

RAILPROF USER MANUAL



December 2017

1. INTRODUCTION

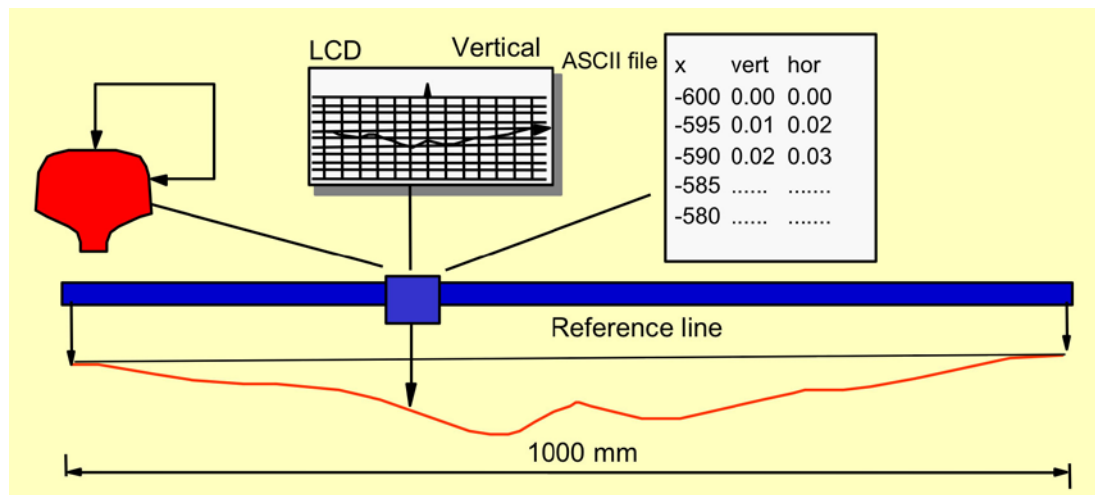
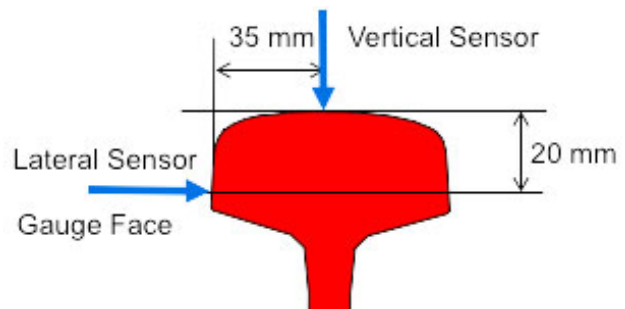
Since 2005 ProRail has introduced force-based weld geometry assessment standards. This requires determination of the first derivative (gradient) of the weld geometry, which is tested against speed-dependent standards. These calculations are efficiently performed in real-time with a Windows smartphone, which communicates wireless with the RAILPROF.

2. MAIN CHARACTERISTICS

The RAILPROF is a field instrument for accurately measuring longitudinal rail geometry -both vertical and lateral over a length of 1000 mm, at ambient temperatures between -5 °C and +40 °C. For detailed specifications please refer to [1] and [2].

The measurements are performed by two contact-free, eddy current based sensors inside the housing of the RAILPROF, which are driven by a step motor. Each 5 mm a measurement is made. Measuring accuracy is +/- 0.02 mm at deviations up to 0.5 mm from a straight line between the first and last measuring point. Beyond that limit the accuracy is +/- 5 % of the measured value up to 1.5 mm deviation.

The vertical sensor is positioned 35 mm from the gauge face. The lateral sensor is measuring the gauge face at 20 mm below the top of the rail.



The present RAILPROF configuration is controlled by a Windows Phone running on Windows 10. Based on research at TU Delft, in cooperation with the Dutch Infra Provider ProRail, force-based standards have been developed. The standards are expressed in terms of a quality index QI, which is directly related to the first derivative of the measured vertical rail geometry. The standards are presented in Chapter 6. Vertical and lateral geometry are measured simultaneously. The measuring results are automatically sent to the Smartphone, which carries out all the calculations like filtering and computing the first derivative of the vertical geometry, in accordance with the force-based weld standards of ProRail.

Due to the additional speed classes in the lower speed range the standards are also applicable to metro and tram networks.

The RAILPROF will be kept awake if the operator is working in the measuring menu on the Smartphone, whereas otherwise the RAILPROF is switches off after 10 minutes of not being used.

The measurements are not influenced by moist, rust and dirt on the rail surface; the actual metal surface below these contaminations is measured, so cleaning of the rail track surface before a measurement is not necessary. Also the measurement result cannot be influenced by the operator.

Through the use of carbon fiber rods and its design, the RAILPROF is robust and shock resistant; it weighs less than 7 kg only in spite of its dimensions (1.16 m long), inevitable because of the measuring length of 1000 mm.

The RAILPROF is both easy and safe to operate. Due to the smartphone control all relevant input data can be provided beforehand via menus. The measurement can then be carried out remotely. Positioning of the RAILPROF onto the rail is easy because of its magnetic feet.

Measurement of top and horizontal geometry takes about 10 seconds. Data transmission to the smartphone and the performance of the calculations in the PDA takes about 6 seconds.

3. INSTALLING THE SOFTWARE

The Windows Phone comes with preinstalled software. If it should be necessary to reinstall the software the App Railprof should be installed from the Windows Store.

4. EXPLANATION OF THE MENUS

To start the Railprof application on the Windows 10 telephone tap the Icon RailprofWPH on the screen or select RailprofWPH from the list of all applications.

Now the 'RAILPROF' program main menu will appear on screen with the following possible choices:

- Projects; here you can look at stored measurement data and modify the text field if necessary
- Templates; here you can create new templates with the fixed data of the measurements yet to be made
- Measure; after completing the measurement header information already displaying data input in template you can start a new measurement
- Tools; here you can change the language of the Railprof software (currently only English, German and Dutch are supported, for other languages please contact us). You can enable Glued Isolation Joint measurement correction, suppressing gap in graph due to isolation. You can verify status of Railprof and shut down the device.



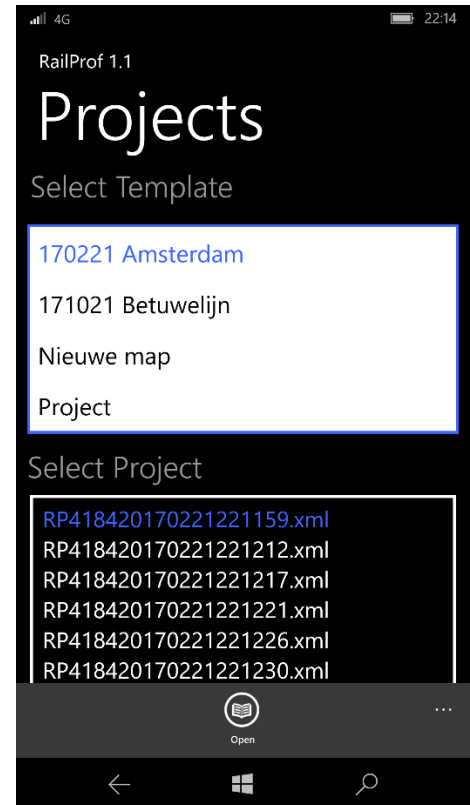
In Projects you can select which one of the stored Projects you would like to look at. By tapping on the text field below Select Template you will get a pop down box with the available projects, select the one you want by tapping it.

Lower part of screen will now list available measurements in the box below Select Project. Here you can select the project (measurement) you want to look at by tapping it.

Once it is displayed in blue tapping the book icon at the bottom of the screen will open the project to display this actual measurement.

Here you can also modify several of the text header fields included in the Info screen of the measurement. Upon closing the measurement, you will be asked whether or not changes made should be saved.

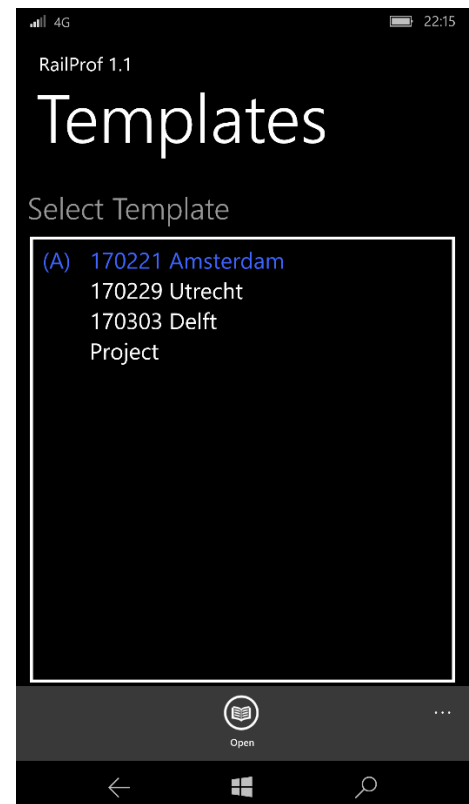
You may also choose to remove the displayed Project by tapping the Remove icon below. This will delete the Template.



In Templates you will see a list of available templates. Active Template is indicated with (A) in column before Template name.

You can now select an existing measurement to display the fixed header data by tapping the Template name, so it turns blue.

Now tap Book icon below to view or modify settings.



You will now see the fixed header text fields of the project. You can now input the actual data like location, job number etc.

Upon completion you can save the Template you opened or save it under a new name in which case a Measurements folder will be created with the same name where the measurements will subsequently be stored.

Once the Template has been saved you can set it to Active template by tapping the A icon below.

The Active template is the one that will be used for new measurements. Data will be stored in a folder with the same name that has now been created in the Folder RPStorage on the SD card.

You may also choose to remove the displayed Template by tapping the Remove icon below. This will delete the Template.

Upon selecting Measure in the main screen, you will go to the Measure screen showing the header information you have input when creating the Template that has been set to active. Please note that you can modify data in the fields now (before measuring) or later after measurement has been done. Typical fields to update would be weld number, welder and switch/km.

You can now select either:

- Reread, this will discard any changes to fields made just now and "reload" headers with the text as input in the Template
- Measure, this will execute measurement on Railprof. Please note Railprof has to be turned on (Red power on indicator Led in Switch should be lit) for at least 30 seconds before starting Measurement.

On the Railprof the large red LED will be lit during the actual Measurement, once the Measurement has been completed the screen on the Smartphone will switch over to the Measurement Information (M) screen.

In the information (M) screen you again have the opportunity to update Measurement specific information. Please note Fields in white can be changed or updated while fields displayed in grey are locked. (These can be changed either before executing measurement in first measurement screen or in some cases only through updating the information in the Template menu.

To switch to the next page of the Measurement please swipe the image to the left and the Information (A) screen will be displayed.

By tapping Save you can save Measurement. Tapping Remove will discard Measurement.

Once you are done viewing the Measurement you can tap Left arrow at bottom of screen and you will be asked whether you want to save the Measurement or not.

The Information (A) page will only display data, it is not possible to change any of the fields.

