

# FURTHER INVESTIGATIONS ON THE WEIGHTED LONGITUDINAL PROFILE

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## ABSTRACT

The weighted longitudinal profile (WLP) is a recent approach to characterize evenness of roads. This paper focuses on the development of an evaluation scheme for motorways derived from the power spectral density of the profile. When the evaluation scheme is established, the derived limits are verified. Different surface types (asphalt, concrete) and the influence of their typical evenness characteristic on the evaluation by the WLP are investigated. The WLP shows to be capable to clearly bring out these characteristics without introducing a bias into the evaluation. Motorway networks in Germany and Austria (data from first and second lane) are evaluated then. In comparison to the IRI (currently in use in Austria), the WLP shows a lot more differentiation between good and bad sections. A comparison of WLP and the planograph in the frame of new work approval of motorway sections in Austria is drawn, but further research is necessary to get a conclusive picture of a possible change in the new work approval regulations. Furthermore, the Austrian motorway ramps and intersections are evaluated. An adaptation of the evaluation scheme is proposed to take into account the different driving speed on ramps and hence lower requirements regarding the evenness.

## 1. INTRODUCTION

Longitudinal unevenness of roads has an impact on the durability of roads – unevenness increases dynamic wheel loads – and on the user experience while driving (i.e. riding comfort). In the last decades, several approaches have been taken to evaluate the evenness. Different indices have been developed (like the IRI [1], the NBO [2] and many others). All of these indices have its strengths and weaknesses. The weighted longitudinal profile (WLP) [3], developed in Germany, is the most recent approach to adequately characterize the longitudinal profile of a road. While developing this index, the following requirements have been kept in mind:

- Evenness evaluation independent of driving speed.
- The ability to distinguish between single irregularities, general unevenness and periodic unevenness.
- Optimal localization of evenness problem.
- Easy to understand parameters.

How and if these requirements were satisfied has been described in [5]. The paper focused on the explanation of the calculation procedure and first results of application. In this paper, the focus will be set on some methodological questions, on how to integrate the WLP into pavement management systems and transferring the method from research to practical application.

## 2. CALCULATION SCHEME AND EXAMPLE EVALUATION

In order to understand the outcome of the investigations the calculation scheme of the WLP, as shown in figure 1, shall be recalled at this point. The WLP is based on the (measured) longitudinal profile of the road (upper left graph). As a first step this profile is Fourier-transformed to give the spectrum of the road (black curve in the upper right graph). This spectrum then is “divided” by a “reference” spectrum (red line) which is typical (or representative) for an average good road, resulting in a “weighted” spectrum as shown in the figure at the bottom right graph.

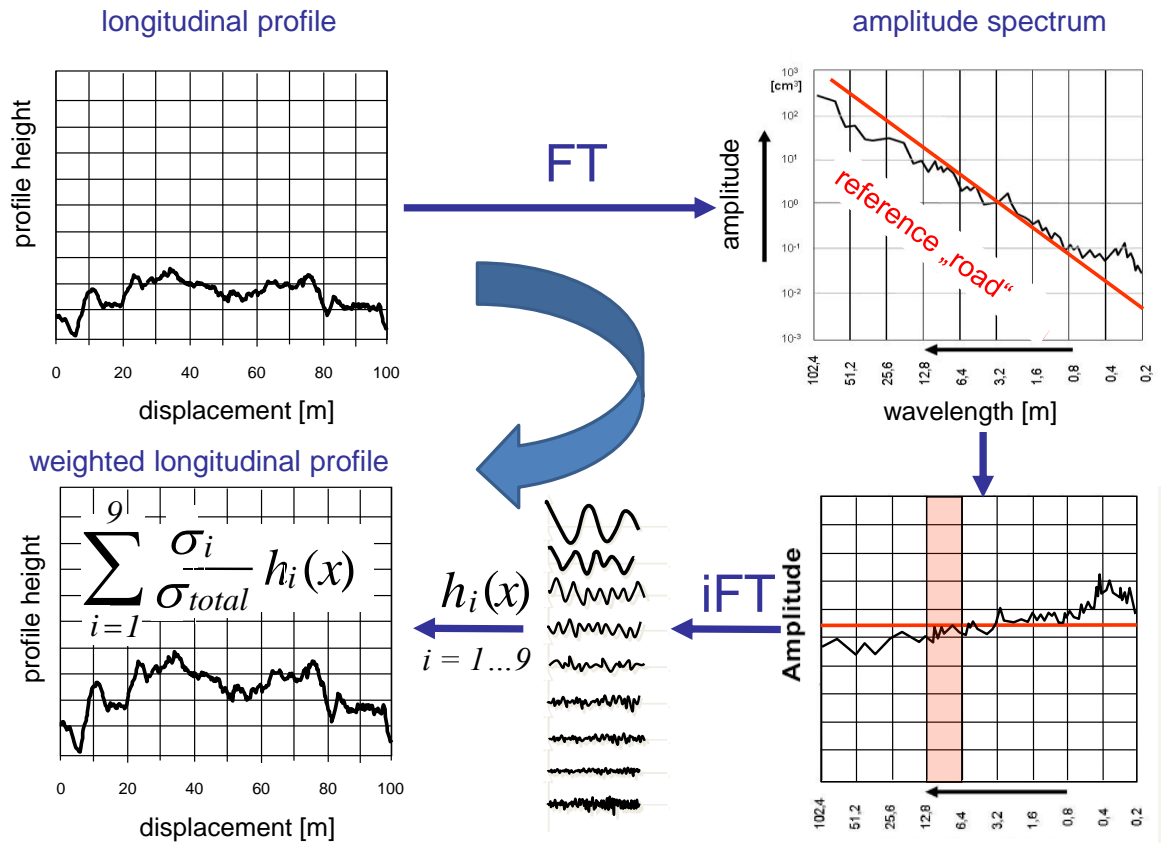


Figure 1 - Calculation scheme for the Weighted Longitudinal Profile (WLP)

The weighted spectrum (bottom right graph) is split into 9 octaves covering all wavelengths between 0.2 and 102.4 meters. Each of the octaves is then transferred back into the spatial domain giving 9 octave-band filtered signals  $h_i(x)$  as shown in the middle of the bottom of the figure. These 9 signals, finally, are summed up provided with prefactors to give the WLP (bottom left graph). The prefactors take into account the respective power contribution of each signal to the sum of the 9 signals, expressed by the ratio  $\sigma_i/\sigma_{total}$  (= standard deviation of signal  $i$  divided by standard deviation of the sum of the 9 signals).

