Evenness of newly laid pavements on the English Strategic Road Network

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Introduction

- Assessment of smoothness on new surfaces on the English Strategic Road Network (SRN)
  - Specified according to the requirements of Series 700 of MCHW
  - Application of the Rolling Straight Edge (measured irregularities in a 3m length)
  - Number of exceedances >4mm and 7mm

	Surfaces of each lane of carriageway, each hard strip and each hard shoulder for each irregularity limit				Surfaces of each lane of bituminous binder courses for carriageway, each hard strip and each hard shoulder for each irregularity limit				Surfaces of lay-bys, service areas, and associate bituminous binder courses for each irregularity limit			
Irregularity Limits	**4mm**		**7mm**		**4mm**		**7mm**		**4mm**		**7mm**	
Length (m)	**300**	**75**	**300**	**75**	**300**	**75**	**300**	**75**	**300**	**75**	**300**	**75**
Category A Roads	20	9	2	1	40	18	4	2	40	18	4	2
Category B Roads	40	18	4	2	60	27	6	3	60	27	6	3

MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS
VOLUME 1 SPECIFICATION FOR HIGHWAY WORKS

SERIES 700
ROAD PAVEMENTS – GENERAL

Contents

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATIONS OF SCOTLAND, WALES AND NORTHERN IRELAND

Northern Ireland

Introduction

- Disadvantages of RSE
  - Slow
  - Requires technicians to walk in the carriageway
  - Old technology does not support ease of data access, location referencing and detail
  - Questionable repeatability
  - The measurements cannot be linked/carried forward to measurements carried out on the in-service pavement
  - Lengths with “good” RSE had user reports of poor ride quality
- So…
  - Newer technologies are available
  - Some countries have already switched
  - How can we make a change for English SRN to
    - **Improve the ability to test the smoothness of new roads**
    - **Support improvements to user experience**
    - **Support reductions in carbon**

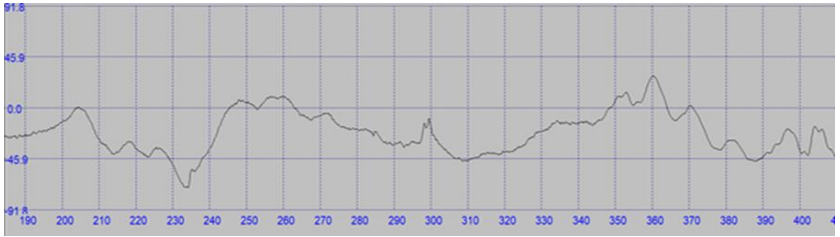
Measurement of smoothness of new surfaces

- Proposed Approach - measure the road profile, not the response
  - Opens the market to any profilometer (*potentially* simplifies implementation)
  - Ensures the full range of wavelengths are measured
  - Allows any ride parameter to be calculated/reported (inc. RSE (simulation))
    - Allows us to explore the options
  - Better able to understand the link between the requirements we set and the capability (of the industry) to achieve
    - Supports threshold setting
  - Enables a link to be established between new and in-service pavements

Dynatest

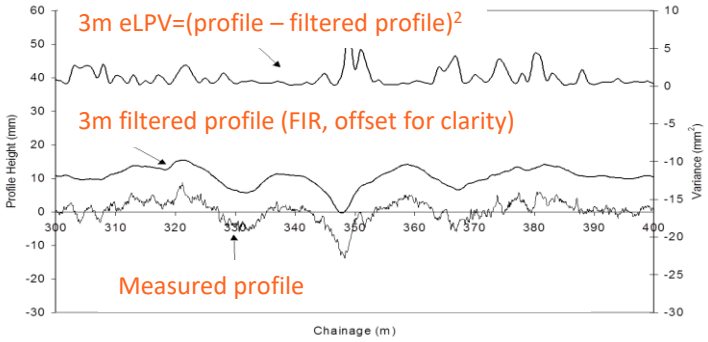
HDS

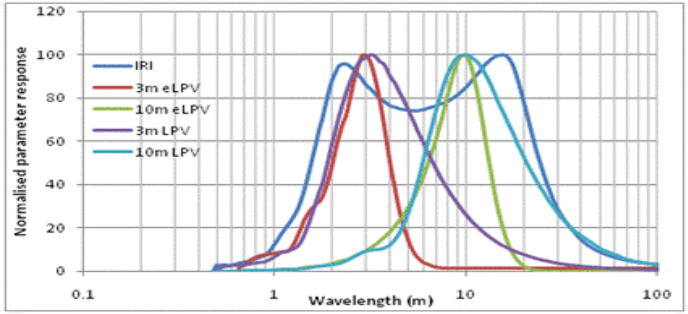
Pavemetrics

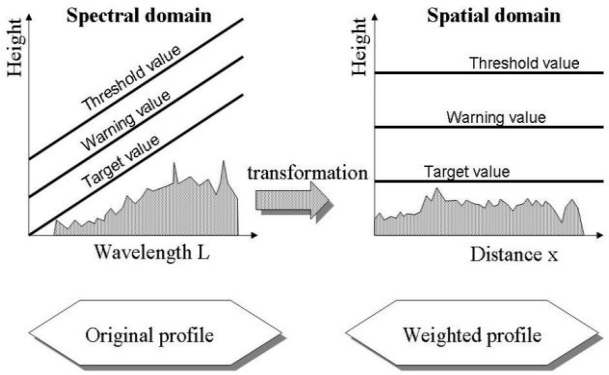


Quantifying smoothness of new surfaces

- To overcome RSE limitations we want to quantify general **and** local roughness – to optimise user experience
- **RSE (simulation)**
  - Allows direct transition, low complication
  - Antiquated, focusses on bumps, low user agreement
- **Waveband measures (E.g. eLPV in UK)**
  - Consistency with in-service roads, smooth transition
  - Good link with general smoothness, question over bumps
- **IRI**
  - Common, international measure, but not UK
  - Good general smoothness, question over bumps
- **WLP**
  - Covers a wide wavelength range, potential “all purpose” measure
  - End user experience, understanding?
- **Bespoke measures**
  - To better focus on user experience?