Displayed are:

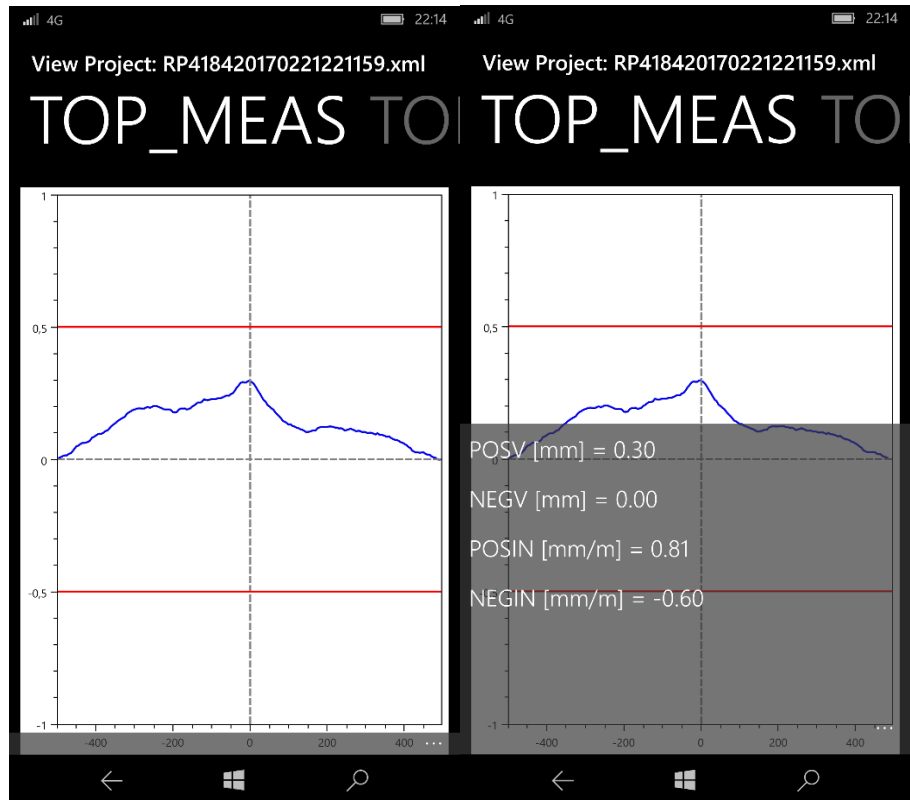
- The actual Railprof serial number, Owner information, Date and time of measurement and Measurement File name.
- Swiping right will return to Information (M) screen.
- Swiping left will get you to the Top Measurement screen.

The Top Measurement screen will show the actual geometry of the top of the rail as measured.

To view numerical values of the measurement you can tap on the three dots in bottom right hand corner and values will be displayed in overlay.

Swiping right will return to Information (A) screen.

Swiping left will get you to the Top Quality screen.

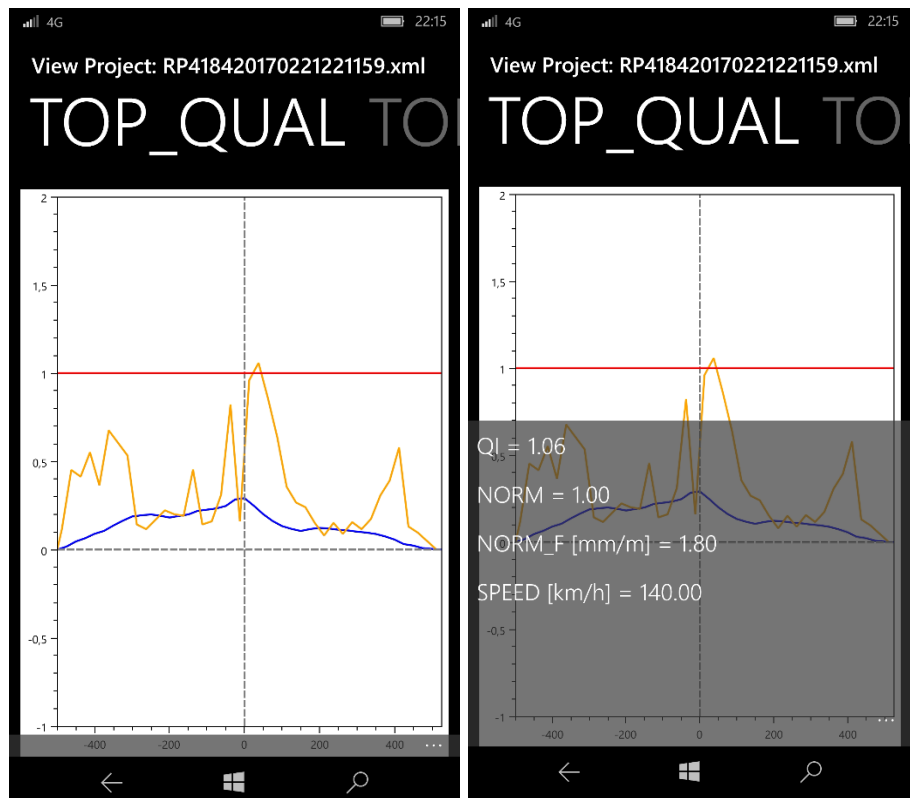


The Top Quality screen will show the actual geometry of the top of the rail in blue as well as calculated Quality Index Value overlaid on graph in Orange.

To view numerical values of the measurement you can tap on the three dots in bottom right hand corner and values will be displayed in overlay.

Swiping right will return to Top Measurement screen.

Swiping left will get you to the Top Short-Wave screen.

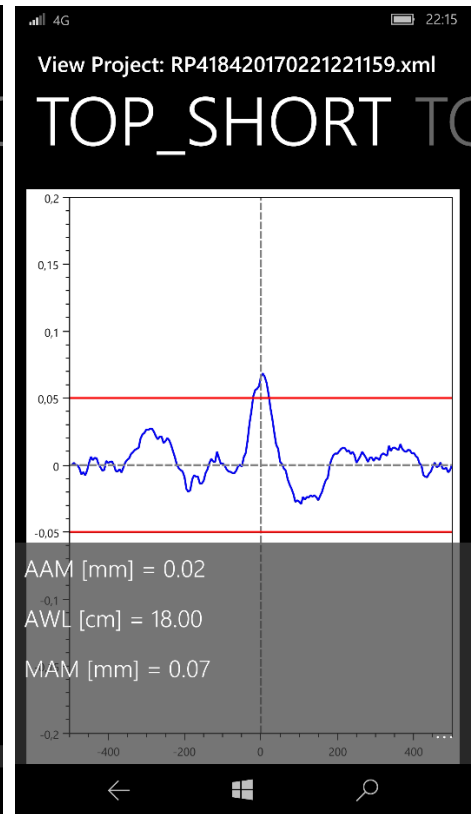
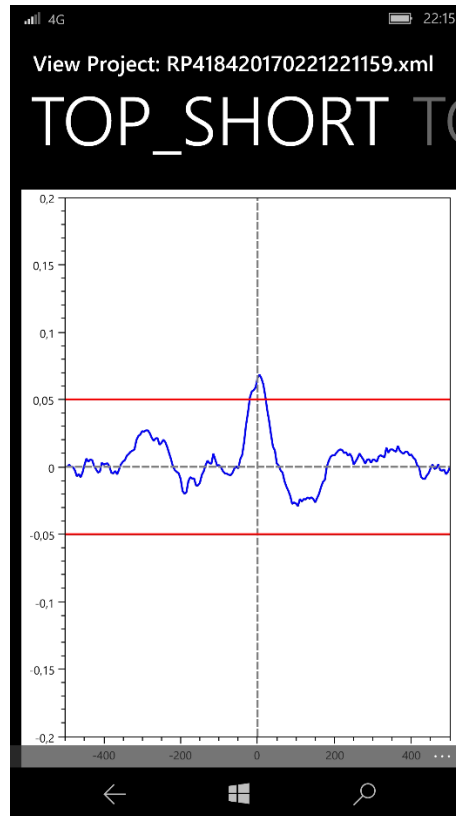


The Top Short screen will show the short wave of the top of the rail.

To view numerical values of the measurement you can tap on the three dots in bottom right hand corner and values will be displayed in overlay.

Swiping right will return to Top Quality screen.

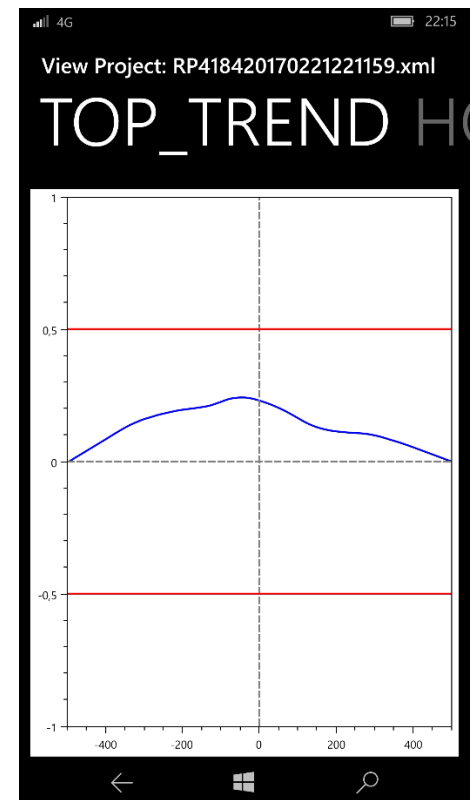
Swiping left will get you to the Top Trend screen.



The Top Trend screen will show the trend of the top of the rail.

Swiping right will return to Top Short screen.

Swiping left will get you to the Horizontal Measurement screen.

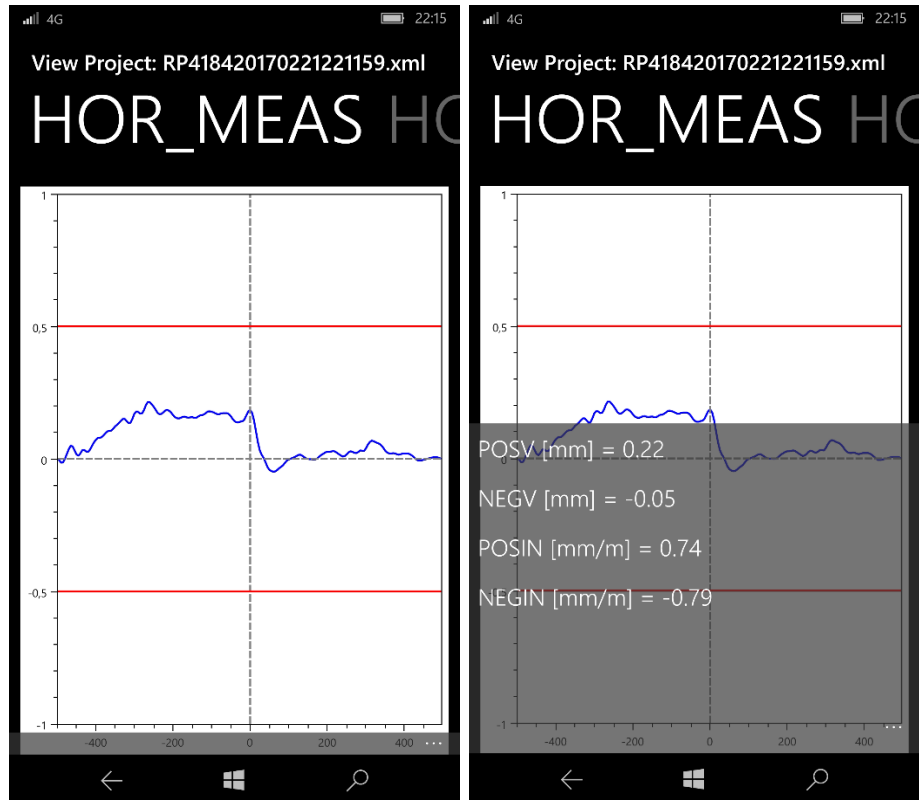


The Horizontal Measurement screen will show the actual geometry of the side of the rail as measured.