To conform to the current definition of longitudinal evenness the WLP is filtered by a band-pass filter (Butterworth 4th order) to contain only wavelengths from 0.5 to 50 meters.

The WLP is characterized by two indicators:

- Standard deviation ( $\sigma_{WLP}$ ), and
- Range ( $\Delta_{WLP}$ ) which is the difference between the maximum and minimum value in the examined road section (here: of length 50 m).

Figure 2 displays the result of a WLP assessment in terms of an evaluation chart: the standard deviation ( $\sigma_{WLP}$ ) is plotted on the abscissa while the range of WLP ( $\Delta_{WLP}$ ) is

plotted on the ordinate. Each point in this chart (3 in this particular case) depicts the evaluation result of one road section. The diagonal marks the relation  $\Delta_{WLP} = 6\sigma_{WLP}$ . Points that are located near this line denote sections which likely exhibit irregular unevenness. Points in the upper triangle and considerably apart from the diagonal stand for sections with noticeable impulsive character ( $\Delta \gg 6\sigma$ ). Points in the lower triangle and considerably apart from the diagonal represent sections with a “wavy” character ( $\Delta \ll 6\sigma$ ). A perfect harmonic profile e.g. would give  $\Delta = 2\sqrt{2} \sigma \approx 2.8 \sigma$ . The coloured areas have the following meanings: grey: better than target value; blue: between target and acceptance value; green: between acceptance and warning value; yellow: between warning and threshold (intervention) value.

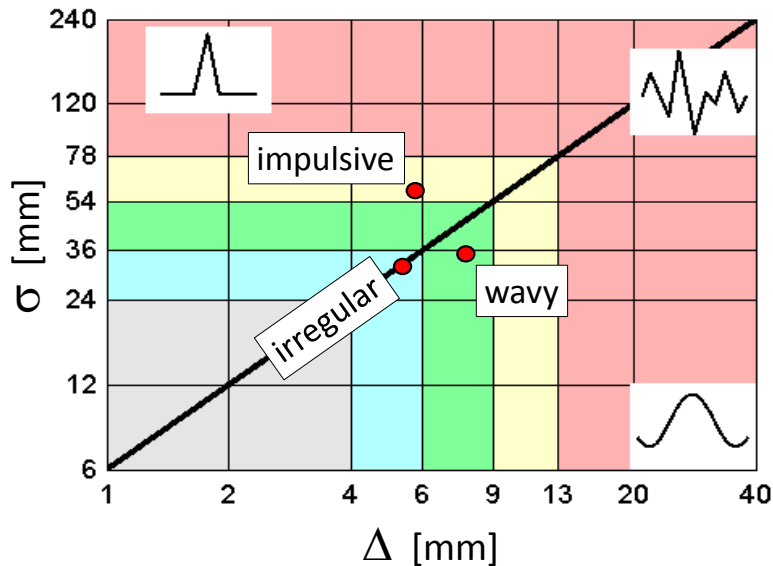


Figure 2 - evaluation chart for the Weighted Longitudinal Profile (WLP)

### 3. DERIVING AN EVALUATION SCHEME FOR MOTORWAYS

Since there is a mathematical relationship between the WLP and the PSD (power spectral density) of the profile [8] and assessment values for the PSD are given in Germany, proposals for the assessment through WLP can be given right away. The PSD is described by two indicators: the unevenness index  $G(\Omega_0)$ , which is the linearized PSD at the reference spatial frequency of 1 rad/m, and the slope of the PSD in the loglog-scale which is called the “waviness” of the road [6]. The relationship is as follows:

$$\sigma^2 = \frac{G(\Omega_0) \cdot \Omega_0^{w^*}}{(w^* - 1)(2\pi)^{w^* - 1}} \cdot (L_{\max}^{w^* - 1} - L_{\min}^{w^* - 1}) \quad (1)$$

With  $G(\Omega_0) = 1 \text{ cm}^3$  for the target value and  $G(\Omega_0) = 9 \text{ cm}^3$  for the threshold (intervention) value, with  $w^* = 2.6$  and the minimum and maximum considered wavelengths  $L_{\min} = 0.5 \text{ m}$  and  $L_{\max} = 50 \text{ m}$  respectively, this results in  $\sigma_{WLP} = 4 \text{ mm}$  for the target and  $SBL = 13 \text{ mm}$  for the threshold value. The respective ranges ( $\Delta_{WLP}$  is set to  $6 \sigma_{WLP}$ ) are  $\Delta_{WLP} = 24 \text{ mm}$  for the target and  $\Delta_{WLP} = 78 \text{ mm}$  for the threshold value. In order to convert  $\sigma_{WLP}$  and  $\Delta_{WLP}$  values to a grading system with marks from 1 (very good) to 5 (very bad) the following root functions

$$\text{grade } \sigma_{WLP} = \sqrt{(2(\sigma_{WLP} - 2.875))}$$

and

$$\text{grade } \Delta_{WLP} = \sqrt{(\Delta_{WLP} - 17.25)/3}$$

were introduced. The complete set of assessment values is listed in Table 1. Their detailed derivation can be found in the literature mentioned above. Target, warning and threshold values are meant for routine monitoring purposes while acceptance and warranty values are for approval of construction work after completion and warranty period of the road. The overall grade for a profile segment is defined as  $\text{grade}_{\text{WLP}} = \max(\text{grade } \sigma_{\text{WLP}}, \text{grade } \Delta_{\text{WLP}})$ .

