User Manual – ADR1

APPROVED
MANUFACTURER: EMVEXIS
MODEL: ADR1
HOM. NO: ADR.003.24
FIA STANDARD: 8872-2018

Revision History

Revision	Description
A	Initial release

Document Identification

Document ID	DC-3147
Document Name	User Manual – ADR1

This document is uncontrolled when printed, or not obtained directly from the Emvexis website.

1 Table of Contents

1 Contact Details

ADR1 is designed and manufactured by Emvexis Limited.

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2 Introduction

The Emvexis ADR1 is a high-performance, robust and cost-effective Accident Data Recorder system designed primarily for motorsport applications and is homologated in accordance with the FIA 8872-2018 Accident Data Recorder standard, under homologation number ADR.003.24.

The FIA technical lists, which detail homologated manufacturers and their products, are published at https://www.fia.com/regulation/category/761

The ADR is suitable for use in motorsport applications which mandate FIA 8872-2018 ADRs, in series where their use is not mandated, and even in series not controlled by the FIA. In the latter case, specific functionality modifications and software features may be supported by Emvexis upon request.

The ADR is also particularly suited for a variety of other applications:

- non-track motorsport applications such as powerboat racing
- law enforcement and coastguard marine applications
- high-performance automotive applications.

The system is comprised of 2 parts:

- The ADR hardware
- Emvexis *ADR Utility* software application

The ADR hardware internally performs high speed sensing, acquisition, real-time signal processing and event-triggered logging of tri-axis acceleration and gyroscopic rate data, in addition to capturing additional parameters from the vehicle via CAN.

It is designed and tested to operate in all weather conditions, with a BS EN 60529 IP66/IP67 rating, protected from dust ingress, powerful water jets and the effects of temporary water immersion, across a wide temperature and operating voltage range.

All electrical I/O is protected against typical automotive transient and EOS conditions, allowing it to operate in electrically harsh environments without additional external protection.

2.1 Definitions, Acronyms and Abbreviations

The following acronyms and abbreviations are used extensively throughout this document and are detailed below for brevity.

Acronym	Expansion
ADR	Accident Data Recorder
ASI	Accident Severity Index
ASN	Autorité Sportive Nationale
CAN	Controller Area Network
CAN-FD	CAN Flexible Data-Rate
DFU	Device Firmware Update
EOS	Electrical Overstress
ESD	Electrostatic Discharge
FIA	Fédération Internationale de l'Automobile
GUI	Graphical User Interface
LED	Light Emitting Diode
LSB	Least Significant Bit
mA	milliamps
ms	milliseconds
MWL	Medical Warning Light
RTC	Real Time Clock
UI	User Interface
USB	Universal Serial Bus

3 Device Overview

3.1 Product Features

- Internal 3-axis high range accelerometer
- Internal 3-axis low range, high resolution accelerometer
  - Synchronization between low and high range guaranteed
- Internal 3-axis high resolution gyroscope
  - Synchronization between gyroscope and accelerometers guaranteed
- Data channels compliant with ISO 6487, CFC60
- Internal backup power supply to allow continued operation after loss of power supply
  - Software configurable charging current limit
- Wide operating voltage front end, including cold crank operation
- Internal storage for up to 25 events worth of data
- Onboard status LED
- 2x constant current LED drivers for external indicator LEDs
- Internal pressure sensor for case seal integrity verification
- Deutsch Autosport / Souriau 8STA electrical connector
- Internal low-drift real time clock with battery backup for time and date stamping of events
- CAN 2.0B for capturing vehicle parameters such as steering angle and brake pressures
  - Hardware is CAN-FD capable
  - Software selectable 120Ω bus termination resistance
  - Software selectable 4.7nF termination split filter capacitor
  - Extensive CAN physical fault tolerance
- USB 2.0 for communication with ADR Utility PC Software
- RS232 hardware for communication with legacy devices

3.2 Product Specifications

3.2.1 Internal Sensor Specifications

Table 1 - Inertial Sensor Specifications

Sensor	Parameter	Typical	Units
High range accelerometer	Range	±200	g
	Resolution	0.1	
	Non-linearity	±0.5	%
	Cross-axis sensitivity	±2.5	

	Sampling rate	3000	Hz
	Logging rate	1000	
Low range, high resolution accelerometer	Range	±16	g
	Resolution	0.000488	
	Non-linearity	±0.05	%
	Cross-axis sensitivity	±1	
	Sampling rate	1000	Hz
	Logging rate		
Gyroscope	Gyroscope range	±2000	°/sec
	Gyroscope resolution	0.060975	
	Non-linearity	±0.1	%
	Cross-axis sensitivity	±1	
	Sampling rate	1000	Hz
	Logging rate		
All	Time synchronisation between high and low range accelerometers, and gyroscope	±1	ms
	Time from power on to ADR functional, including automatic zeroing complete	8 note 1	sec
		13 note 2	sec

1. USB **not** connected to PC
2. USB connected to PC, ADR waits 5 seconds listening for a firmware recovery command before booting main application firmware

3.2.2 Electrical Specifications

The device must be operated within the ratings listed in the table below in order for all homologated performance characteristics to be valid.

Table 2 – General System Specifications

Parameter	Min	Typical	Max	Units
Supply voltage	6	-	40	V_{DC}
Operating temperature range	-40	-	85	°C
Backup Power Supply duration	-	5	-	minutes
Constant current LED driver current	-	19	-	mA

3.2.3 Current Consumption

The ADR is optimised for low power consumption, and whilst its current consumption is heavily dependent upon configuration options, under normal conditions its current

consumption is extremely low. The baseline current consumption, and factors affecting current consumption are listed in the table below.

Values listed as +, are additive to the baseline consumption.

