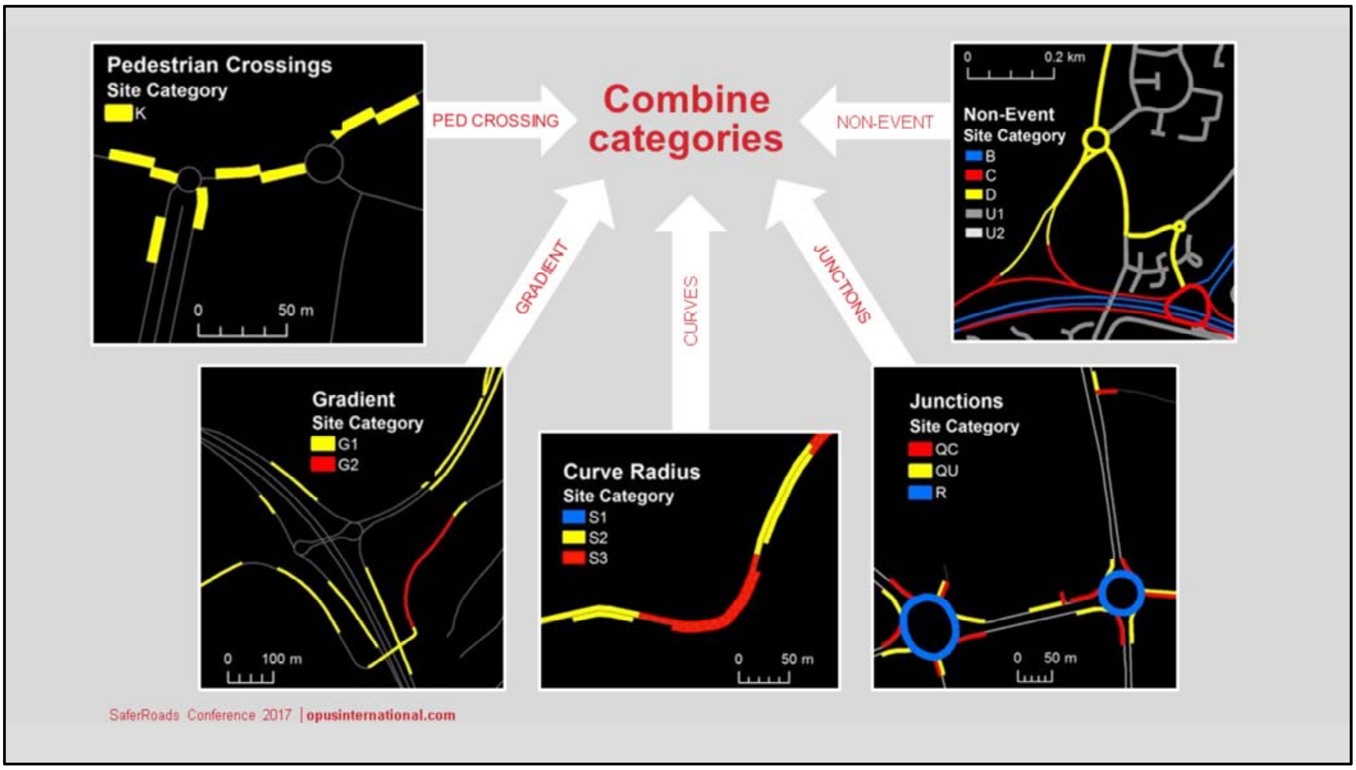
Similar approach to singles carriageway curves. Main difference is the gradient categories are not unique to carriageway type, so single and dual carriageway can be analysed together instead of being done separately.



Combining all classed network outputs into one output dataset. Need to ensure the datasets have the same fields present, and that these have matching field types and field names. Meant adding and removing some before compiling.

Combining overlapping features from different datasets, and because the feature extents are defined by the extent of the same combination of values the network becomes more fractured as any change in the combination is defined as its own extent.

