TELEMATICS
MOBILE INFORMATION EXCHANGE

FM36xxi & FM37xxi
3-Axis Accelerometer Setting

Table of Contents

1 Overview

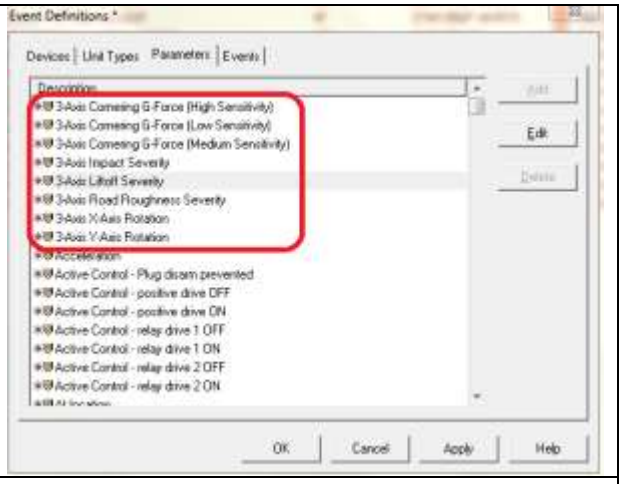
The purpose of this document is to provide detailed instructions on how to configure the new 3-Axis accelerometer on the FM36xxi and FM37xxi product range. The document will provide examples of how to set up the events as well as how to configure the "Impact Severity Parameter" used by the 3-Axis Accelerometer in the FM36xxi and FM37xxi units for Impact Detection.

The document also contains a section with frequently asked questions about the accelerometer functionality and the output from the events.

Note that some of the features were extended and new features were added with FM3xxx firmware release BAS 1.70a (E15.08.05). So please take note that some of these features are only applicable to newer firmware releases. These specific features are highlighted in the relevant sections below.

2 General Event Configuration

It must be noted that all the examples listed in the section below are just for illustration purposes and that you will have to find thresholds and values that work for your specific vehicle and application. Since the accelerometer is built into the FM3xxxi unit (on the PC board) the values are affected by where and how the FM unit is installed.

<table>
<tr>
<td>For the FM37xxi and FM36xxi the following parameters have been defined for the on-board 3-Axis accelerometer:
3-Axis Cornering G-Force (High Sensitivity)
3-Axis Cornering G-Force (Low Sensitivity)
3-Axis Cornering G-Force (Medium Sensitivity)
3-Axis Impact Severity
3-Axis Lift-off Severity
3-Axis Road Roughness Severity
3-Axis X-Axis Rotation
3-Axis Y-Axis Rotation</td>
<td> 
</td>
</tr>
<tr>
<td>Units and recommended usage:
1. 3-Axis Cornering G-Force (High Sensitivity) occur in increments of 1G and the value is always positive (i.e. it cannot distinguish between left and right cornering). A value of means 0.3G cornering force is recommended.
2. Impact Severity gives values between 0 and 100 with 100 being the most severe impact.
3. Lift-off severity occurs in increments of 10 mili-G, this means a value of 100 = 1G; 200 = 2G
4. Axis Rotation occurs in degrees, 90 degrees means it is on its side and 180 degrees means it is upside down.</td>
<td>• 3-Axis Impact Severity … 0 (min) to 100 (max)
• 3-Axis Lift-off Severity … increments of 10 mili-G
• 3-Axis Road Roughness Severity… 0 (min) to 100 (max)
Note that X-Axis Rotation and Y-Axis Rotation will provide the same value for all firmware releases older than BAS 1.70a (E15.08.05) and can be used interchangeably. For newer firmware releases (> BAS 1.70a E15.08.05) it will provide different outputs.
• 3-Axis X-Axis Rotation … 0 degrees to 180 degrees
• 3-Axis Y-Axis Rotation … 0 degrees to 180 degrees
Note also that "3-Axis Cornering G-Force (High Sensitivity)", "3-Axis Cornering G-Force (Low Sensitivity)" and "3-Axis Cornering G-Force</td>
</tr>
</table>

