Roadroid

Road Surveying using Smartphones.

App version Pro 3

Road Data Management system version >2.6.20

Table of Contents

1. Introduction

1.1. User guide overview

This guide gives an introduction and describes how to:

- Collect road roughness (IRI) data + photos or video.
- Upload data and media from smartphone.
- View data and media on Road Data Management System.
- Download files in segments and make charts in Excel.
- Download data as Shape or KML files to GIS.
- Overview of the API for export to RAMS.
- Introduction to Road Inventory.
- Introduction to Image Analyzing.
- Calibrate the system to a known reference.

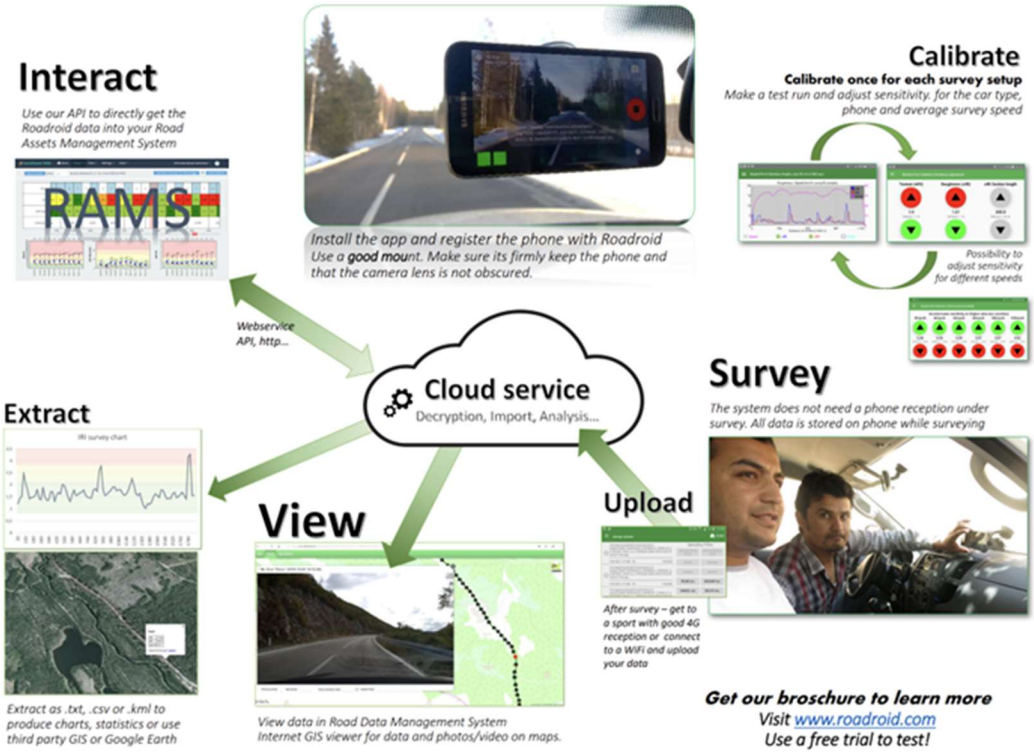
Refer to other user guides for Road inventories and API Specifications, and our Quick Start Guide for initial testing of the system.

1.2. Roadroid overview

Roadroid is a smartphone & cloud-based road survey system (IRI/IQL3).

The app for data collection is installed on an Android Smartphone and utilizes the Accelerometer. Every second it records a road-condition value + GPS Coordinates, with photos taken at a set interval.

After the data has been transferred via our cloud service to the Road Data Management system it can be viewed on a map. The data is assigned 4 color legends depending on the road condition. Data can be aggregated in 5–200-meter sections and can easily be downloaded to create tables and charts in Ms. Excel, or to a Road Asset Management system (RAMS), via API.

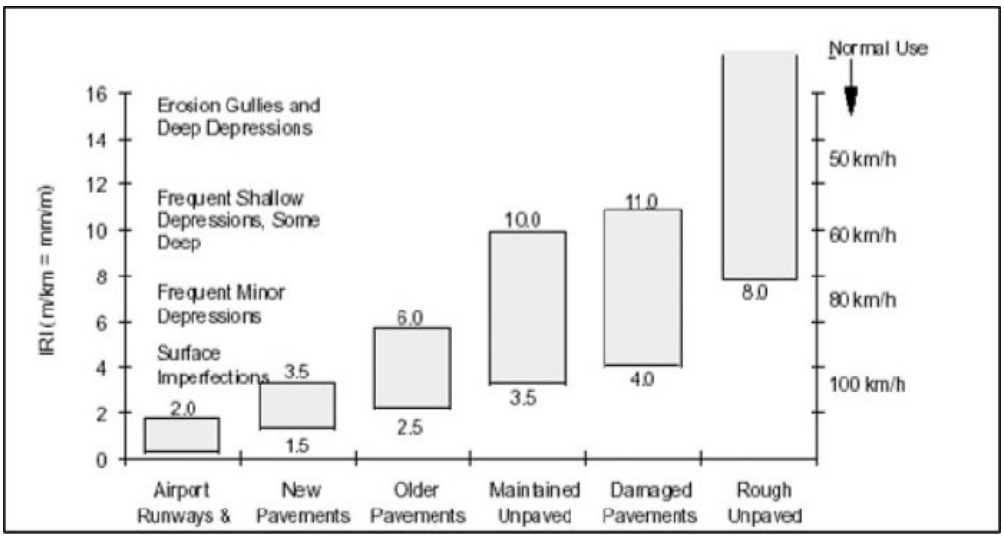


1.3. Road maintenance and data collection

Road assets management is about optimizing road maintenance to get the most out of your maintenance budget. To do that, you need to know the road condition. Road condition survey is also useful in Performance Based Contracts - as an objective KPI - index of your road's performance.

The Roadroid App measures the road roughness (**IRI**) by using the smartphone accelerometer - and can automatically capture photos or videos of the road. Data is positioned with GPS coordinates. The system is portable and easy to use.

IRI is a global standard for road condition. It has been expressed as a summary of a road's standard.



IRI is measured with different methods and at Information Quality Levels (IQL), a relative accuracy:

- IQL 1 - Precision profiles (10–20 m intervals expensive and complex to use)
- IQL 2 - Other profilometric methods, as the manual rolling straight edges
- IQL 3 - IRI by correlation (Response type measurements - as Roadroid)
- IQL 4 - Subjective ratings/ocular inspections (subjective and time consuming)

https://en.wikipedia.org/wiki/Information_Quality_Level

Roadroid collects IRI-data at Class 3 – IQL 3 level.

- Compared to Class 1 Roadroid is very easy to use, portable and cost efficient. It can be used almost anywhere - where heavy/expensive equipment can´t!

- Compared to Class 4 Roadroid is objective and gives a quick and effective data collection with a powerful visualization on internet maps.

2. Collect Data

2.1. Installing and registration

Install the app on your smartphone from Google Play Store or, if not available on Play Store in your country, contact Roadroid by email to market@roadroid.com . We will pass a link for registration.

You need a registered, paid & approved account to use Roadroid.

You need to identify your phones IMEI – to add it into the app settings (important).

Observe:

- ✓ The app uses the accelerometer signal from your phone. The sensitivity may vary between different phones and vehicles. The default sensitivity can be adjusted.
- ✓ Updating the phones Android operating system may affect the sensitivity and other application functions. Avoid **updating operating system** when you have tuned the system. Uncheck automatic updates in Android!
- ✓ The app home button at top right takes you to the Roadroid web. From there you can see available app updates, manuals etc. *www.roadroid.com*

2.2 The survey & data collection system

The survey system consists of:

Vehicle

- Use standard vehicles close to the types you can choose in the App settings > Device & Vehicle > Vehicle Type.
- Avoid poor or special suspensions (as sport suspension).
- Use standard tire pressure.
- Make sure all wheels are balanced - unbalanced wheels will corrupt survey.

Phone & mount

- Accelerometer and sampling performance.
- Version of android operating system.
- The phone mount – it is **very important** with a stable mount, such as RAM® X-Grip® Universal Phone and Tablet Holders – RAM Mounts. Magnetic holders are also recommended.
- Photo/video - for best quality use a phone with OIS, *Optical Image Stabilization*.

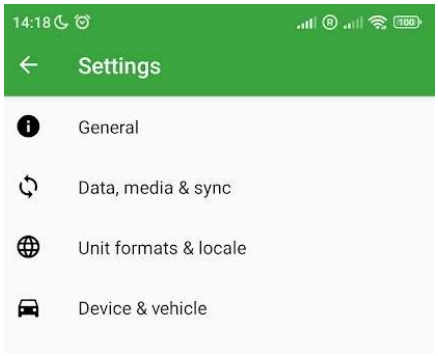
Survey speed

- Speed affects the survey result - maintain consistent speed (+/- 10 km/h).
- The best correlation for IQL3/response type methods is around 60-70 km/h.
- The system can be tuned for lower survey speeds down to 30 km/h.
- IRI values are not recorded if driving under 20km/h or over 100 km/hour.

The system should be tuned on a road with a known IRI value, see **appendix 1** about calibration.

2.3 Preparations - Settings menu

2.3.1 Settings

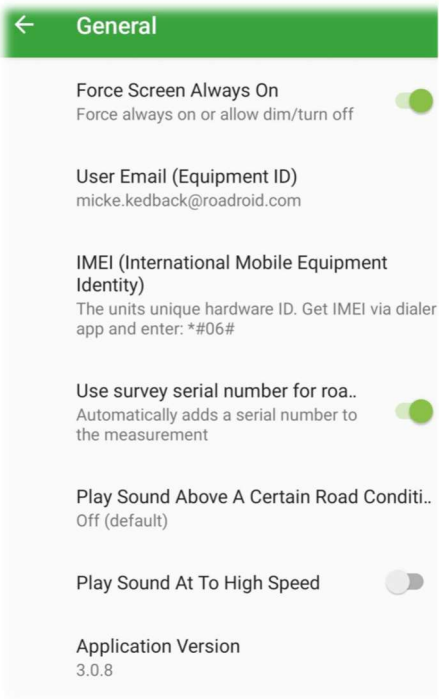


Under Menu -> Settings you will find different sub settings:

- General
- Media & Sync
- Units, formats & locale
- Device & Vehicle

Have a look through all of these settings to make sure it matches your setup. As the App develops, this documentation might not exactly match the App menu over time.

2.3.2 General



Force screen always on
(Active as default, keeps the app running).

Add your user email
(Shown in the photo overlay.

IMEI (International Mobile Equipment Identity):
Add the IMEI of your phone.
IMPORTANT: You need to enter your phone's IMEI number so can upload and connect data to the right account.
You can get your phone's IMEI no. by dialing *#06#, or under the settings menu in your android phone.
If your phone has 2 IMEI numbers, just enter one of them. The IMEI is 15 digits long. If you phone manufacturer have added 2 numbers after a "/", for example /16. Disregard these added numbers.

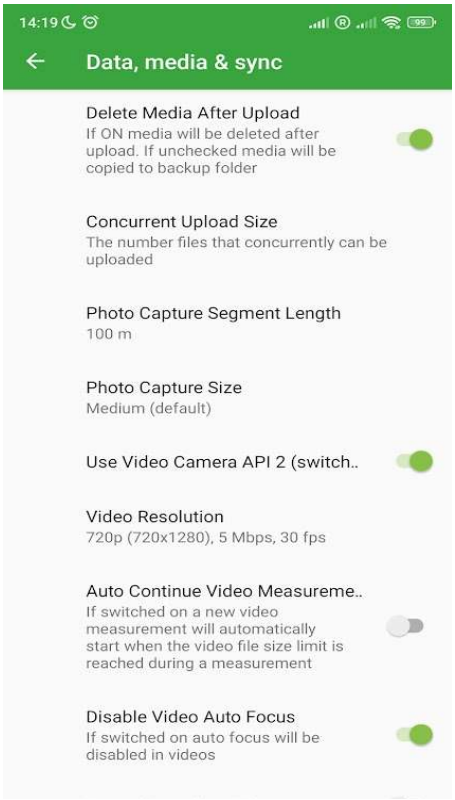
Use survey serial number for road will automatically add a serial number to the measurement. Before you start your survey, you can manually change this to a named section, for example "Route 69 East Section 1".

Play sound above a certain road condition: Not to be used.

Play sound at too high speed sets a warning sound at high speed.

Application version: Be sure to stay updated to latest version (its 3.0.9 in Jan 2024).

2.3.3 Data, media & Sync



Delete Media After Upload: If you want to keep a copy of your survey media on your mobile memory, then uncheck this option. The media will be moved to a backup folder; if unchecked. If checked the media will be deleted after a successful upload.

One advice is to copy surveys files and media/photos with a cable to a PC it you want a copy, but data removed from phone,

Concurrent upload size: Set to 2 as default. Can be changed according to needs.