Table 1 - Assessment values for the Weighted Longitudinal Profile (WLP)

	target value	acceptance value	warranty value	warning value	threshold value
grade	1.5	2.5	2.87	3.5	4.5
$\sigma_{\text{WLP}}$ [mm]	4	6	7	9	13
DBL [mm]	26	36	42	54	78

#### 4. VERIFICATION OF THE ASSESSMENT VALUES

The application of the calculation scheme on the German motorway network based on data from 2005/2006 gives the following results for the frequency distribution of WLP grades as shown in figure 3. The lower part of the figure depicts the results for  $\sigma_{\text{WLP}}$  and the upper those for  $\Delta_{\text{WLP}}$ . The data comprised 38,725 km of asphalt and 13,856 km of concrete pavements. The calculations yielded that – with respect to  $\sigma_{\text{WLP}}$  – 98.4 % of the asphalt lanes and 98.7% of the concrete lanes exhibited a satisfactory evenness (green areas). With respect to  $\Delta_{\text{WLP}}$  93.5 % of the asphalt and 93.6 % of the concrete lanes exhibited a satisfactory evenness.

Note that – over the whole network – asphalt and concrete pavements perform almost identical with respect to the longitudinal evenness. This is an important outcome since it makes clear that the WLP does not favour either of them systematically or a priori. However, there are considerable differences between asphalt and concrete pavements; but this will be shown in the next chapter.

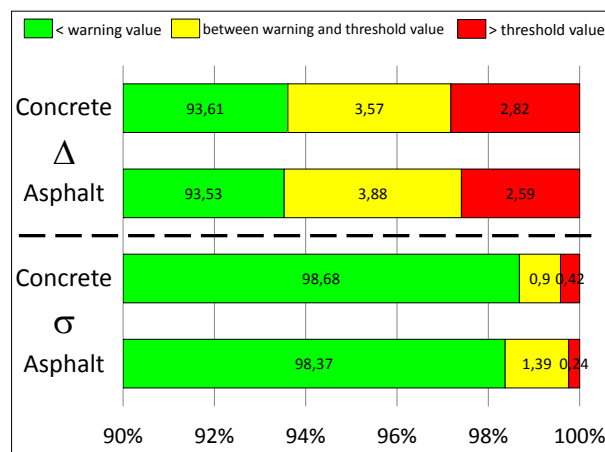


Figure 3: Frequency distribution for  $\Delta_{\text{WLP}}$  and  $\sigma_{\text{WLP}}$  on German motorways (2005/2006)

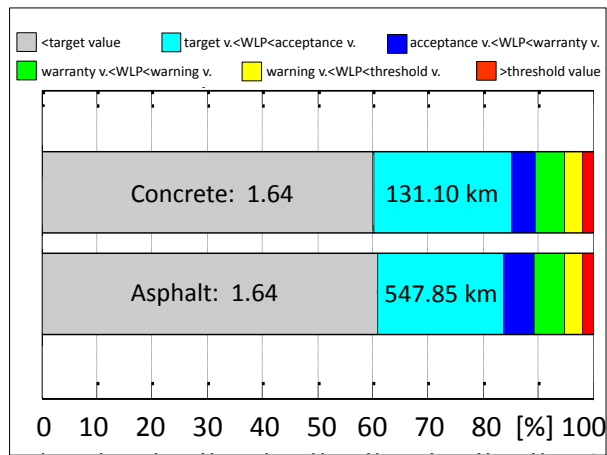


Figure 4 - Frequency distribution of WLP on collected data(1) (679 km).

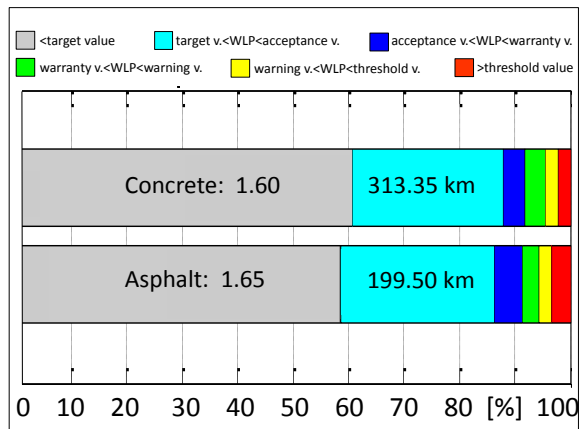


Figure 5 - Frequency distribution of WLP based on collected data(2) (513 km).

Before dealing with the differences between asphalt and concrete let's have another look at the similarities of both in the outcome of the investigations.

In the research project mentioned above [8] the WLP had been applied to different collectives of measured road profiles originating from different measurement campaigns. The frequency distributions of two of them (both consist of motorways) are shown in figure 4 (covering 131 km of concrete and 548 km of asphalt pavements) and figure 5 (comprising 313 km of concrete and 200 km of asphalt pavements). While figure 3 shows the frequency distributions of the two indicators  $\sigma$  and  $\Delta$  separately, figures 4 and 5 exhibit the frequency distribution based on the decisive one in each case (as already mentioned at the end of chapter 3, the overall grade of a profile segment is defined as the worst of both:  $grade_{WLP} = \max(grade_{\sigma_{WLP}}, grade_{\Delta_{WLP}})$ ).