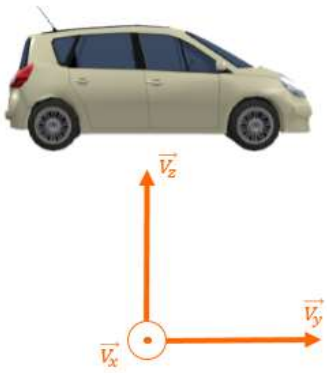
5. Road Roughness gives values between 0 and 100 with < 20 on a smooth road and > 45 on a very rough road.	*(Medium Sensitivity)" will provide the same values, so it is recommended that only "3-Axis Cornering G-Force (High Sensitivity)" is used.* • 3-Axis Cornering G-Force (High Sensitivity) • 3-Axis Cornering G-Force (Low Sensitivity) • 3-Axis Cornering G-Force (Medium Sensitivity)

2.1 New Functionality introduced with BAS 1.70a (E15.08.05)

In previous versions the energy in the XY-plane were always summed. In BAS 1.70a the X and Y planes are automatically calibrated using the speed input and will therefore produce different (separate values).

The Auto calibration has the following benefits:

1) It uses the 3-Axis accelerometer and any speed input to calibrate the orientation of the unit.
2) Any speed input is valid (not just GPS) e.g. Speed sender, CAN or GPS.
3) It can determine if orientation of the device has changed and will automatically recalibrate (e.g. after re-installation or when the unit is moved to another location)
4) It provides more accurate cornering forces and acceleration and deceleration via accelerometer.

Independent of the actual orientation and position of the unit, the 3-Axis will be calibrated as in the picture on the right. In the past, X and Y rotation values were calculate based on any deviation from the flat vehicle X, Y plane. Now they are separate: • X axis rotation (DDR Call 42, 8, 4), is rotation about the vehicle X axis • Y axis rotation (DDR Call 42, 8, 5), is rotation about the vehicle Y axis And only the true cornering force will be used in the calculation (Force along the vehicle X axis) • There is only one call to get the cornering force (DDR Call 42, 8, 6)	

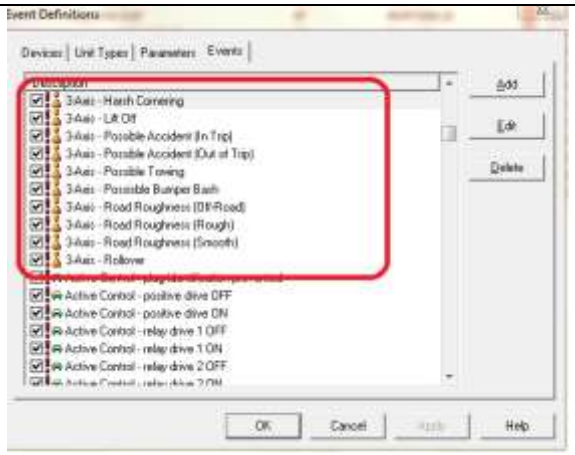
In the past if Cornering events were used, it would trigger false also on Harsh braking and Harsh acceleration events (since all energy in the X-Y plane were combined). With the new implementation it will no longer trigger false since only the energy in the X-plane is used.

In BAS 1.70a it is also possible to record any of the "transformed" X,Y,Z values to TACHO data as well as any other parameter (such as Rate of Turn in degrees per second)

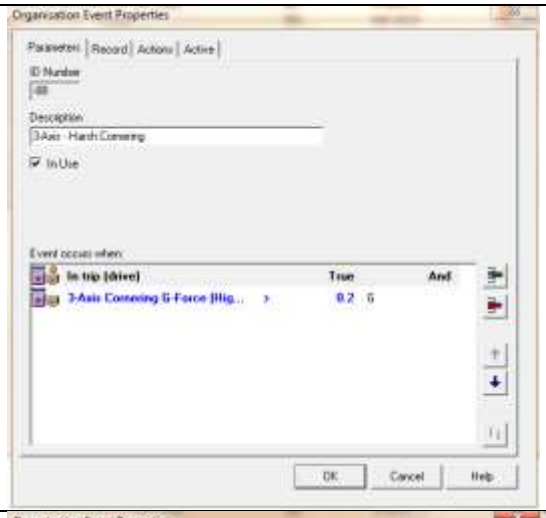
2.2 Example Definitions of Each Event in FM-Pro