Photo Capture Segment Length: Off as default. 50m-100m are recommended to make a Road Inventory from the photos.

Lengths > 500 meter can be used only for orientation purpose. Every 3 or 4 seconds needs a fast phone and distance between photos varies with speed.

Photo Capture Size: Medium is default and is often good enough. Small should only be used if you have limited phone memory and upload bandwidth. Large can be used if you have sufficient memory, good bandwidth, and need high-resolution images.

Use Video Camera API 2: Camera API 2.0 is New API which allows you much better camera control by camera apps and increase the performance of camera.

Video resolution: We recommend only using the highest resolution 720 p (default). The lower resolution will demand less memory, but the quality is often too low to be useful. Note that different camera APIs might distort the video format.

Auto Continue Video Measurement: If switched on a new video will automatically start when the video file size limit is reached.

Disable Video Auto Focus: Sometimes a tiny spot on the front windshield of the vehicle can capture the focus of the camera resulting in a poor view of the surveying road. Here you have the option to switch the auto focus off if necessary.

Record sound in Video: Sound capture is off as default, but it can be activated. It can be used if you want to comment on your survey. For example if you see or notice something along the road. Note all sounds/talks from inside the car will be recorded.

Save photos to Mapillary®: On as default. Photos and videos can be shared on www.mapillary.com, when checked. By that you provide content to global crowd sourced road-views. Lots of useful features are added from your data in Mapillary.

Photos from all Roadroid users are shared through a common Roadroid account at Mapillary. All collected videos are shared.

Save Media (Camera Direction) Via Vehicle Rear Window: This option should be activated if you want to survey and capture photo for Dust Image Analysis via placing the phone at rear windshield of the car. Refer to Image Analysis section!

Send Location Update Interval Time: Off default, not used (can sent a heartbeat).

Practical tip

Make a plan of how to collect data. Print a map, possibly with the start and stop sections and Road IDs highlighted. Press start/stop in logical locations as intersections, bridges, different pavements etc.

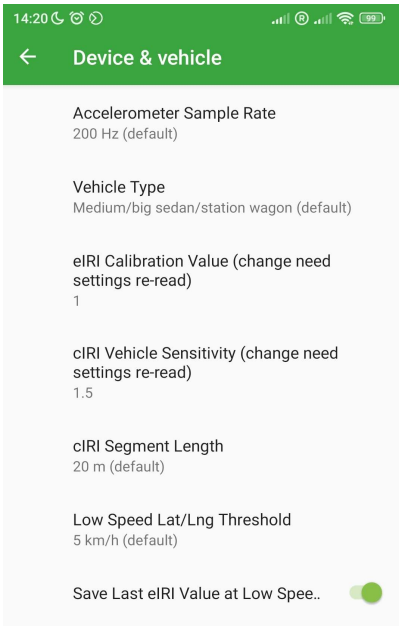
Install a role based gmail.com address, like roadteam01@gmail.com to your survey units. Install and activate Google+ location sharing on the phones – and get a real-time survey fleet monitoring system. The address can also be used to reach one or several teams with messages.

2.3.4 Units formats & locale

Speed unit: km/h is default but can be changed to mph.

Language locale (change need app to restart): Options to switch between English & Swedish is currently available.

2.3.5 Device & Vehicle



Accelerometer Sample Rate: Accelerometer measures the acceleration force in m/s2 applied to a device on all three physical axes (x, y, and z), including the force of gravity. By default, it is set to 200 Hz which is the frequency we developed the correlations formulas for. In newer smartphones the sampling can reach over 500 Hz but that does not increase the accuracy. Although you can choose the device's max rate, 100 or 200 Hz.

Vehicle Type: Here you can choose the type of vehicle you are using. It partly changes the signal processing. Different vehicles behave differently for different speeds. The setting is set to adapt with three types of vehicle characteristics and speed.

But the Roadroid app can also set the sensitivity for different speed ranges and vehicles in a manual way. to use this function, set/make User defined active in the Vehicle Type setting. Remember that you must go to the Survey and presets > Vehicle speed sensitivity screen to use/select it. Otherwise, the app is going to use the default Medium/big sedan/station wagon setting.

Navigate to the Vehicle speed sensitivity screen in the Survey and presets section from the main menu. Adjust the desired sensitivity for every speed level (20 – 120 km/h) between 0.1 – 0.9.

- A lower value will lower the threshold limit/value during measurements and give a higher resulting eIRI value for a certain speed.
- A higher value will raise the threshold limit/value during measurements and give a lower resulting eIRI value for a certain speed.

If it is not possible to drive faster than 80 or 100 km/h in your surveys, just let the setting be the same as the last set one speed-wise. i.e. if you set it to 0.6 at 80 km/h set it to 0.6 or close to it for 100 and 120 km/h as well.

When finished with the calibration/sensitivity setting, exit the screen and answer if the new values should be saved. Follow the Calibration procedure (appendix 1).

eIRI calibration value (change needs settings re-read): Default is 1.0. You can change the sensitivity manually based on results from calibration (see appendix 1).

A *lower* value means higher sensitivity.

cIRI Vehicle Sensitivity (change need settings re-read): Default is 1.5. You can change the sensitivity manually based on results from calibration (see appendix 1).

A *higher* value means higher sensitivity.

cIRI Segment Length: 20 m is default, but it can be changed from 10 m up to 200 m.

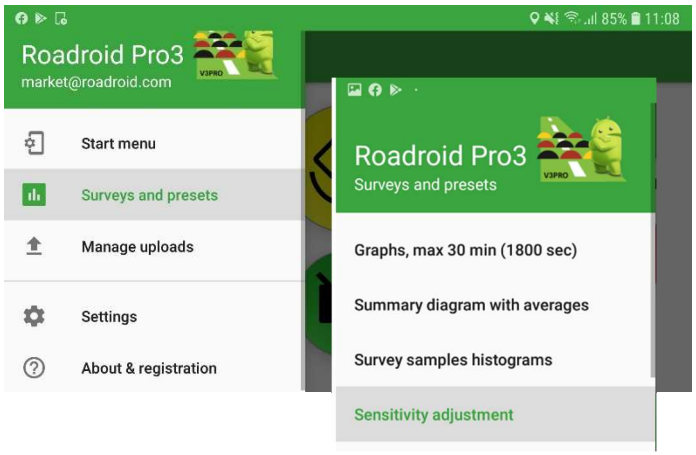
Low Speed Lat/Lng: Threshold set the lowest speed coordinates are saved. As you do not want to save data at very low speeds or when standing still. 5 km is the default setting.

Save last eIRI Value at Low Speed: if this is checked, the last value that was collected before the speed dropped below 20 km/h will be saved for the following registrations/seconds, until the speed again increases over 20 km/h. If not checked – no value will be saved.

2.4 Calibration overview

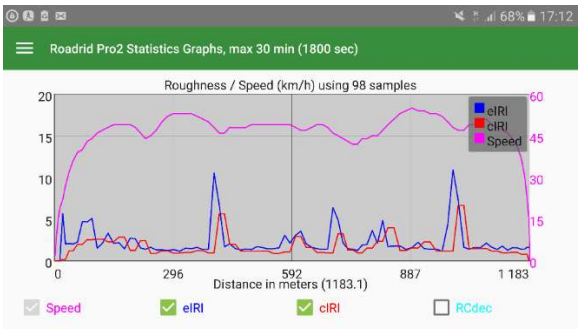
We recommend a calibration procedure where the equipment is calibrated towards sections with known IRI measured with an IQL 1 device. There is also a calibration procedure based on subjective rating of road sections when IQL 1 measured sections are not available. Both procedures are described in Appendix 1.

Below in this section (2.4) is a brief overview of the different calibration features in the app.

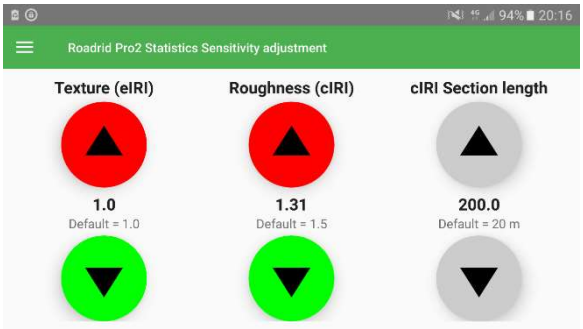


Menu -> Surveys and presets: Hereunder you will find tools for calibration. You can monitor the result from the latest survey in three different graphs, so you can make an immediate check if you are on a known test section.

You can adjust the sensitivity of the **estimated IRI** (picks up more of the roads macro **texture**).



Graph after a survey



Sensitivity adjustment

You can also adjust the sensitivity - and section length for the calculated IRI (more focused on the roughness using the quarter car formula).

As mentioned in section 2.2, the system consists of #vehicle, #phone and #speed, so find your suitable setting for each of these conditions.

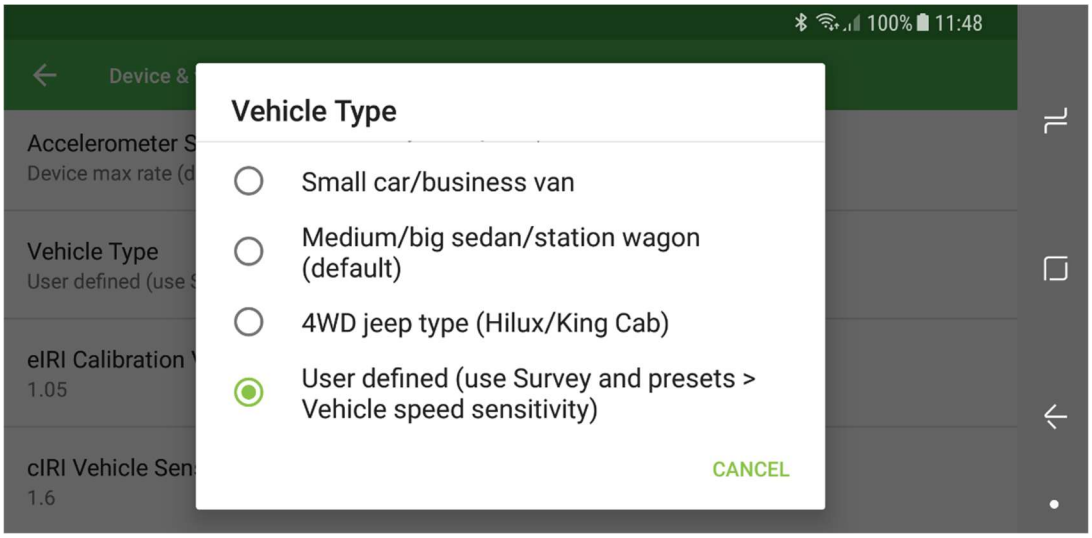
For description of "Manage uploads", refer chapter 2 in this user guide.

2.5 Vehicle speed sensitivity adjustment

As mentioned, the system consists of the phone with its rigid mount, the vehicle and its speed. Different speeds give different results, and the calibration procedure (appendix) describes how to set the sensitivity for a certain speed.

Different vehicles behave differently at different speeds. Setting Vehicle type preset values use three type vehicle characteristics for the eIRI/Texture analysis. But the Roadroid app can also set sensitivity for different speed ranges.

To use this function, set/make User defined active in the Vehicle Type setting:



Then navigate to the **Vehicle speed sensitivity** screen under **Survey and presets** selection from the main menu. Adjust the desired sensitivity for every speed level (20 – 120 km/h) between 0.1 – 0.9.

Then go to the Survey and presets > Vehicle speed sensitivity screen to manage the speed settings. The default setting is Medium/big sedan/station wagon setting (below):

- A lower value (**red** button) will lower the threshold limit/value and give a higher eIRI value for a certain speed.
- A higher value (**green** button) will raise the threshold limit/value and give a lower eIRI value for a certain speed.

When finished with the **speed** calibration/sensitivity setting, exit the screen and **save settings**.

Follow the **general** calibration procedure in the appendix, **but** calibrate for every speed level (20, 40, 60, ...) until satisfaction with the eIRI values for every different speed is reached. During the process, it is possible to use graph tools in the app and your own notes.

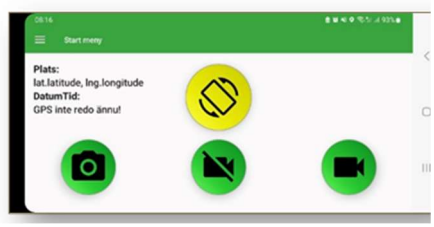
Observe that the speed calibration feature only affects the eIRI **reading**. Also note that a general setting can be made for Texture (eIRI) in the Sensitivity adjustment screen, thus using one of the preset vehicles.