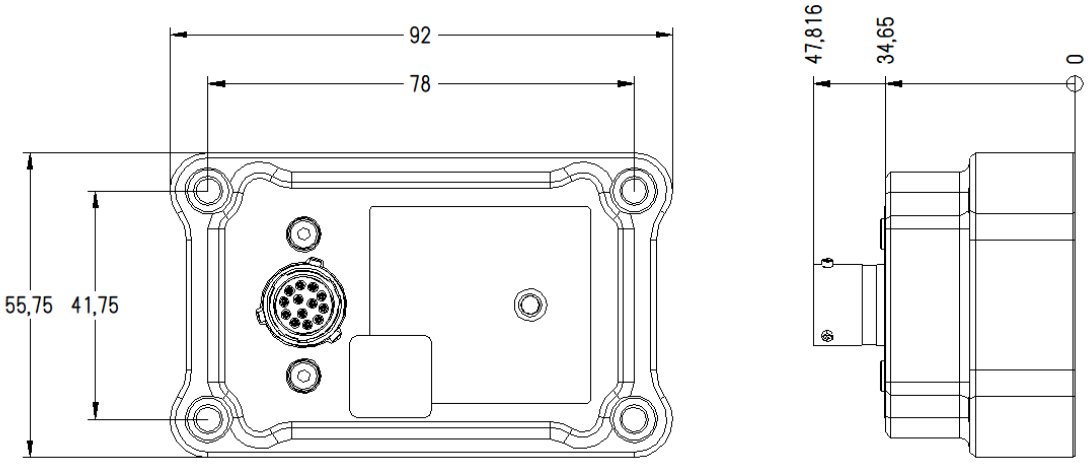
Table 3 - Current Consumption

Parameter	Conditions[1]	Typical	Units
Current consumption	Baseline: CAN bus and termination disabled, no external LEDs connected, backup supply charged, no faults present	14	mA
	CAN bus termination enabled	+2	
	CAN bus termination split filter enabled	+2	
	External status LED enabled and illuminated	+6	
	External Medical Warning Light LED enabled and illuminated	+6	
	CAN bus active, with bus activity limited to the CAN messages defined in FIA standard messaging protocol	+2	
	Backup power supply charging at maximum configured rate	+196	

1. All currents given at 13.8V_{DC} supply voltage

3.3 Mechanical and Environmental

- Electrical connector: see Electrical Connector Pinout
- Construction: machined billet aluminium case, blasted and anodised
- Ingress Protection Rating: BS EN 60529 IP66 / IP67
- Weight: 260 grams
- Physical dimensions:



4 ADR Utility PC Software

The ADR is supported by our free-of-charge Windows® PC software application, *ADR Utility*, which may be downloaded from here. The software is used to configure and interact with an ADR, and to download and view event files.

Throughout this User Manual, usage of ADR Utility is demonstrated as and when each functionality of the ADR is described, such that both ADR and ADR Utility functionality are introduced together.

4.1 System Requirements

- Operating system
  - Windows® 10 (Home, Professional, IoT Enterprise) 64-bit
    - Version 10.0.17763.0 or higher
  - Windows® 11 (Home, Professional, IoT Enterprise) 64-bit
- Hardware Requirements
  - Processor: 1GHz minimum
  - Memory (RAM): 4GB minimum
  - Storage: 1GB free space
- Display:
  - Minimum 1024x768 pixels
- Additional:
  - Dedicated GPU not required
  - Installation is not required, application is portable
  - Internet connection is preferable, but not required

4.2 Installation

ADR Utility does not require installation on a PC, the application is a single standalone Windows® executable, and is launched by a double-click on the file, as per any other file or shortcut.

It is even possible to run the application directly on a USB stick, although it is strongly recommended to copy the application locally to your PC – this is because removing the USB stick will close the application unexpectedly.

4.3 Features

ADR Utility includes features to enable use of all of the ADR's capabilities, in addition to productivity enhancing features. The software includes:

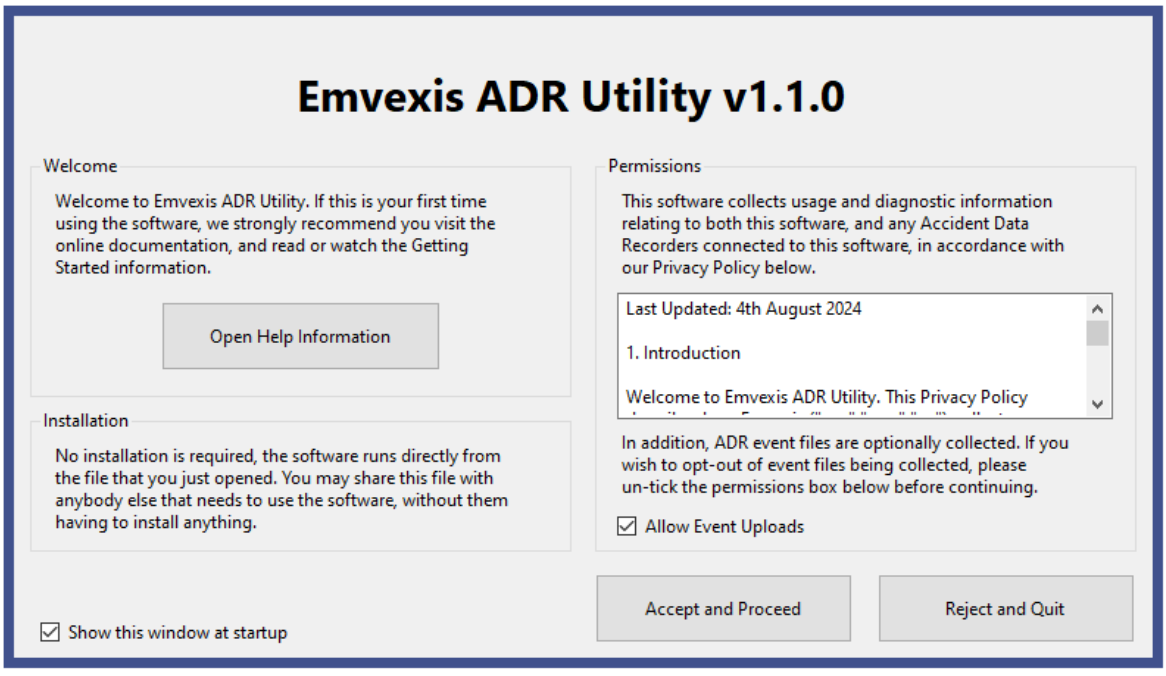
- A graphical, interactive data visualization user interface, allowing ADR event data to be plotted, zoomed, isolated etc
- Ability to view, download and delete stored event files
- ADR configurator, to configure both user settings and FIA restricted settings
- ADR health information, displaying extensive diagnostic and fault information
- Numerous tools such as the ability to manually trigger an event, explicit sensor zeroing etc

4.4 Getting Started

ADR Utility is a simple graphical user interface that will immediately feel familiar to any PC user with experience using traditional Windows® desktop applications.

On first launch of the software, an onboarding screen is displayed. To use the software you must read and accept the privacy policy.