To view numerical values of the measurement you can tap on the three dots in bottom right hand corner and values will be displayed in overlay.

Swiping right will return to Top Trend screen.

Swiping left will get you to the Horizontal Quality screen.

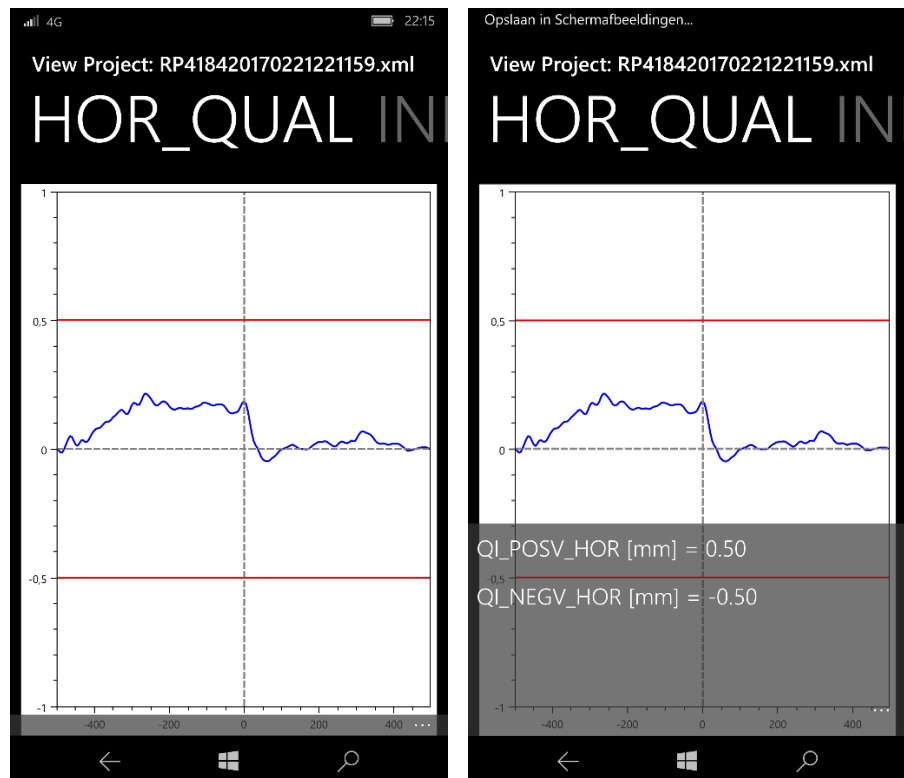


The Horizontal Quality screen will show the actual geometry of the side of the rail as measured.

To view numerical values of the measurement you can tap on the three dots in bottom right hand corner and values will be displayed in overlay.

Swiping right will return to Horizontal Measurement screen.

Swiping left will return you to the Information (M) screen.



In the Tools Page you can select Language of Railprof Program, currently supported languages are English, German and Dutch. Other languages may be possible on request.

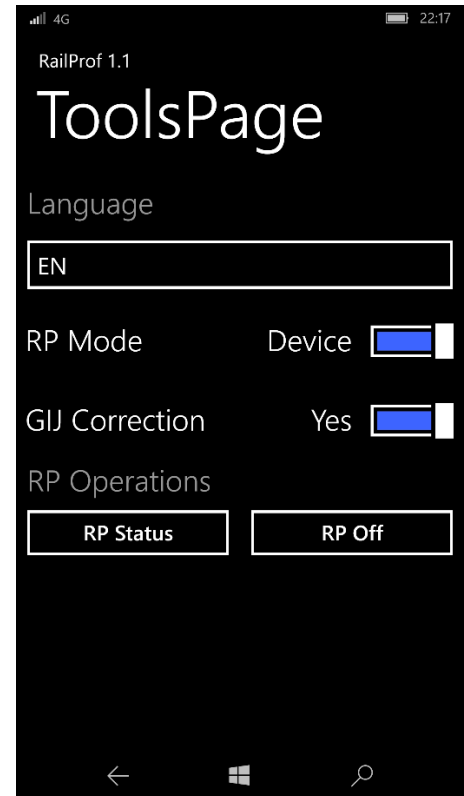
Tap on box below Language and select.

RP Mode selects Device (Railprof) or Debug for training. Keep it set to Device.

GIJ Correction will correct gap in Measurement of Glued Isolation Joint caused by isolating plate in middle of joint by eliminating it. This feature is only available when type of Weld in Measurement screen is set to GIJ. Software will after completing of measurement give message that GIJ correction has been made.

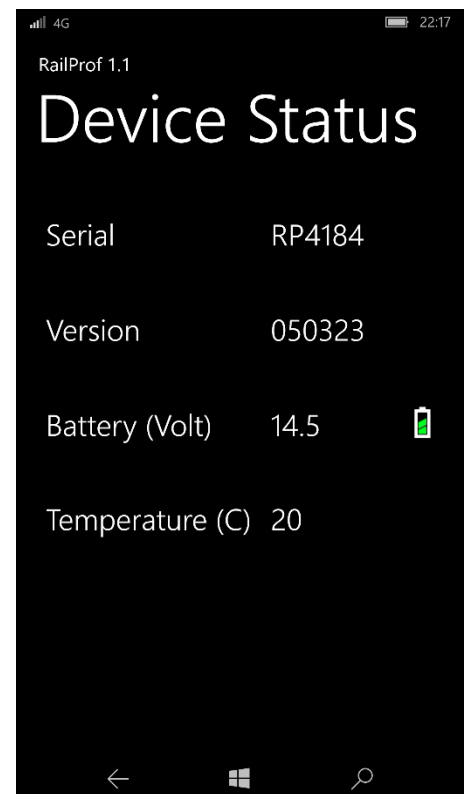
RP Status will show Railprof Status, see below.

RP Off will turn of Railprof immediately, otherwise Railprof will shut down after 10 minutes of inactivity.



Status displays Railprof Serial Number and Firmware version.

You can furthermore see the Voltage of the Railprof Internal Battery as well as Device temperature.



5. MEASURING

The 'RAILPROF WPH' program on the Smartphone is started by pressing the Icon.

In the Main Page you can select Project to browse stored Measurements, Template to edit existing or create a new Template, Measure to start Measurement, or Tools for Language and Status.

In Template so-called templates can be found and saved in which data, constant for that group of welds, can be stored. The user can make new templates by changing an existing one and saving it under a new name. The 'Active Template' is used for a new measurement.

Position RAILPROF at the weld and switch it on. The red led in power switch lights up. After 10 minutes of inactivity the RAILPROF will automatically switch off. To continue measurements, push the switch again.

Be sure that the right template is activated and tap 'Measure'. Now the active template appears and changes can be made if necessary.

Tap 'Measure icon' to start the measurement.

After completion of the measurement ('top' and 'side' are measured in one go and stored in one record), which takes about 10 seconds, the results are transmitted to the smartphone. The smartphone will then perform all calculations such as filtering of short waves, trend, determination of the first derivative for 'Top' etc..

The results can be browsed by swiping the screen left or right to switch between screens.

At 'Info' the template data are shown; almost all information can be modified, except speed, standards and measuring results.

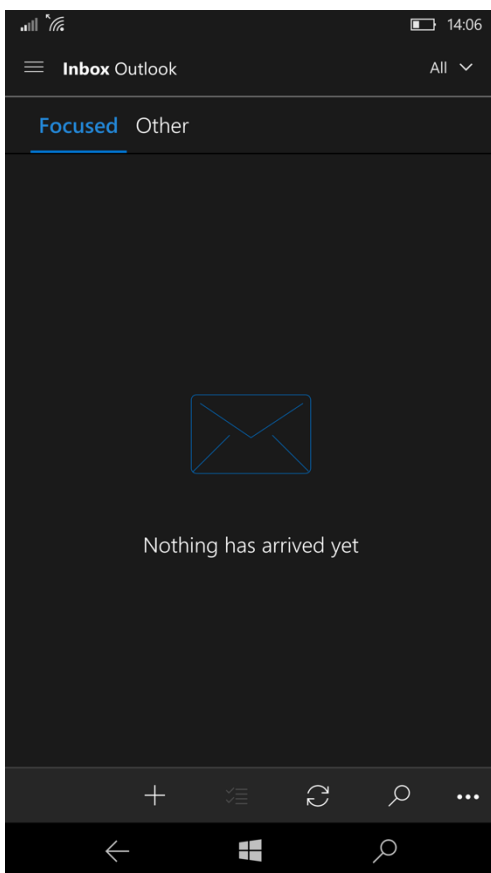
The file name is unique, it contains the serial number (RP4175 in example), date and time. De extension is always xml.

After viewing the measurements tap Save or left arrow (return) below. Now there is a choice of 'yes' or 'no' storing the record.

At the next measurement the input data of the previous saved measurements are kept in memory (previous modified template), so that only changes should be keyed in.

Templates can be created for each measuring job. The values of the active template are used for the current measurement.

6. SENDING RAILPROF MEASUREMENTS WITH OUTLOOK



The Microsoft Lumia smartphone facilitates to send stored measurement files directly to your office, supervisor, or principal by email. This evidently requires a Data Sim to be installed in the smartphone and an email account to be setup in Outlook. If this still has to be done on your smartphone and you need help, please contact us for more detailed instructions.

To start Outlook Mail, tap the Outlook Icon on the Desktop of the smartphone, once you have exited the Railprof program. Outlook will now launch the Outlook Inbox screen.

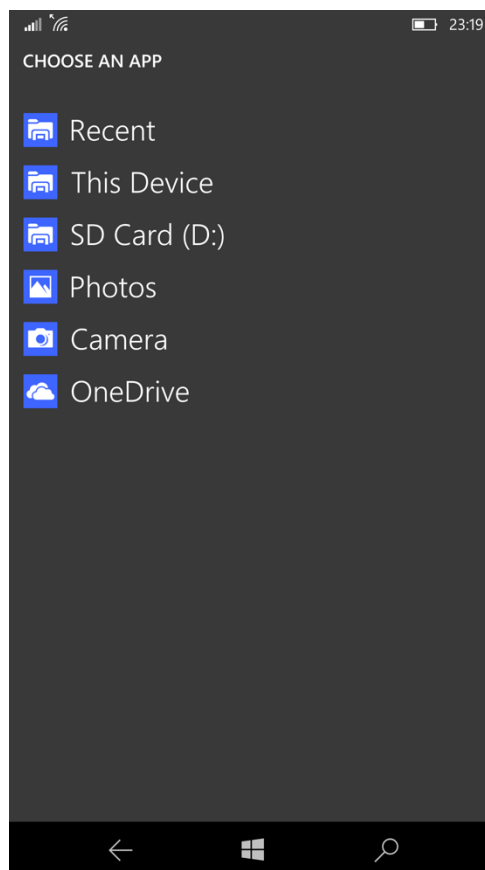
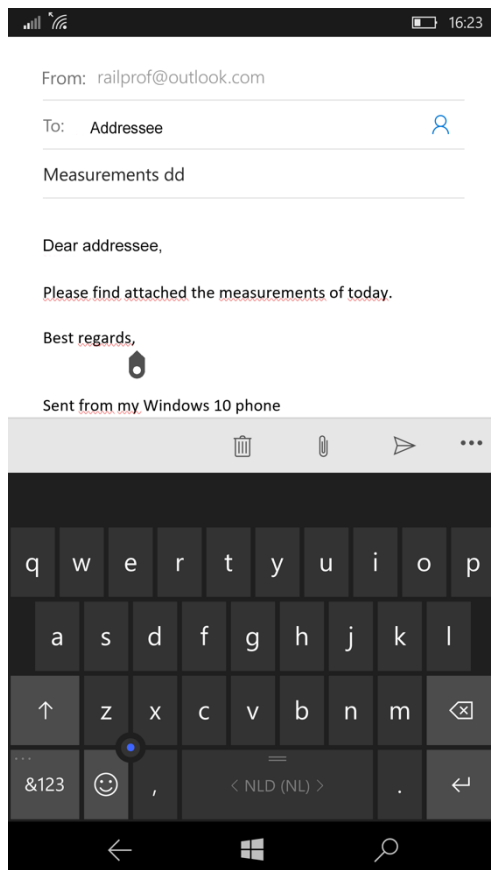
In this screen compose a new message by tapping the + (plus) on the left side of the grey banner near the bottom of the screen. A new message will be opened.