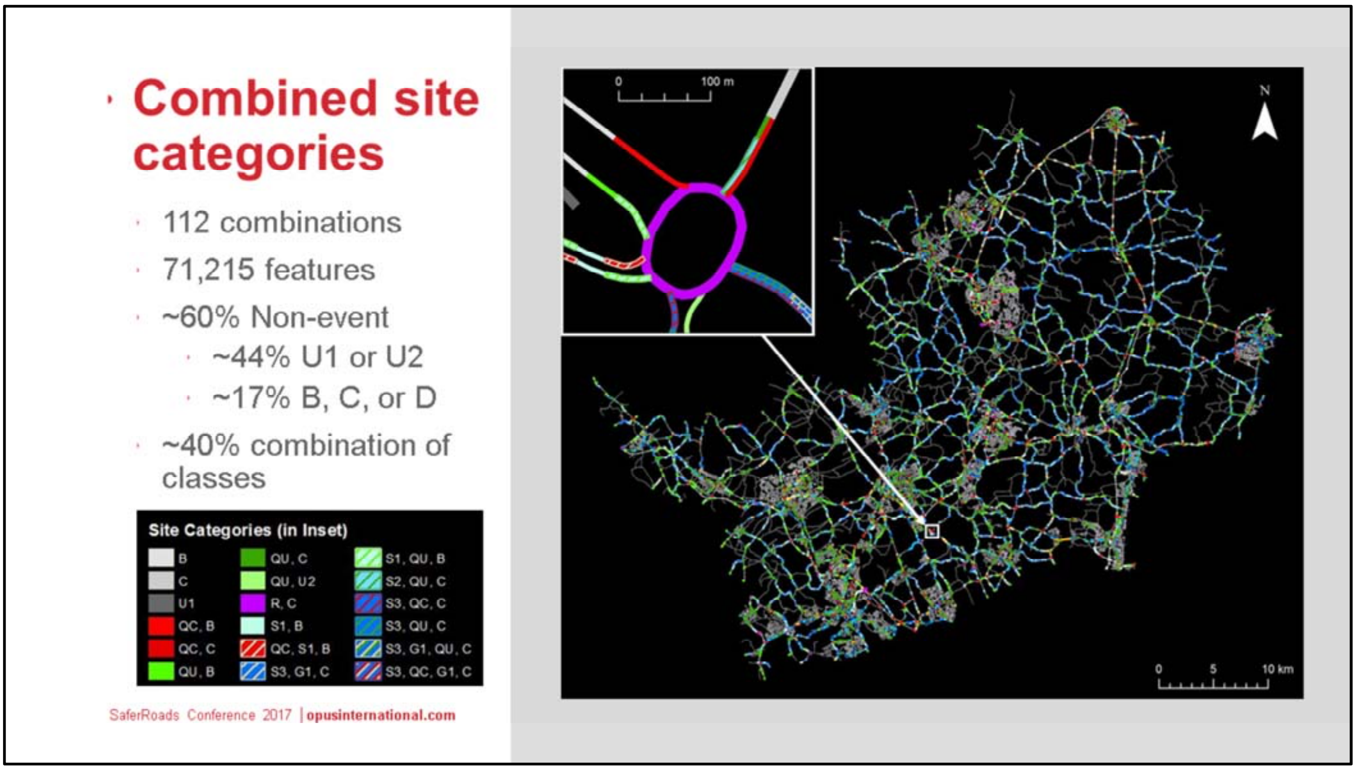
Through this process there are slithers (e.g. areas <$2m^2$) and overlaps that need to be ratified, which the model process attempts to do through a stepwise process.

<u>Additional Detail:</u>
On combining, need to have the same data schema i.e. all the fields in the attribute tables need to match in terms of field name and field type (e.g. short integer, double, text, etc.). This meant copies of the outputs were made with several fields dropped and a very few added where these were to be included in the combined output.