Figure 1 - ADR Utility Onboarding Screen

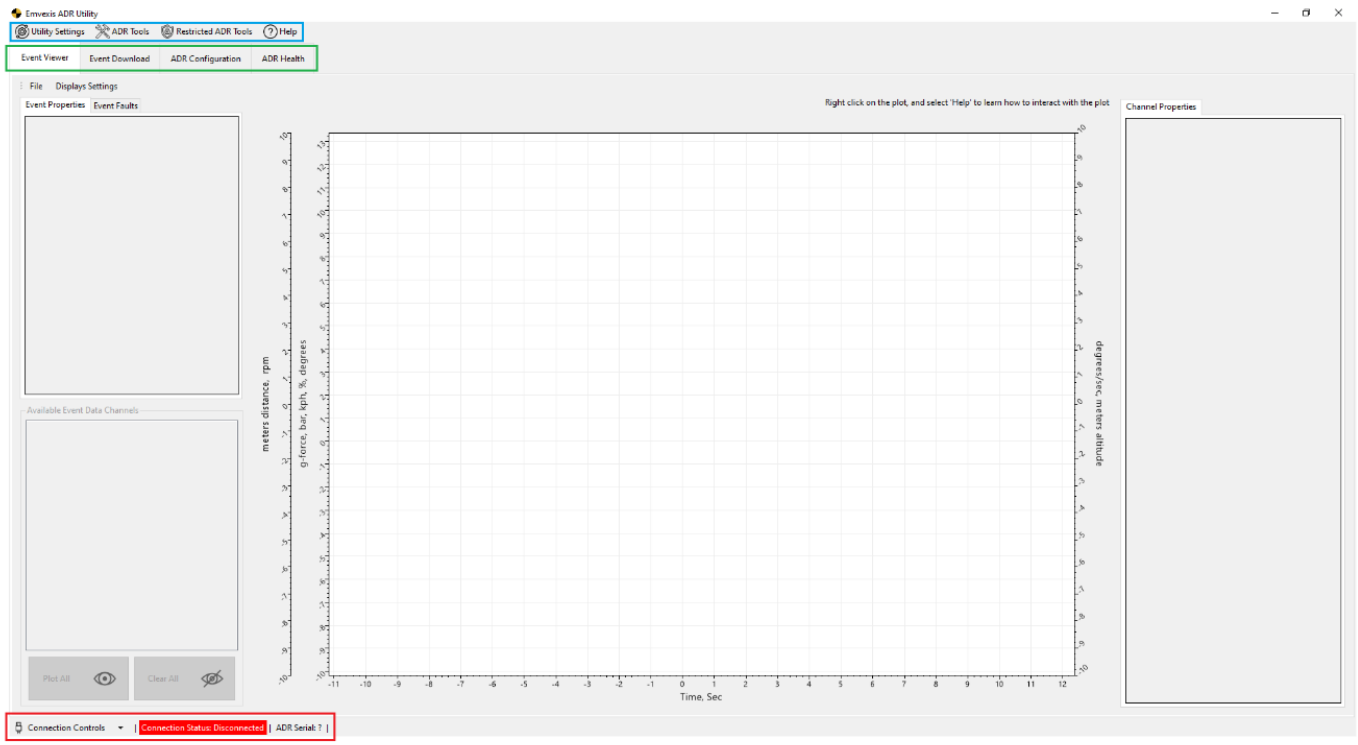


After proceeding past the onboarding screen, the main software UI is displayed. The three highlighted regions of the UI, remain constant at all times in the UI:

- Blue – main tool strip, includes typical application functionality such as application settings and help menu, and multiple ADR tools
- Green – application tabs, opening different environments used for purposes such as viewing events, downloading events and configuring the ADR

- Red – lists current ADR connection status, serial number etc, and includes controls for connecting to an ADR

Figure 2 - ADR Utility Main UI



4.5 Connecting to an ADR

To connect to an ADR requires only a few steps

1. Connect the PC to the ADR using an ADR Interface Cable
2. Open the 'Connection Controls' menu in the lower left corner
3. Select an ADR from the drop-down list. The list contains **only** Emvexis ADR1 devices, and excludes all other connected USB devices
4. Click 'Connect', and ADR Utility will connect with the ADR, and display the serial number of the connected ADR in the status strip

Figure 3 - Connecting to an ADR

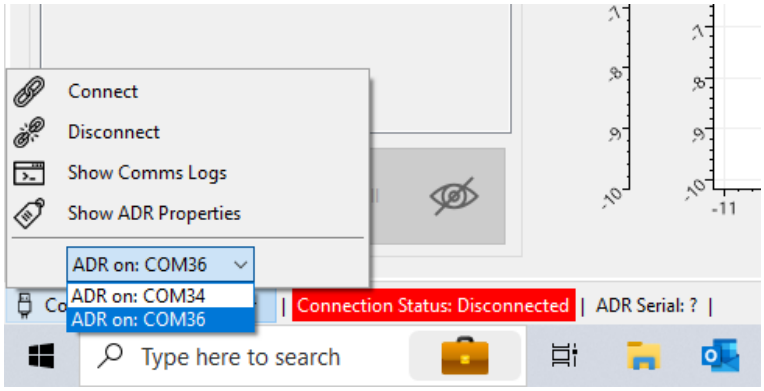
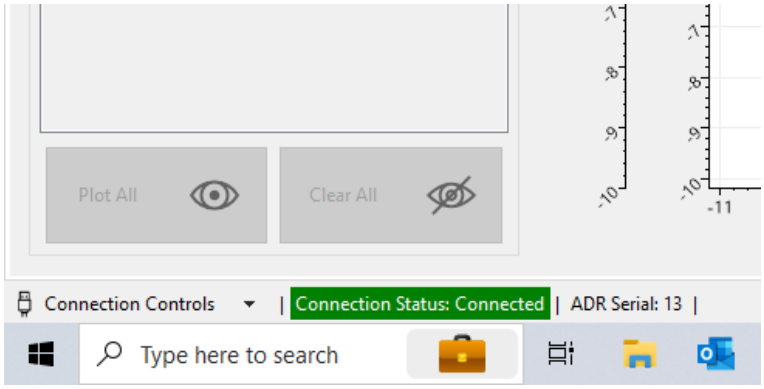


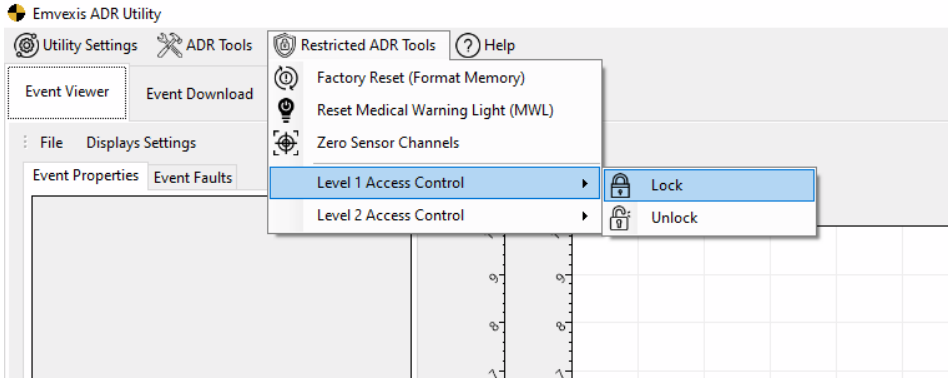
Figure 4 - Connection Made



Further details about the connected ADR may be viewed under Connection Controls > Show ADR Properties.