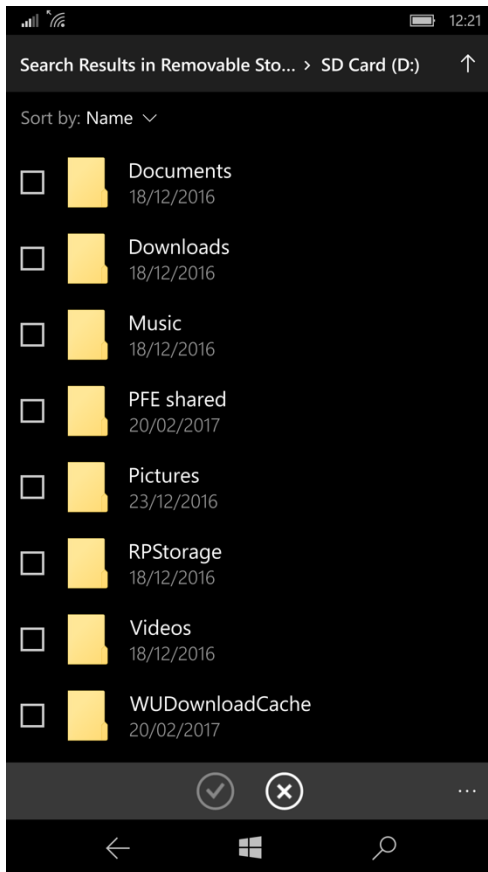
In the To: box either enter an email address of the addressee manually, or select an existing one from your contact list. Of course, you can address multiple recipients, or add CC or BCC recipients.

Subsequently enter a message subject in the next box, for example "Measurements of today".

You can now add the message text in the box below.

After completion of the message text, tap the paperclip on the right-hand side of the light grey banner at the bottom of your message to attach files. In the next screen select the folder "SD-card (D:)" by tapping it.

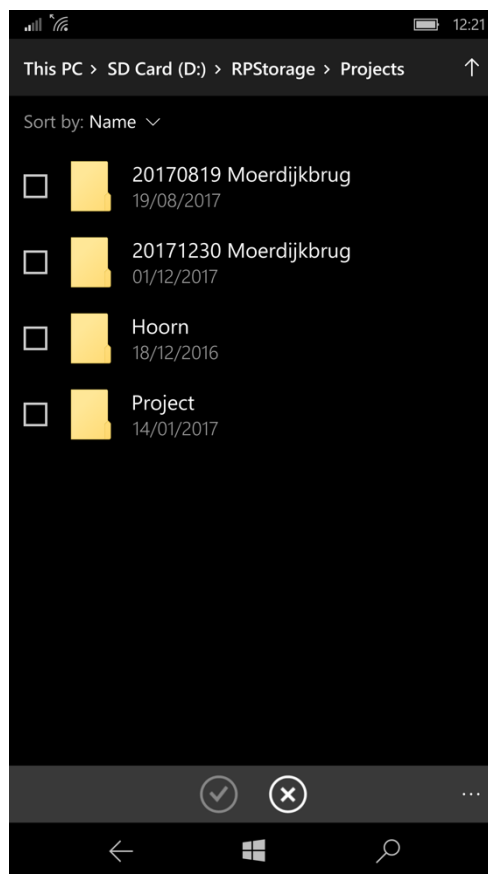
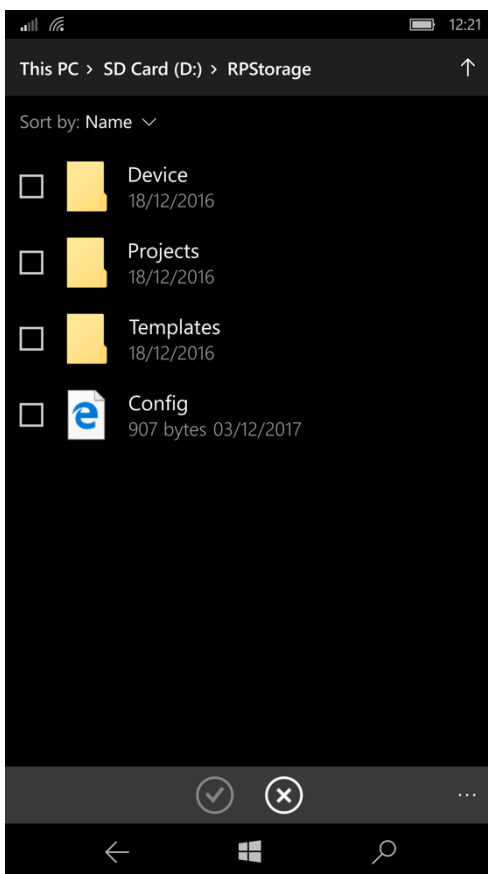


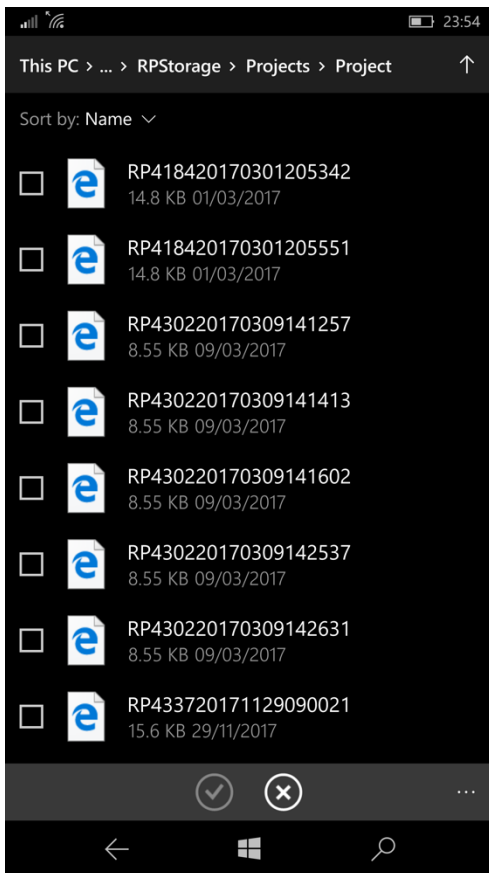


Now the screen with the content of the SD Card is shown. Here, go to the folder "RPStorage" and select the folder "Projects".

This screen will be different on each smartphone, depending on the list of Project names setup so far.

The folder "Project" will be present as it is the default one upon installation. Select the project containing the measurement you want to send, here we will select "Project". This will take you to the next screen with the measurement files.





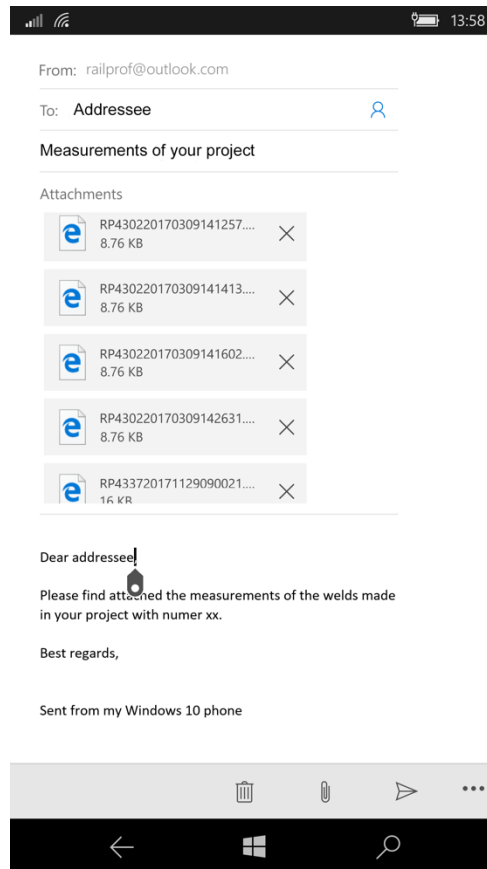
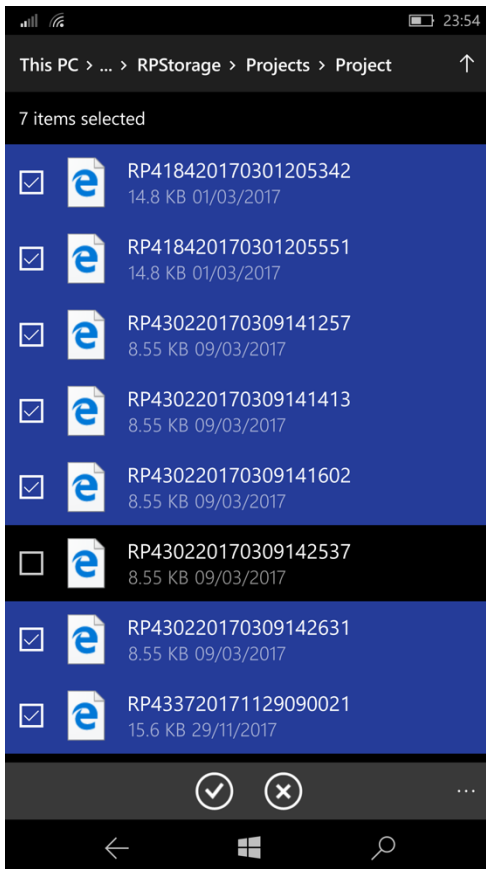
Selected measurement files will be highlighted in blue. You can select all or some of the measurements. Please be aware that when you have more than 8 measurements in the folder you will have to scroll down to see all available files. Once you have completed your selection you can tap the Check mark in the grey banner at bottom of screen and your selected files will be attached to the Email message. You will now return to the Outlook message screen where the message will be displayed including the attached files.

Please be aware that a larger number of files may take some seconds before they appear in the outlook message display.

The message screen will look like the picture below. Should you want to add more files or pictures to the message you can select the paperclip again. For Photos you can select the Photos folder and select the Photos you want to attach. Upon completion you can once again tap the Check mark in the grey banner at the bottom of the selection box to return to the outlook message screen. To send the message tap the send icon on right hand side in light grey banner at bottom of message. Message and all attachments will now be sent to the specified recipients.

You can verify the message by looking into the Sent box of Outlook. To leave Outlook, tap on the Left-hand arrow at the bottom of the screen and you will return to the Smartphone desktop.

As an alternative to email, files can be stored and synchronized via Microsoft's cloud service OneDrive.