Combining datasets through a spatial union results in a chopped up output wherever there is a different combination of values in the row for a feature's attributes than its neighbouring features. As a result small slithers can eventuate.
The polygon features for different roads in each of the datasets can have overlapping

features as a result of the buffer width, so its important to be able to distinguish which features belong to which road and that the features unioned belong to the same Road ID (Feature ID) and direction (XSECT) and retain those while dropping those that don't match.

As the datasets are combined in a stepwise process, there is a ratification process as part of that to identify the really small areas and any overlaps and seek to combine them with the most appropriate feature, before moving on to the next union process. The results of this ratification process has minimised the areas of $<2m^2$ to just 3 records.



The majority of the non-events are U1 (29,056 = 41% of all classes) and to a lesser degree U2 (2,058 = 3% of all classes).

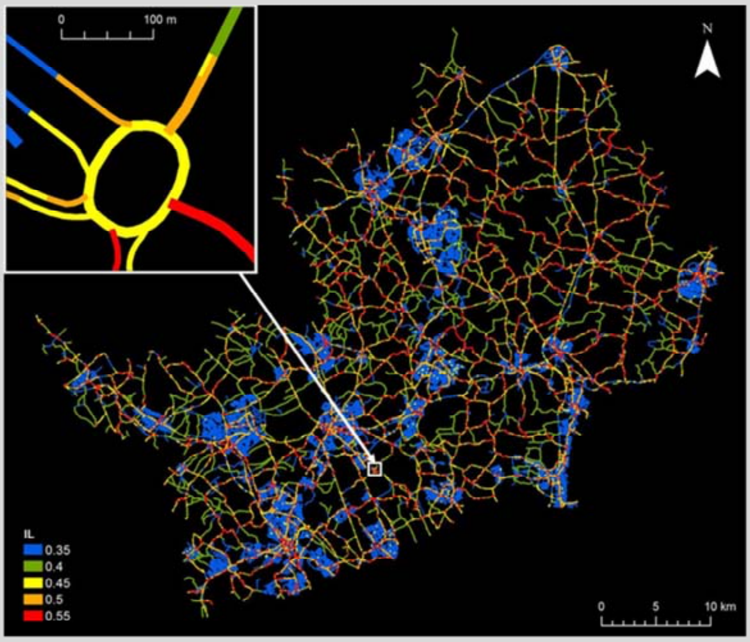
The main focus was on the A/B/C roads, which had more complete data coverage, higher speed limits, and likely greater traffic volumes

Analysis on U roads was limited. Curve and gradient data did not cover U roads. Can't rely on hierarchy in junctions consisting only of U roads where there are no records in the spatial data of any controls meant these would be more difficult to determine which approaches are controlled and which are not.

Combined ILs

- Theme by max IL for each feature

IL	Site Categories
0.55	S3
0.50	G2, K, QC, S2
0.45	G1, QU, R, S1
0.40	C, U2
0.35	B, D, U1