4.6 Restricted Functions

Numerous functions performed using ADR Utility, are required by the FIA 8872-2018 standard to be passcode protected, such that these functions are restricted to the FIA, or an authorised delegate such as an ASN or championship organiser.



An attempt to perform these functions without unlocking the ADR, simply results in a rejection notification.

4.6.1 Access Control Levels

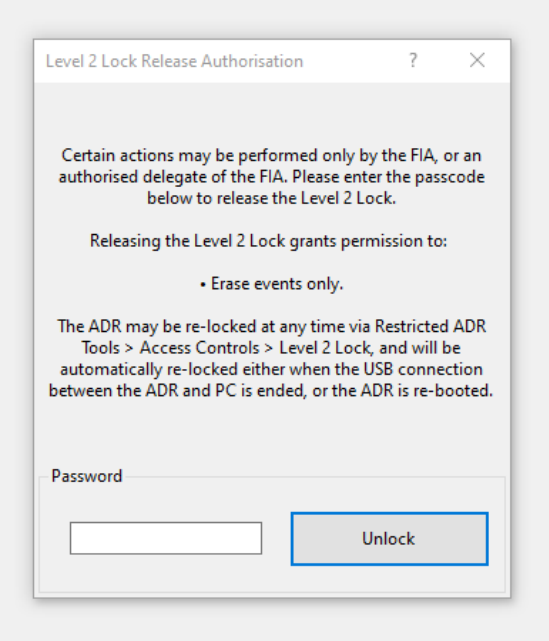
The functionality is protected by 2 different lock levels; a 'level 1', and 'level 2' lock.

The level 1 lock protects functions only permitted to be changed by the FIA, whilst the level 2 lock protects functions authorised to be changed by delegates. Each lock has a separate passcode.

Table 4 - Protected Functions by Lock Level

Function	Protected By	
	Level 1 Lock	Level 2 Lock
Deleting events	✓	✓
Factory reset	✓	
Resetting the External Medical Warning Light	✓	
Re-zeroing the internal sensor channels	✓	
Changing restricted configuration parameters (orientation and triggers)	✓	

The ADR is locked, and unlocked using the menu commands shown above, which raises a window to enter the passcode.



4.7 Configuration

Configuration of the ADR is performed using *ADR Utility.* The configuration may be edited 'live', by changing parameters and settings on the connected ADR directly, or, configurations may be loaded from a configuration file.

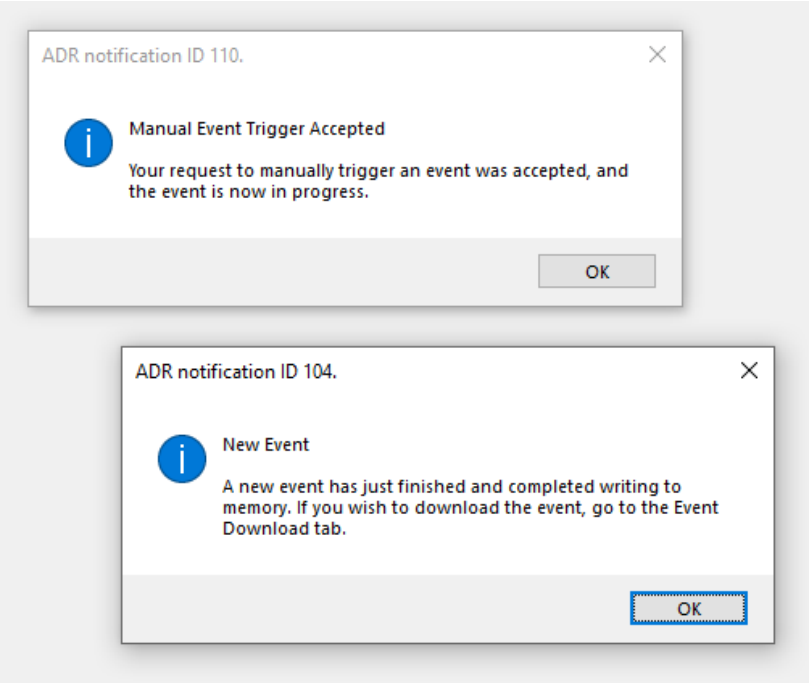
The latter is useful where multiple ADRs need configuring with the same settings

4.8 Manual Event Triggering

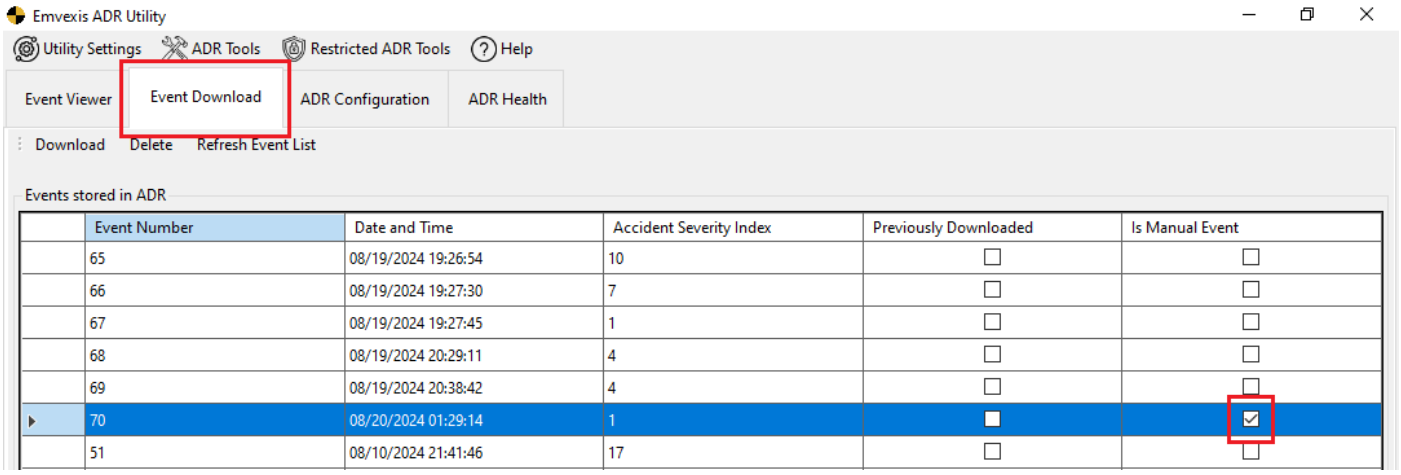
Events may be triggered manually for the purposes of demonstration and test. A manually triggered event is the same as a triggered event in all respects as described in the Events and Event Files section, with the sole exception that a manually triggered event is marked as such, this is because a manually triggered event can be triggered with no impact acceleration data high enough to trigger an event present, and thus it is important to show why this event exists.