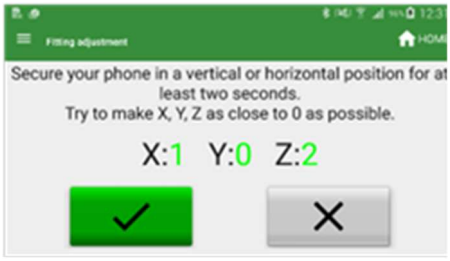
2.6 Survey preparation in the car

Mount the phone in a car rack in the windshield:

- horizontally/landscape mode, vertically from road.
- It should be easy to reach the display.
- make sure camera lens capture the road view.

- Start the Roadroid application by tapping its program icon, then press the yellow "fitting" button.
- Stay parked on flat ground to make the fitting.
- Adjust the phone to X, Y and Z as close to = 0 as possible.
- The OK button will turn green when you are within the tolerances.
- Press the green OK button.





This procedure is to ensure you pick out the vertical (Y) accelerations exclude influence by breaking (X) or turning (Z).

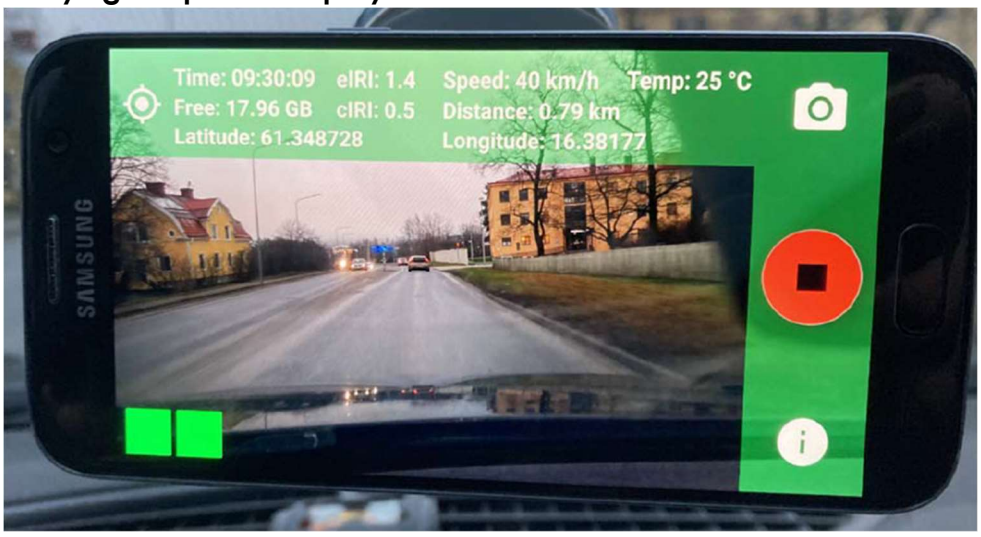
Tip: you can always "go back" with the android **back-button** in the bottom corner of the phone.

2.7 Start your survey – only Roughness or with photo or video.

Use the camera button (left) for auto photos and film camera (right) for video. If you do not like to capture any visual information, use the button with a crossed camera. Then the app will only collect roughness data (IRI).

Note: System starts only if a GPS signal is available. Stand still to receive GPS (may take a minute).

While surveying the phone display will look like this:



- The top bar displays if GPS is connected, time, memory space, estimated and calculated IRI values, speed and distance surveyed.
- It also shows the temperature of the phone battery. Observe eventual overheating - in warm/sunny conditions – **keep your AC on windshield to cool the phone down**.
- Under 20 km/h the App will show "low speed" and roughness data is not captured.
- Over 100 km/h it will show "high speed" and roughness data is not captured either.
- Photo/video icon button gives technical data about the camera.
- The info button gives current survey info.
- The bar with colored squares indicates the current roughness from green (good) to poor (black).

Start survey: Press the record button (red round circle on green background) **to start** the survey. You can enter an optional comment or road id when starting a survey. It is a good support later in the Road Data Management System, as it shows up in the import history list.

Stop survey: Press the same button (now a black square on red background) **to stop** the survey. After pressing stop you can decide if you want to save or delete the survey.

3. Upload data

3.1 Before you upload.

Data and photos/videos are saved on phone while surveying. **You do not need an internet/3G/4G/5G connection to conduct the surveys.** But you need a good connection to upload your data after a survey.

The survey data itself is relatively small in size and can be uploaded through 3G/4G.

But to upload media you should have a stable Wi-Fi/internet connection. Connect to Wi-Fi through normal Android procedure. Videos are more demanding than photos!

A photo can vary in size between 500 kb - 2 Mb. Estimate how many photos you can capture by the survey length and capture length. We recommend 50-100 meters.

We advise copying video files to a computer before uploading (use a cable to copy the video files from the phone to the computer). The reason is that sometimes the file format can be damaged during upload. In special cases it is also possible to use an FTP-client to upload video files.

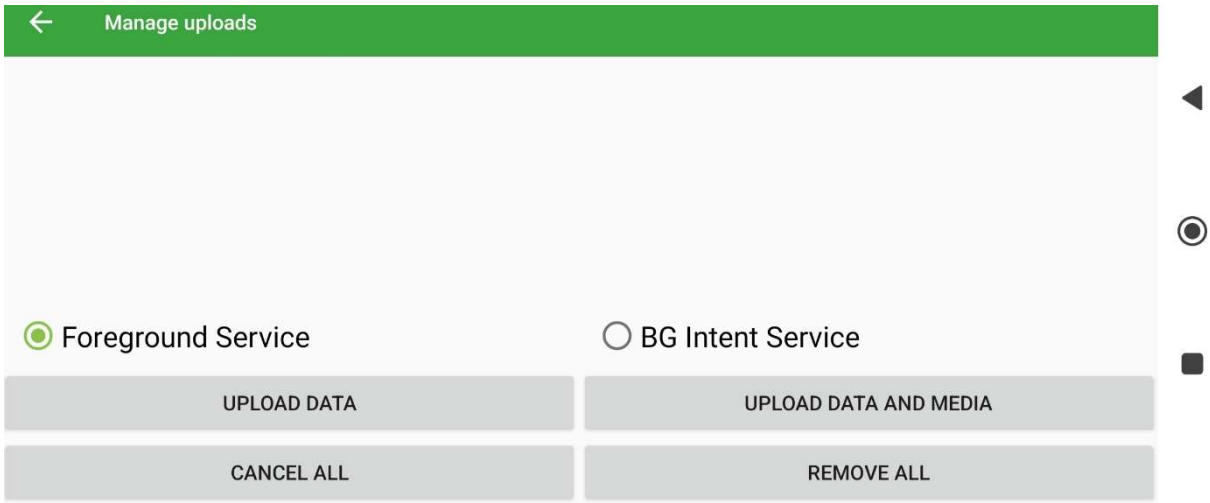
Use video only if you have a good capacity WIFI for uploading!

A video file quickly builds up to over 100 MB, and its transfer can take hours depending on your network's upload capacity. When collecting video, it is recommended to start/stop survey every 5-10 km to reduce each video file size.

If you have a phone with sufficient memory, you can also uncheck the option "delete media after upload" to ensure that you have a backup of photos or videos stored locally on the phone. This is done in Settings Data, media & sync.

3.2 Start the upload.

Navigate in the app to the menu "manage uploads", where you will find some different options for uploading collected data.



Foreground Service: If you choose the "Foreground Services", you will be able to cancel or pause the upload process.

BG Intent Service: This upload option is a background internal upload service that cannot be cancelled or paused once the upload starts. Both processes are intended to upload the media and data, so use the alternative service if one fails.

It might happen that the upload procedure stops/pauses by an interrupt in the network. Just reset and start the upload again to proceed.

When the Upload Data button is pressed:

1. Data Files in the /Internal storage/Android/data/com.roadroid.pro3/files/data folder are compressed.
2. The Roadroid app transfer function starts, and finally,
3. If the file transfer is successful, the zip files will be moved to /Internal storage/Android/data/com.roadroid.pro3/files/backup folder.

This repeats for every file. If one file transfer is incomplete the function will continue next time an upload is started - until they are successfully transferred.

The files on the phone are encrypted and will be decrypted in the web import. Make sure you have enough space on the phone, especially capturing photos/video.

Photos and videos as per default are deleted from the phone after a successful upload. It is possible to use a cable to make a backup of photos/videos before transfer. You can also uncheck the options in settings "delete media after upload" if you have sufficient memory to store videos & photos on the phone after upload.

Remember that, after a successful upload of survey files, it will take a few minutes before they are visible on the Roadroid web.

If there is an issue with the upload, contact support at Roadroid for troubleshooting.

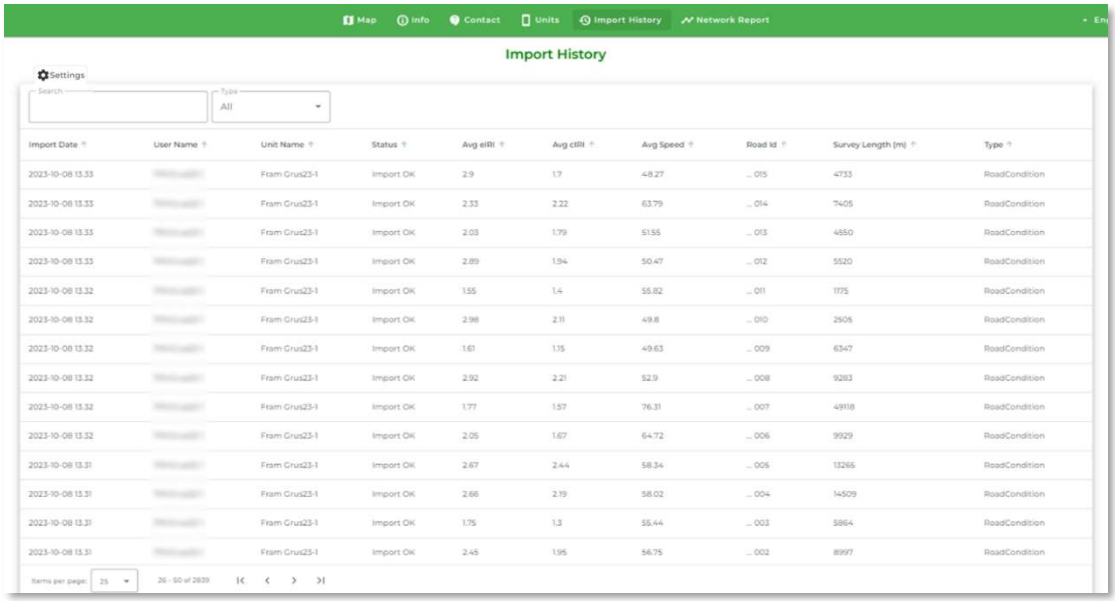
4. View data in the Roadroid data management system

4.1 Introduction

When data is successfully uploaded, it will be imported to our cloud service based Roadroid data management system within 15-20 minutes. Enter www.roadroid.com and log-in with your username and password to view the details of your data.

4.2 Import history

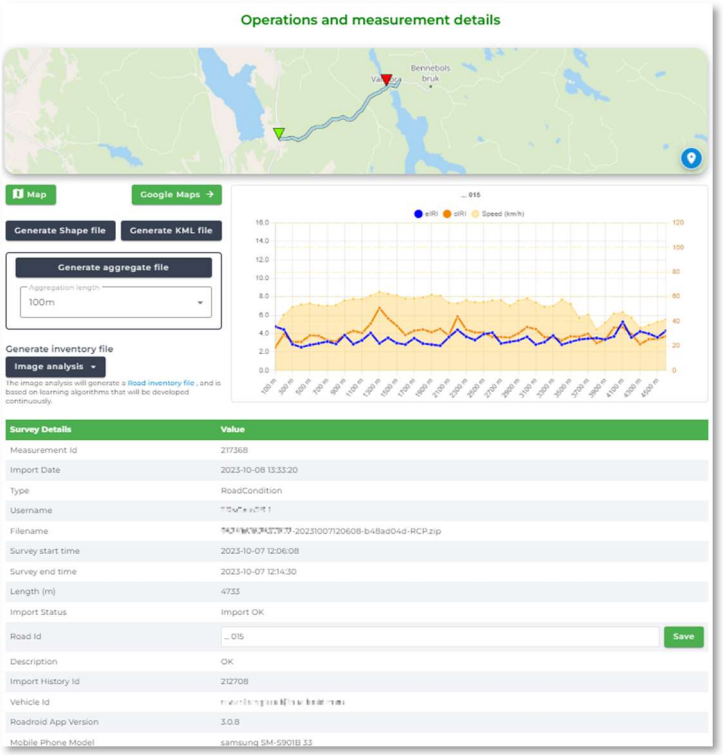
The "Import History" page will give you an overview of the files that are uploaded to Roadroid data management system.