7. PRORAIL STANDARDS FOR WELD GEOMETRY

The weld geometry standards applied in the smartphone software are based on a study of TU Delft. These standards have been in force at ProRail since 1 January 2005. The vertical weld geometry should comply to:

| Standards vertical rail geometry | |
|----------------------------------|--------------------|
| Speed [km/h] | Inclination [mrad] |
| 250 < V ≤ 300 | ≤ 1.0 |
| 200 < V ≤ 250 | ≤ 1.1 |
| 180 < V ≤ 200 | ≤ 1.3 |
| 160 < V ≤ 180 | ≤ 1.4 |
| 140 < V ≤ 160 | ≤ 1.6 |
| 120 < V ≤ 140 | ≤ 1.8 |
| 100 < V ≤ 120 | ≤ 2.0 |
| 90 < V ≤ 100 | ≤ 2.2 |
| 80 < V ≤ 90 | ≤ 2.3 |
| 70 < V ≤ 80 | ≤ 2.4 |
| 60 < V ≤ 70 | ≤ 2.6 |
| 50 < V ≤ 60 | ≤ 2.8 |
| 40 < V ≤ 50 | ≤ 3.0 |
| V ≤ 40 | ≤ 3.2 |

| Standards lateral rail geometry | |
|---------------------------------|----------------|
| Speed [km/h] | Versine p [mm] |
| 80 < V ≤ 300 | -0.5 ≤ p ≤ 0.5 |
| 40 < V ≤ 80 | -0.7 ≤ p ≤ 0.7 |
| V ≤ 40 | -1.0 ≤ p ≤ 1.0 |

$$QI = \frac{Inclination_{max}}{Inclination_{norm}} \leq 1 \rightarrow OK$$

8. THE PC DESKTOP SOFTWARE

Installation:

The PC software runs under WINDOWS. The software should be downloaded via the following link:

<http://www.railprof.com/Download/RAILPROF/Desktop%20software/index.php>

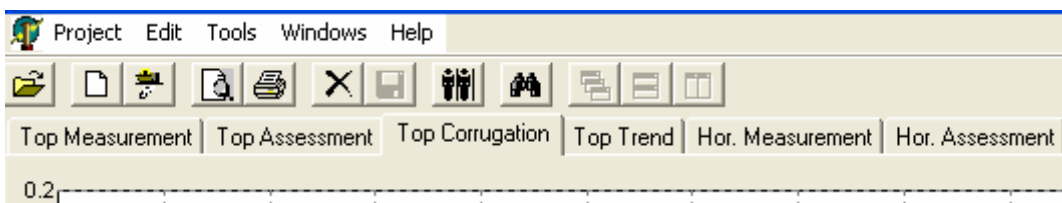
Directory Listing of /Download/RAILPROF/Desktop software/

home

| File | Size | Last Modified |
|---------------------------|--------|-------------------------|
| Railprof_Examples/ | - | Mar 07 2017 10:07:59 AM |
| Desktop software.zip | 2907KB | Oct 16 2017 05:02:50 PM |
| fortlib.dll | 24KB | Oct 16 2017 05:02:48 PM |
| manual1_EN.pdf | 116KB | Oct 16 2017 05:02:50 PM |
| manual1_NL.pdf | 116KB | Oct 16 2017 05:02:50 PM |
| manual2_EN.pdf | 1311KB | Oct 16 2017 05:02:52 PM |
| manual2_NL.pdf | 1064KB | Oct 16 2017 05:02:53 PM |
| rp_gui.exe | 1756KB | Oct 16 2017 05:02:54 PM |
| rp_gui.exe - Shortcut.lnk | 2KB | Oct 16 2017 05:02:53 PM |
| RP_GUI.INI | 0KB | Oct 16 2017 05:02:53 PM |
| RP_GUI_EN.INI | 5KB | Oct 16 2017 05:02:53 PM |
| RP_GUI_NL.INI | 10KB | Oct 16 2017 05:02:54 PM |

All the files should be places in one directory. Name and location of the directory can be chosen by the user.

The main program is called RP_GUI (RP for RAILPROF, GUI for Graphical User Interface). The ini-file contains the language dependent information and can be modified by the user with a text editor such as Windows Notepad. At first the map must be opened where the reports are copied. In the directory of the desktop software a series of profiles is available in 'Railprof_examples'. In RP_GUI select 'Project' and then 'Open Project' en go to for example the directory 'Railprof_Examples'. Click on one of the names to view the profile data.

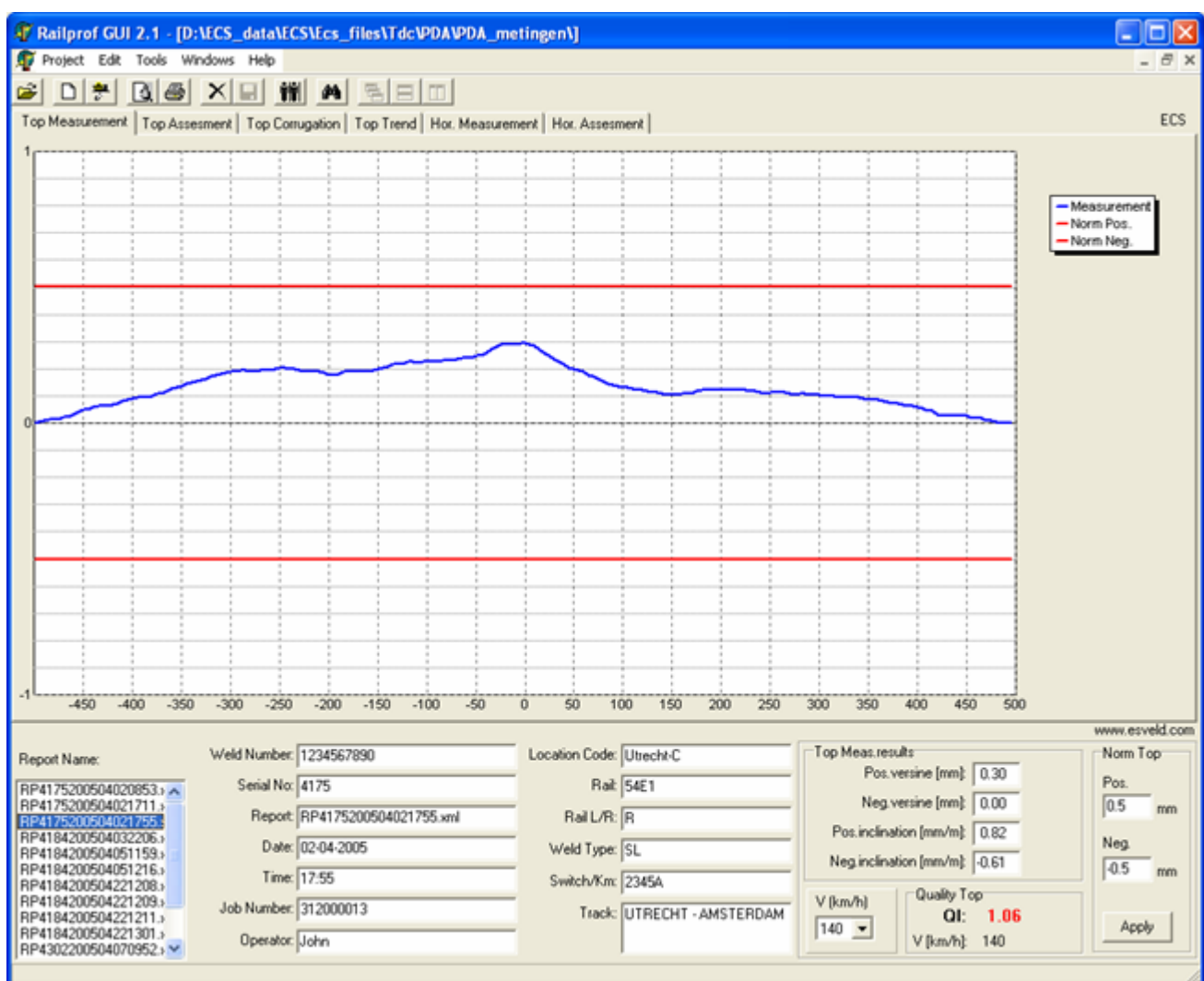


Assessment of weld geometry

Basically, the vertical (Top) and horizontal (Hor.) profiles, if measured, can be viewed. 'Top Measured' shows the profile as measured, without any filtering. The user can set the position of two red lines and click apply. Default is ± 0.5 mm. This option just gives a quick look at maximum values (versines). At the bottom of the screen the vertical positive and negative versines as well as the inclinations are given. The inclinations are calculated over a length of 20 cm.

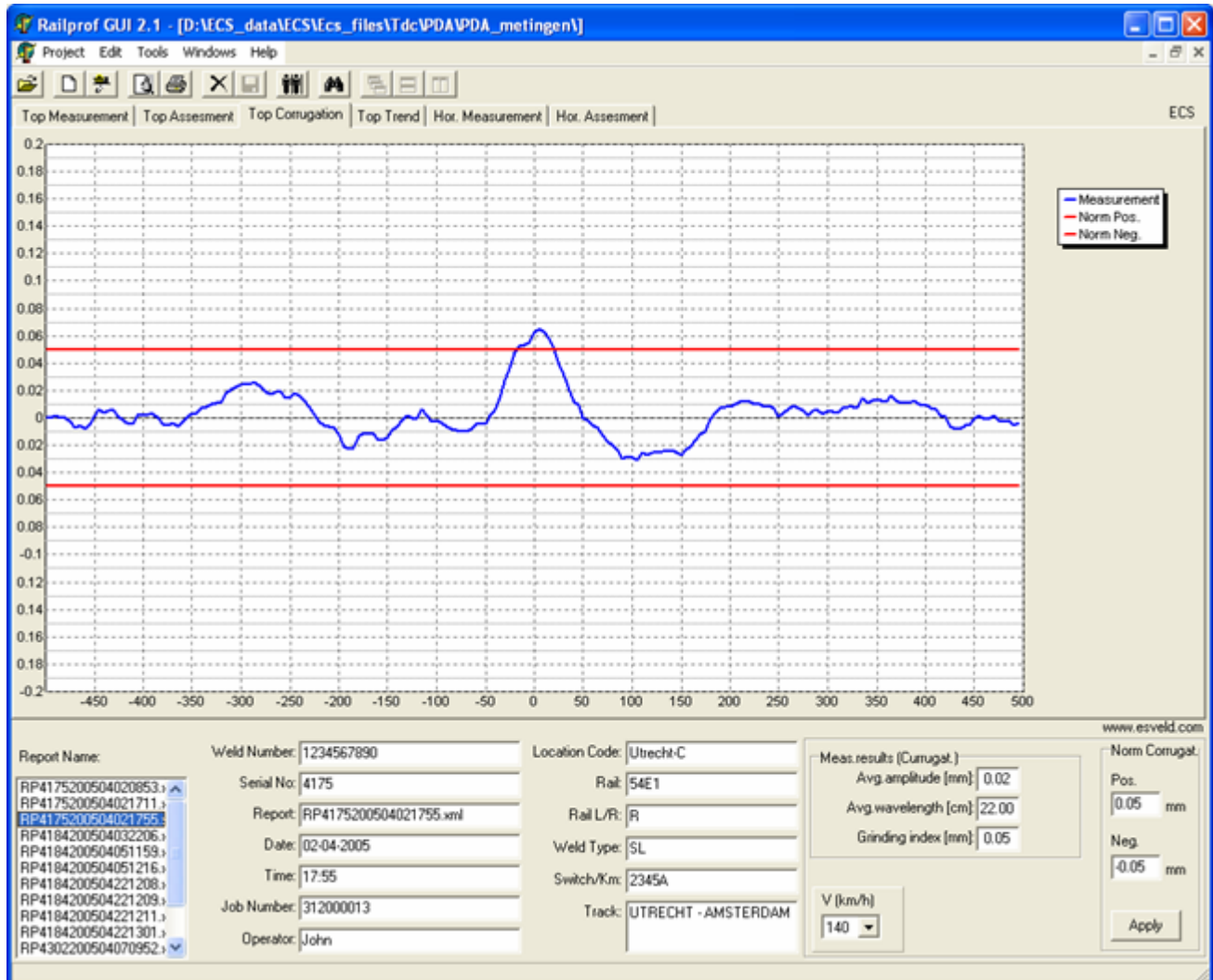
Top assessment shows the first derivative of the geometry from which the irregularities shorter than 25 mm have been removed by filtering. This signal is scaled according to the speed in such a way that if the signal is less than 1 the weld is OK and if larger than 1 is rejected. The maximum allowable inclination according to the Dutch Infra Manager ProRail is for an operational speed of 40 km/h (marshalling yards) 3.2 mrad, for 140 -200 km/h 0.9 mrad and for high-speed 0.7 mrad. For further details please refer to the article 'FORCE-BASED ASSESSMENT OF WELD GEOMETRY' in the appendix.