To manually trigger an event:

1. Connect to the ADR in question
2. Click ADR Tools > Test Functions > Trigger Manual Event. In some cases the request will be rejected (if for example, an event erase is in progress). Either way, ADR Utility will inform if the command was accepted or rejected. When the event completes, a second notification will be displayed.



3. The event may be viewed in, and downloaded from, the event download list and will be shown with a tick in the 'Is Manual Event' box to display that this event was manually triggered



4.9 Sensor Zeroing

In normal operation there is no need to zero the ADRs internal accelerometers and gyroscopes, as this is performed automatically on power up of the ADR.

However there may be some cases where this is necessary, for example:

- The ADR was powered on whilst removed from a vehicle, at an arbitrary inclination
- The vehicle itself was in a severely inclined position whilst the ADR was powered on

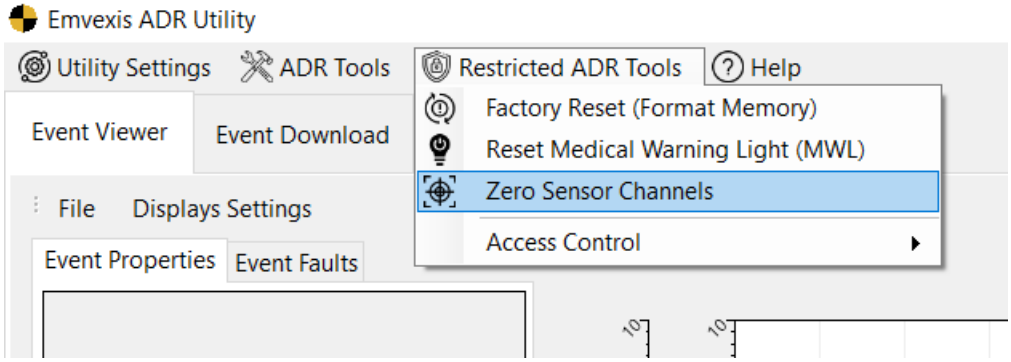
If such a scenario has occurred, the ADR will still fundamentally function, though the following should be noted:

- The zero offsets of each channel will be incorrect, for example if a vehicle was on a 45° incline in X or Y, when the ADR is powered on, when the vehicle returns to horizontal, the Z axis will report 1.293g at 1g, due to sensing a real 1g, plus the vector component of 1g at 45 degrees
- Trigger thresholds may be affected, for example if an ADR was powered on, on its side, the Z axis will sense 2g when the ADR is righted. This means impacts will falsely read 1g higher, thus reaching trigger thresholds earlier

Zeroing the sensors is a restricted function, per the requirements of the FIA 8872-2018 regulation. To zero the sensors:

1. Connect to the ADR in question
2. Click Restricted ADR Tools > Zero Sensor Channels. In some cases the request will be rejected (if for example, an event is in progress). Either way, ADR Utility will

inform if the command was accepted or rejected. When the process completes, a notification will be displayed.



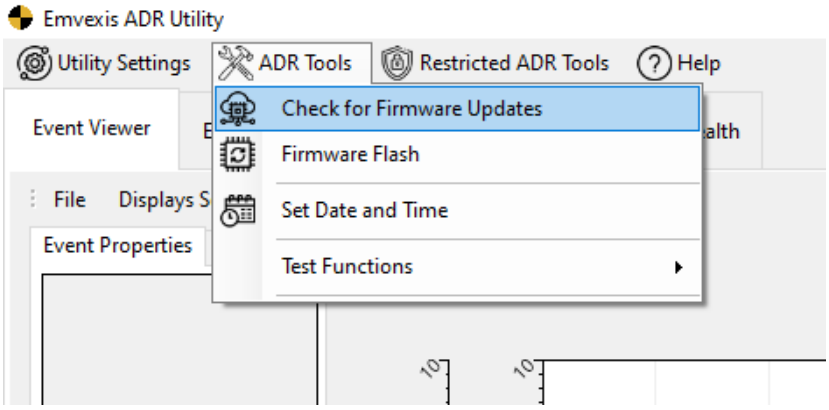
4.10 Updating ADR Firmware

The ADR firmware is easily updated if necessary, by ADR Utility. Firmware files are encrypted binary files, named using the following typical format:

adr-application-fw-6dde15d2afc25e32c0de5fd0088b26d34ec7ba99-clean

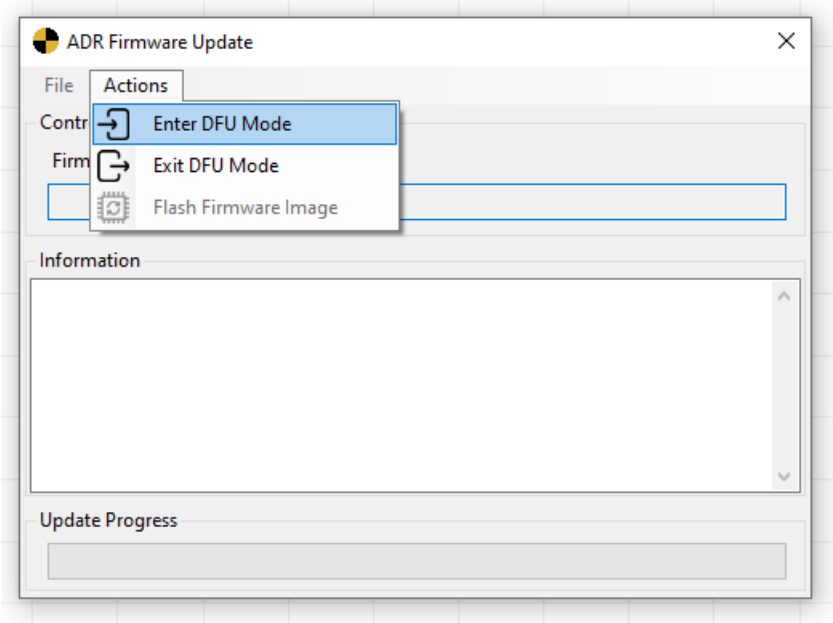
Firmware updates are made available through the Emvexis website and may be accessed from the following location in ADR Utility.