4.3 Survey details

When clicking on a file and then on "Details" you will get additional information on the specific uploaded survey file.

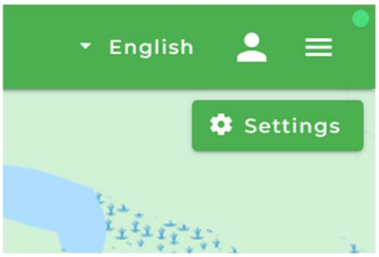
At the top of the page you will see a small map preview of the measurement and a graph window showing an overview of the collected data. You can zoom in/out on both the map and the graph by scrolling.



4.3.1 Show survey data on map

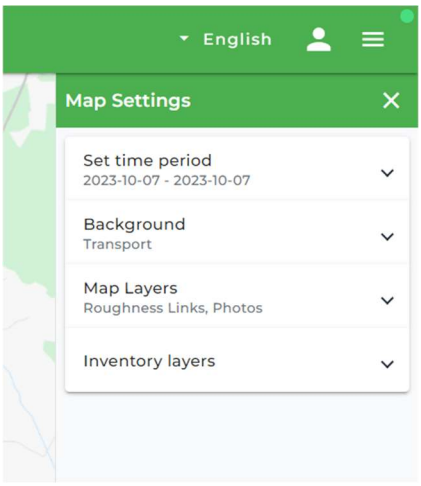
If you click on the "Map" option, you will get an overview of the collected data. As a default the background road map data will be Open Street Map (OSM). In the top corners of the screen there are some additional options.

To control the different map layers, click on "Settings" at the top right corner of the screen.



A menu will appear on the right corner of the screen, where the following map layers can be managed:

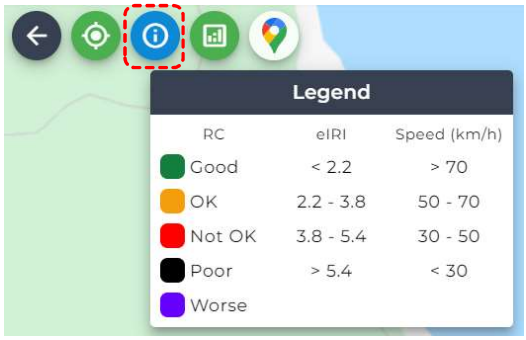
- Roughness Points
- Roughness Links
- Photos
- Videos
- Speed

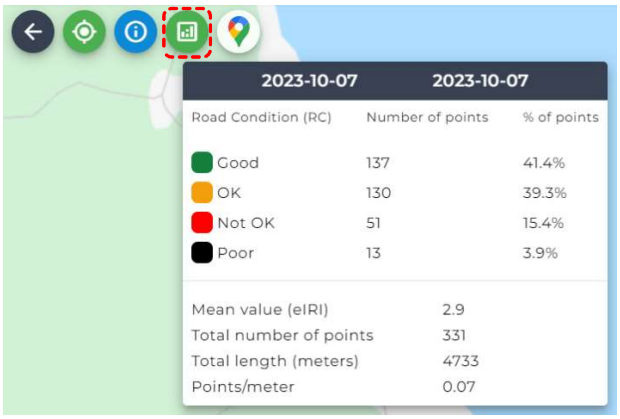


Here you can also adjust the time interval, change background map and view inventory layers.

- •The number of points shown at the same time is limited (for server performance reasons).
- •When you zoom in to the map, eIRI – labels will appear at each dot a certain zoom level.
- •Photo or video appear as clickable black camera icons. The active photo has a red circle around it.

Clicking "i" will display a legend showing the color coding that Roadroid use. If you instead click on "Survey summary" it will show a table with additional information such as average eIRI and percentage of collected values in the different color categories from good to poor. The Google Maps icon will open a new tab in your browser with the measurement route plotted in Google Maps.

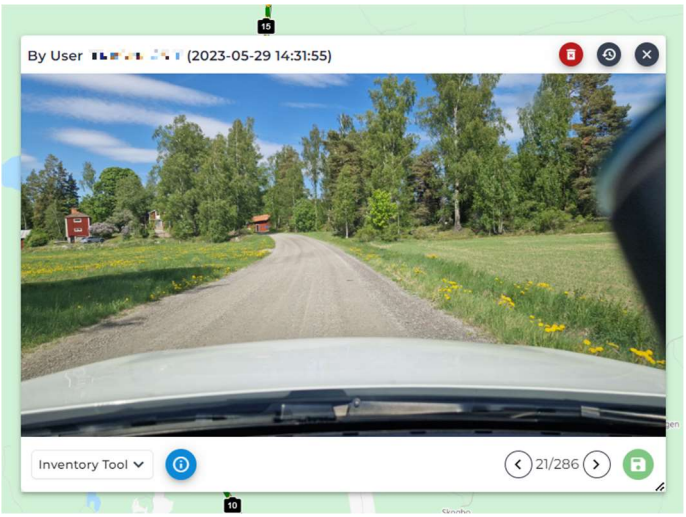




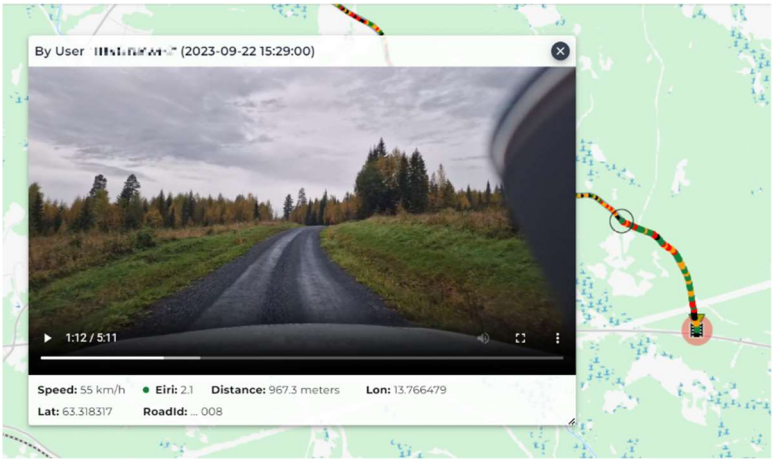
If you have recorded with photos and choose the map layer with photos, all captured photos will appear on the map as photo icons.

Click on a specific photo icon to see the photo.

The photo window can be re-sized by dragging the bottom right corner.



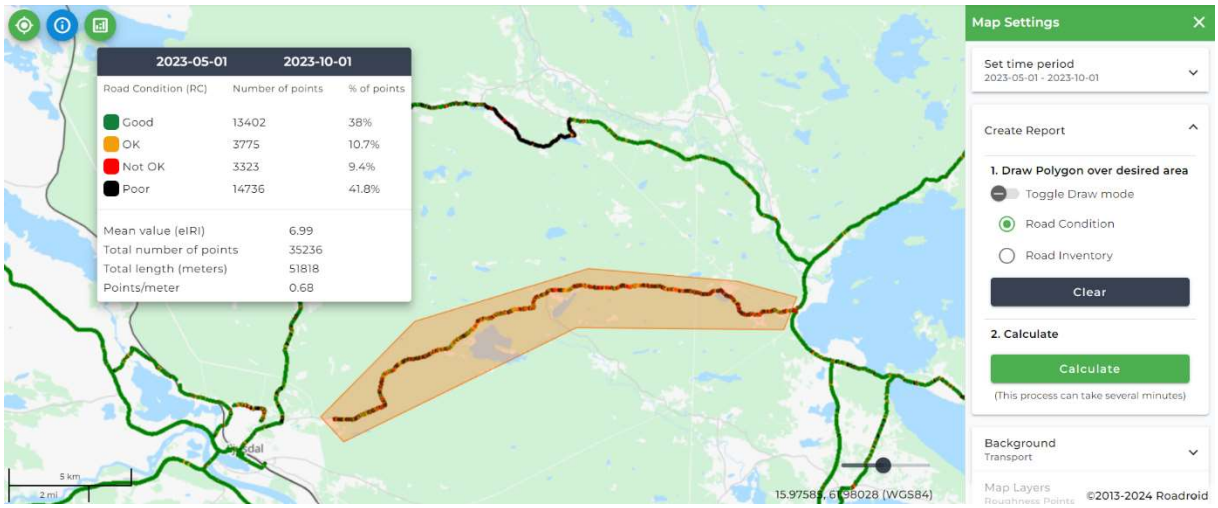
If you have recorded with video, you will see a video icon at the start point of the survey. Click on the video icon to view the video. You can follow the current location on the map as you play the video.



4.4. Road Condition – view & analyse.

For further options to view and analyse the collected data, open "Create Report" under "Settings" in the map view.

Depending on if there is a road network layer available – colored road links will appear on the map.



The time filter is used to display and measure point data only within the set time interval. It can be used to look at changes over time and obtain statistics with the report functions.

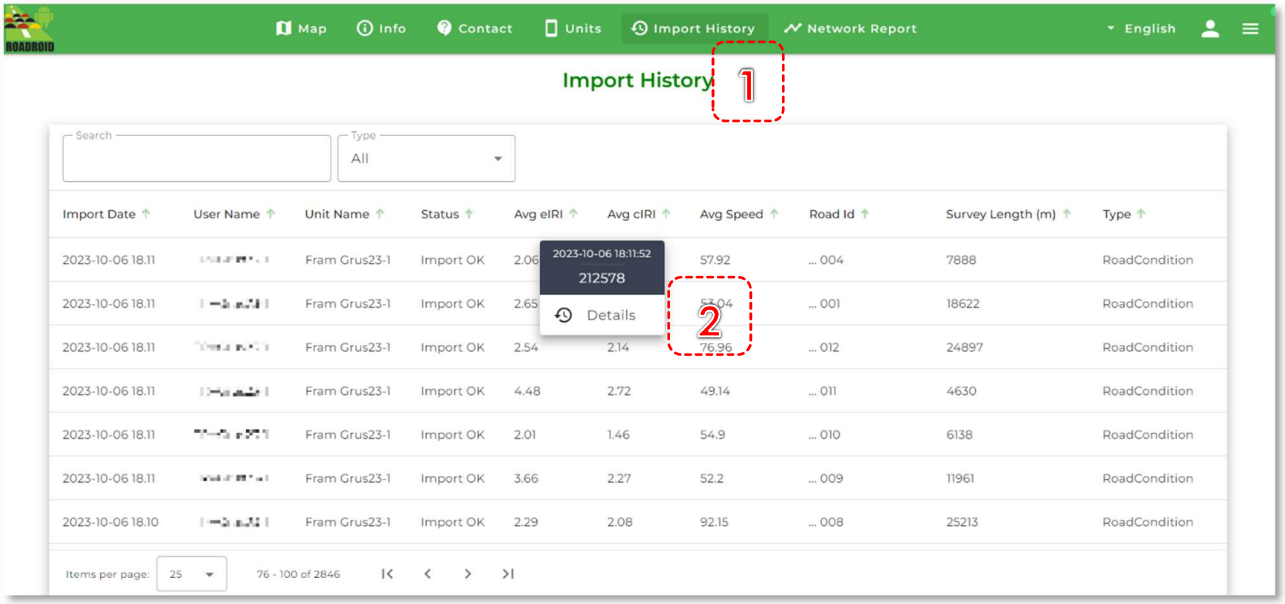
"Road Condition" will give you a summary of the road condition data.

"Road Inventory" will give you a summary of the inventory data.

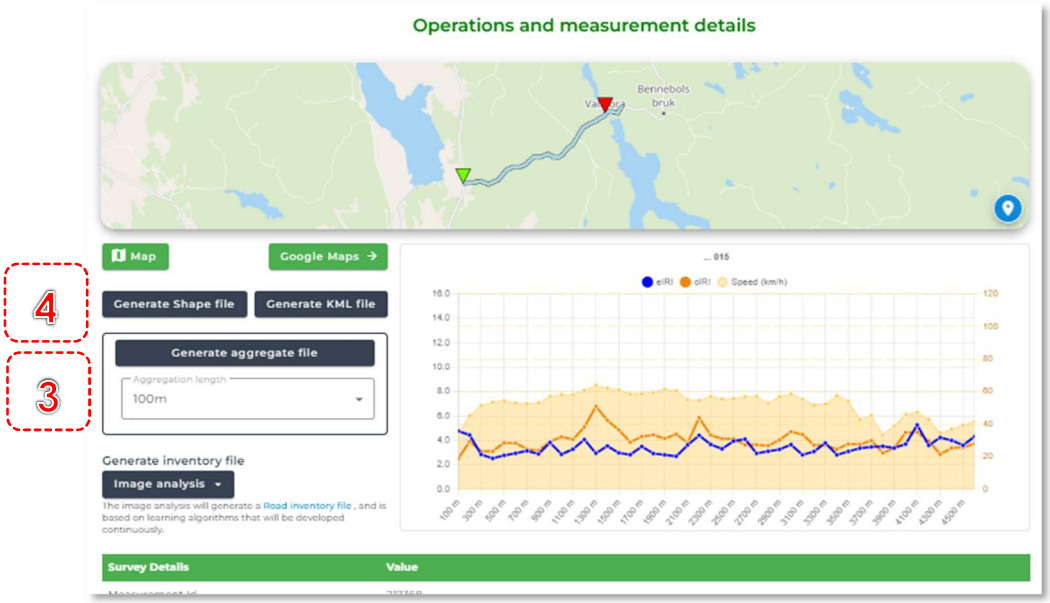
By toggling draw mode on you can click on the map to draw a polygon for an area to calculate. Close the polygon by double clicking. Click "Calculate" to calculate and you will get a summary of your chosen data category.