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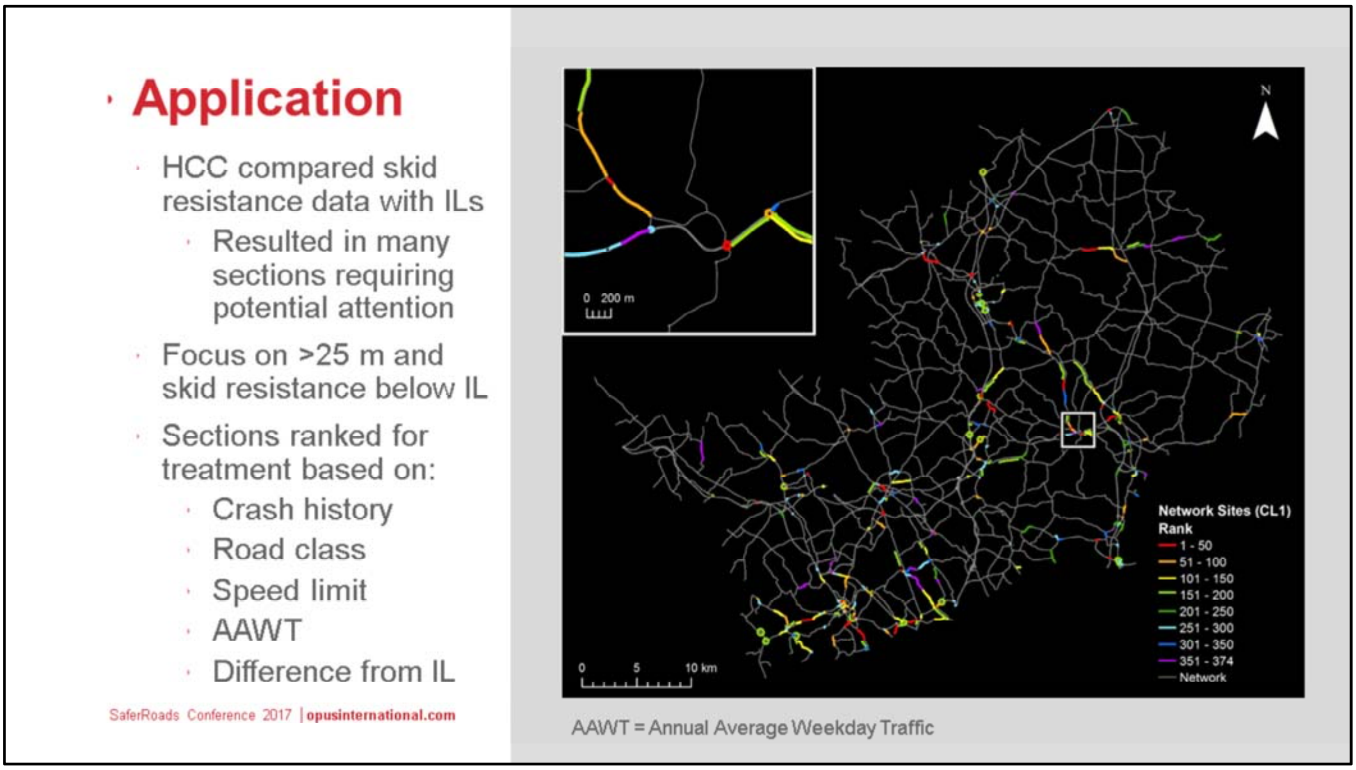
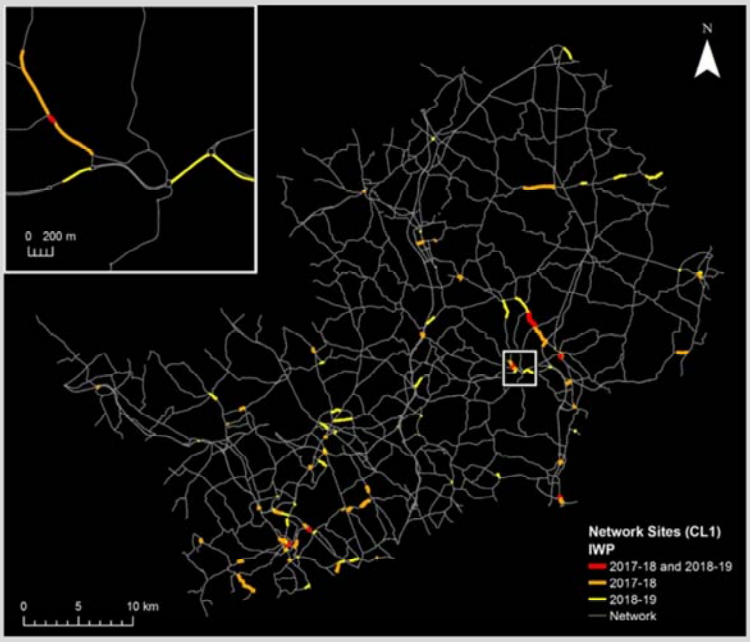


