Harry's GPS LapTimer

Documentation v1.6

DRAFT | NEEDS PROOF READING AND NEW SNAPSHOTS

Harry's Technologies

Scope

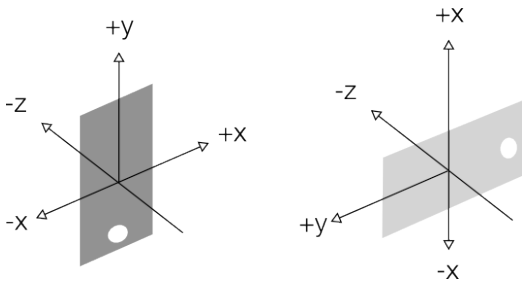
This paper is part of LapTimer's documentation. It covers all available editions LapTimer comes in – both for iOS and Android. In case functionality or wording differs, the document marks the respective sections using and Apple or a Droid . For historical reasons, most snapshots are iOS pictures. However, as both apps converge over time and will show only minor differences, pictures are not doubled in general.

For further documentation http://www.gps-laptimer.de/documentation is the first address for everything.

Acceleration Handling

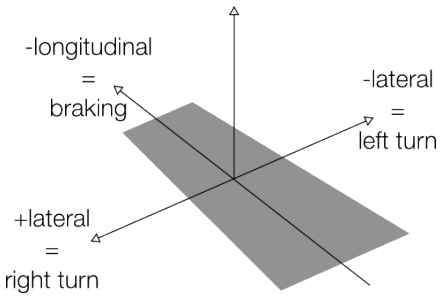
Overview

All modern smartphones feature accelerometers measuring all three dimensions. Accuracy is high and sampling rates are 100 Hz and beyond. So why a chapter on acceleration handling? The challenge when measuring acceleration with a smartphone is their orientation is not the same as the acceleration of the moving vehicle.



Acceleration measured by a smartphone

The smartphone accelerometer's axles are aligned to the smartphone's case–which may be any orientation. Forces measured need to be mapped to forces acting on the car / motorbike (we use "car" in the remainder of this chapter except when discussing the motorbike specific lean angle topic) to get lateral and longitudinal acceleration for analysis.



Acceleration aligned to the car's axles

LapTimer supports two approaches to accomplish this mapping, both are described in detail in this chapter:

1. Acceleration Presets for standard use
2. Individual calibration for advanced / optimized measurements

Reading this Chapter

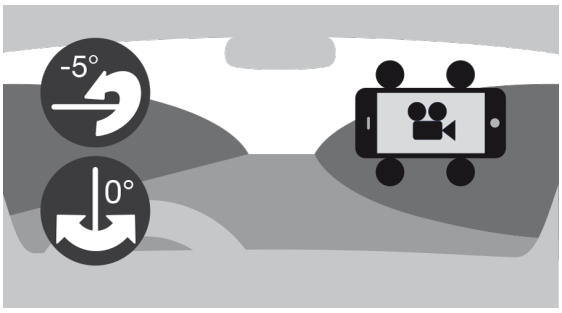
As (almost) always, LapTimer offers a solution matching most user's requirements in a simple way. So in case you do not want to dive into the math but want to get clear directions what to do to get proper lateral and longitudinal acceleration measured, continue with Acceleration Presets and skip Individual Calibration. In case you want to get very precise measurements or want to repair some odd recordings, read Individual Calibration too.

Acceleration Presets

LapTimer knows four typical orientations a smartphone is mounted and has standard transformations prepared to map acceleration measured in this mounting position to the car's driving direction. Even better, it will select the correct preset automatically by monitoring the mode of operation.

Video Preset

This preset is selected when video recording is active. LapTimer will assume you have the phone pointing to the front in driving direction. It will assume it has a slight tilt of 5 degree to the front to have a some additional "street" in the field of view. Orientation (portrait / landscape) doesn't matter like for all presets we will discuss, but landscape orientation will be what you want when recording video using the internal cam.