For the horizontal direction two screens are available. In this case only unfiltered data are used.



Assessment of rail corrugation and rail grinding

'Top Corrugation' shows the high-pass filtered vertical geometry signal in the band 0 – 20 cm. This screen should be used for monitoring rail corrugation and grinding results. The user can set the red horizontal lines to have a quick overview of exceedences. The default values are ± 0.05 mm. The user can alter the settings in the screen menu, but can also change the default values in the file RP_GUI.INI.

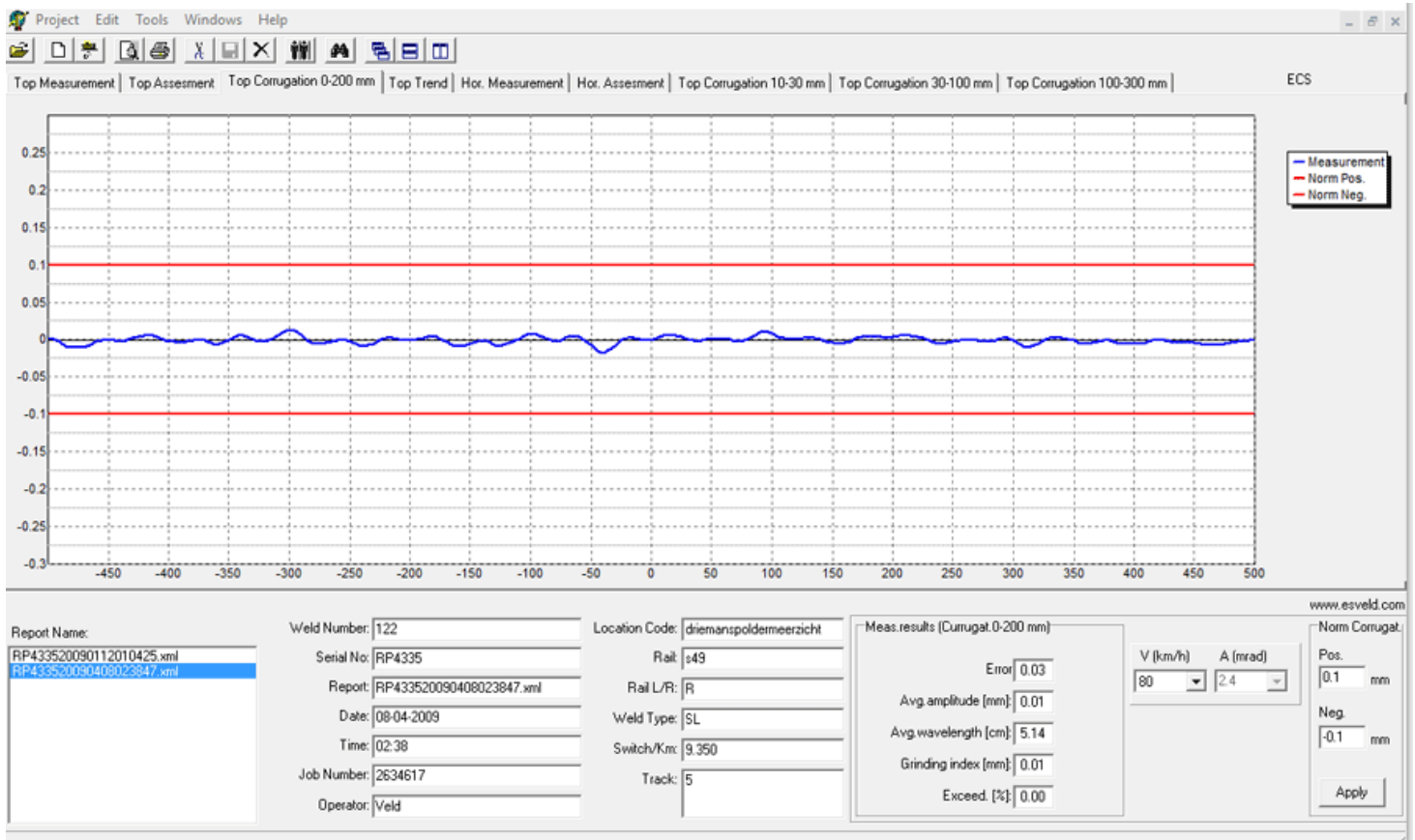


Special menu based on the German standards

To facilitate German grinding practice standards a special menu was added to the desktop software. In the wavebands 1-3 cm, 3-10 cm and 10-30 cm the percentage of exceedance of the standard is presented. The standard can be set by the user per waveband as the admissible displacement in mm.

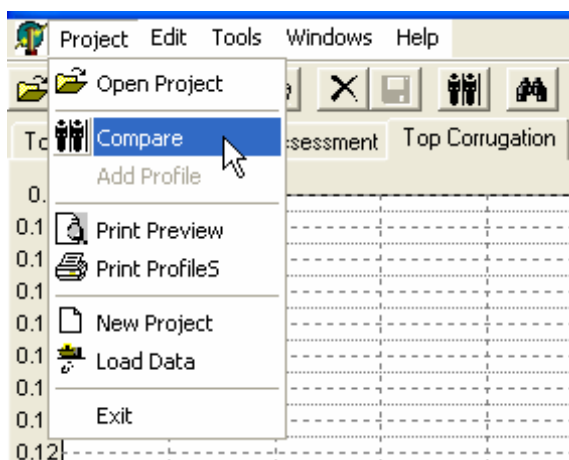
Furthermore, the following grinding indices are produced:

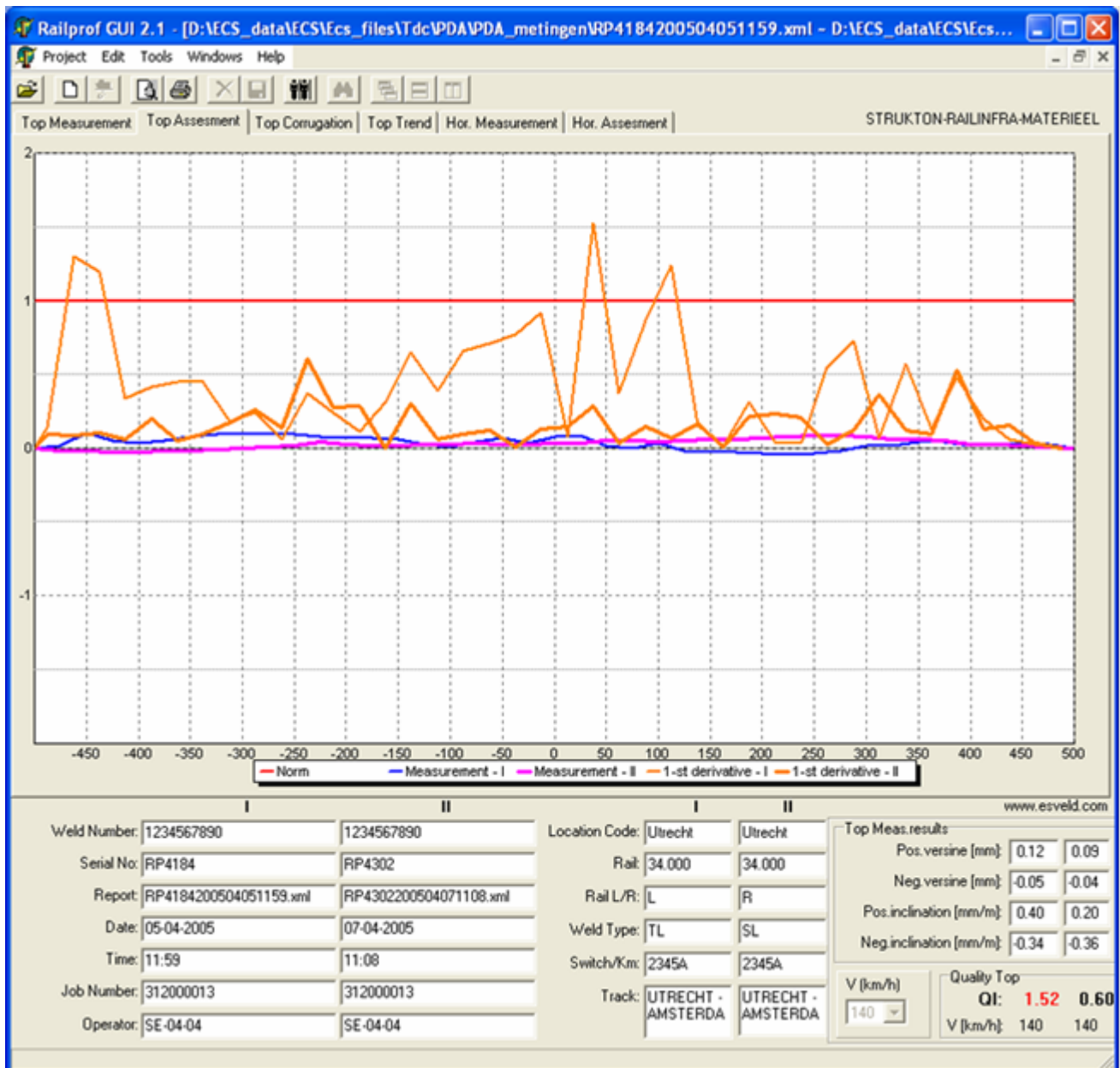
GA = Grinding Amplitude, GG = Average Wavelength, GSD = Average Grinding Depth.



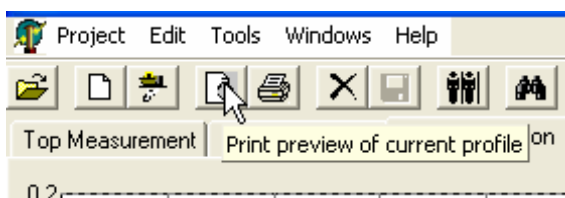
Comparison of profiles

If required two profiles can be compared (Compare) by displaying them in one screen. Both are shown.