Again, as can be seen in figures 4 and 5, concrete and asphalt pavements perform very similar and achieve almost the same frequency distributions (grey: better than target value, light blue: between target and acceptance value, dark blue: between acceptance and warranty value, green: between warranty and warning value, yellow: between warning and threshold / intervention value, red: above threshold value).

Despite of these conformities there are considerable differences between asphalt and concrete pavements which are brought out by the WLP analysis as well. They shall be explained in the following chapter.

## 5. DIFFERENT EVENNESS CHARACTERISTIC OF ASPHALT AND CONCRETE PAVEMENTS

One of the collectives of road profiles mentioned above [5] was a special net of monitoring roads which had been set up by the German road authorities about 10 years ago for observing pavement performance over time. They comprised 880 km of motorways with different asphalt (termed AG and AS) and concrete constructions types (termed BA, BH, BU and BV). One third of the net was built in asphalt, the rest in concrete construction. Without going into details, figure 6 illustrates in how many cases  $\sigma$  (dark grey columns) and  $\Delta$  (light grey columns) determined the result of the evenness evaluation. A third colour, medium grey, stands for all those cases where  $\sigma$  and  $\Delta$  produced the same grade. As can be seen from the chart, most of the results for the asphalt pavements are determined by the standard deviation ( $\sigma$ ) of the WLP, while, for concrete pavements, the opposite is the case: there is an emphasis on the range ( $\Delta$ ) being the decisive indicator. This is interesting since it brings out that asphalt surfaces, in general, exhibit a more “wavy” and concrete surfaces a more “impulsive” character (see chapter 2). That is in agreement with human perception when driving on asphalt and concrete roads. Through the paving and rolling process asphalt gets a smoother and wavier characteristic than concrete which, due to the joints between the slabs, exhibit, over all, a more impulsive character. “Impulsive” always goes along with short wavelengths. In combination with typical slab lengths one would expect that concrete pavements - in general – are determined by short wavelengths up to 5 or 10 meters while asphalt pavements exhibit mainly longer waves.

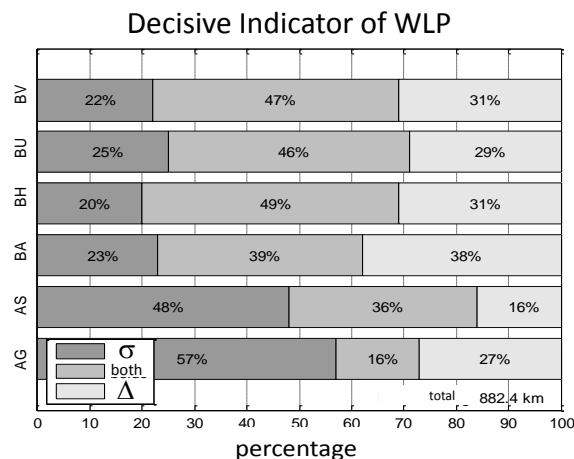


Figure 6 - Decisive indicator ( $\sigma$  or  $\Delta$  or both) for different pavement constructions. AG, AS are asphalt pavements, BA, BH, BU and BV are concrete pavements.

In order to check this assumption we can analyze the 9 wavebands of the WLP regarding their relative power contents with respect to the total power of the WLP. This will give us the desired information. Figure 7 shows the result of the investigation. On the abscissa you find the 9 wavebands of the WLP and on the ordinate the information how often these particular wavebands were the dominating ones in the WLP analysis (dominating regarding the power content of the particular octave bands).

And indeed – the dominating wavelengths of the concrete pavements (termed BA, BH, BU, BV) are between 0.5 and about 7 meters, while for the asphalt pavements (termed AG and AS) the dominating wavelengths lay between 7 and 50 meters. This is a very important outcome since it makes clear that despite of the almost identical performance of asphalt and concrete pavements in the WLP analysis the WLP clearly differentiates between the two construction types.

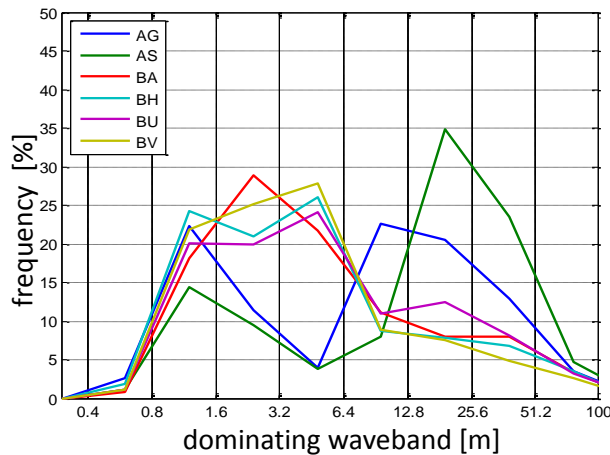


Figure 7 - Dominating waveband in WLP analysis

## 6. COMPARISON OF THE CURRENT NEW WORK APPROVAL METHOD “PLANOGRAPH” WITH THE WLP

For the Austrian motorway network, there is currently a mandatory new work approval with the planograph or the 4 m straight edge in place. The planograph can detect single obstacles, but evenness problems with longer wavelengths or periodical unevenness cannot be evaluated with the planograph. So the question was if the WLP would be suitable for new work approval as well. The evaluation was done in two steps. First, planograph measurements were compared to planograph simulations on a measured true profile. In a second step, the simulation results were compared to WLP calculations.