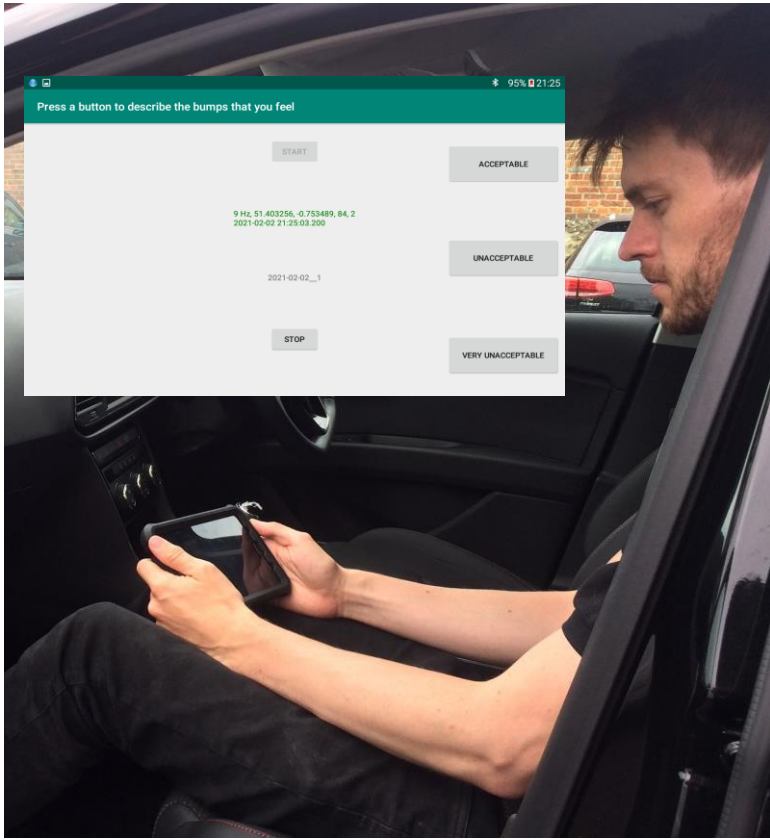






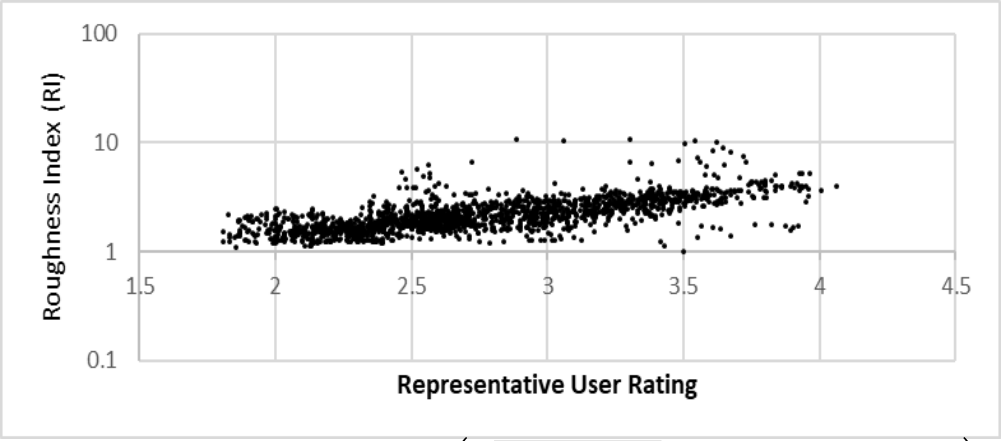
Quantifying smoothness of new surfaces – Parameters for user experience

- In parallel work we have carried out user studies to better understand user experience
  - Developed an App that allows users to record their views on general smoothness and to report bumps
  - >150 driven surveys, range of vehicles and routes
  - Comparing user ratings to selected parameters calculated from the profile

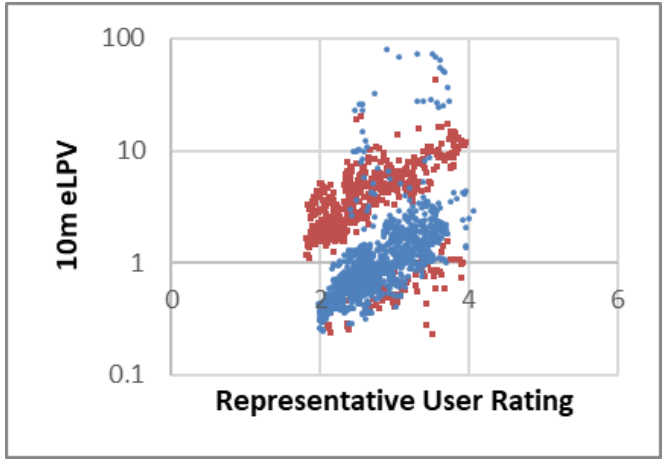


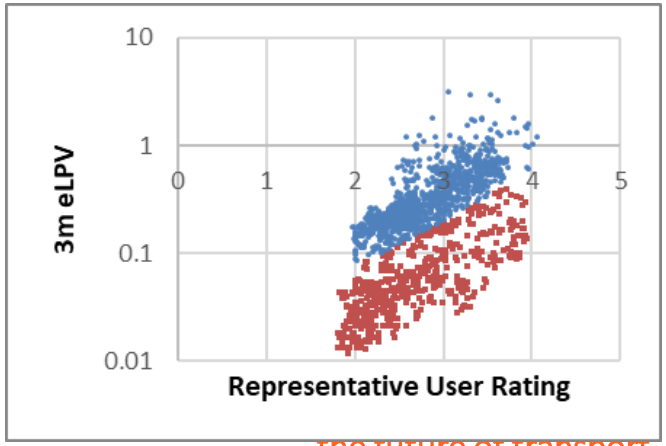
Existing parameters to reflect user experience of general smoothness

- For general smoothness, an interesting result from the 2021/22 trials
  - The relationship between 3m and 10m wavelength smoothness and user ratings was not consistent between sites
  - But a combined measure, the **Roughness Index**, provides a good estimate of user experience
  - And is correlated with IRI (!)



