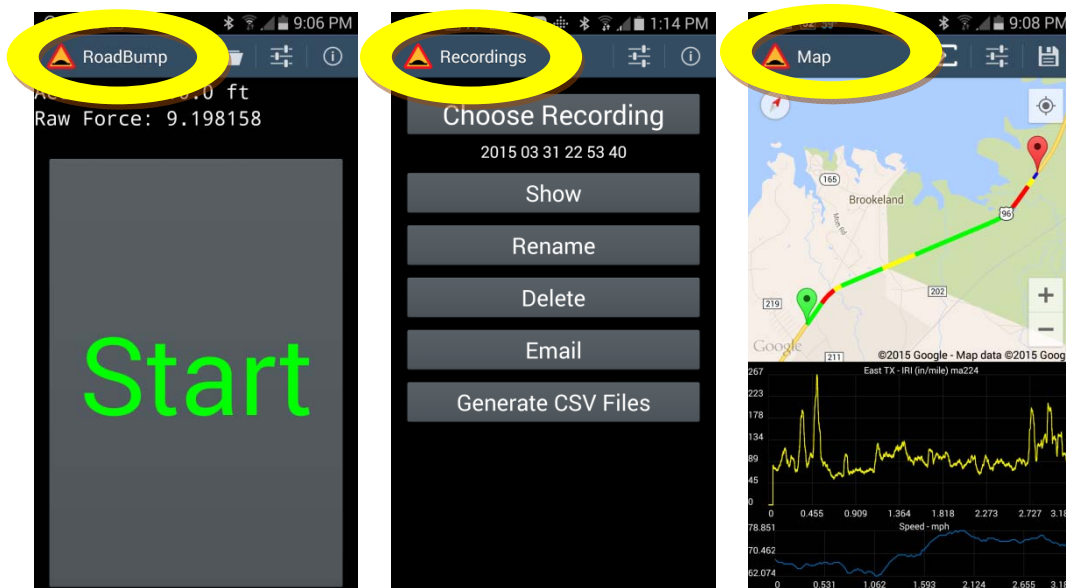


RoadBump User's Guide

RoadBump is an app that measures the roughness of a road. It uses your device's accelerometer and GPS sensors to record vibrations as you travel down a road. The app provides a color coded path on a map showing the roughness of the path you recorded. It also provides graphical representations of the vibrations (roughness) from the road - expressed as an estimated International Roughness Index (IRI) and Present Serviceability Rating (PSR).

The data captured and generated by RoadBump can be emailed, moved to a cloud service (Google Drive, DropBox, etc) or copied to a PC for further analysis.

This document is laid out in five sections. The first three correspond to the three screens you see in the RoadBump app titled "RoadBump", "Recordings" and "Map":



The final two sections cover the layout of the files produced and tips for best results.

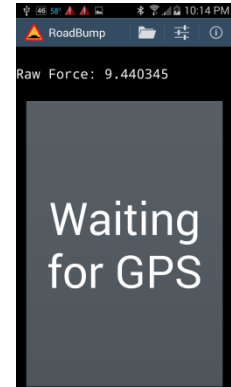
Please contact us with questions, problems or suggestions by email to Dave@GrimmerSoftware.com or visit us at www.grimmersoftware.com



RoadBump User's Guide

Section 1 - RoadBump Start / Stop Screen

When RoadBump starts, you will briefly see a screen saying "Waiting for GPS". RoadBump must have GPS enabled to record data.



Once RoadBump has a good GPS signal, it changes to showing a giant Start button. This is when you should place your device on the dashboard or in a windshield mount. The giant Start button is easy to hit when the phone is laying flat on the dashboard or at arms length in a windshield mount.

Press Start and begin driving. It's OK to start from a standstill or while you are moving.

When you press the Start button, it changes to being the Stop button.

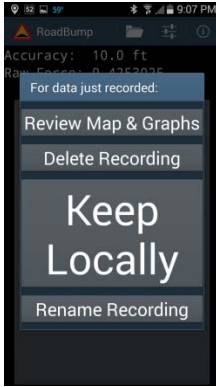
After you have reached the end of the path you are recording, pull off the road and press the giant Stop button. You should not press the stop button until you are at least 1 second past the endpoint of the path you want to record



Congratulations! You have just recorded and measured the roughness of a road!