### 6.1. Comparison of planograph measurements and planograph simulation

Unfortunately there is no central collection of evenness new work approval results for the Austrian motorway network. So a direct comparison of Planograph results and WLP calculations was not possible. Four road sections with a length of app. 500 m each were selected to compare Planograph measurements and Planograph simulations on identical measurement lines. The four road sections were selected for different evenness characteristics ranging from very good evenness to high unevenness. To ensure comparability and reproducibility, the measurement lines were marked with paint. Two measurements were made on each section with a planograph with electronic measurement registration. The sampling interval was 1.7 cm along the road. The two planograph measurements showed good correspondence and were averaged.

The measurements for the true profile were done with a laser profilometer (beam length of 2 m, 4 sensors with a spacing of 0, 0.1, 1 and 2 m). Both methods were evaluated for reproducibility. The planograph measurements were then resampled to 0.1 m interval to match the sampling interval of the true profile.

For the true profile, a planograph simulation was carried out. A 4 m rod is placed on the true profile and the deviation at 2 m is calculated. Then, the rod is moved 0.1 m along the profile and the deviation is calculated again. The result of these calculations is a simulated planograph measurement on the true profile.

As shown in Figure 8, the simulation shows higher deviations than the measurements. The differences for measurement minus simulation were calculated and their cumulated frequencies are shown in Figure 9; 80.2 % of the differences are below 1 mm. Although

the differences are small, the part of the sections where the limit of 4 mm is exceeded is higher than with the measurement.

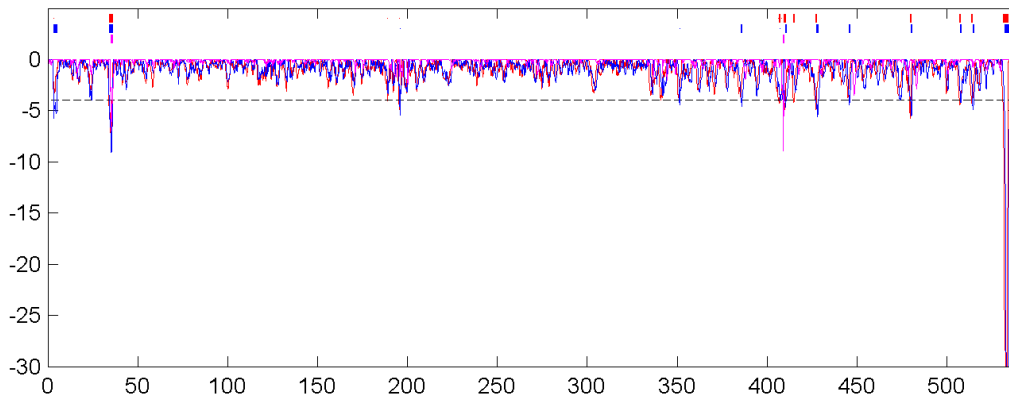


Figure 8 - Comparison of planograph measurement (magenta) and planograph simulation (red: 1<sup>st</sup> measurement, blue: 2<sup>nd</sup> measurement) of section M4. Markings at the top show sections where acceptance test limit (4 mm, dotted line) is exceeded.

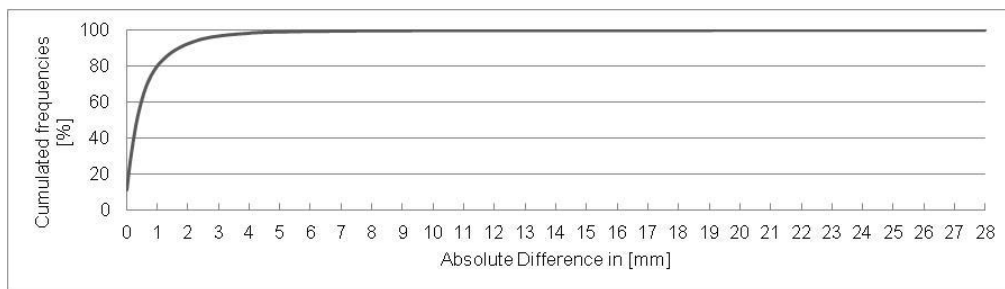


Figure 9 - Cumulated frequencies of the absolute differences of planograph measurement minus planograph simulation.

## 6.2. Planograph simulation versus weighted longitudinal profile

Due to the fact that the Planograph measurements are not collected centrally, the comparison of Planograph and weighted longitudinal profile for new work approval was done using the Planograph simulation. From the year 2006 on, there have been mandatory skid resistance acceptance tests for newly built surfaces of motorways. While measuring the skid resistance on these sections, the true profile has also been collected when possible. During the years 2008 to 2010, a total length of 1.241 km newly paved lanes on the motorway network (including ramps) has been measured. This gives the opportunity to examine the consequences of a change in the new work approval procedure on real data.

For all profiles, the WLP was calculated for 50 m-sections. For the Planograph simulation, there is no such defined evaluation length as every deviation above the threshold (4 mm for wearing courses) is treated separately. The Planograph simulation was calculated and a classification was made for the same 50 m-sections – if or if not there was any deviation above the threshold in the section. The number of deviations was not taken into account.

Figure 10 shows a comparison of WLP results (percentage of 50 m-sections that would have been below the acceptance level) and Planograph simulation results (percentage of 50 m-sections where no deviations above threshold appear), sorted by year and lane. The lane numbering starts on the right lane (i.e. the most trafficked lane). There is a difference of about 10 % between WLP and Planograph simulation that only slightly changes over the



year and lanes. Taking into account that the Planograph simulation returns higher deviation values than the actual measurements (see above), the results seem to be in the same order of magnitude. Nevertheless, a comparison of WLP and measured planograph deviations seems necessary before switching to the new method.