It is possible to define any event using the parameters above and we recommend that the following events are defined:

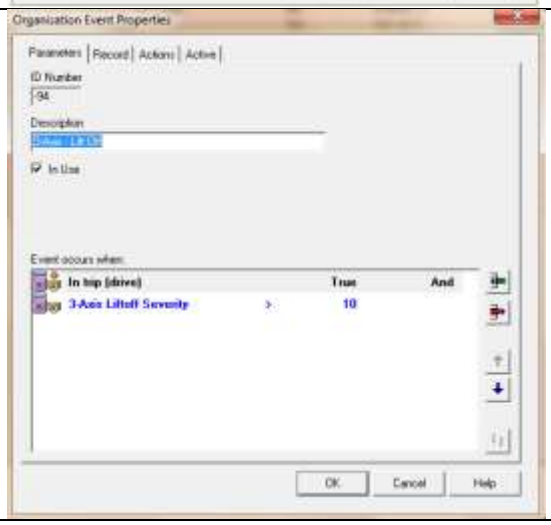
1. 3-Axis – Harsh Cornering
2. 3-Axis – Lift Off
3. 3-Axis – Possible Accident (In Trip)
4. 3-Axis – Possible Accident (Out of Trip)
5. 3-Axis – Possible Towing
6. 3-Axis – Possible Bumper Bash
7. 3-Axis – Road Roughness = Off Road
8. 3-Axis – Road Roughness = Smooth
9. 3-Axis – Road Roughness = Rough
10. 3-Axis – Rollover

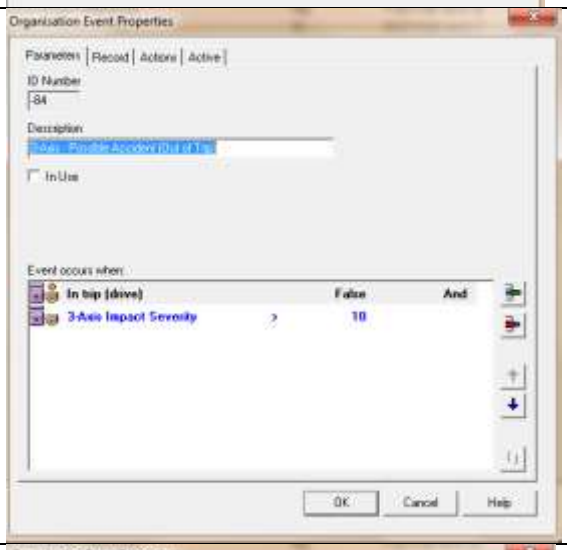
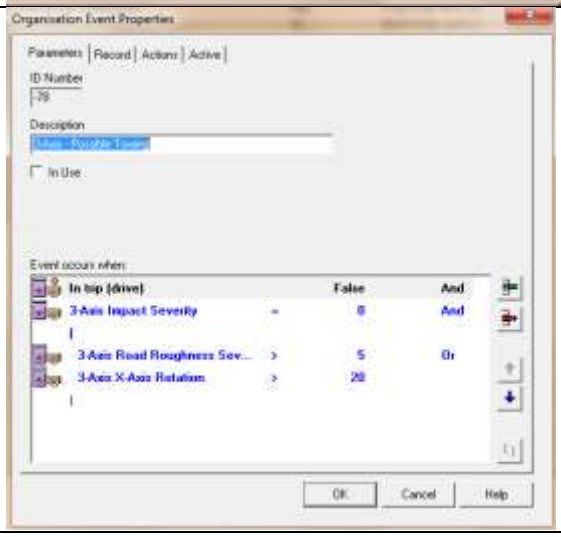