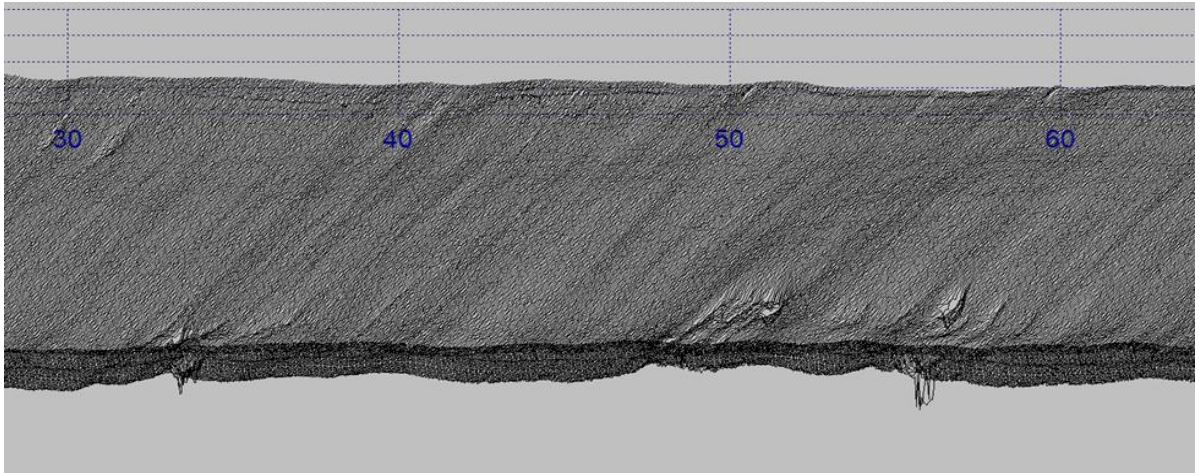
- $$\textit{Roughness Index} = Max\left(\sqrt{\frac{10}{3} \times eLPV3} + \sqrt{eLPV10} - 0.1, 0\right)$$