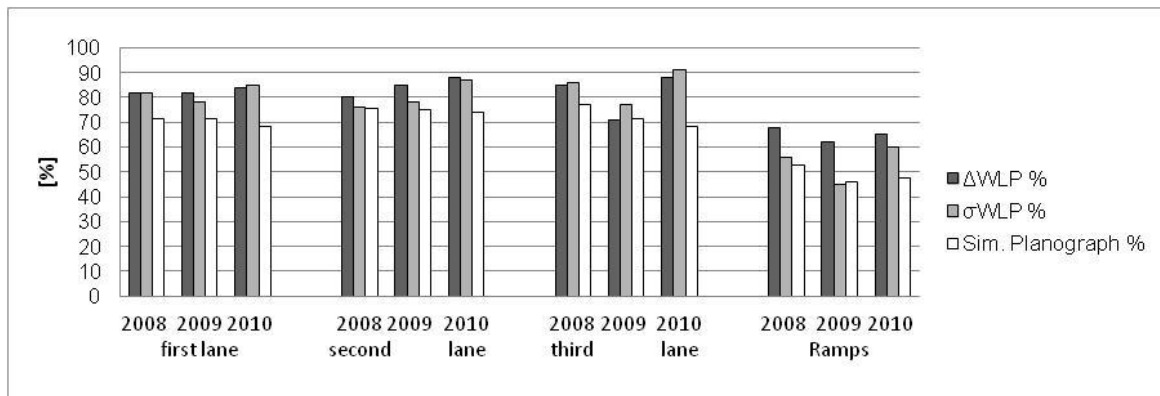


Figure 10 - Proportion of positive 50 m section in „virtual“ acceptance tests; WLP ( $\Delta_{WLP}$ ,  $\sigma_{WLP}$ ) and planograph simulation.

## 7. RESULTS OF MOTORWAY NETWORK EVALUATIONS IN AUSTRIA

In Austria, the longitudinal evenness parameter currently used is the International Roughness Index (IRI). There is also an according evaluation scheme for pavement management purposes. From the practitioners, there was the complaint that the IRI doesn't distinguish good and bad sections very well. The impression was that the proportion of sections with average evenness is much too high, and that the proportion of very good and very bad sections is too low. For the introduction of a new parameter, data of the routine measurements for the whole Austrian motorway network were evaluated with both the IRI and the WLP and their according evaluation schemes. All parameters were calculated for presentation lengths of 50 m.

### 7.1. Main Carriageways

The data set contains profile measurements of two years on first (right) lane from 2009 and second lane from 2010. The according network lengths are 4.153 km on first lane and 3.926 km on second lane. Figure 11 and Figure 12 show the comparison of IRI,  $\sigma_{WLP}$  and  $\Delta_{WLP}$ . In comparison to the IRI, the proportion of "very good" (Class 1, blue) sections has increased dramatically. On the other hand, the number of "poor" (class 4, orange) and "very poor" (class 5, red) sections has increased as well. Comparing first and second lane, a shift to better values can be recognized. This seems reasonable, as the heavy traffic that accounts to road deterioration is concentrated on the first lane. Taking into account that large parts of the Austrian motorway network were completely rebuilt in recent years, the large part of sections rated Class 1 seems reasonable.

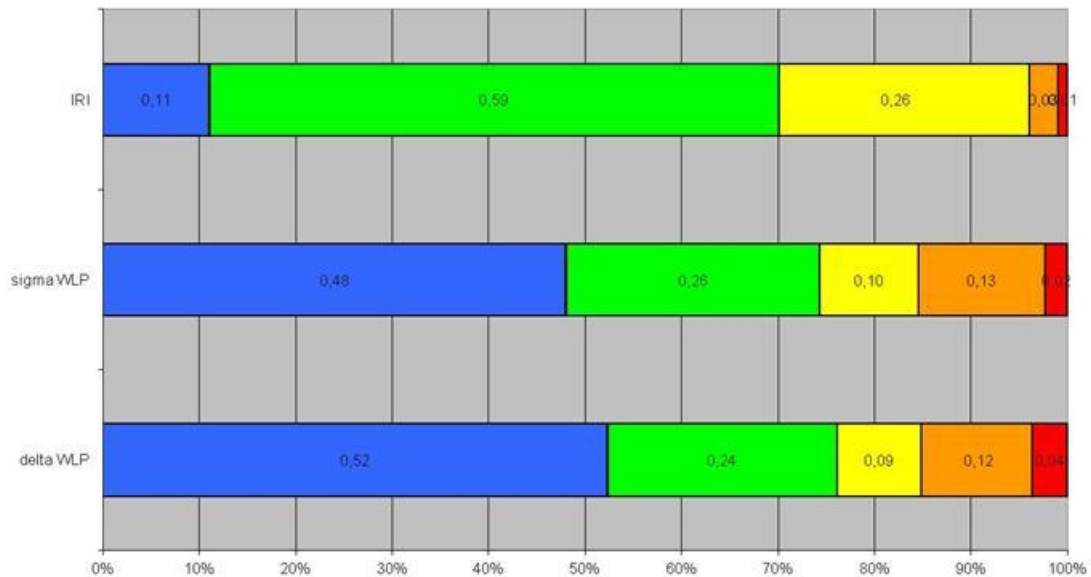


Figure 11 - Comparison of class distribution of IRI,  $\sigma_{WLP}$  and  $\Delta_{WLP}$  on the first (right) lane of the Austrian motorway network. From left to right: blue: class 1 to red: class 5.