5. Download Aggregated Files

Data is saved in the phone every second between 20-100 km/h - the distance between these "points" will vary depending on the speed. To make tables and charts for studies on a road, or to import data to HDM-4, you need average data in fixed sections lengths. Through the "**Import History**" (1) you can download the data aggregated in sections as text files. The aggregation length can be between 5 and 200 meters.



Choose your file and click "**Details**" (2), to view the file details: Filename, Start/stop time etc. Here you have use of your RoadID note. The filename consists of IMEI - Survey start time.



There are functions to zoom into the location on a map, and to "**Generate Aggregate file**" (3). This operation will create a .txt file with data in preferred sections. Save or open the file to copy the data to MS Excel (next chapter).

The measurement can also be "**Generated as a shape- or KML-file**" (4) – giving the opportunity to build a spatial road database from your data or plotting it on Google

Earth. The shape file only contains geometry data, but the KML includes roughness data. See chapter 6.

Again: Make a good plan for data collection, with starts and stops in logical joints. It's then easier to make charts, to handle imports/exports and eventual shape file editing can be minimized in your GIS.

6. Make Charts from Aggregated Files

Mark all data in the aggregated .txt file and choose copy. Open MS Excel and paste it (or you can save the .txt-file and open it in excel). This guide is not teaching basic excel knowledge.

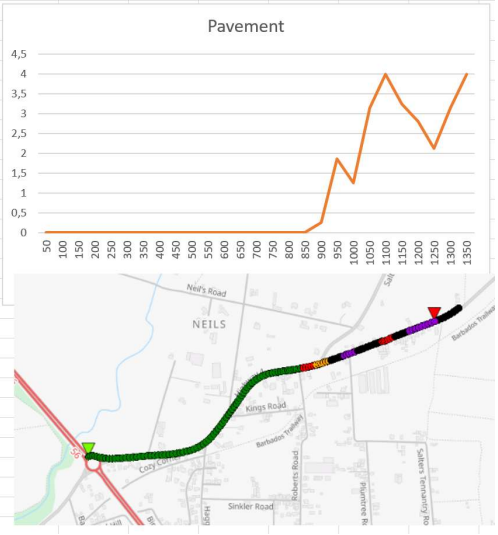
A tip is to name the tab with date and time, and possibly name of the actual section. In the aggregated file you will find following columns:

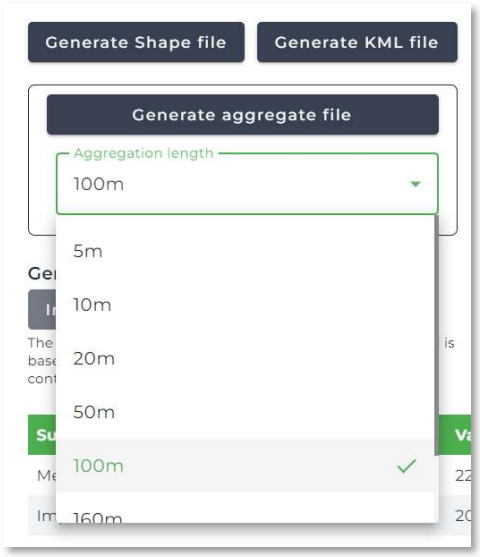
DateTime, Latitude, Longitude, Distance(m), Speed (km/h), Altitude (m), Grade (%), eIRI and cIRI and an eventual RoadID added before starting the survey.

eIRI is an estimated value - cIRI is calculated and its sensitivity and calculation segment length is adjustable in the app. See here for more information: *https://www.linkedin.com/pulse/20141130211746-97325448-roughness-and-texture?trk=mp-reader-card* .

When you have pasted/imported your data in excel, you can start making charts.

DateTime	Latitude	Longitude	Distance(m	Speed (km	Altitude (m	Pavement	Pothole	Camber/Pr	Drainage
11/22/202	13,11389	-59,5836	50	32	-7	0	0	0	0
11/22/202	13,11385	-59,5831	100	41	-6	0	0	0	0,14
11/22/202	13,11383	-59,5827	150	45	-6	0	0	0	1
11/22/202	13,11386	-59,5822	200	47	-5	0	0	0	1
11/22/202	13,1139	-59,5818	250	47	-4	0	0	0	1
11/22/202	13,11393	-59,5813	300	47	-3	0	0	0	1
11/22/202	13,11397	-59,5808	350	47	-3	0	0	0	1
11/22/202	13,11404	-59,5804	400	46	-3	0	0	0	1
11/22/202	13,11418	-59,58	450	47	-4	0	0	0	1
11/22/202	13,11444	-59,5796	500	46	-4	0	0	0	1
11/22/202	13,11478	-59,5793	550	44	-5	0	0	0	1
11/22/202	13,11514	-59,579	600	43	-4	0	0	0	1
11/22/202	13,11551	-59,5787	650	42	-4	0	0	0	1
11/22/202	13,11588	-59,5785	700	42	-3	0	0	0	1
11/22/202	13,11622	-59,5782	750	42	-2	0	0	0	1
11/22/202	13,11645	-59,5778	800	41	-1	0	0	0	1
11/22/202	13,11656	-59,5773	850	31	0	0	0	0	1
11/22/202	13,11662	-59,5769	900	30	2	0,25	0,12	0	1,12
11/22/202	13,1167	-59,5764	950	34	2	1,86	1	0	1,86
11/22/202	13,1168	-59,576	1000	34	1	1,25	1	0,38	1,25
11/22/202	13,11694	-59,5755	1050	36	1	3,14	1,29	3	3
11/22/202	13,11709	-59,5751	1100	37	1	4	3	3	3
11/22/202	13,11723	-59,5746	1150	41	2	3,25	2,12	3	3
11/22/202	13,11739	-59,5742	1200	16	2	2,8	1,13	2,8	2,8
11/22/202	13,11754	-59,5738	1250	29	3	2,12	2,88	2,12	2
11/22/202	13,1177	-59,5734	1300	40	3	3,14	2	3	2,14
11/22/202	13,11786	-59,5729	1350	43	4	4	2	3	2,83





The data aggregation length can be changed between 5 m to 200 meters. 100 meters is a usual import length in HDM.

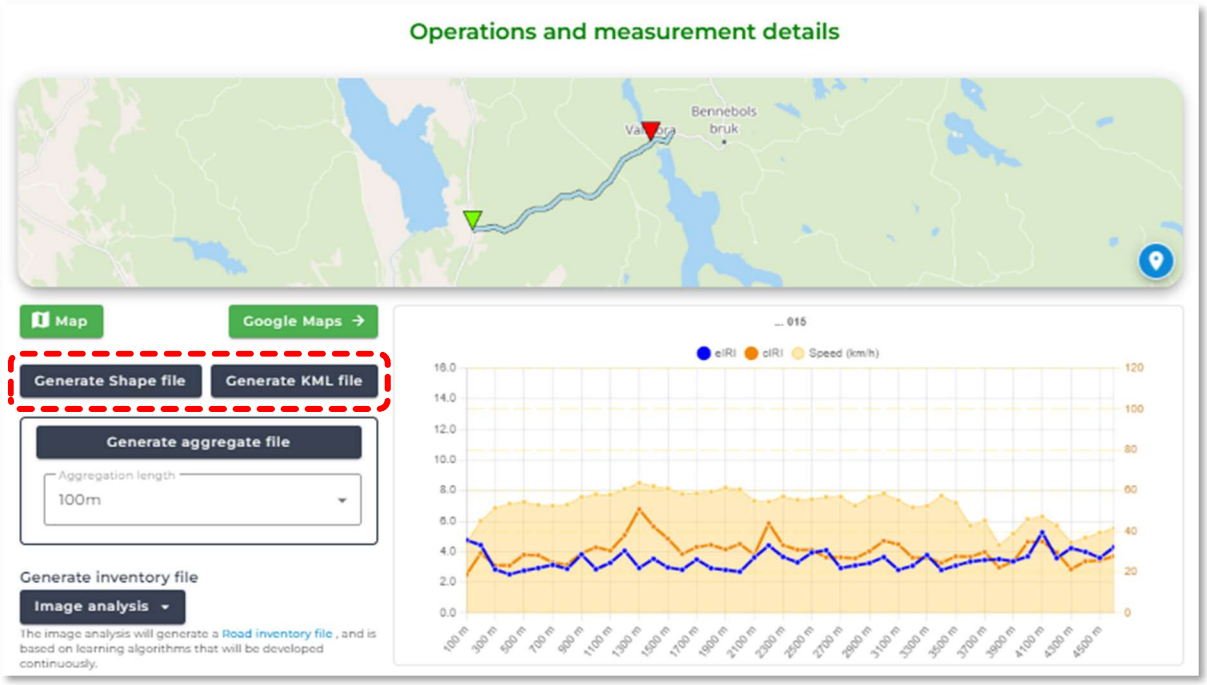
Speed and vertical profile are of value to get an overall view. The data can preferably be used with photos or snapshots from a GPS-video capture.

7. Spatial data exports

7.1 Single survey download

Under file details you have an option to export data in spatial formats as:

- Shape file (https://en.wikipedia.org/wiki/Shapefile) or
- KML (https://en.wikipedia.org/wiki/Keyhole_Markup_Language)



The shape file only contains the geometrical data (the .shp file of the four files in the zipped shape directory). The KML also contains roughness, speed and other attributes.

Please refer to your GIS-resources for working with these files and formats.

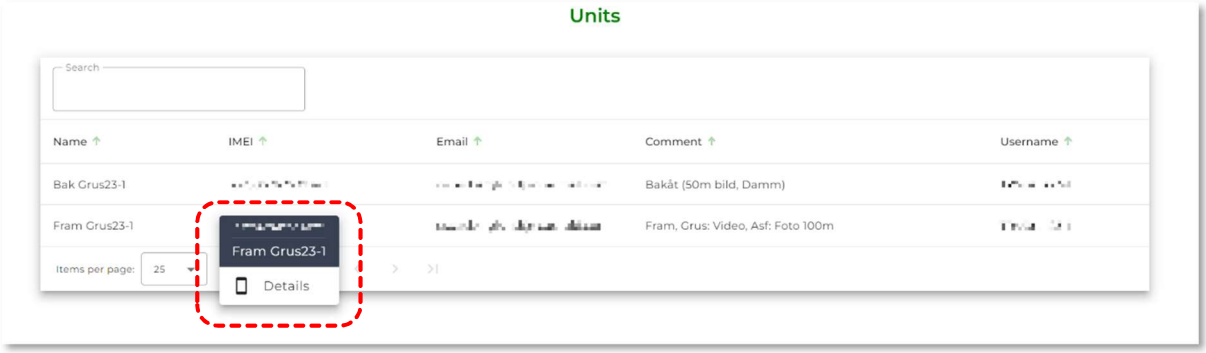
Roadroid can also offer custom or automated exports from a survey period and specific survey units.