RoadBump User's Guide



When the Stop button is pressed, you are presented with the following choices:

Review Map and Graphs

This choice takes you to the screen that shows the path you recorded graphs of the road roughness and your speed along the recorded route. This is the heart of the app and the reason you use it. When you leave the Map and Graphs screen you are returned to this set of choices. The Map and Graphs screen is described in more detail in the Map and Graphs Screen section further down in these instructions.

Delete

This choice deletes the data you just recorded and takes you back to the giant Start button.

Keep Locally

This choice keeps the data you just recorded in a set of files with a naming convention of YYYY MM DD HH MM SS. After choosing this option you are taken back to the giant Start button.


Rename

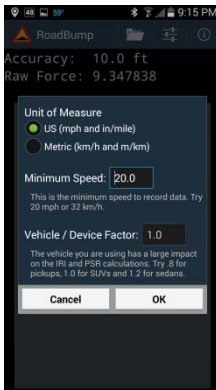
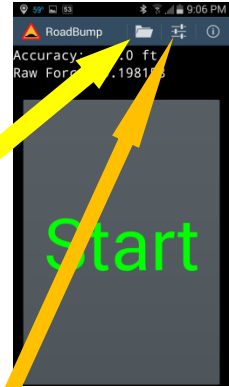
This lets you keep the data you just recorded in a set of files that you name. After choosing this option you are taken back to the giant Start button.




RoadBump User's Guide

Working with recorded data (Recordings)

To get to road recordings you have made and kept, touch the Recordings (folder) icon  from the top of the giant Start button screen (or the Waiting for GPS screen). The Recordings screen is described in the next section.



The  Settings icon at the top of the screen allows you to:

- Select US or Metric
- Set a minimum speed at which to begin recordings
- Set a factor to adjust for the type of vehicle you are driving



RoadBump User's Guide

Section 2 - Recordings Screen

The Recording screen offers these choices:

Choose Recording

This lets you choose a recording to work with. You have to choose a recording before any of the other choices will work.

Show

This screen is described in detail in the Map screen section in Section 3.

Rename

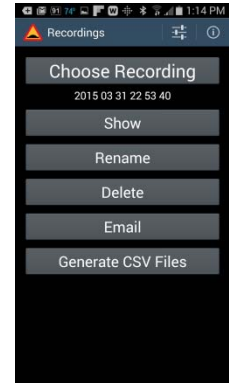
This choice allows you to change the name of an existing recording.

Delete

This choice allows you to delete a recording.

Generate CSV Files

This choice presents you with the option to create 3 types of CSV extracts. You can also specify a different Vehicle / Device Factor than what was used when the recording was made. A different factor will affect the CSV files generated, but it does not change the underlying data.



Interpolated

The GPS data is recorded once every second and the accelerometer data is recorded about 100 times per second. The interpolated file combines the GPS and accelerometer data into 1 file that can be opened by MS Excel. The GPS file contains latitude, longitude and speed values. These values are interpolated to provide a value for every accelerometer record. The resulting file from this choice will have an extension of .Interpolated.csv. The data in a spreadsheet is shown in the image below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Time	Raw	MovingAvg	Speed (m/s)	t(s)	x(km)	x(miles)	delta t(s)	IRI (in/mile)	IRI (m/km)	PSR	Diff	Int Long	Int Lat	Int Speed (m/s)
2	1,424,966,680,629	9.2719965	9.441717	30.5	0.8059998	0.024683122	0.015337382	0.005	68.44481	1.0802526	3.7756488	0.16972065	-93.99048995	31.12945616	30.49899864
3	1,424,966,680,641	9.449669	9.463412	30.5	0.81799984	0.025049122	0.015564803	0.012	31.37556	0.4951951	4.3959656	0.013743401	-93.99049	31.1294595	30.49599266
4	1,424,966,680,650	9.127833	9.395327	30.5	0.82699984	0.025323622	0.01573537	0.009	95.11858	1.5012403	3.384193	0.26749325	-93.99049003	31.12946202	30.49373817

Segment Level

This choice summarizes the IRI and PSR data to the segment level. The CSV file can be emailed and then opened with a spreadsheet. The data in a spreadsheet is shown in the image to the right.