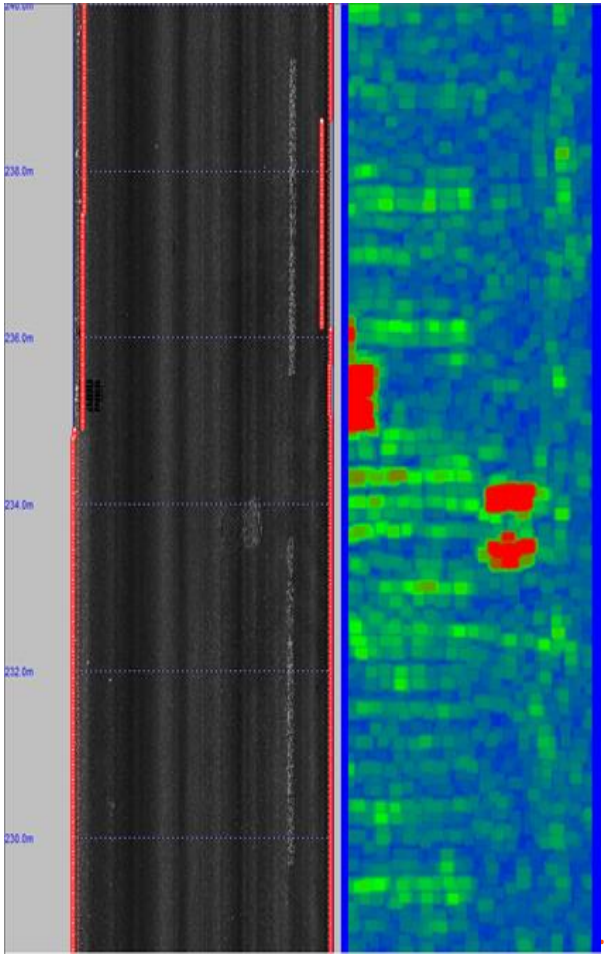




Bespoke parameters to reflect user experience of bumpiness

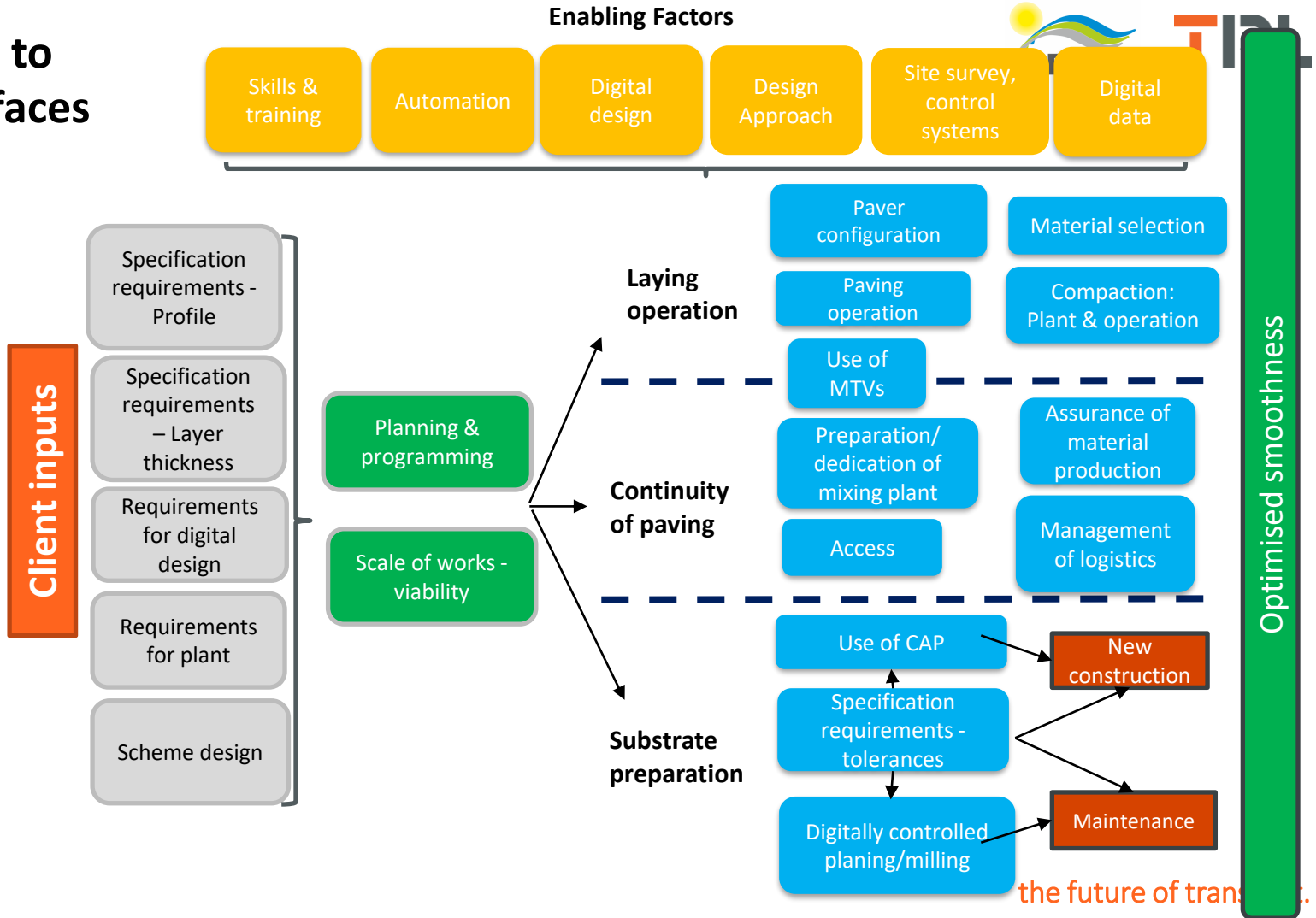
- General smoothness measures do not provide a good estimate of user experience of bumpiness, s bespoke measure that focusses on bumps is needed
- We have developed a measure, the **Bump Index** that estimates bumpiness by evaluating the area between the profile and the local smoothed plane, over the full width of the 3D profile
- And, via the trials, correlated this with user experience to identify lengths that users would report as bumpy





The transition to smoother surfaces

- Parameters / specifications are the start point
- Collaborative improvement will support any transition in the approach to delivering smoother surfaces



Influence of the maintenance process

- Setting new standards may challenge the industry to deliver improved approaches to construction
- There are a number of methods that help to improve the smoothness achieved

Overall Approach	Examples
Minimise the need to stop / start	Continuity of material supply; Material transfer vehicles (MTVs) Longer working windows for continuous paving and resulting fewer joints, e.g., full weekend closures
Laying operations	Paver configuration (tracked paver, averaging beams, integrated spray bars) Optimal paver speed (to prioritise compaction under the screed rather than maximising output) Material specifications, compaction control
Preparation of the Substrate	3D modelling to provide digital output for connected/autonomous construction plant, 3D milling, automated control, substrate reprofiling
Larger scale paving	Extent of works access to accommodate wider paving widths or echelon paving

Influence of the maintenance process

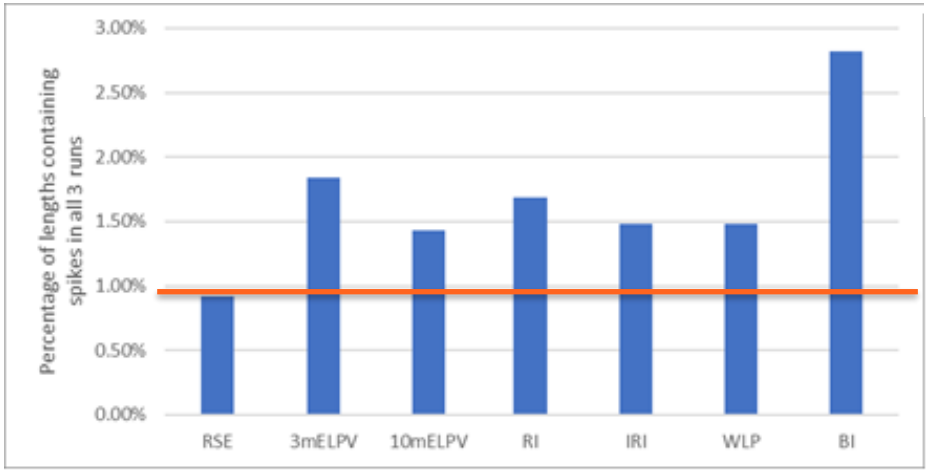
- Consider four sites where the industry has applied different techniques
  - Pre and post surveys to understand in the relationship between industry practice on site and the achieved smoothness
  - Can inform threshold setting and understanding the challenge

Site	Laying techniques
1	Standard
2	Shuttle Buggy
3	Continuity of paving (fewer joints) via Material transfer vehicles (MTV) and 6m wide paving GPS-located cold milling machines fitted with laser profile scanners and averaging beam technology Thermal image mapping and compaction control/technology
4	3D profile model fed into GPS controlled planers Three pavers operating in echelon to eliminate longitudinal joints Material transfer vehicles (MTVs) Oscillating rollers with onboard compaction control systems