7.2 Surveys period download

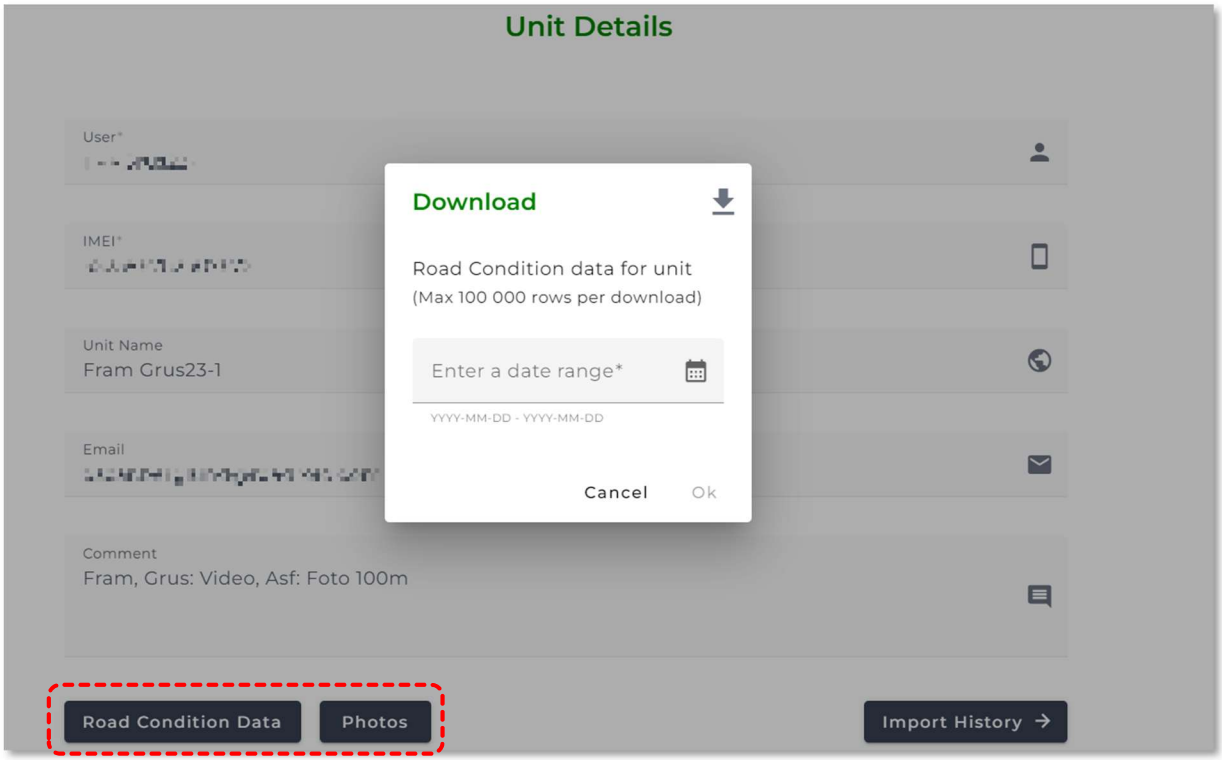
This is a function to export all data points (raw) data from a specific unit and a period.

To do this:

1) Log in and go to "Units".
2) Choose the certain unit and click "Details".



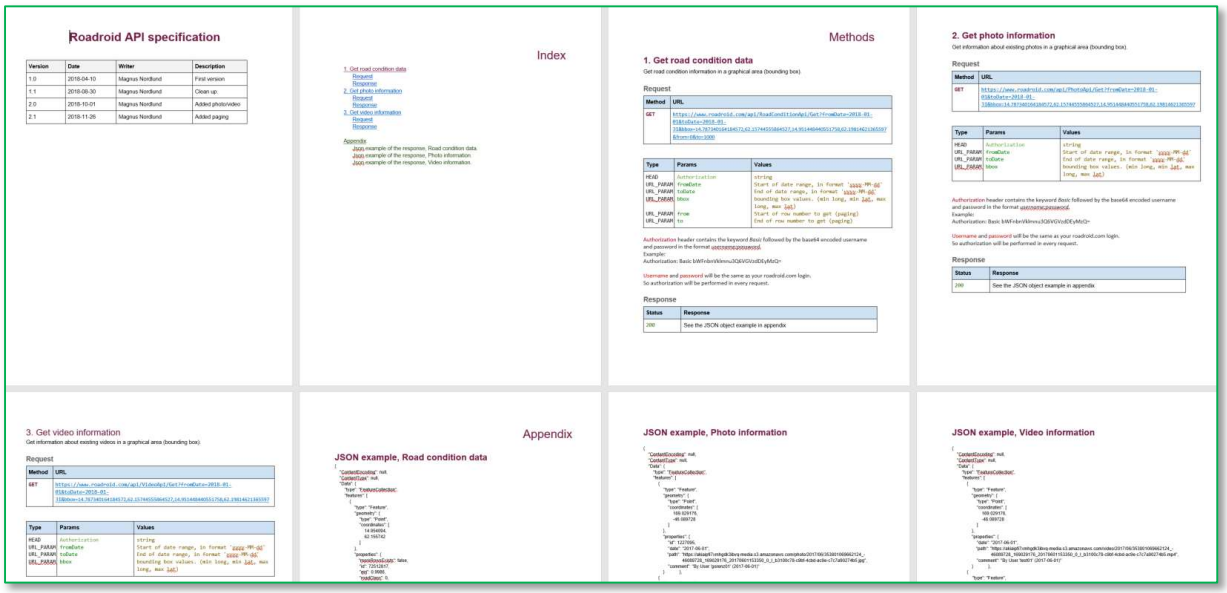
3) Click "Road Condition Data" or "Photos"
4) Choose a date range – and press "Ok".



Data for the period will be downloaded as a zipped .csv file with following columns: GpsId;unitId;MeasurementId;Timestamp;Longitude;Latitude;RoadClass;CalculatedIRI; EstimatedIri;SpeedInKph;Altitude;LinkId;OffsetOnLink;RoadId.

7.3 Using Roadroid API

This feature is described separately in (RoadroidAPISpecification) and only shortly described here. The API enables you to use the Roadroid data directly in your Assets/Maintenance Management or GIS through a webservice.



If you want to use the API, additional documentation is available at www.roadroid.com/info. Please also contact your Roadroid representative or send an e mail to market@roadroid.com for support.

8. Roadroid Inventory

8.1 Introduction

As photos and videos with GPS data can be captured with the Roadroid app we have created an additional complementary tool for Road Inventory. As a result, you get both objective road condition IRI – and records for road inventories.

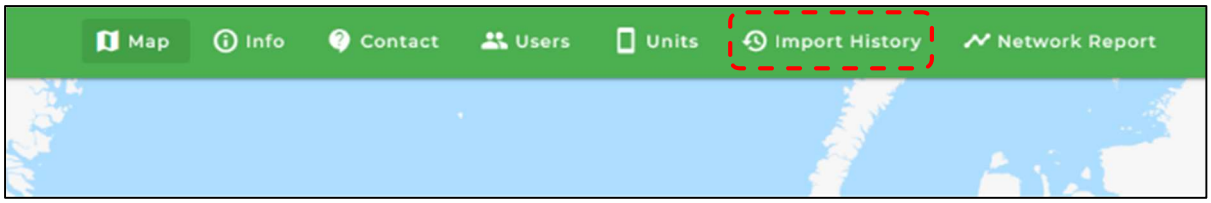
Benefits of road inventory from photos:

- Photos with GPS data can be captured with the Roadroid app for roughness IRI.
- You get both objective road condition IRI – and records for road inventories.
- No need to travel to site to view or rate the conditions; it can be done from an office anywhere.

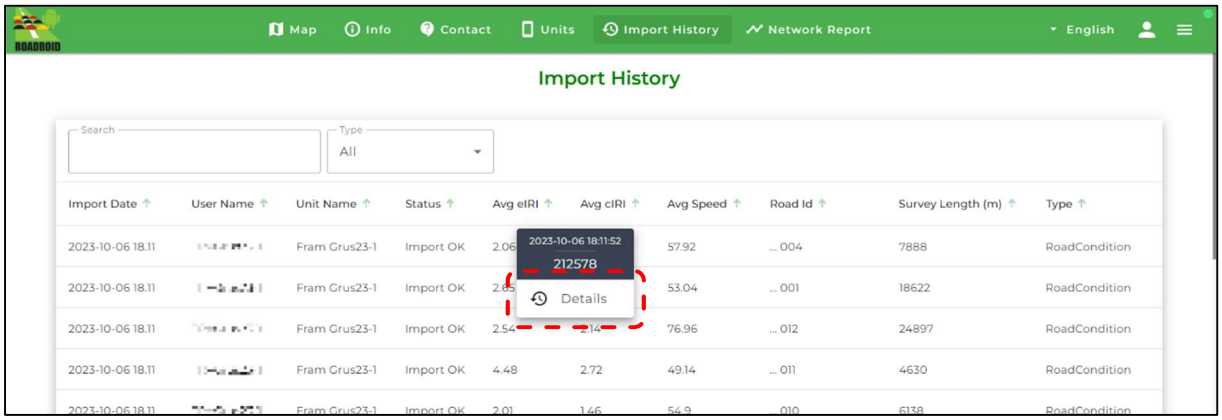
8.2. Road Inventory from photos

To perform an inventory using photos you first need to log in to the Roadroid website.

Next you click on the "Import History" tab.

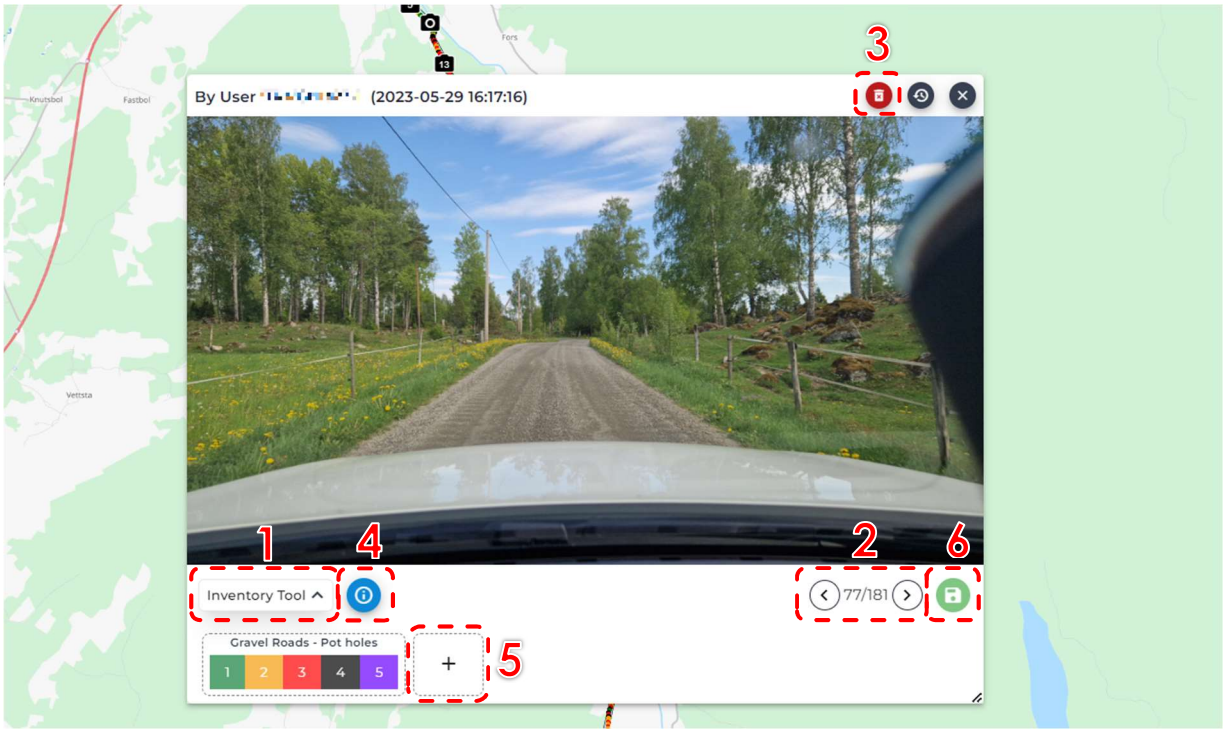


In the import history list, click on the survey you want to perform an inventory on and then click "Details".



On the details page, click on the "Map" button to show the survey on a map.

As the survey opens on the map, click on the first photo icon in the survey (the beginning of the survey is marked by a green triangle and the end by a red triangle). A photo window will open and there you can open and close the inventory toolbar by clicking the **"Inventory Tool" button** (1). By clicking the **arrow buttons** (2), you can go to the previous and the next photo. The numbers in between the arrows tells you what photo you are currently viewing and the total number of photos in the survey. By clicking the red **trash can button** (3), you can delete the current photo. The blue **"i" button** (4) will display a list of keyboard shortcuts.



To perform an inventory, follow these steps:

1. Click the **"+" icon** (5) to add an inventory parameter. You can add as many parameters as you like.
2. In each parameter, select the classification that corresponds to the current photo. (**1**/**green**=Good) (**5**/**purple**=Bad)
3. Click the **right arrow** button to proceed to the next photo. An inventory entry will be created for every GPS-point in the survey that is between the current photo and the next photo.
4. Repeat step 2 and 3 until you have gone through all the photos in the survey.
5. To finish and save the inventory, click the green **save button** (6) and enter your email address and a comment. The comment will be used as RoadID for the inventory.