	A	B	C	D
1	From Mile	To Mile	IRI Avg	PSR Avg
2	0.00	0.10	81.51	3.58
3	0.10	0.20	96.28	3.37
4	0.20	0.30	85.07	3.53
5	0.30	0.40	134.52	2.88
6	0.40	0.50	146.27	2.74
7	0.50	0.60	115.82	3.11

Accelerometer & GPS

This choice will convert the binary accelerometer and GPS files captured in a recording to CSV files. The CSV files can be emailed or copied to a PC for further analysis. The layouts of the .acc.csv and .gps.csv files produced are described in Section 4.



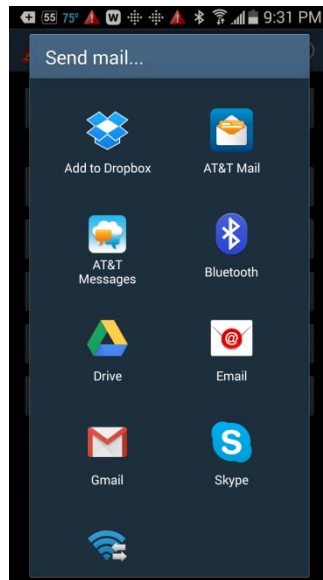
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Email

This choice will bring up a list of Android applications that are capable of sending files. If you move the data files with email, you can use the

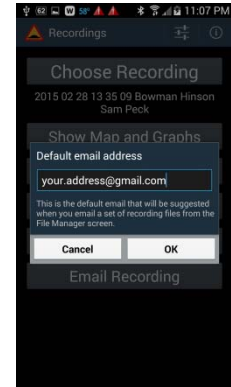


settings icon  at the top of the screen to set a default email address for the files to be sent to. The files that get attached to the email (or sent to a service like Google Drive or Dropbox) are the:

- Accelerometer data (.accb)
- GPS data (.gpsb)
- 1 record info file (.info)

Also, if you have generated any of the following, they will be attached too:

- Interpolated (.interpolated.csv)
- Segment Level (.SegmentLevel.csv)
- Accelerometer and GPS (acc.csv and gps.csv)



RoadBump User's Guide


Section 3 - Map Screen



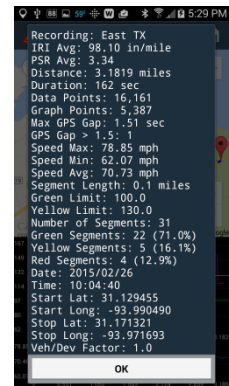
The Map Screen is the heart of RoadBump. It is where you see the path traveled on a map and where you see a variety of graphs indicating the roughness of the recorded path.


The longer the recording is the longer it takes to bring up the screen. A 45 minute recording covering 47 miles takes about 11 seconds to load on Samsung Galaxy S4. This involves reading and displaying over 300,000 accelerometer records and 3,000 GPS records.

At the top of the Maps screen there are 3 buttons:

Summary –  - This provides a summary of the data between the map markers. The fields in the summary are:

- Recording: base name of the recording
- IRI Avg: average IRI for all data between the markers
- PSR Avg: average PSR for all data between the markers
- MA Dev Avg: average deviation from the moving average
- Dist-Path: total distance of the recorded path between the markers
- Duration: number of seconds of data between the markers
- Data Points: number of accelerometer records between the markers
- Graph Points: number of accelerometer records in the graph
- Speed Max: maximum speed found between the markers
- Speed Min: minimum speed between the markers
- Speed Avg: average speed between the markers
- Segment Length: length of each step in the IRI Step graph
- Green Limit: IRI limit for green segments on the map
- Yellow Limit: IRI limit for the yellow segments on the map
- Number of Segments: number of segments in the IRI Step graph
- Green Segments: number of green segments in the IRI Step graph
- Yellow Segments: number of yellow segments in the IRI Step graph
- Red Segments: number of red segments in the IRI Step graph
- Date: date the recording was made
- Time: time the recording was made
- Start Lat: latitude of the start marker
- Start Long: longitude of the start marker
- End Lat: latitude of the end marker
- End Long: longitude of the end marker
- Veh/Dev: Vehicle / Device constant applied in the recording