Expected improvement

Applying the profile measures on these sites

- **RSE (simulation)**
- No site will be perfect…
- On our sites, what is the repeatability of the RSE and other measures in terms of their ability to identify poor lengths?
    - In addition to its low level of agreement with user experience, the RSE is less repeatable than other parameters
- Not desirable for a tool that will be used for acceptance of quality

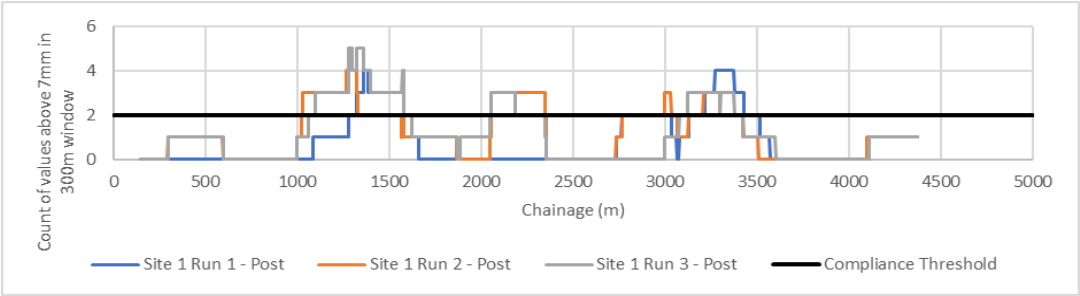


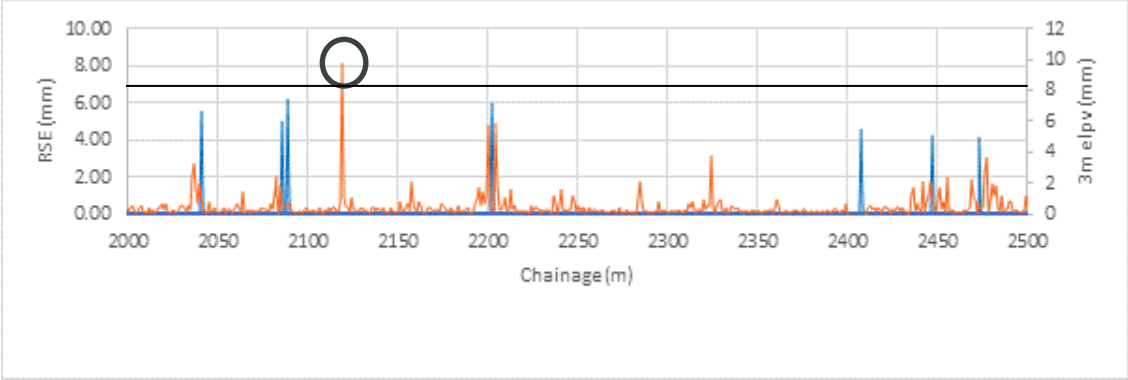
- Percentage of lengths that had high values (spikes >95%ile) reported in all three survey runs

Applying the profile measures on these sites

Site 1

- Laid using standard processes
- The RSE reports lack of compliance at some locations
- There were transverse features associated with the paving process
  - Evidence of discontinuous paving and “truck bumps”
  - Inconsistently identified by the RSE, and often do not reflect manual inspection of the profile
  - Other profile measures provide more consistent assessment