Figure 5 - Firmware Update Web Link

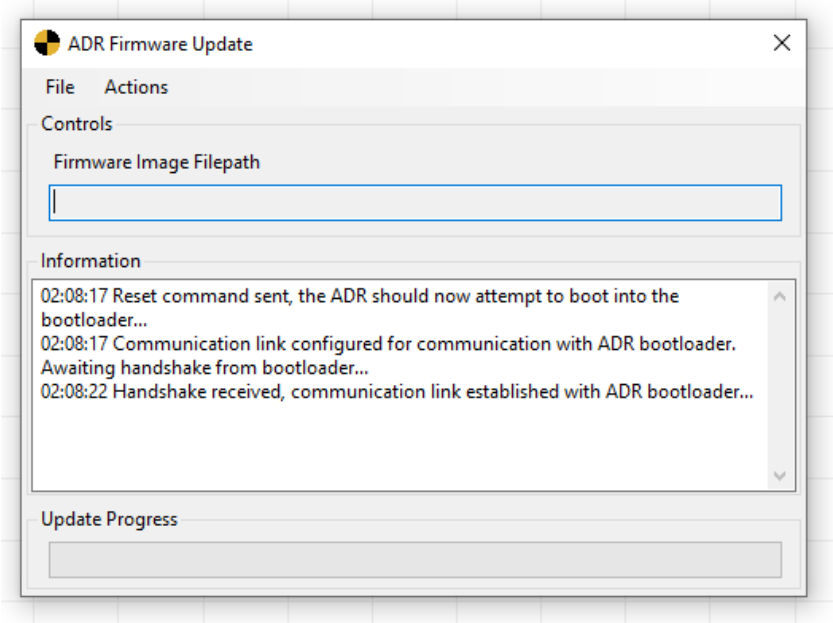


To perform a firmware update:

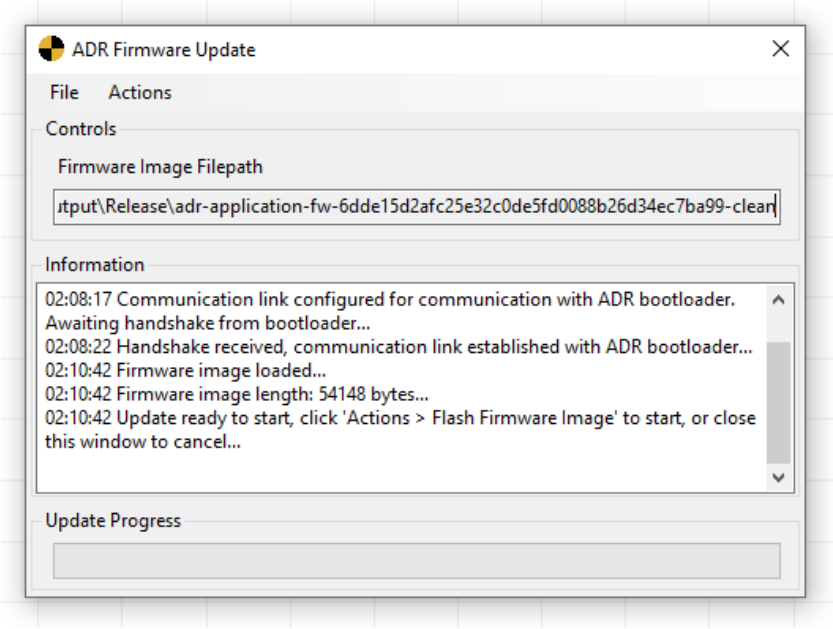
1. Connect to the ADR to update
2. Open ADR Tools > Firmware Flash
3. In the window that opens, click Actions > Enter DFU Mode



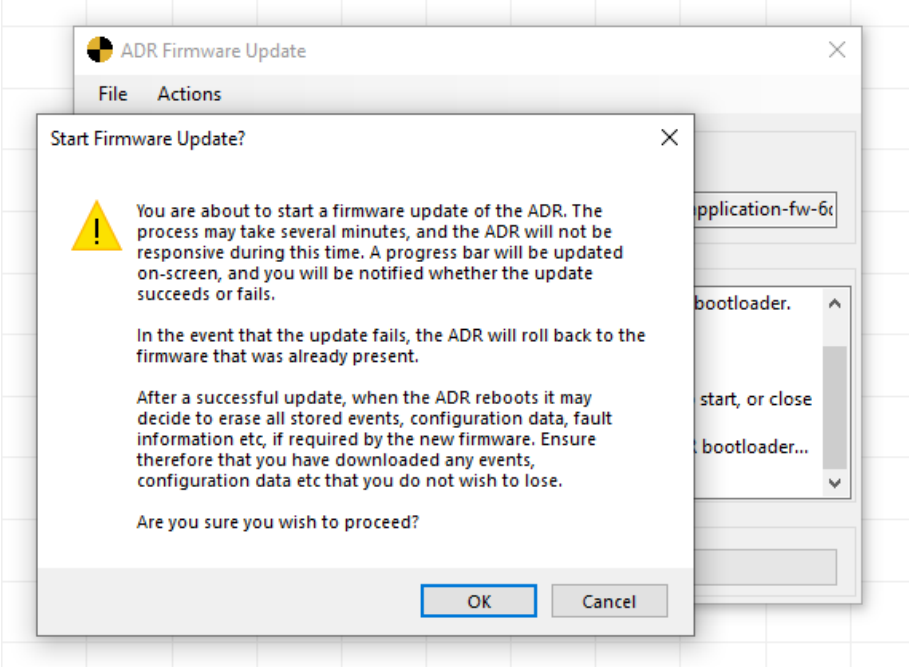
4. The ADR will reboot, and the onboard status indicator LED will show a solid orange status. Information on the DFU progress so far, is displayed