Settings –  - This gives you control over these settings that affect the Map and Graphs screen:

- Color coded map line (selected or not)
- Green Limit (IRI limit for segments shown as green)
- Yellow Limit (IRI limit for segments shown as yellow)

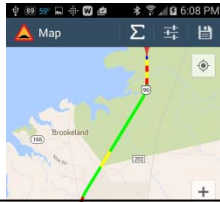


RoadBump User's Guide

Vehicle / Device Factor (does not change underlying data)

Save –  - This allows you to create a new recording from the data contained between the map markers.

The top half of the screen is a map from Google Maps. It can be zoomed and rotated. Your recorded path goes from the green marker to the red marker. The markers can be drug to any point on the line. When you move a marker, the graph below changes to show you the data between the markers. Under the menu button you can choose to see the map as a satellite image instead of the normal map.



The map line by default is color coded. Green segments are smooth, yellow are medium rough and red is very rough. The values that dictate the colors can be changed with the Settings button at the top of the screen.



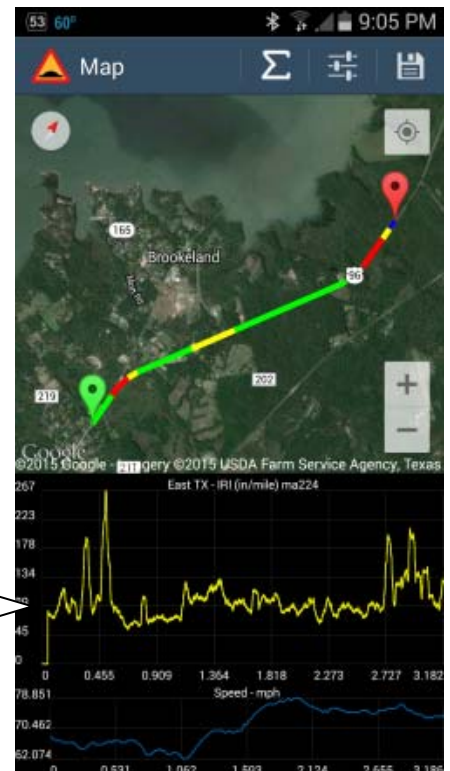
The map can be changed between the Normal (road map) and Satellite view with the Menu button.

The lower half of the screen consists of two graphs. The bottom graph always shows your speed on the path between the markers.

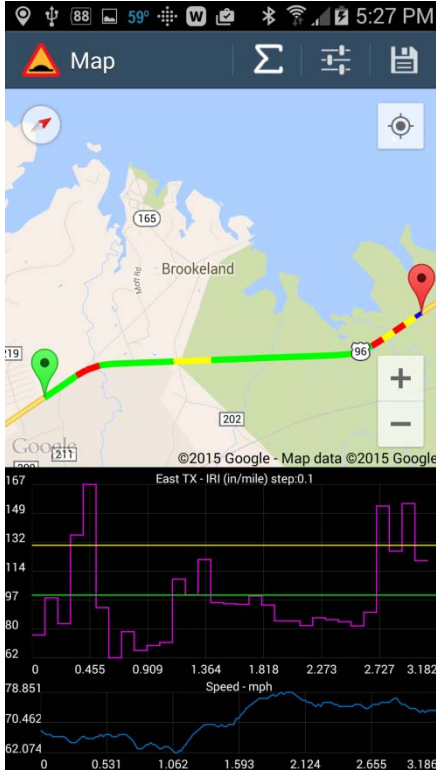
The upper graph is controlled from the Menu button. The menu choices from the map screen that affect the graphs are:

IRI Moving Avg Graph - IRI is the International Roughness Index. This is the industry standard was to describe the roughness of a road. RoadBump approximates this value using the equation of motion and differential equations.