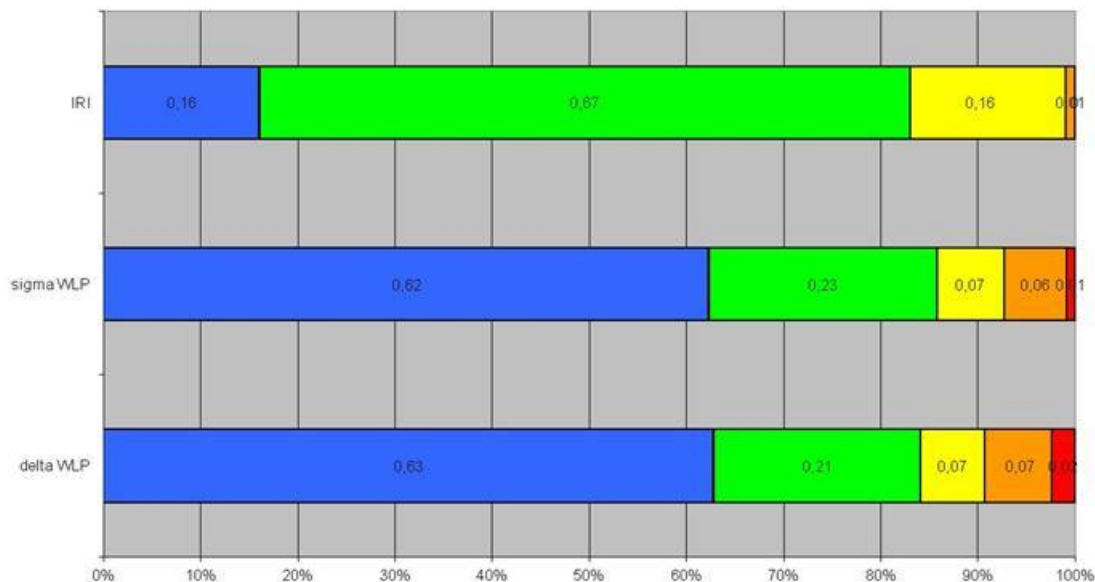


Figure 12 - Comparison of class distribution of IRI,  $\sigma_{WLP}$  and  $\Delta_{WLP}$  on the second lane of the Austrian motorway network. From left to right: blue: class 1 to red: class 5.

## 7.2. Ramps

A third dataset containing all ramps of the Austrian motorway network has been evaluated in the same way as the main carriageways. The data includes the deceleration lane, the ramp itself and the acceleration lane. Altogether, there are 393 exits and intersections in the Austrian motorway network; these add up to a total length of 1.488 km. The evaluation was made the same way as the evaluation on the main carriageways. There has been no distinction made between the acceleration/deceleration lane and the ramp itself. In Figure 13, a comparison of IRI,  $\sigma_{WLP}$  and  $\Delta_{WLP}$  is shown. For all three parameters, a shift of proportions to the worse in comparison to the main carriageways can be observed. Comparing IRI and WLP, the same pattern of higher differentiation is visible at the WLP. Again, the proportion of sections in class 1 and class 4 and 5 is higher than with the IRI.

For the general shift, the question arises if the evaluation scheme that fits on main carriageways is suitable on ramps too. The average speed on ramps is apparently lower than on main carriageways, so the evenness requirements could be reduced on ramps. This would mean to change the evaluation scheme to reflect the lower demands. Dynamic effects ( $q$ ) of random unevenness change with driving speed ( $v$ ) approximately like

$$\frac{\text{var}(q)|v_2}{\text{var}(q)|v_1} = \left(\frac{v_2}{v_1}\right)^{w-1}$$

where  $\text{var}(q)$  is the variance ( $\sigma^2$ ) of the dynamic effects and  $w$  is the waviness of a road [7]. For  $w = 2.5$  and the relation of driving speed on ramps to driving speed on main carriageway like 50/120, follows:

$$\frac{\sigma(q)|v_2}{\sigma(q)|v_1} = \sqrt{0.4^{1.5}} = 0.5$$

This means that the dynamic effects of unevenness decrease by 50 % on ramps, compared to main carriageways. The values mentioned above are of course assumptions and could be argued, they are used as examples. Following this, the limits in the evaluation scheme would have to be doubled. This would lead to a change in the class distribution as shown in Figure 14. Now a much higher proportion is in class 1, class 5 sections almost vanish. This example is meant to show a way how to adapt the evaluation scheme to reflect the characteristics of ramps. The same considerations could be drawn to adapt the evaluation scheme to other road classes like secondary roads or municipal roads.

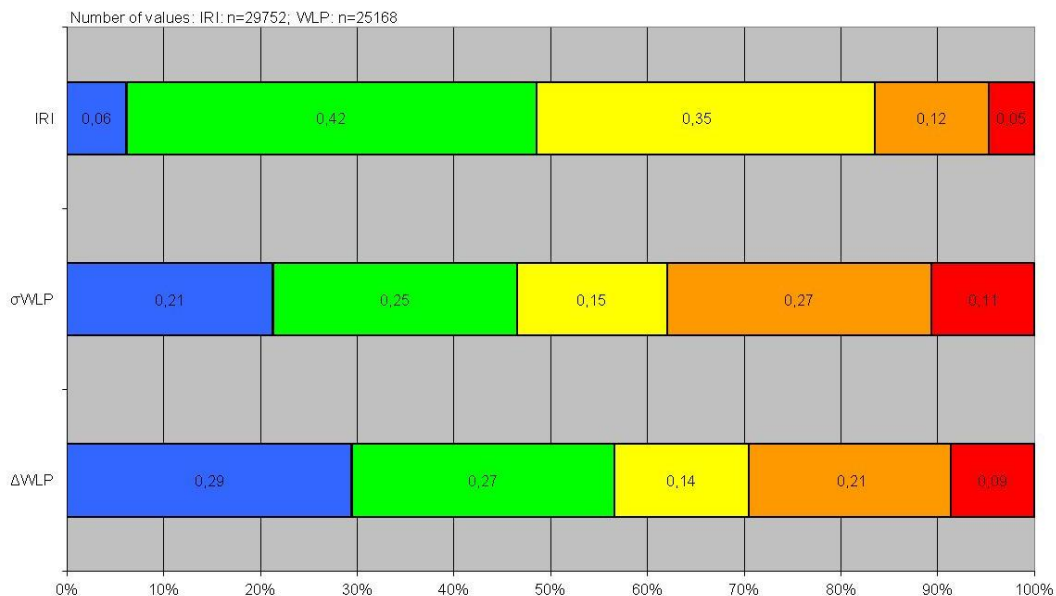


Figure 13 - Comparison of class distribution of IRI,  $\sigma_{WLP}$  and  $\Delta_{WLP}$  on the ramps of the Austrian motorway network. From left to right: blue: class 1 to red: class 5.