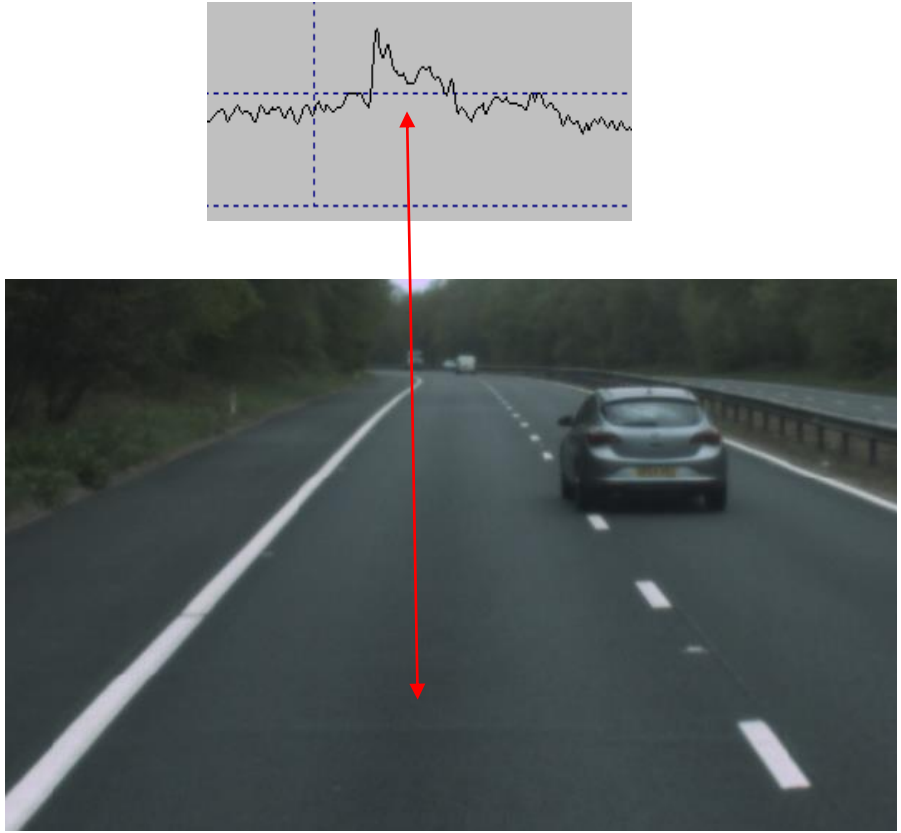




Applying the profile measures on these sites

Site 1

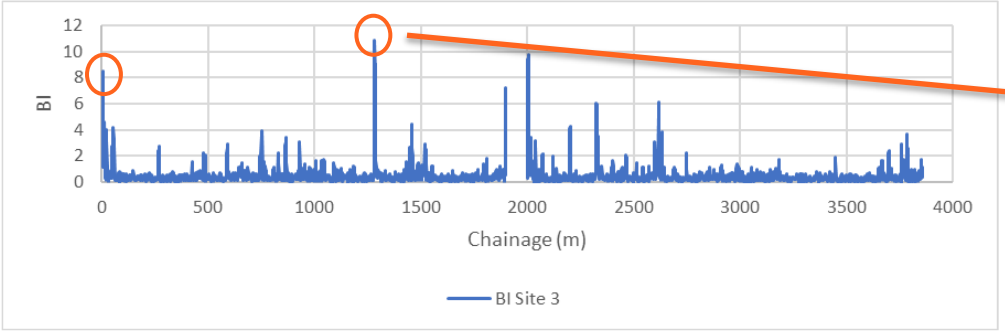
- Laid using standard processes
- The RSE reports lack of compliance at some locations
- There were transverse features associated with the paving process
  - Inconsistently identified by the RSE, and often do not reflect manual inspection of the profile
  - The alternative measures provide more consistent assessment
  - **E.g. this bump at 2120m missed by RSE, reported by WLP, BI**



Applying the profile measures on these sites

Site 3 - transitions

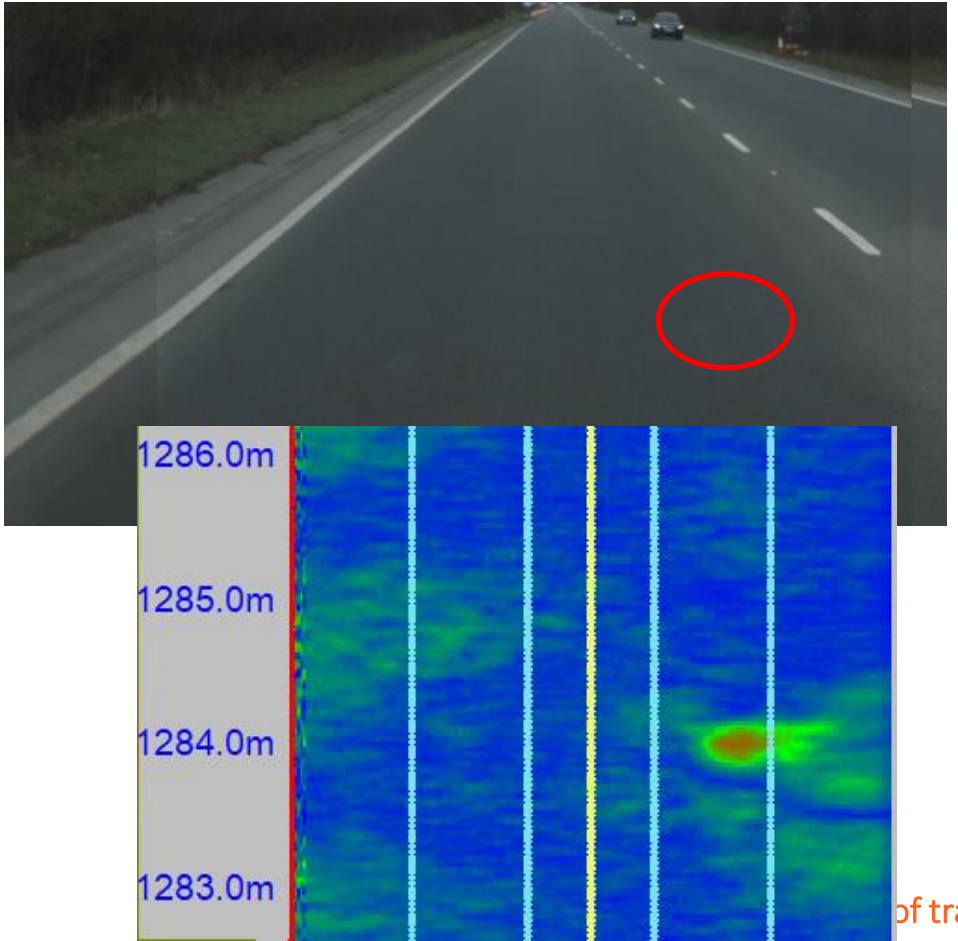
- Laid using several methods to optimise smoothness
- Was a smoother site for all metrics
- **BI** and **WLP** particularly able to highlight bumps at the start and end of the site due to the transition
- *These lengths not usually included in the UK compliance testing?*