The IRI Moving Avg Graph uses a variable sized moving average. The number of accelerometer readings being averaged into each point on the graph varies with the number of accelerometer records between the markers. There will always be a minimum of 25 records used to calculate the moving average. The title of the graph includes the number of records used in the moving average. The ma274 text in the title of the IRI graph means that each point in the graph is the average of the preceding 274 accelerometer records

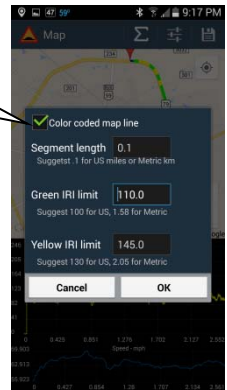


RoadBump User's Guide

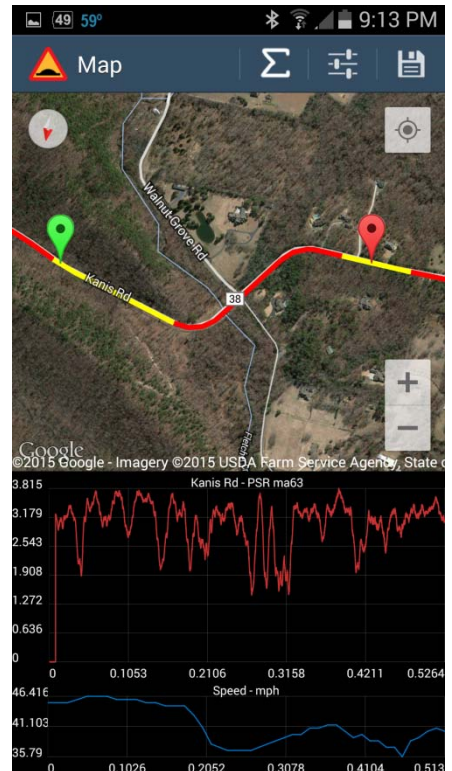


IRI Step Graph – This graph is another way of looking at the IRI of the road. Instead of a moving average, it shows the average for each (user defined) segment. The example here shows 31 segment averages where each segment is 1/10th of a mile. The yellow and green horizontal lines indicate the IRI limits used in the colored map line.

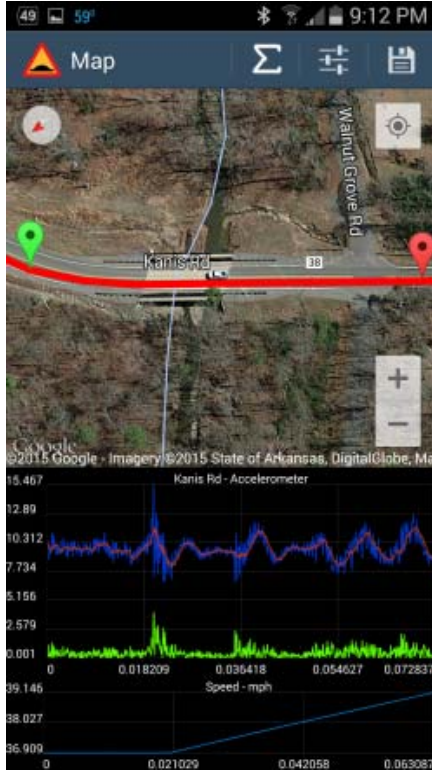
The segment size, green IRI limit and yellow IRI limit are set with the settings button on the action bar .



PSR Moving Avg Graph - PSR is the Present Serviceability Rating. PSR is a subjective rating from 0 (almost impassable) to 5 (fantastically smooth). PSR is estimated as a logarithmic function of IRI.



RoadBump User's Guide



Accelerometer Graph - The accelerometer graph is really 3 graphs in one. The top blue line is the raw accelerometer reading. The red line is a moving average of the blue line. The green line is the absolute value of the difference between the raw and moving average lines. This will show precise positions for specific bumps.

In the example on the left, the accelerometer graph shows the “bumps” in the road associated with each end of the bridge and the rough area where Walnut Grove Rd joins Kanis Rd.