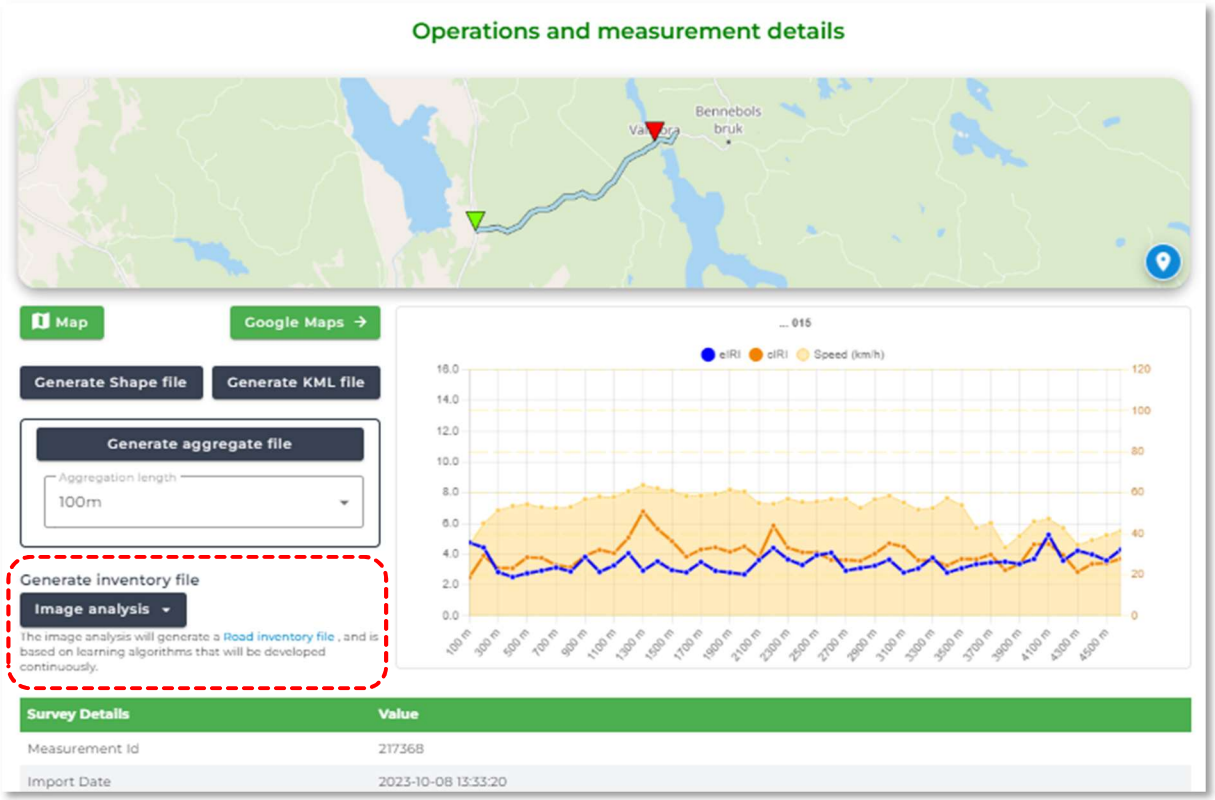
When finished, an inventory import file will be created in the background and automatically imported to your account as any other inventory/survey file (see chapter 4, "View data in Roadroid Web Services").

9. Image analyzing

The Roadroid Image Analysis module can be used for automated classification of various parameters based on survey photos. Currently the system supports classification of unpaved roads: Dust (photos from rear window), Corrugations, Potholes and Loose gravel. More parameters will be added continuously.

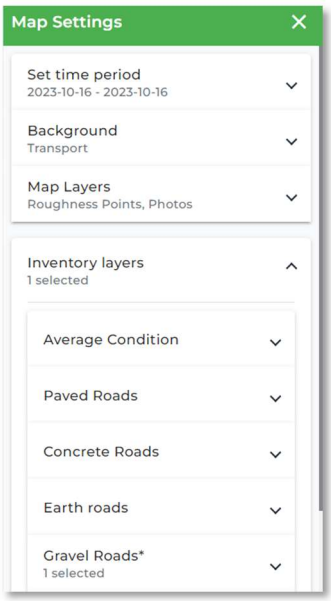
9.1 Getting Started

The Image Analysis module is available on roadroid.com for logged-in users. To start an automatic image analysis, simply navigate to the 'Import History List' and click on 'Details' for the survey you want to classify. The survey must be of type 'Road Condition'. On the survey details page, a dropdown menu is used to choose image classification algorithm and start the classification of the measurement photos. An email address and a comment can be submitted to help keep track of measurements.



9.2 Analysis Result

The result of the classification is a new survey of type 'Inventory (generated)', which will be accessible from the 'Import History List' when the classification process is finished. On the survey details-page of the generated measurement, the classification data can be exported in multiple formats, or viewed on a map by clicking the "Show survey data on map" link and selecting the preferred "Inventory layer" under "Settings". An asterisk (*) next to the category indicates available inventory data.



Generated inventory measurements contain some additional survey data; a link to the measurement from which it was generated, and the algorithm used to perform the classification.

Appendix 1: CALIBRATION PROCEDURE

To get Roadroid to perform an output according to IQL3 it is necessary to calibrate the device for the system used (Car, Phone and Survey speed). The calibration is carried out with the Android smartphone in the vehicle and can be performed by the customer.

Step 1: Identify Road sections with an accurate IRI

To to tune the Roadroid system, a section with an IRI defined with a more accurate IQL (1 or 2) should be used:

- IQL1 is often referred to as a laser profilometer and they exist in many different solutions and from different suppliers. These machines is complex to use, and it needs a professional set up and calibration procedure itself.
- IQL2 is referred to manual equipment as a rolling straight edge or Merlin. It is accurate but simpler than IQL1 equipment. As it is manually operated (rolled) along the road – it is time consuming to use.

It is also possible to use a leveling rod to determine the heights of points above a surface (should be done every 10 cm).

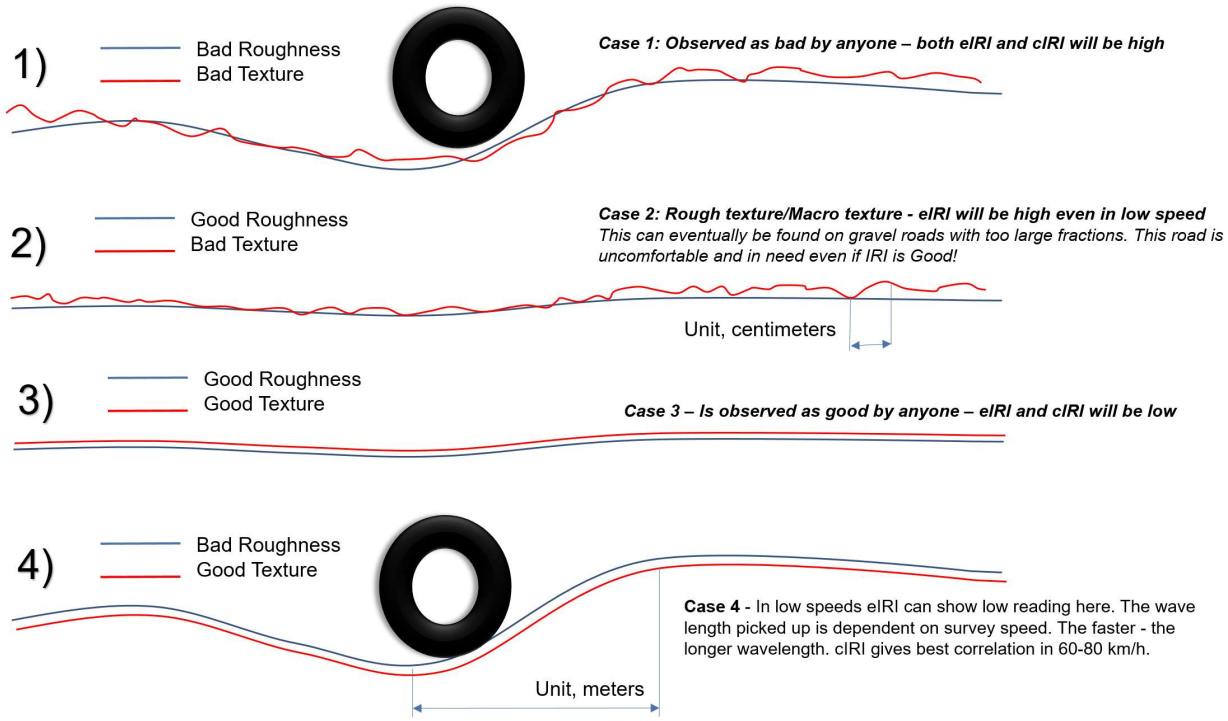
Subjective rating can be done as a reference, but it is not preferrable.

Demands on the calibration section/-s:

- A calibration section should be at least 300 meters long, higher speeds demand longer sections.
- The section/sections should be representative for the surveys you are going to perform.
- It is advisable to use sections containing different condition as examples:
    - Good paved road, with IRI values between 1-2 and a poor paved road, with IRI values between 3-5
    - Good gravel road, with IRI values between 2-6, and poor unpaved road with IRI values between 6-10
- The condition of the section should be consistent, possibly with a few short divergences along the section to be analyzed in the data.
- It should be possible to gain a sufficient and stable survey speed before entering the survey section, and enough length to stop safely after the section.

Comments on unpaved sections: Unpaved roads can be difficult or impossible to survey with IQL1 methods. The IRI on a poor gravel road vary a lot along a section so it is advisable to work mainly with a section average. IRI levels > 10 is difficult to quantify in general. Roads with IRI values > 15 is difficult or dangerous to drive in speeds above 20 km/h. For assets management, these poor roads are a matter of reconstruction and is not that important to quantify exactly with an IRI value.

General comments: The reference system should possibly give both one roughness value and one texture value. This makes it possible to tune the Roadroid system for both parameters.



In any case the calibration should be aware of the cases above, and that both roughness and texture is of interest for road assets management. It can also be a confusion in the calibration process as it's not always clear what the calibration reference survey was focused on.

After the test sections are marked visually it is time to make the test surveys.

Each section should be surveyed at least three times with each survey set up (same settings in the app and same surveys speeds).

The road can be marked with a spray can directly on the pavement, or by marker cones.

All works should be carried out according to ruling regulations for work on roads. It is best if you can work on a closed road or test facility.

- Mind traffic safety and choose time of day with low traffic impact.
- At the start of each run, use the Comment/Road ID to name the survey as "*Good Asphalt*". This tag will appear in the system import history list and help extract data.
- Try to keep the same wheel paths as the reference system. The device should also be placed at the same side of vehicle as the reference survey is made (IRI right or IRI left).

Step 2: Make surveys

Use a vehicle of the same type as you are going to use for the surveys later. Same type means a similar car body, like a 4WD, as similar cars to Toyota Highlux is VW Amarok, Nissan King-Cab/Navarra or Ford Ranger. Use normal cars, not extremely large SUV: s as Chevrolet Suburban or Ford Excursion, or a very small cars as Fiat 500 or Nissan Micra.

The driving operation is helped by a good plan, that should include a paper print of a table, where you can take notes while surveying. In the table you can plan what settings you are going to use, and leave open fields for actual time and eventual survey comments by pen while surveying:

Tip: If you have more than one unit, you can use 2 or 3 units with the same specification

Use same phone model and OS version,

and test different settings on the different phones.

By this you can save survey runs.

Use the desired future average survey speed during the calibration.

Upload your data after surveys and go to the office to download and assemble results!