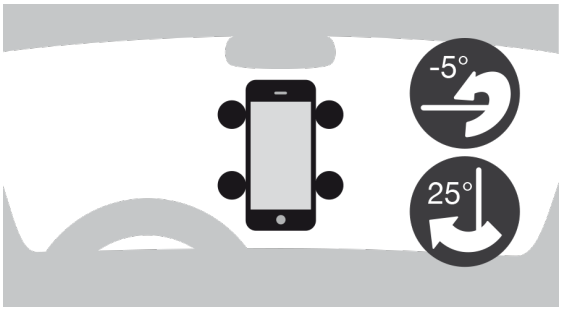


Correct mounting position for Video Preset

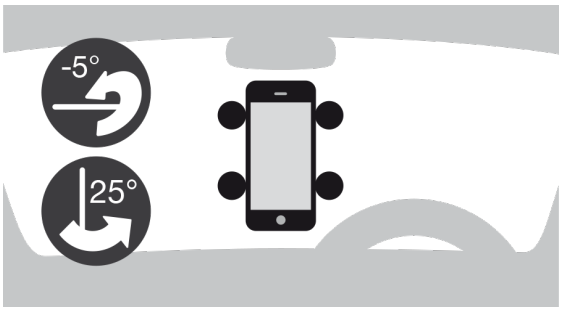
To verify you have selected a 5 degree tilt, simply watch the acceleration circle in Video View. It will show zero when mounted correctly. In case it doesn't change the tilt slightly before leaving the pits.

Right / Left Hand Traffic Presets

This is kind of the standard mounting position in a car when not recording video with the internal cam. LapTimer will derive right hand or left hand traffic from your phone's country setting. In case the derived assumption is wrong, you can switch LHT / RHT manually (see below). LHT / RHT presets assume you have the phone mounted in the windscreen centered horizontally (i.e. not near the A-pillar) pointing to the driver with an angle of 25 degrees and with a slight tilt of 5 degree.



Correct mounting position for right hand traffic

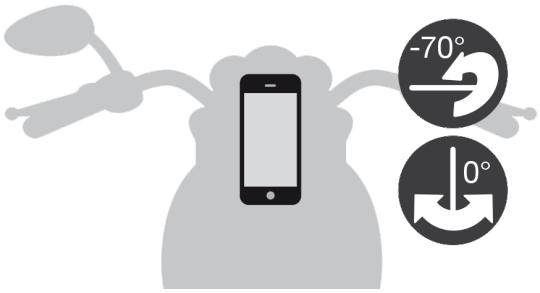


Correct mounting position for left and traffic

Similar like for Video Preset, you can check the tilt be checking any longitudinal acceleration display - it should be zero or near zero.

Motorbike Preset

This preset is selected automatically in case your current vehicle has a type that leans. Motorbike is the most common vehicle type leaning when going through corners, but speedboats or bicycle do it too. Motorbike Preset will assume you have the device installed nearly flat (tilt 70 degree where 90 degree would be flat) and pointing accurately into driving direction.

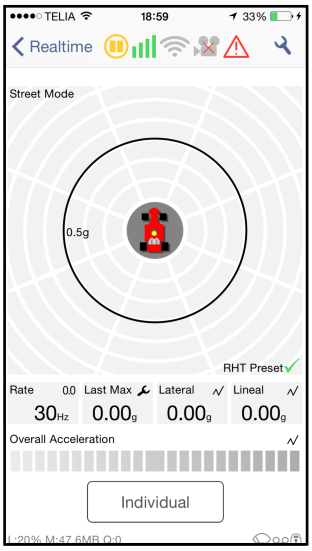


Correct mounting position for motorbikes and other leaning vehicles

For motorbikes a correct tilt is extremely important as it influences the lean calculation directly. Symptoms for a wrong tilt are too low lean angles (lateral acceleration). Again, checking the correct tilt can be done while standing still and checking one of the acceleration display (e.g. Acceleration View).