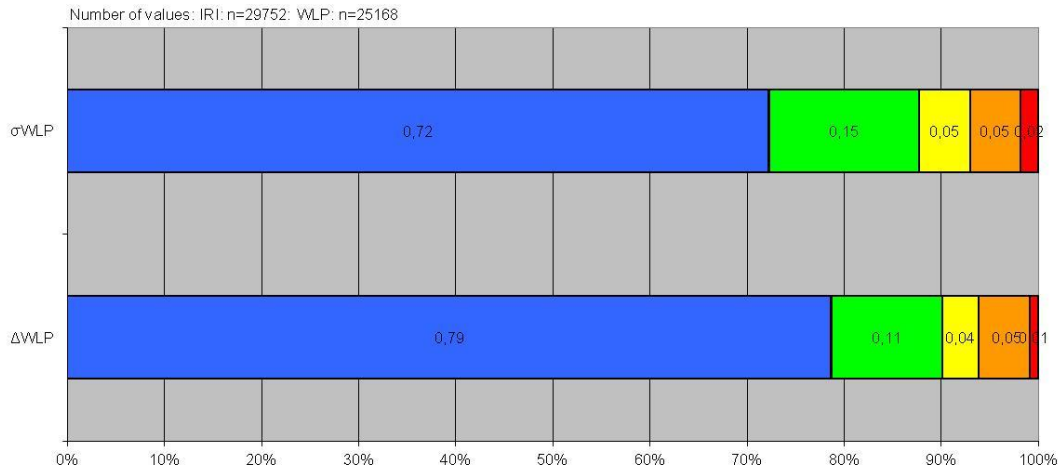


Figure 14 - Class distribution of  $\sigma_{WLP}$  and  $\Delta_{WLP}$  on the ramps of the Austrian motorway network with altered evaluation scheme. From left to right: blue: class 1 to red: class 5.

## 8. CONCLUSIONS

The weighted longitudinal profile (WLP) has shown to be a versatile index that is capable to detect various evenness problems. The evaluation scheme for motorways is derived from a linearized PSD and is easily adaptable. While no bias could be observed for the evaluation of different surface types, the WLP clearly differentiates the characteristics of asphalt and concrete pavements. For the use of the WLP in the context of new work approval in Austria, a comparison of the current method planograph and the WLP has been drawn using planograph simulation on newly built motorway sections of the last three years (2008-2010). As the planograph simulation does not give results identical to the planograph measurement, further research is needed for a conclusive result. The derived evaluation scheme has been applied to the Austrian motorway network and showed a well balanced distribution between the classes. The methodology presented to adapt the evaluation scheme to the different requirements of motorway ramps allows an easy adaptation of the evaluation scheme to the needs of other types of networks. The adaptation of the evaluation scheme to motorway ramps has been shown exemplary. The research has filled remaining knowledge gaps for the introducing the WLP into Austrian and German pavement management systems.

## 9. ACKNOWLEDGEMENTS

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## REFERENCES

1. Sayers M. W., Gillespie T. D. und and Queirioz C.A. (1986), The International Road Roughness Experiment,, Establishing Correlation and a Calibration Standard for Measurements,, World Bank Technical Paper Nr. 45, Washington, USA

2. Delanne Y., Pereira P., (2000), Analyse de la relation entre l'uni et la qualité d'usage des routes – Application à la fixation de spécifications pour les travaux neufs et à la définition de classes d'uni pour la gestion de l'entretien, Bulletin 228, LCPC, Nantes 2000
3. Ueckermann A., Steinauer B. (2008), The Weighted Longitudinal Profile (WLP) – A New Method to Evaluate the Longitudinal Evenness of Roads. Road Materials and Pavement Design. Volume 9 – No. 2/2008, pages 135 to 157
4. Ueckermann, A., Maerschalk, G. (2011). On-Road Test of the WLP, Report on FE 29.0202/2008 BAST, Institute of Road and Traffic Engineering, RWTH Aachen University, Germany (in German).
5. Maurer P., Spielhofer R., Kempkens E., Ueckermann A.(2008), The weighted longitudinal profile (WLP) – a new unevenness index. Technical specifications and experiences in Austria and Germany (2008). 6<sup>th</sup> Symposium on Pavement Surface Characteristics SURF, Portoroz 2008
6. EN 13036-5 (2004), Road and Airfield Surface Characteristics, Determination of Longitudinal Evenness Indices, CEN TC 227, WG5, TG1
7. Ueckermann, A. (2002): Der Längsebenheitswirkindex LWI. Forschung Straßenbau- und Straßenverkehrstechnik, Heft 839, Bonn 2002
8. Maerschalk G., Ueckermann A., Heller S. (2011), Laengsebenheitsmessverfahren "Bewertetes Laengsprofil", Berichte der Bundesanstalt fuer Strassenwesen, Strassenbau S 73, BAST, Bergisch Gladbach, December 2011