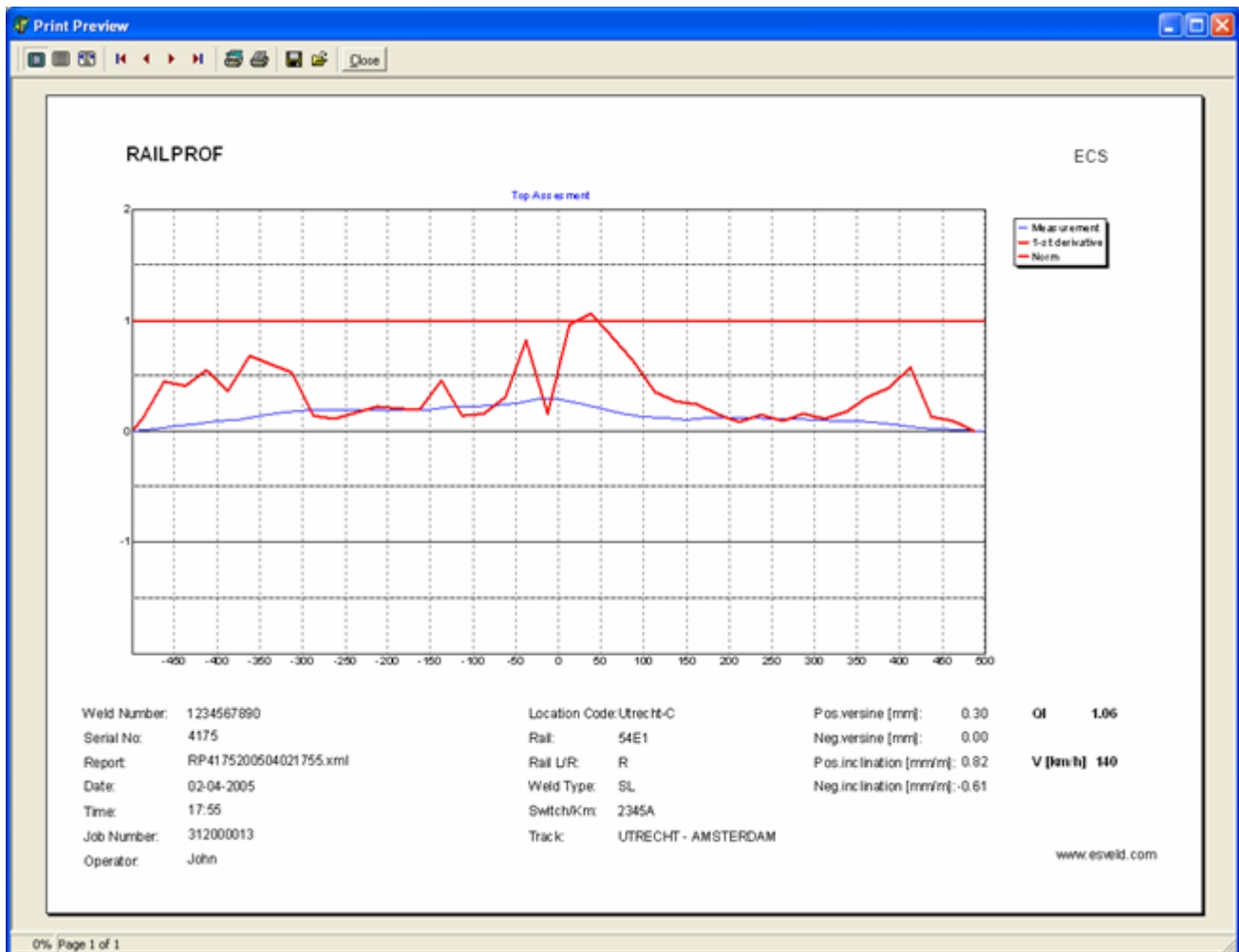




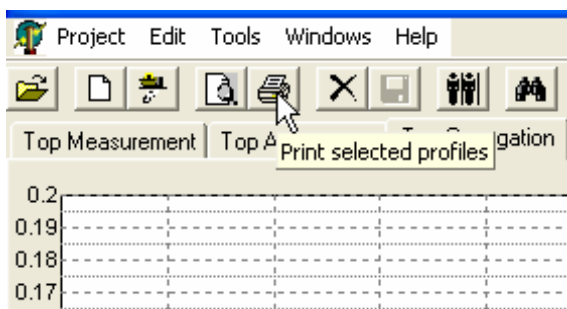
Print preview



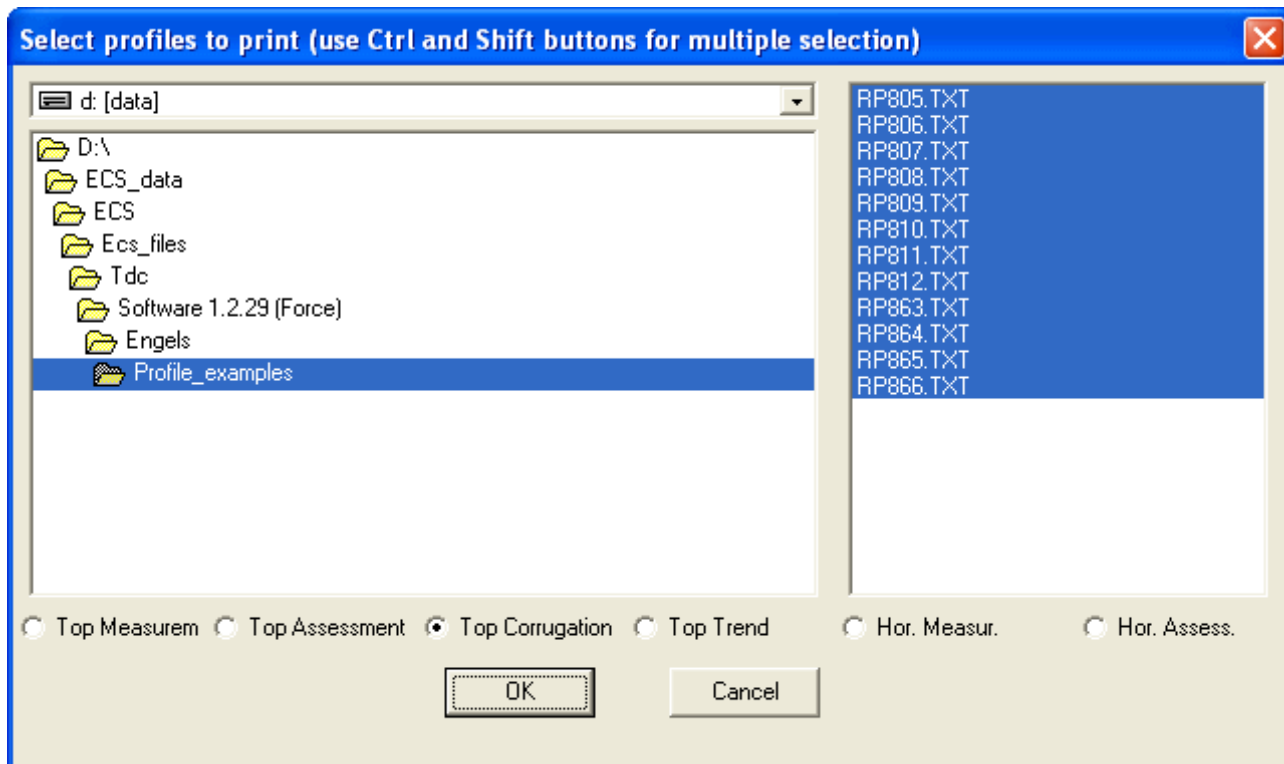
The print preview icon gives a preview of the printed page and can optionally print it.




The printer icon gives the possibility to print a number of consecutive measurements. A window appears where the relevant directory can be selected. The first file to print is chosen by clicking the filename, the last is chosen by keeping the shift key pressed, going to the last report to print and clicking its file name.



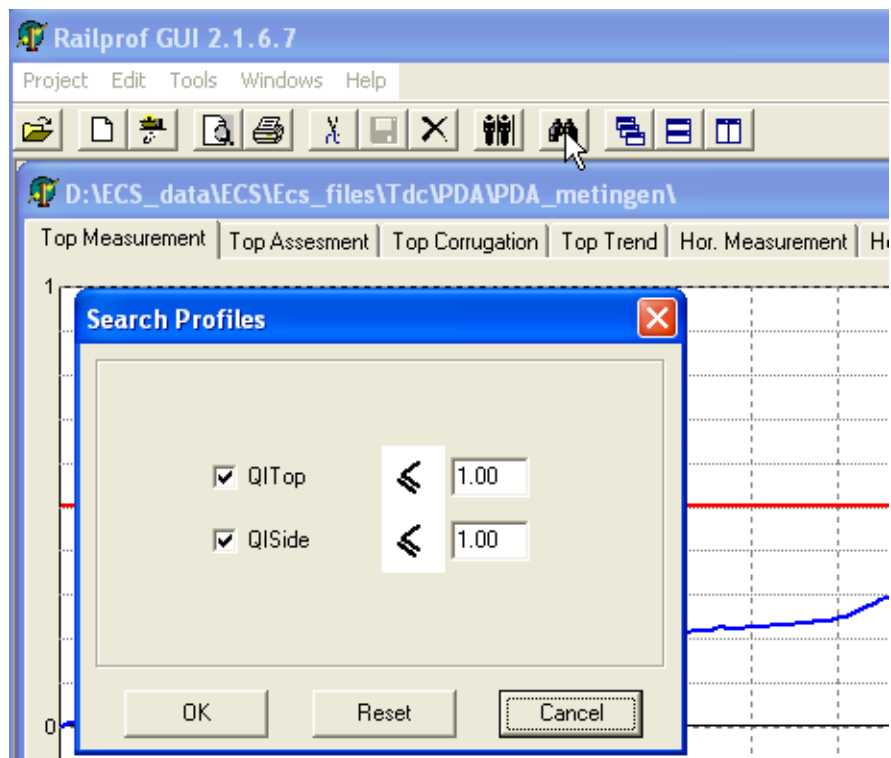
This feature is especially important if a series of measurements should be printed as one pdf file. The files are selected as described above and then one of the six evaluation screens should be selected. After pressing OK a preview of the selected files is displayed. At the top of this screen the printer setup should be selected to choose the pdf printer. Next give the print command and now one integrated pdf file is produced. An example is also stored in the directory 'Profile_examples'.



Profile selection based on QI

The desktop software offers the possibility to select records based on the quality index QI. Via the find icon a screen is opened in which a choice can be made for QITop, QISide, or both. The selection value is default 1.00, but the user can assign any other value. After OK the screen at the bottom left shows just the selected records. These can be moved to a selected directory via , or via the menu 'Edit' and 'Move to'.

It is not necessary to fill in the 'file name'. In this menu a new directory can be made, or this can be done previously with Windows explorer. The selected files are actually moved to the new directory by clicking 'Open'.



9. DEFINITIONS

The profile is defined as the deviation from a straight line connecting the first and the last measured point. This is displayed without further processing. For the other parameters the profile is split up into long waves (the trend) and short waves. The trend in every point is the mean value over a length of 10 cm on either side. The positive and negative versine are the highest and lowest points of the trend. The positive and negative slope are the steepest ascending and descending point of the trend. The short waves are the difference between profile and trend.

The average amplitude is based on the short waves. It is the average of the maxima minus the average of the minima. The average wavelength is twice the average distance between (ascending and descending) zero crossings.

A grinding index is a measure for the amount of material that has to be ground away over the measured length of 1000 mm of the rail. It is a weighted average of the positive part of the trend.

The profile is defined as the deviation from a straight line connecting the first and the last measuring point.