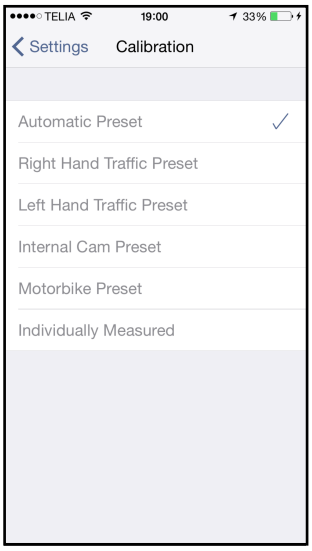
Overriding the Preset Selected

The preset is usually selected based on the named criteria (video active, vehicle type, country). The preset active currently is displayed in many acceleration gadgets, e.g. in the large acceleration display of Acceleration View.



Acceleration View showing RHT Preset is selected currently

In case you want or need to override the preset selected by LapTimer, change it in LapTimer ▸ Administration ▸ Settings ▸ Acceleration ▸ Calibration. The default is Auto Preset.



Selecting a preset other than Automatic

Typical situations overriding the preset will make sense: driving a LHT car by a user living in a RHT country, or mounting the smartphone near the A-pillar instead of the windscreen's center. For the later, RHT and LHT need to be switched as the smartphone will be rotated to the opposite direction. Please do not set a preset manually in case it isn't needed. You may change the vehicle tomorrow and end up with a wrong setting!

Individual Calibration

Before we go into individual calibration, we need to understand the full process of mapping acceleration measured by a device in a certain position and orientation, to one that matches the car's driving direction. The math behind this mapping can be described by a transformation using vectors and matrixes:

$$a_V = R_Y \times R_T \times R_O \times a_D$$

This means acceleration for the car (a_V) can be derived from the acceleration measured by the smartphone (a_D) by applying 3 rotations. In a simplified description, R_O is the rotation to compensate device orientations different from portrait, R_T is the rotation to compensate the smartphone's tilt, and R_Y is the rotation to compensate the smartphone's yaw.

As an example, the RHT Preset has a known rotation $R_Y \times R_T$ which rotates acceleration measured by a smartphone with a tilt of 5 degree and a yaw of 25 degree to acceleration aligned to the car's driving directions. Or to cover acceleration presets completely: LapTimer comes with four known rotations $R_Y \times R_T$ which are used when the respective preset is selected.

Individual calibration means deriving an individual rotation $R_Y \times R_T$ which matches your the individual mounting position you may use in your car. Before we go into the process that is applied to measure and calculate this individual rotation, let us cover the missing rotation R_O:

This rotation maps any current device orientation (portrait, portrait upside down, landscape left, landscape right) to a standard orientation used for calculation. Going back to our example RHT Preset, the rotation $R_Y \times R_T$ is actually always the same–independent from the current device orientation. When the device is rotated and LapTimer accepts this rotation (i.e. the current view is available in the new orientation and rotation is not blocked because we are driving at high speeds), R_O is changed but the other rotations are unchanged.

The process for individual calibration can be monitored in detail when using the Calibration Assistant (LapTimer ▸ Prepare Race ▸ Calibration). Starting the assistant will automatically turn off Acceleration Presets and reset R_Y and R_T. During Pitch Calibration, which is triggered when LapTimer detects the car is standing still, R_T is set in a way the acceleration measured by the smartphone is mapped to the gravity vector (which is exactly the acceleration applied to the car at this time: zero lateral, zero longitudinal acceleration, and 1G downforce). During Gear Calibration, which is triggered when the car is driving a straight line and accelerated or decelerated strongly, R_Y is calculated in a way the longitudinal acceleration for the car is a certain positive or negative force, lateral accelerations is zero and downforce is 1G again.

So with individual calibration active, LapTimer will automatically derive the individual rotation needed to calculate car acceleration values from (almost) any smartphone orientation and corresponding acceleration measured.

The weak point of individual calibration is it may fail. This happens in case LapTimer does not interpret the "standing still" or "driving straight decelerating" correctly. This in turn will derive a wrong rotation and odd data as a consequence. The good news is: it is probably not necessary to run this calibration again and again (including a failure from time to time). In case you have a fix mount, i.e. the same smartphone orientation every time you drive, you can lock calibration. Locking Calibration (offered as a last step in Calibration Assistant) will store the current $R_Y \times R_T$ rotation for your next session. When calibration is locked, the calibration process is not restarted if e.g. LapTimer is started the next time.