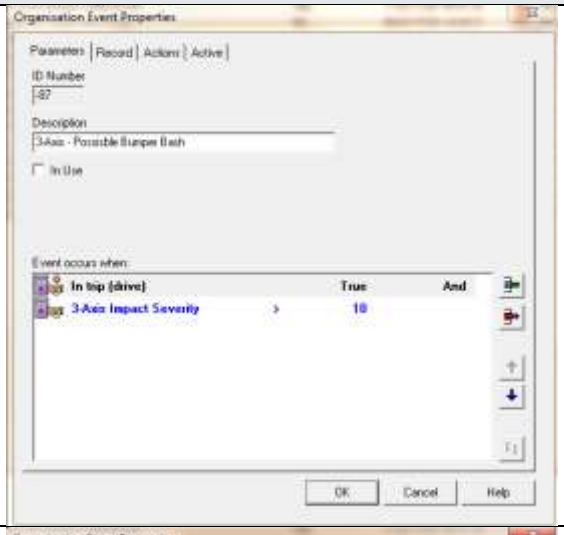
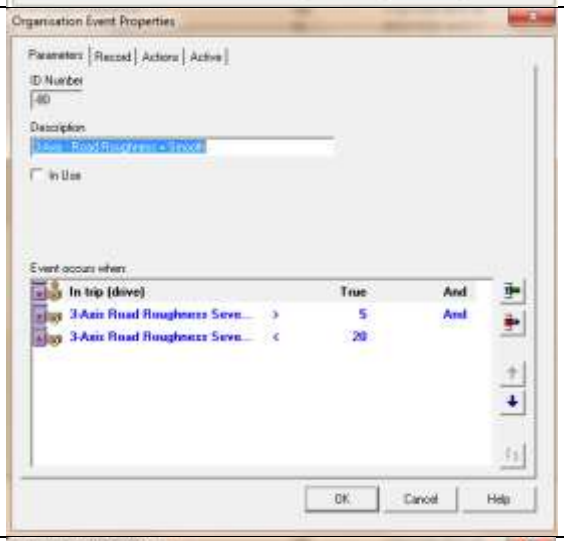
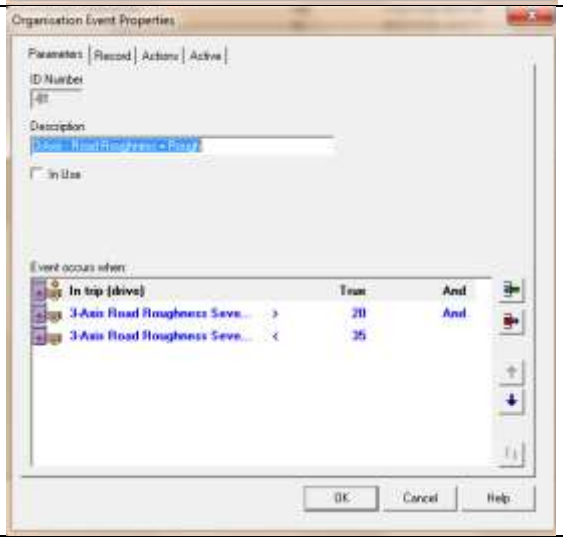
2.2.1 3-Axis – Harsh Cornering

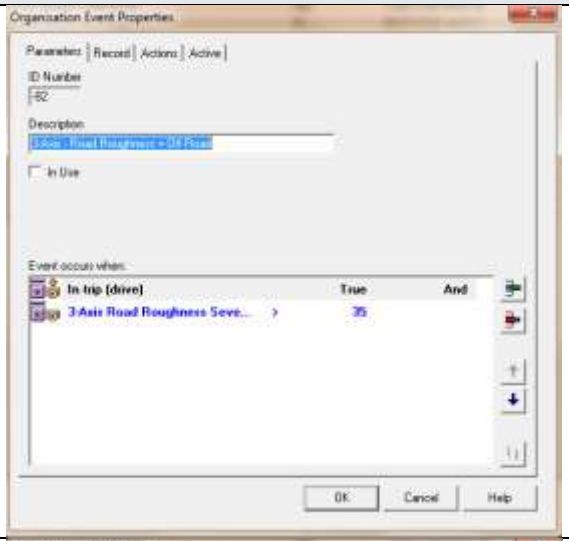
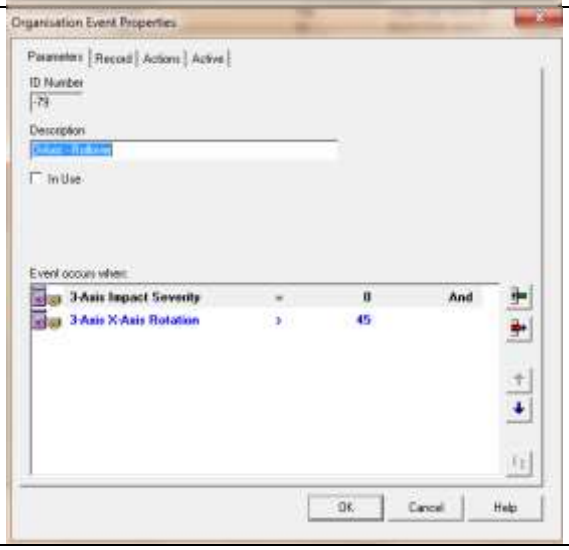