AAWT = Annual Average Weekday Traffic
IWP = Integrated Works Programme

Application

- Identified lengths compared with the HCC Integrated Works Programme (current and future) to identify efficiencies for timing of the skid resistance works
- Additional uses of model outputs being applied in other road safety spatial analysis applications



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AAWT = Annual Average Weekday Traffic
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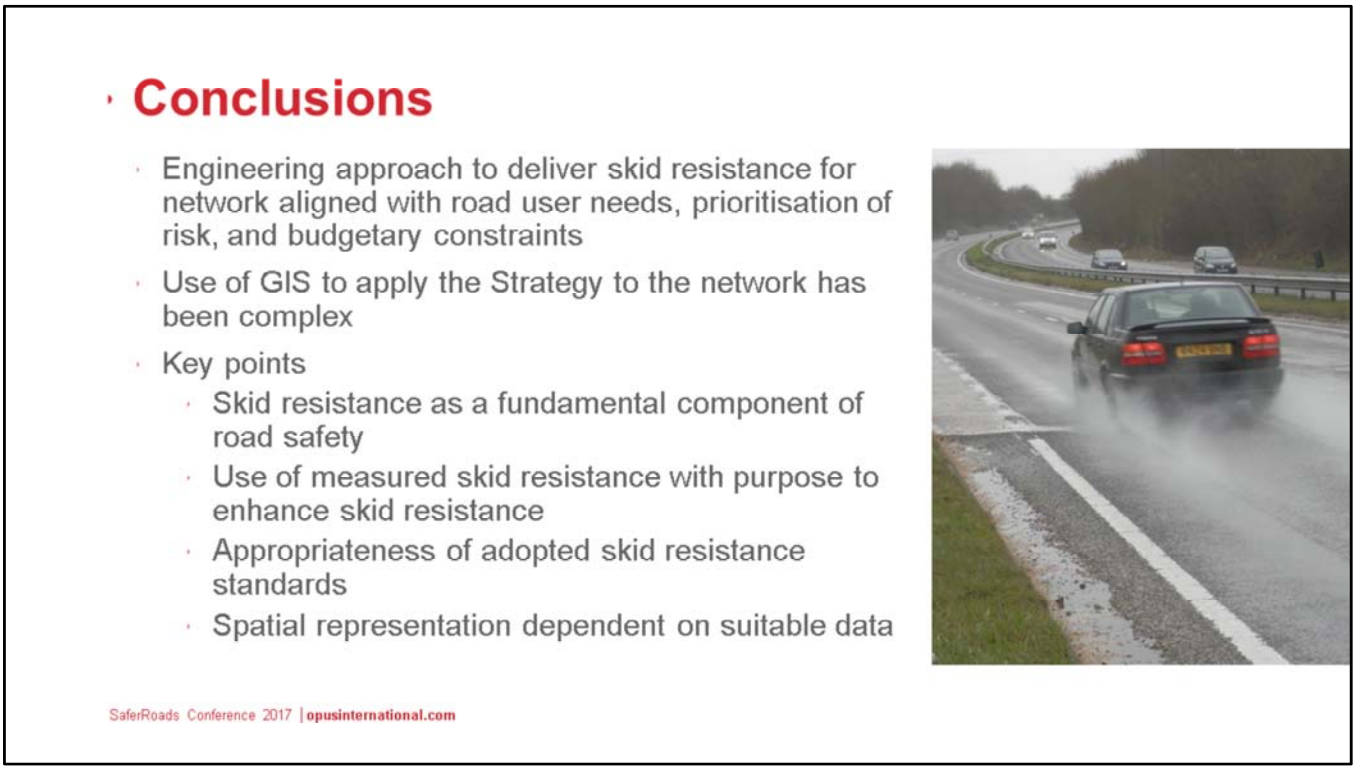

- Strategy which meets needs
- Strategy applied in GIS, complex but valuable.

- Skid resistance important to road safety
- Measure to enhance
- Appropriate standards
- Spatial output reliant on good data

Shout out to the team who all contributed to the strategy and provided valuable input throughout the development of the automated spatial models.