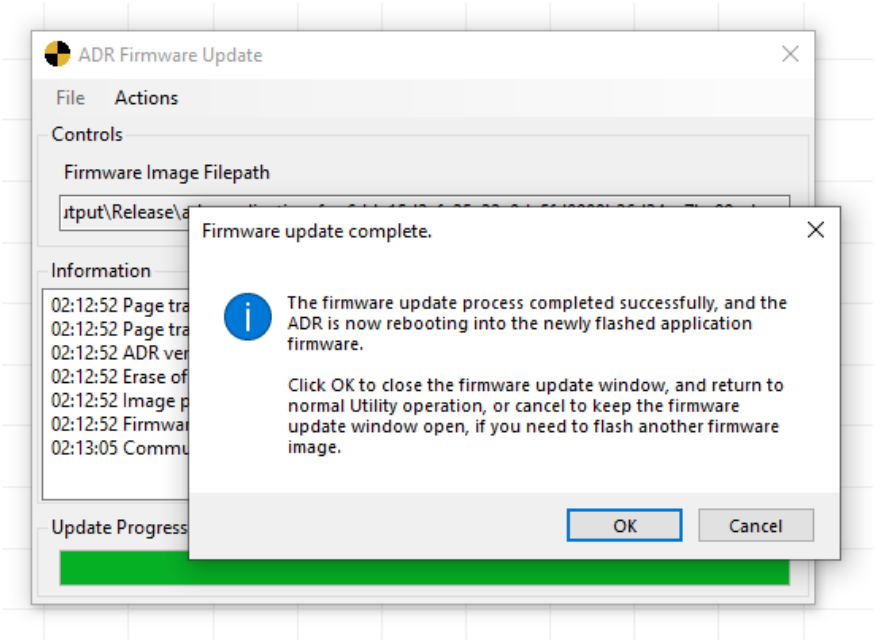
5. Click File > Open Firmware Image. Navigate to the firmware file using the standard file dialog window that opens.



6. Click Actions > Flash Firmware Image. Read and understand the warning notice that is displayed, and click OK



7. The process takes only a few seconds to complete, and when complete the ADR will reboot into the new firmware. Click OK to return ADR Utility to normal operation


ADR Firmware Update
File
Actions
Controls
Firmware Image Filepath
Information
Update Progress
Firmware update complete.
The firmware update process completed successfully, and the ADR is now rebooting into the newly flashed application firmware.
Click OK to close the firmware update window, and return to normal Utility operation, or cancel to keep the firmware update window open, if you need to flash another firmware image.
OK
Cancel

5 Modes of Operation

The ADR may operate in one of two modes:

1. Standalone, connected only to the vehicle's power supply
2. Networked, connected to the vehicle's CAN network, for the purpose of capturing additional vehicle parameters (steering angle, brake pressures etc) used to supplement the event data captured by the ADR

5.1 Standalone Operation

In this mode, the ADR uses its internal accelerometers and gyroscopes to measure and log acceleration and gyroscopic rate data. If an event is triggered in this mode, the event files contain two sets of 3 axis acceleration data (high range XYZ, and high resolution XYZ), in addition to 3 axes of gyroscopic rate data (XYZ).

All other event channels normally used in networked operation, will read as zero.

Therefore whilst standalone operation still captures the fundamental inertial data, the datasets lack the additional channels that are present when the ADR is networked, which are extremely useful in any crash analysis

5.2 Networked Operation

In this mode, the ADR functions fundamentally the same as in standalone operation, except for that an additional 12 data channels are captured from the vehicles CAN bus. These channels are defined in Channels.

Further to the 14 additional data channels, 2 additional event properties are captured via CAN:

- Lap number at the point of the event trigger
- GPS time

Wherever possible it is highly recommended that the ADR be used in this mode.

6 Events and Event Files

The ADR operates on the principle of continuously holding the last 45 seconds of data from all channels in memory. Each time a new sample is captured, the oldest sample is overwritten.

This temporarily held data is **not** stored in permanent memory.

For the ADR to permanently store data, it must be **triggered.** A **trigger** is what causes an **event** to be captured.

Triggers are acceleration thresholds, combined with time counters, that when exceeded - trigger an event. Triggers are discussed in more detail in 6.5.

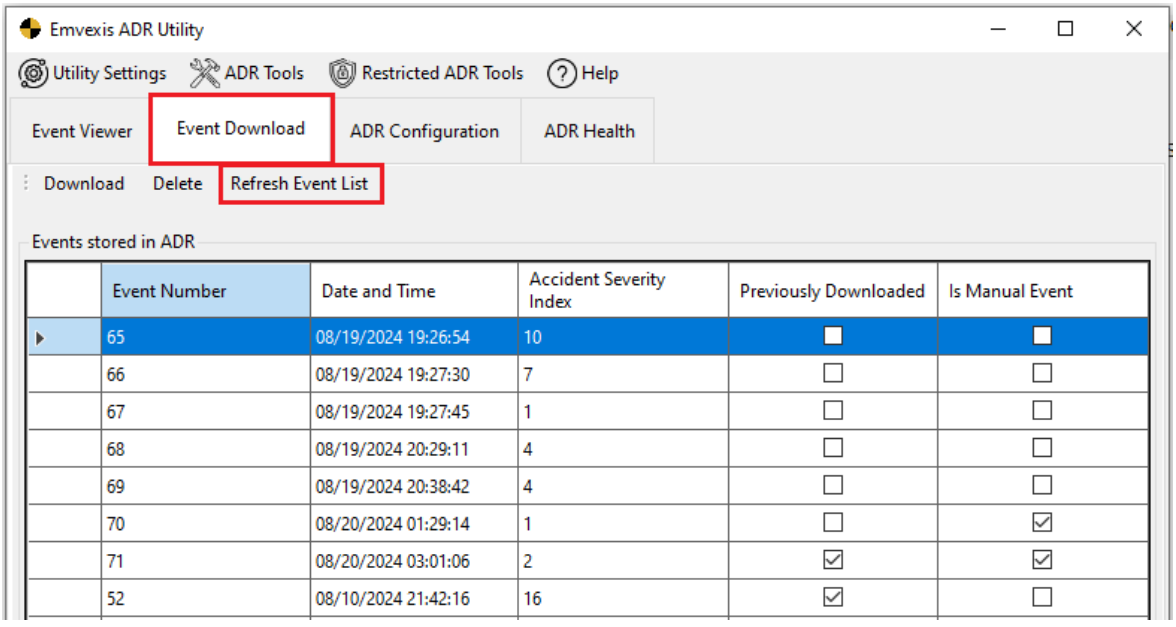
In the following sections events and triggers are discussed in detail, including an overview of how to download, and view events is given.

6.1 Downloading Events from an ADR

ADR Utility displays a list of all events currently saved in the ADR, to view the event list:

1. Connect the PC to the ADR using an ADR Interface Cable
2. Open the Event Download tab in the main user interface
3. Click 'Refresh Event List'

The list of all events stored in the ADR will be displayed, including timestamps, ASI, whether the event has been downloaded before, by anybody, and whether it was a manually triggered event.