2.2.2 3-Axis – Lift Off



2.2.3 3-Axis – Possible Accident (In Trip)	
2.2.4 3-Axis – Possible Accident (Out of Trip)	
2.2.5 3-Axis – Possible Towing	

2.2.6 3-Axis – Possible Bumper Bash	
2.2.7 3-Axis – Road Roughness = Smooth	
2.2.8 3-Axis – Road Roughness = Rough	

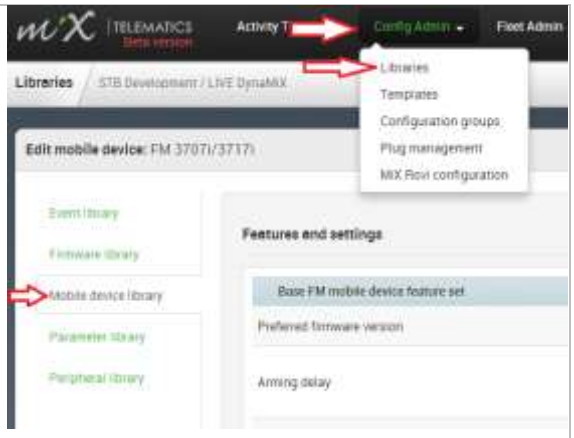
2.2.9 3-Axis – Road Roughness = Off Road	
2.2.10 3-Axis – Rollover	

2.3 Sensitivity Settings in MiX Fleet Manager

In MiX Fleet Manager there are additional sensitivity settings for the 3-Axis parameters. These settings are available for the following unit types:

- FM 3607/FM 3717 Communicators and FM 3616i Tracers
- FM 3707/FM 3717 Communicators and FM 3717 Tracers
- FM 3807/FM 3817 Communicators (Note the FM38xx range does not have a Tracer)

Changing any of these parameters will have an impact on the sensitivity of the 3-Axis accelerometer and might result in different optimum values than those recommended above.

The settings can be found in the following location: Config Admin ➔ Libraries ➔ Mobile device library	
Scroll down until you see the “Three Axis Accelerometer” section: 1. All default values are 50 2. A value of zero (0) means the feature is disabled 3. Liftoff (and Cornering) Sensitivity is also used for Pitch and Roll 4. Pitch and Roll Detection Sensitivity is not used by Firmware. 5. Road Roughness is scaled and filtered from 1 second (**100%**) to 100 seconds (**1%**). A value of 50 means it is filtered over 50 seconds. 6. Liftoff and (Pitch and Roll) Sensitivity is scaled and sampled from 10 ms (**100%**) to 1 second (**1%**). A value of 50 means it is sampled over 50 ms (0.5 seconds) 7. Impact Detection Sensitivity is scaled from 0.5G (**100%**) to 3.5G (**1%**). The default of 50 therefore means the threshold is set at 2G (50%)	

It is possible to combine some of the parameters and adjust these thresholds in order to define new events. For example if you want to measure the degree of "Customer Comfort" on a bus, you can for example define an event like the following to achieve this:
Define: Speed = A (in km/h)
Define: Road Roughness Severity = **B** (RMS energy filter window in seconds)
Define: 3-Axis Cornering = **C** (in G force)

THEN: If (Speed > **A** km/h) AND (Road Roughness > **B** OR 3-Axis Cornering G-Force > **C**)

A ROUGH RIDE will then be classified triggered if the passengers experience forward movement (braking), backward movement (acceleration), sideways movement (cornering) or up-down movement (pot-holes or speed-bumps) when you use values of:

A = 20 km/h
B = 15
C = 0.2 G

3 Impact Severity

The ***Impact Severity Parameter*** measures the amount of energy observed in a specific time frame, and returns a value between 0 and 100. The major differences between the other/older algorithms and the current FM implementation are:

- G-Force due to gravity is effectively removed from the calculation
- Acceleration history is stored as a buffer of 3D vectors, instead of being stored as a magnitude average
- Acceleration data is integrated over time to calculate the impact energy, which eliminates ringing as a cause of false triggers

3.1 Conversions

To convert between configurations for the old crash detection module (impact sensors) and the new algorithm the following calculation can be used:

Define **A** = acceleration in g
Define **B** = time in milliseconds
THEN
Using the specification of an average A g acceleration over B milliseconds

- **A** (acceleration in g) is capped at 8g, so for example for 11g over 25ms, only 8g will be considered
- **B** (timeframe in milliseconds) is capped at 300ms (which is generally larger than most specifications), so for example 11g over 350ms, only 8g over 300ms will be considered.

The severity value specified in the configuration then translates to:

Impact Severity = (A * B) / 10

3.2 Examples

1. Average 11g over 25ms: 11g capped to 8g, so Severity = (8 * 25) / 10 = 20

2. Average 5g over 50ms: Severity = (5 * 50) / 10 = 25
3. Average 1g over 350ms: 300ms is capped at 300ms, so Severity = (1*300)/10 = 30

3.3 Recommendations

A study done for MiX Telematics on 31 March 2013 by Dr. George Rechnitzer and Dr. Raphael GrzebietaIt, recommends that the G-force impact sensor algorithms are set at detecting crash pulses which equal or exceed a 5g average over 50ms, or a 3g average over 100ms.

Relying on the data and recommendations from this study, it is advisable to set the minimum severity value that would indicate a slight injury to 20.

4 Frequently asked questions

4.1 Must the FM3xxx be installed in a specific orientation for the accelerometer to work?

For example with the old impact sensors X, Y axis?

No, it is not important. The FM36xxi and FM37xxi can be installed in any orientation and direction and the 3-Axis accelerometer will do an auto-calibration using GPS data to figure out which direction is forward/backward/sideways and up and down.

4.2 At what point does the auto-calibration occur?

Let's say a unit was installed in a certain orientation, and then at some point the orientation was changed, does the auto-calibration occur after an OBC Unit Reset?

The calibration occurs constantly. When the FM unit powers up, we assume that the unit is lying still in the horizontal plane, and use the values on the 3 axis as the unit's orientation. This assumption is then fine-tuned by adjusting each axis (if necessary) by 1 mili-G every second.

4.3 Why is “Impact Severity” and “Road Roughness” not specified in G?

Severity is a measurement of the amount of energy observed in a specific time frame and specified as a value between 0 and 100. The value is not expressed in G. Road Roughness is the RMS value over a specific time frame (currently 50 seconds) in 0.1 G resolution i.e. Road Roughness of 30 indicates 300 mG.

4.4 Why is there no direction (left/right) for Harsh Cornering?

Why can we set up Harsh Cornering Left and Right when using GPS, but for accelerometer there is only harsh cornering (without direction)?

The current accelerometer algorithm cannot distinguish between cornering forces and rotations in the XY-plane, this will be an enhancement in future versions of the firmware. If direction of the corner is required, then the GPS must be used as source of the cornering force.

4.5 Will Harsh Cornering with different sensitivity levels be available at some point?

A single setting can adjust the sensitivity of Lift-off, Tilt, and acceleration in the horizontal plane (i.e. acceleration, braking and cornering combined). This setting is not adjustable on FM Web. Currently the setting get fixed to smooth the accelerometer data over a 500ms window before using the filtered data for analysis. (In the old concept for FM3316 Impact sensor, the only difference between High, Medium, Low was a hard coded Filter of 1, 2, 3 seconds smoothing). In Dynamix we will allow any value to be configured, so we will not have hard coded High, Medium and Low values, but rather a value and filter duration.

4.6 Is it possible to store the 3-axis values on a second-per-second basis as TACHO data?

This feature depends on configuration changes and will only be available after a future release of DynaMiX. The minimum Firmware release required for this feature is BAS 1.70a (E15.08.05)