Applying the profile measures on these sites

Site 3 - Localised features

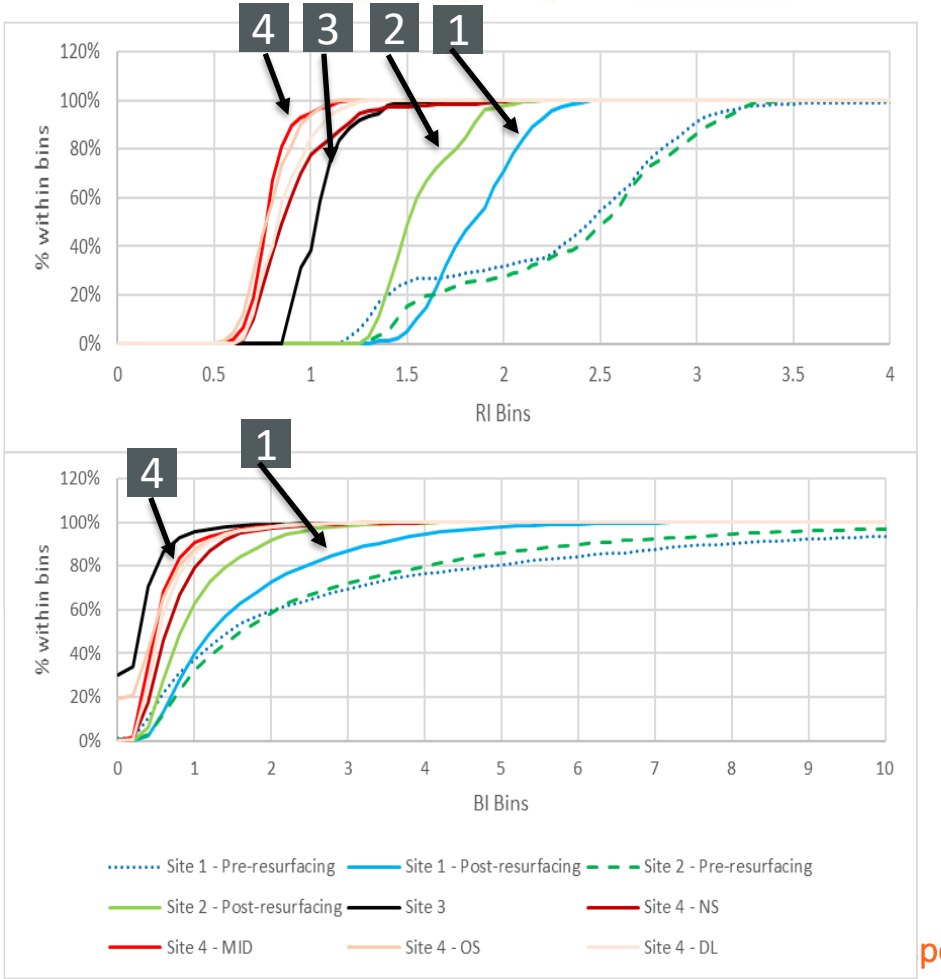
- Some large features that can only be seen in the 3D profile
- The BI is able to detect these
  - Highlights additional capability of this parameter, using the detail available in the 3D data
- *But has implications for the capability of a measurement system for compliance*
  - *Can we reduce the intensity of data required and still deliver the need?*



Applying the profile measures on these sites

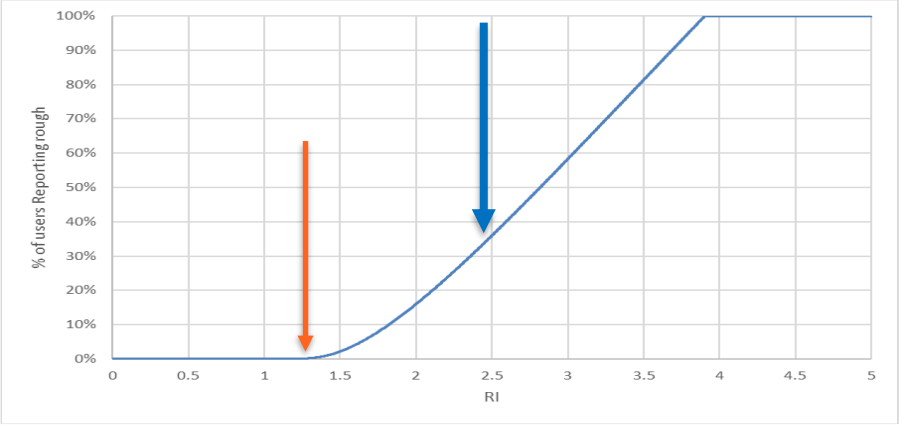
Relative Performance of all Sites

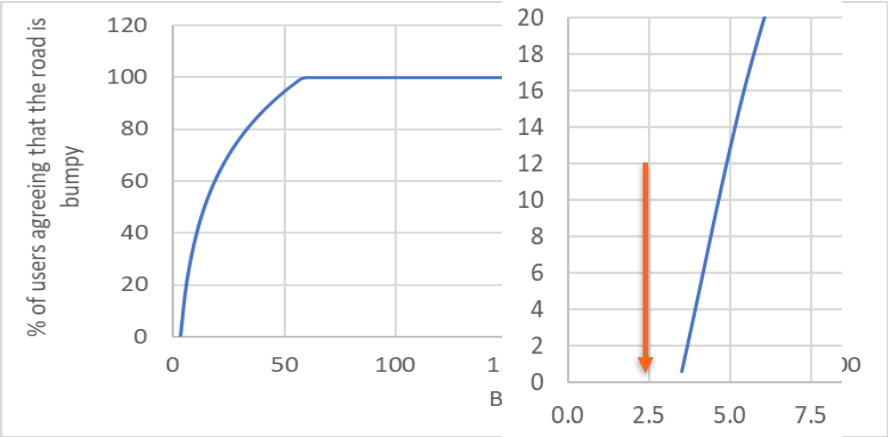
- Our general smoothness measures rank the sites as increasingly smooth – e.g. roughness index
- Demonstrate an improvement over the ability of RSE to separate the sites
- Demonstrate the benefits of the approaches taken on sites 3 and 4 to deliver a higher class of performance
    - These used Material Transfer Vehicles and advanced systems for milling/planing
- Highlights “achievability”



Implications of user experience on setting standards for new surfaces?

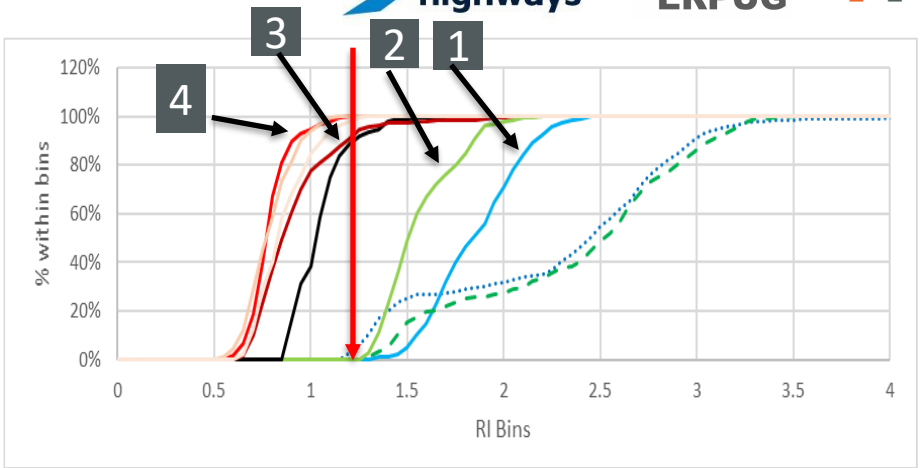
- From the user trials we can establish relationships between the user experience and the parameters based on **the percentage of users that agree the road is rough**, **or** that it is **bumpy**
- For **in service** roads we can use this to decide on performance requirements that balance asset management and user satisfaction strategy
- For **new surfaces** we could ensure that the requirements deliver smooth roads (e.g. 0% of users would be affected?) for long term performance, lower carbon and high user satisfaction