Explanations

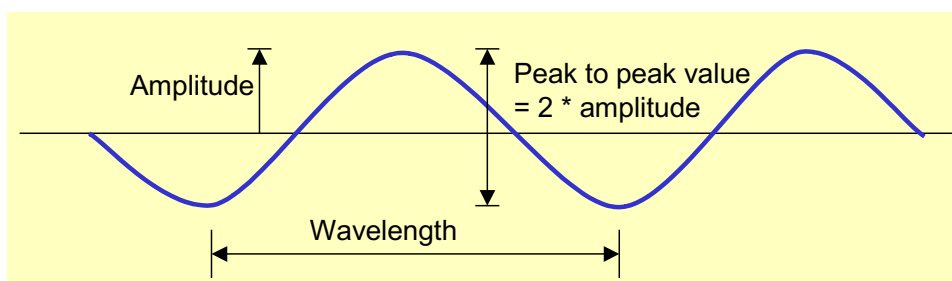
Sometimes the finer structure of the profile is not relevant, so it can be removed, leaving the general trend, also called the long waves. The short waves are explained under question 2. The trend in any point is defined as the average of the profile from 10 cm left to 10 cm right of that point. It is often used for positioning rails prior to welding. It is also used in combination with the definition of other parameters, used to describe the quality.

Versine definitions

The positive versine is the highest point of the trend. The Netherlands Railways Standards¹ require this value to be less than 0.3 mm vertical after welding and less than 0.2 mm after finish grinding. The negative versine is the lowest point of the trend. It should be greater or equal to 0 mm. The positive inclination is the steepest point of the trend, assuming the train runs from left to right on the graph, as it will do on the right rail. At this point the wheel of the train has the highest velocity in vertical direction. Over 200 mm the inclination should be less than 1:1000 in vertical direction. The negative inclination has the same effect for the other (left) rail where the train will run from right to left on the graph. So the requirements will be the same. Horizontally the requirements are: versine between – 0.5 and 0.5 mm, inclination over 200 mm less than 1:500.

Grinding index

The grinding index is a global measure of the amount of material that has to be ground away to get a rail profile with a positive versine equal to the highest allowed value. Mathematically it is the weighted average of the difference between the trend and a parabola through the first and last measuring point with its top at the highest allowed value of the positive versine, being 0.2 mm. Please note that the grinding index can be used as an indication only, as the actual grinding work depends on several factors, such as the grinding machine used for the job.



Corrugation

¹ See Esveld, C.: Modern Railway Track 2nd Edition, ISBN 90-8004-324-3-3, page 316

Corrugation is the deformation of the rail profile from a straight line into a shape as shown in the figure below. Wavelength and amplitude are indicated in the figure. In general, the corrugation wavelength is 3 to 4 cm. As compared with the trend (the long waves) the wavelength is relatively short. When corrugation takes place the amplitude of the deformations builds up gradually, creating noise as trains pass by. In the process the rail material toughens locally in phase with the corrugation waves, causing a faster reoccurrence of corrugation waves after grinding, if one waits too long with the grinding. To prevent this, grinding should take place when the amplitude of the corrugation waves is approaching 0.05 mm peak to peak.

The short-wave profile is defined as the difference between the total profile and the long wave profile. If the long waves are removed one can zoom in further without the long waves causing the graph going off the screen. In this way an accurate look at the corrugation is made possible. (On the RAILPROF zooming in is done by pressing the > key, the WINDOWS software is doing it automatically.)

Deviations due to horizontal curves

The radius of a rail curve commonly in use by metro companies is 100 m. Then over a measuring length of 1.0 m the horizontal deviation from a straight line in a curve is 1.25 mm or less. As the top surface in the middle of the rail is nearly flat ($R = 300$ mm) this deviation has no significant effect (less than 1 micron) on the measurement of the profile of the rail top.

10. SPECIFICATIONS

1. Weight: less than 7 kg;
2. Length: 116 cm;
3. Microsoft Windows Phone, with Windows 10:
 - Wireless communication with RAILPROF via Bluetooth to control measurements and data transfer;
 - Data analysis, such as filtering and computing of QI;
4. Measuring length: 1,000 mm in accordance with the EN standards for weld geometry; sampling interval 5 mm;
5. Measuring time: about 10 sec;
6. Time for data transfer to Smartphone and data analysis: about 6 sec;
7. Data storage: unlimited on Smart Phone internal memory, Secure Digital (SD) card, or in the Cloud;
8. Data transfer to desktop PC via mobile network, wifi, or wired synchronization;
9. Presentation of measurements on desktop PC via Windows menu. Easy generation of reports in pdf format;
10. Accuracy:
 - a. Temperature range of operation: - 5 °C and + 40 °C;
 - b. Vertical geometry: +/- 0.020 mm;
 - c. Lateral geometry: +/- 0.050 mm;
 - d. Inclination associated with QI: +/- 5 %;
11. Measuring principle transducers: eddy current. Results are not influenced by moisture, rust and dirt, so that actual metal surface is measured;
12. Bottom of RAILPROF is resistant to temperatures up to 150 °C;
13. Shipping information:
 - a. Total weight of flight case, RAILPROF, PDA and carton protection box: approximately 19 kg;
 - b. Dimensions: approximately 137 x 43 x 17.5 cm.

11. SOFTWARE LICENSES

The licenses for smartphone and desktop software are considered as one combined license coupled to the serial number of the RAILPROF.

12. REFERENCES

- [1] Esveld, C.: Modern Railway Track, Second Edition: <http://esveld.com/mrt.html>.
[2] Esveld, C.: Modern Railway Track, Digital Edition: <http://esveld.com/mrt-digital.html>.

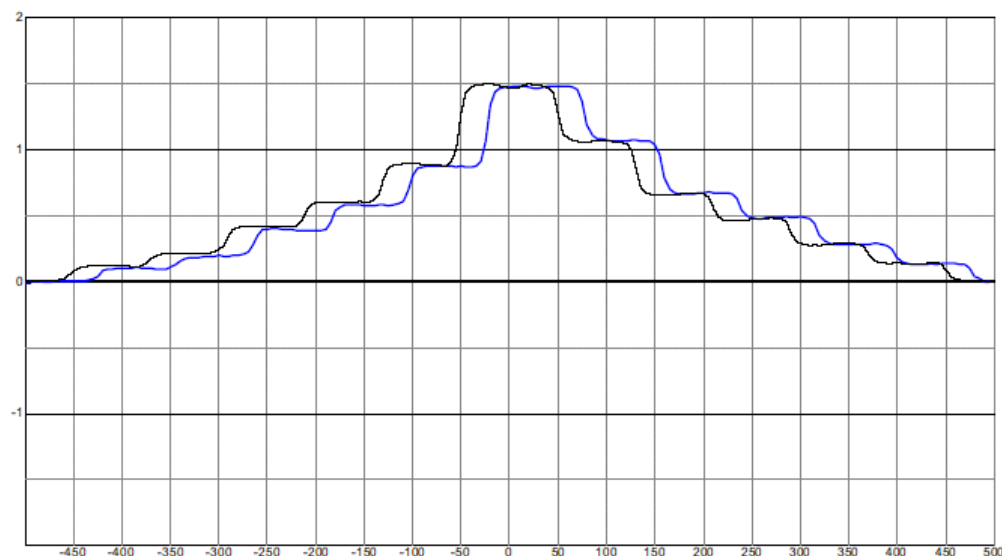
ACCURACY OF RAILPROF

Appendix 1

For calibrating the RAILPROF, amongst others, use is made of so-called step rails, one having positive versines up to 1.5 mm and the second one with negative versines up to -1.5 mm. The measurements below show results of a comparison with a time difference of about 3 years. The absolute deviation relative to the straightness standard was about 0.03 mm, whereas the repeatability as difference in versine was 0.01 mm.

RAILPROF

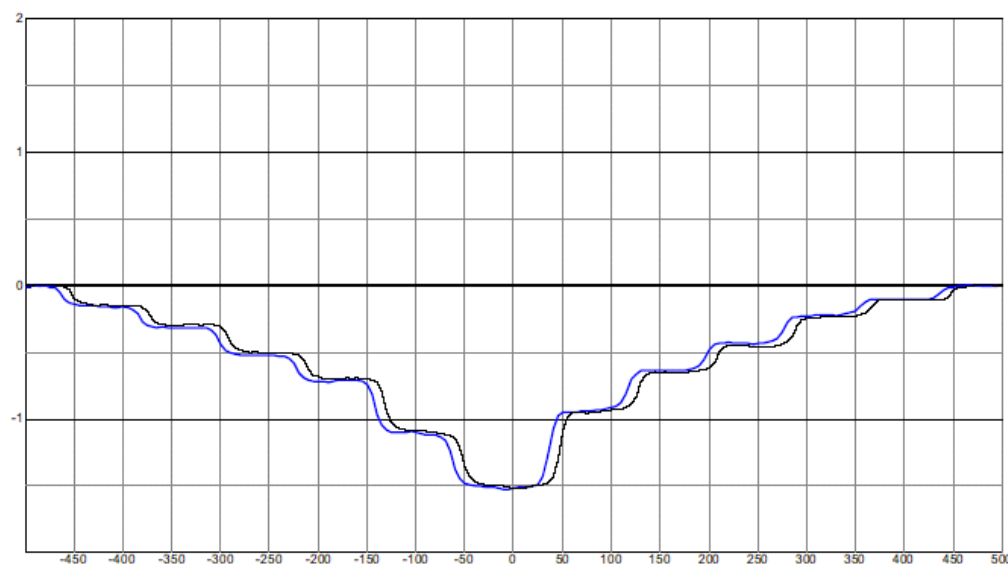
ECS



| | | | | | | | | |
|------------------|--------------|--------------|-------------|-------|--------|-----------------|-------|-------|
| Profiel top/zij: | TOP | TOP | Locatie: | -- | 680705 | Pos. pijlwaarde | 1.49 | 1.50 |
| Serienummer | RP4183 | RP4183 | Km/wissel: | OOST | | Neg. pijlwaarde | 0.00 | 0.00 |
| Rapport: | RP000023.183 | RP001043.183 | Rail L/R: | COR | | Pos. helling | 3.87 | 3.80 |
| Datum: | 1980-1-4 | 2005-1-12 | Lastype: | LAS-1 | 23938 | Neg. helling | -3.79 | -3.84 |
| Tijd: | 0: 1 | 19:23 | Opmerkingen | | | Gem. amplitude | 0.09 | 0.08 |

RAILPROF

ECS



| | | | | | | | | |
|------------------|--------------|--------------|-------------|-------|--------|-----------------|-------|-------|
| Profiel top/zij: | TOP | TOP | Locatie: | -- | 680705 | Pos. pijlwaarde | 0.01 | 0.01 |
| Serienummer | RP4183 | RP4183 | Km/wissel: | OOST | | Neg. pijlwaarde | -1.53 | -1.52 |
| Rapport: | RP000029.183 | RP001046.183 | Rail L/R: | COR | | Pos. helling | 3.87 | 3.77 |
| Datum: | 1980-1-4 | 2005-1-12 | Lastype: | LAS-1 | 23938 | Neg. helling | -3.77 | -3.81 |
| Tijd: | 0: 5 | 19:24 | Opmerkingen | | | Gem. amplitude | 0.07 | 0.07 |

Nowadays the accuracy is mostly dependent on the QI, i.e. the first derivative of the vertical rail geometry. Generally speaking, the required accuracy is 5 % of the admissible standard, which depend on the allowable line speed. For 300 Km/h the maximum deviation is 0.05 mrad and for 140 km/h 0.09 mrad.

Also refer to the document in the Download section entitled: RAILPROF Adjustment & Calibration.