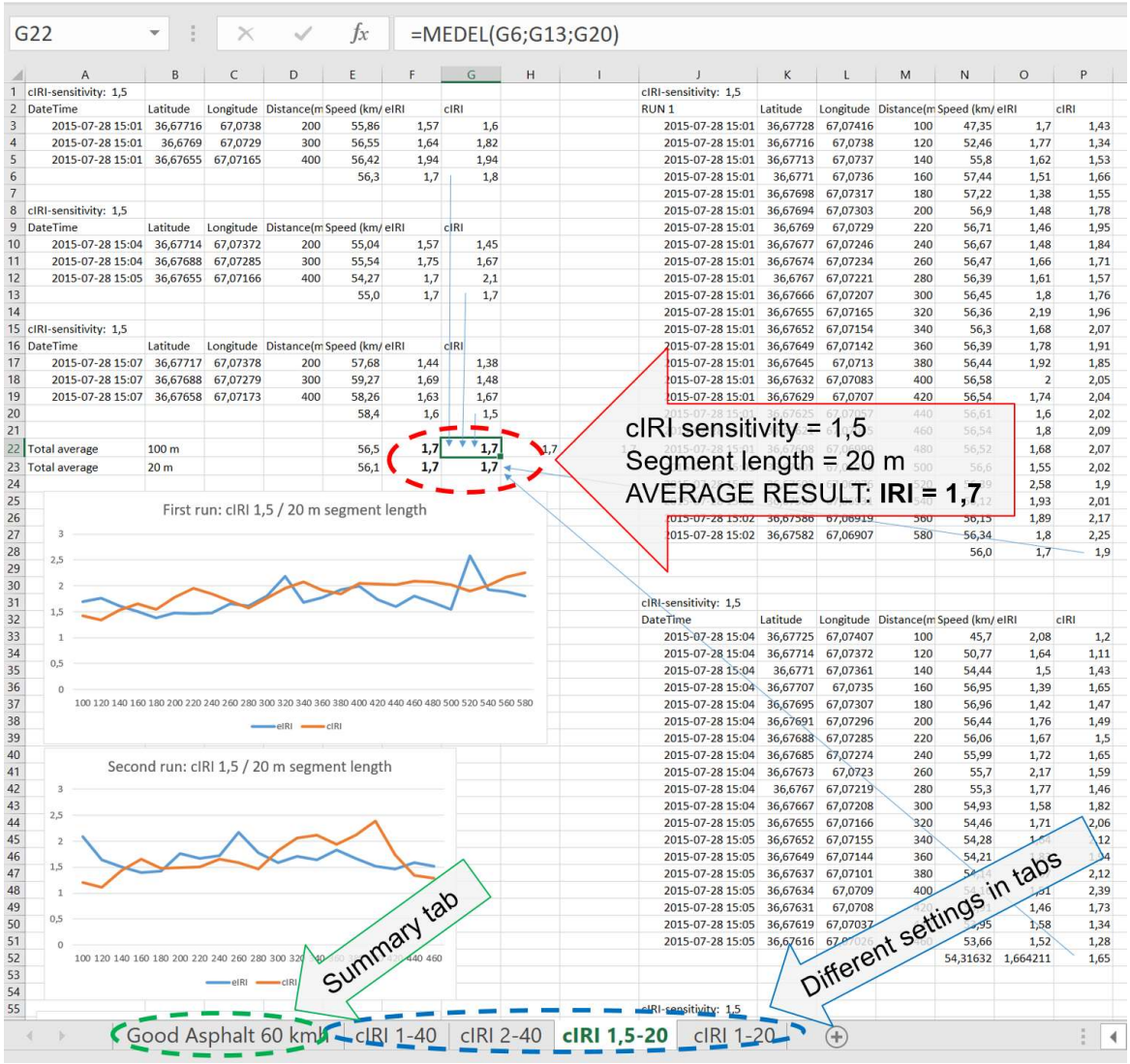
Step 3: Assemble Data from Calibration Surveys

A calibration survey operation requires a methodology with a good plan, patience, and MS Excel skills. When each section is surveyed three times with a certain setting, you can start evaluating the data. Data is extracted from the system according to the *User Guide Chapter 4– Download aggregated files*. As said – you are helped by having a name tag at the start of each survey.

Below is an example of how a suitable cIRI setting was identified for a paved road in good condition.

Assemble aggregated data from the three surveys in MS Excel. You can choose to use either 100 m or 20 m aggregation length form the system (averages for the whole sections should be the same). 100 m files mean less data to handle, while 20 m file is more convenient for plotting a graph from.

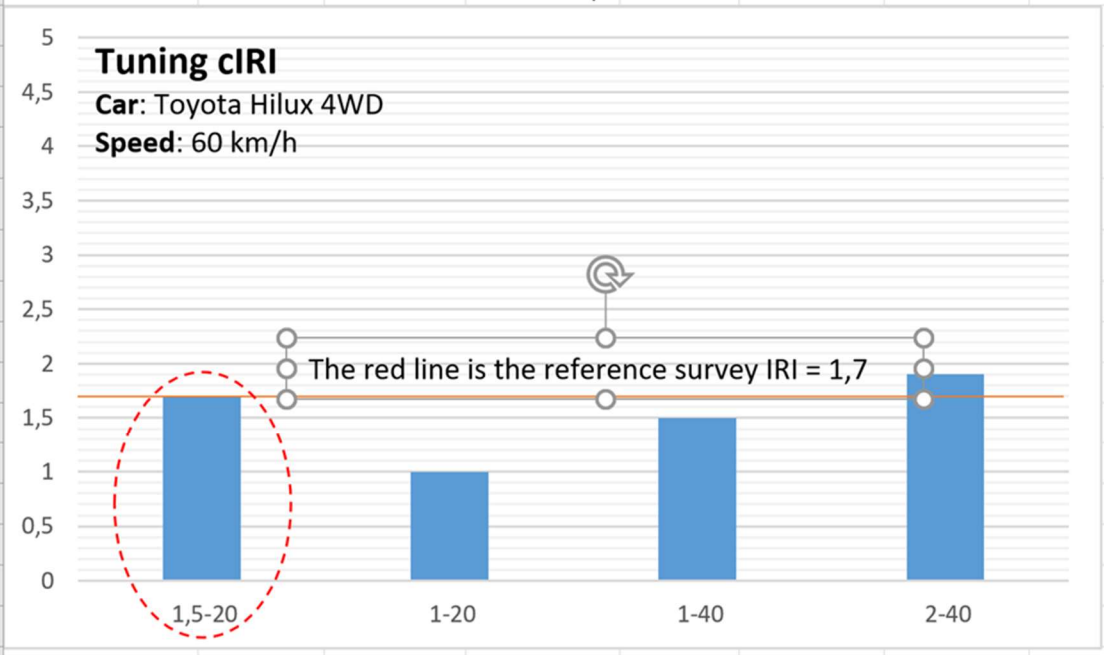
In the example below the setting of cIRI sensitivity was 1,5 and calculation section length 20 m. The output resulted in an average of **IRI =1,7** (in red dotted circle below). Each survey setup can be assembled separately in tabs in Excel (blue dotted circle below).



Each run from each tab is summarized in a separate tab (green dotted circle above).

In the summary tab, you assemble the averages from (in this case four different) the cIRI settings:

	A	B	C	D	E	F	G	H
1	**Summary section 2 - Good Asphalt road**							
2	**Road name**	Example road						
3	**Road type**	New pavement						
4	**Survey speed**	60 km/h	**IRI = 1,7**					
5	**Survey name**	cIRI settir	cIRI avg	eIRI avg				
6	2-1 - 2-3	1,5-20	**1,7**	1,7				
7	2-4 - 2-6	1-20	1	1,8				
8	2-1 - 2-3	1-40	1,5	1,6				
9	2-4 - 2-6	2-40	1,9	1,7				
10				1,7				



The outcome from this calibration event was that, for the specific Toyota Hi-Lux in 60 km/h (55 km/h in survey data) a sensitivity of 1,5 and a segment length of 20 m is suitable. The output can be presented in different manners and you need to define your preferences. It is a good learning exercise to plan, perform surveys and evaluate the result. We hope you can make it yourself from these instructions, but Roadroid can offer to support the process as consultants.

Phone	eIRI sens	cIRI sens	eIRI avg	cIRI avg	Texture reference	Roughness reference
1	1,0	1,5	3,7	2,5	6-10	8-15
2	0,75	2,5	5,0	5,5		
3	0,5	3,5	8,6	11,3		

Table 189:2– Eastbound

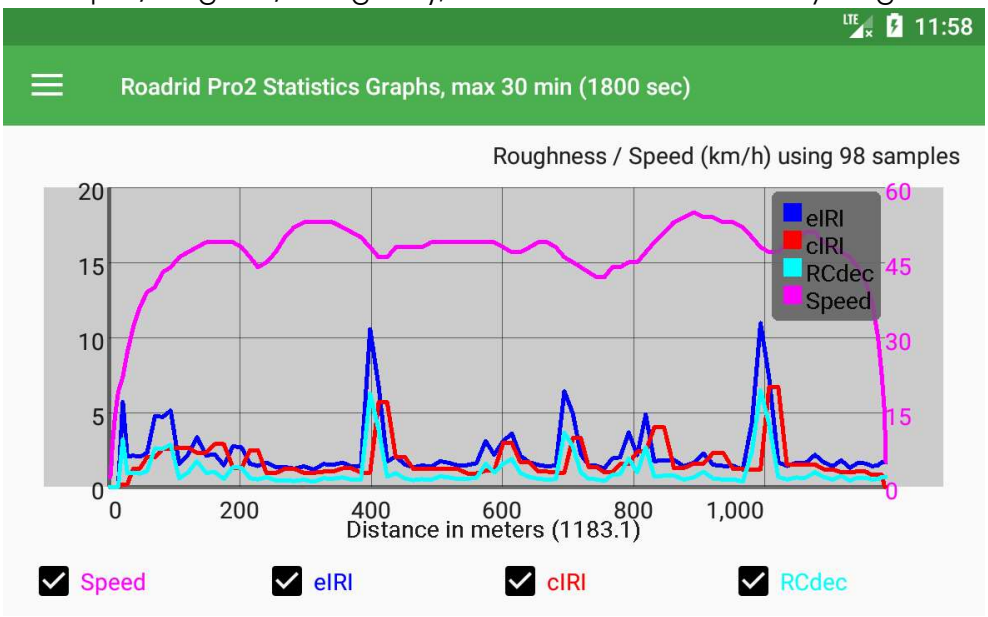
Adjustments are done according to user guide chapter 1, Collect data (Survey and presets).

Observe that the settings of sensitivity on cIRI and eIRI are saved and transferred with the survey file.

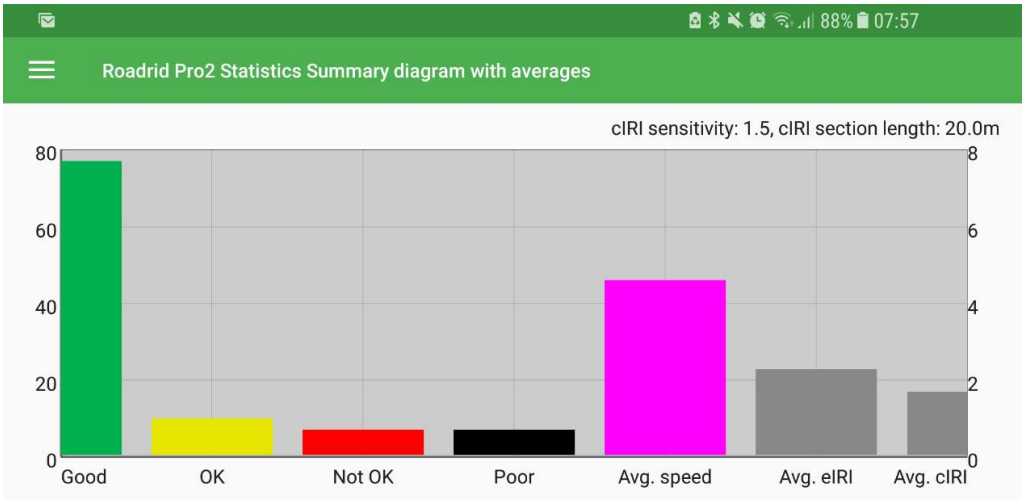
Step 4: System checks and infield readings

The system should be regularly checked (at least annually or after major system changes and an OS update, wheel, or suspension change).

If you have access to a test track with a stable know IRI it's possible to make a run through that and monitor the result directly in the app (Survey and Presets > Graphs/diagram/histogram), both as charts over survey length…



And as averages for a whole section…



This gives an opportunity to recheck the system without completing a whole calibration procedure.

The operator of the system (vehicle/phone and Roadroid app) is responsible for maintaining calibrations and should use a logbook detailing the times and dates of rechecks and calibrations.

Appendix 2: Comments on GPS-accuracy, survey distance and altitude

The accuracy of the distance is dependent on a number of parameters connected to the quality of manufacturers internal GPS, current number of satellites in the hemisphere and the vehicles current reach of open sky.

In tunnels (urban canyons or dense vegetation) where the system loses contact with satellites the system uses dead counting for 6 seconds, estimating the vehicle position using the speed and direction when the contact was lost. If the system can't reach enough of satellites after these 6 seconds, the system will stop collecting data until contact is regained.

The phone's GPS system can be supported by a Bluetooth GPS with an external antenna connected to the system. An antenna that can be mounted on the car's roof top can give a better signal than a phone mounted inside the vehicle. We see a number of other factors affecting GPS accuracy, as new phones constantly produce more accurate circuits and the satellite operators introduce new and more accurate services.

A modern smartphone should produce an accuracy better than a few meters in absolute accuracy for an individual reading, sometimes often much better.

Survey distance: It is possible that the system gives different results on the length calculations for a section. The reason is the accuracy dependencies above – but also when you press the start and stop button, and the actual GPS-location of the starting and stopping point of a survey.

Altitude: The Z coordinate and vertical height above sea level sometimes produce an offset. Is it not considered to be as accurate as the Long/Lat values. It gives a more reliable relative change in altitude rather than an absolute reading of the altitude.