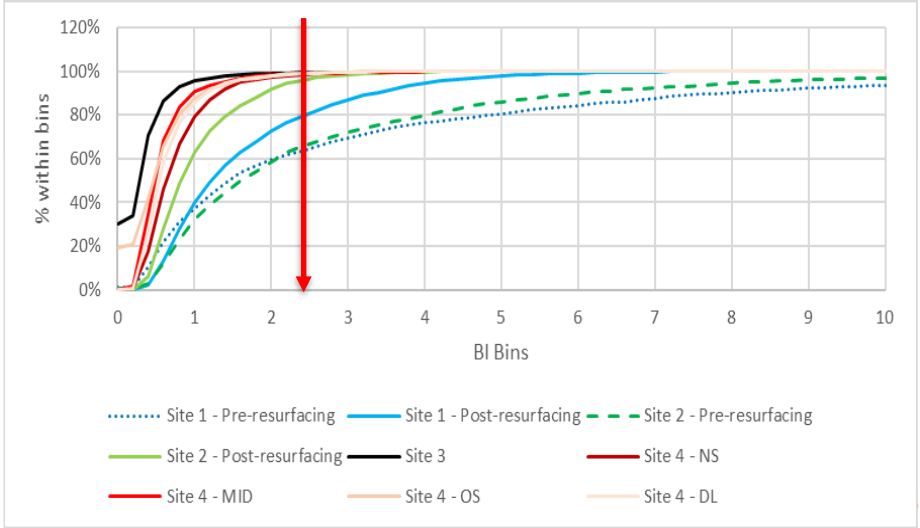


Implications of user experience on setting standards for new surfaces?

- **Establishing requirements?**
- The data shows the higher level of user satisfaction sites 3 and 4 would have delivered
- Selecting requirements will require a balance between
  - Achievability (is it possible)
  - Cost (is it affordable)
  - Practicality (can the industry provide, can it be measured)
- Which will require
  - Collaboration with paving industry to develop strategic and practical solutions
  - collaboration with measurement industry to establish compliance assessment tools



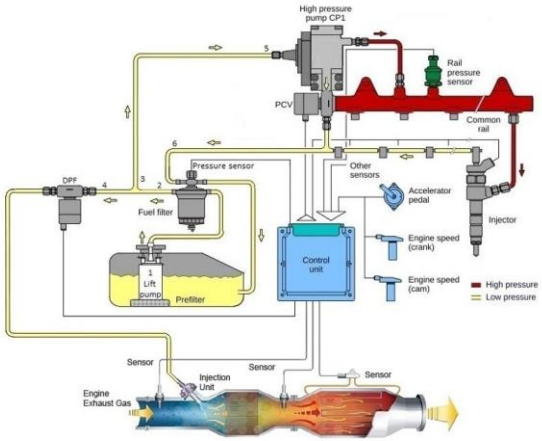
Roughness Index

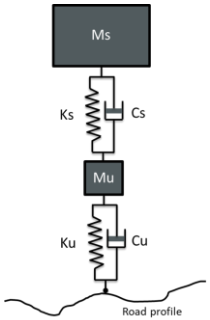


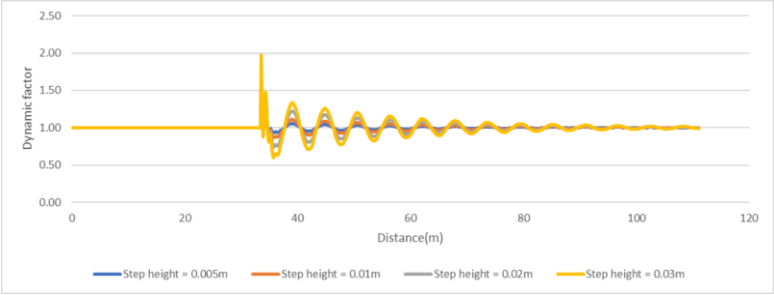
Bump Index

The carbon case

- In addition to user experience and engineering benefit, the case for change can consider the relationship between
  - Roughness and fuel consumption (rolling resistance)
  - Roughness and dynamic loading
- Both influence the carbon case. Work is ongoing
  - To provide a practical demonstration of the direct link between roughness and **fuel consumption**
    - Measuring direct benefits on treated pavements
  - And to provide a simple tool to link roughness to dynamic loading/lifetimes
- To hence support the business case for changes in standards







Summary

- The current QA/QC (compliance) for new surfaces on the English SRN uses tools which do not optimise smoothness
- Improvements to the smoothness of new surfaces will deliver benefits to User experience, Pavement lifetime and carbon

- This National Highways sponsored research
  - Will establish a profile based compliance regime
  - Using parameters to optimise smoothness and bumpiness
  - With targets derived from studies of user experience
  - Supported by a pavement lifetime and carbon case
- Practicality and achievability is being verified via studies of resurfacing
  - Using both typical approaches and new methods
- Implementation will draw on collaboration with the industry to
  - Understand the implications of change
  - Establish thresholds and support transition to the new requirements

Questions?

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