RoadBump User's Guide

Section 4 - File Layouts - All 5 file types listed below are all in comma separated values (CSV) format. MS Excel is able to read this file type. The .info file is produced automatically (along with the .accb and gpsb files) when you make a recording. The .accb and .gpsb are binary files that are only usable by RoadBump.

.acc.csv - 1 record for every accelerometer event, generally 100 per second.

Date and Time - Big integer representing how many milliseconds since 1/1/1970
Combined Force - Accelerometer force sensed in meters per second squared
Moving Average - of combined forces over 10 records
Most Recent Speed - in meters per second
Total Time - in seconds
Total Distance Km - Running total of distance in km
Total Distance Miles - Running total of distance in miles
Increment Time - time since last record
Inches Per Mile IRI - IRI for this point in inches per mile
Meters Per Km IRI - IRI for this point in meters per km
Present Serviceability Rating - PSR for this point

.gps.csv - 1 record for every GPS event, generally 1 per second

Date and Time - Big integer representing how many milliseconds since 1/1/1970
Longitude - of the recorded point
Latitude - of the recorded point
Speed - in meters per second

.info - 1 record file

XX:XX:XX:XX:XX:XX - not used

Device / Vehicle Factor - used to modify the results for the type of vehicle and device used

.Interpolated.csv - combination of the GPS and Accelerometer data with GPS values interpolated across the accelerometer records to provide a location and speed for every record.

Date and Time - Big integer representing how many milliseconds since 1/1/1970
Combined Force - Accelerometer force sensed in meters per second squared
Moving Average - of combined forces over 10 records
Most Recent Speed - in meters per second
Total Time - in seconds
Total Distance Km - Running total of distance in km
Total Distance Miles - Running total of distance in miles
Increment Time - time since last record
Inches Per Mile IRI - IRI for this point in inches per mile
Meters Per Km IRI - IRI for this point in meters per km
Present Serviceability Rating - PSR for this point
Difference - absolute value of moving average minus combined force
Interpolated Longitude - of the recorded point
Interpolated Latitude - of the recorded point
Interpolated Speed - in meters per second



RoadBump User's Guide

.SegmentLevel.csv - combination of the GPS and Accelerometer data with GPS values interpolated across the accelerometer records to provide a location and speed for every record.

From Mile (or km) – Beginning distance of segment

To Mile (or km) – Ending distance of segment

IRI Avg – IRI average of segment

PSR Avg – PSR average of segment



RoadBump User's Guide

Section 5 - Tips for Best Results

Device Configuration

- Put your device in Airplane mode to avoid time differences between cell towers, interruptions and to save battery life
- GPS must be on
- Confirm minimum speed setting is what you want
- Confirm Vehicle / Device setting is what you want
- Check battery status - heavy draw on the battery

Device Placement - from Best to Worst

- Flat spot on a non-slip pad on the dashboard
- Non-slip pad on center console
- Windshield mount (the steadier the better)
- Floor (keep from sliding)
- Cup holder (keep from moving)
- Seat (keep from bouncing)
- Thigh (really!)
- Hand (last resort)

Driving

- Start RoadBump while your vehicle is at rest
- Come to a full stop before ending the recording
- Set a minimum speed so you don't have to start or stop RoadBump while driving
- Record at least a few seconds before and after the path you are measuring – you can easily set the start and end markers and save the smaller path later
- Record long paths in 1 run and later save smaller sections as individual recordings
- Best results are around 40 to 60 mph
- Calculations are done based on testing on tracks with known at speeds between 30 and 60 mph. The estimated IRI results from speeds outside this range are projected from the test data.
- Use cruise control where practical
- Accelerate and brake smoothly
- Drive the same path multiple times, focus on consistent lane positioning
- If it's windy, it will affect the recording

Reviewing Results

- Rotate the map so your path goes from left to right – that helps match up events in the graphs with their location on the map
- Get the start and end markers close to where you want them and then zoom in on the map and change to the satellite view to place them precisely. The markers will snap to points on the path where the GPS data was recorded (every 1 second).
- If you don't have a network or cell connection, you can still review the results. You can have a detailed map without a network connection if you use the "Save offline map" feature in Google Maps.