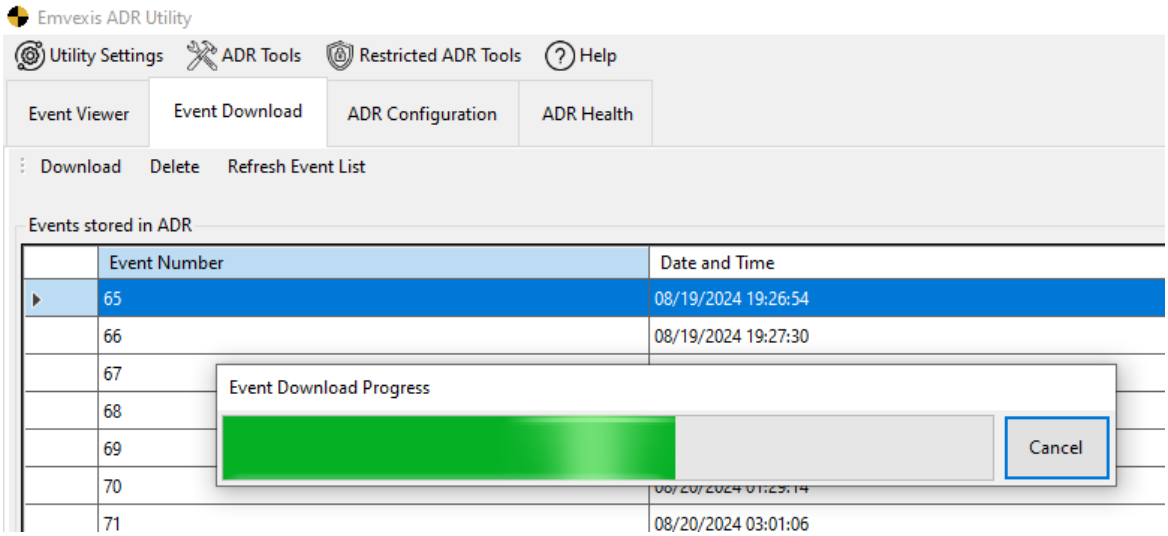


	Event Number	Date and Time	Accident Severity Index	Previously Downloaded	Is Manual Event
▶	65	08/19/2024 19:26:54	10	☐	☐
	66	08/19/2024 19:27:30	7	☐	☐
	67	08/19/2024 19:27:45	1	☐	☐
	68	08/19/2024 20:29:11	4	☐	☐
	69	08/19/2024 20:38:42	4	☐	☐
	70	08/20/2024 01:29:14	1	☐	☑
	71	08/20/2024 03:01:06	2	☑	☑
	52	08/10/2024 21:42:16	16	☑	☐

To download an event:

1. Highlight the event row to download
2. Click Download > Download Selected
3. Select where you wish to save the event in the dialog that is displayed

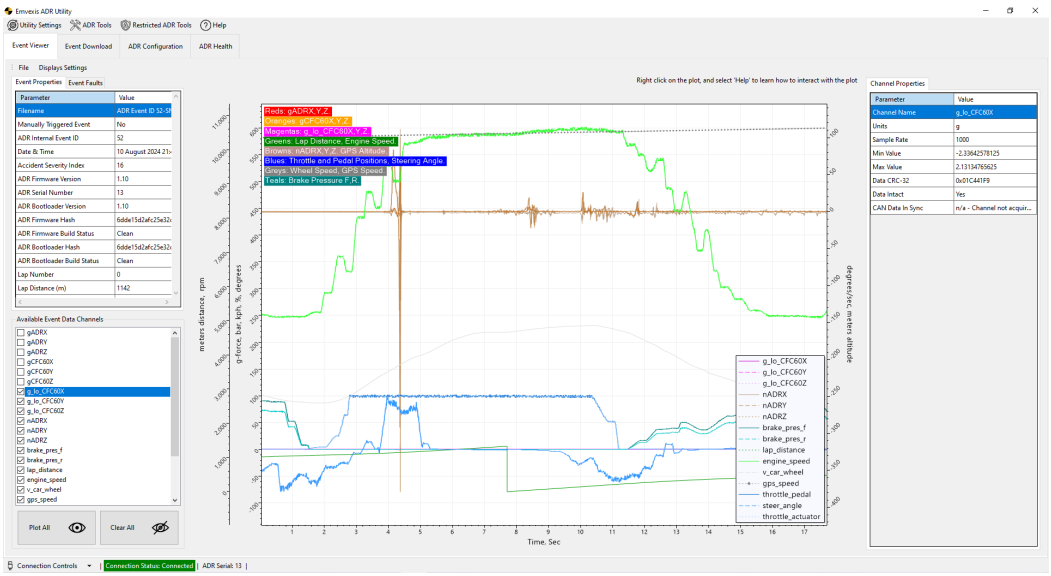
When the event download starts, a progress bar is shown, and the download can be cancelled at any time. Each download takes approximately 8.5 seconds.



Events may be deleted from the ADR using Delete > Delete Selected, or Delete All. Note however this is a restricted function.

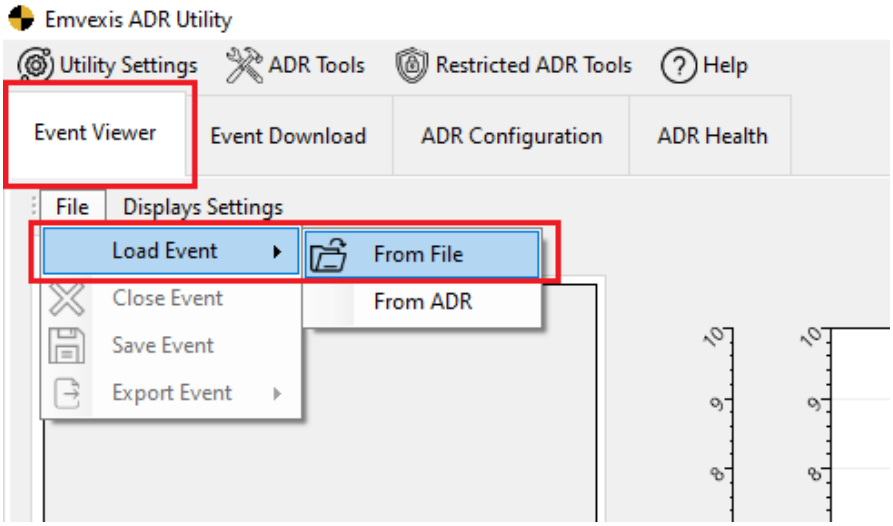
6.2 Opening and Viewing Event Files

ADR Utility includes a graphical event viewer, under the 'Event Viewer' tab.



Event files downloaded from the ADR are opened into the Event Viewer from an event file saved on the PC. To open an event file:

1. Click File > Load Event > From File.
2. Navigate to the file using the dialog that is displayed

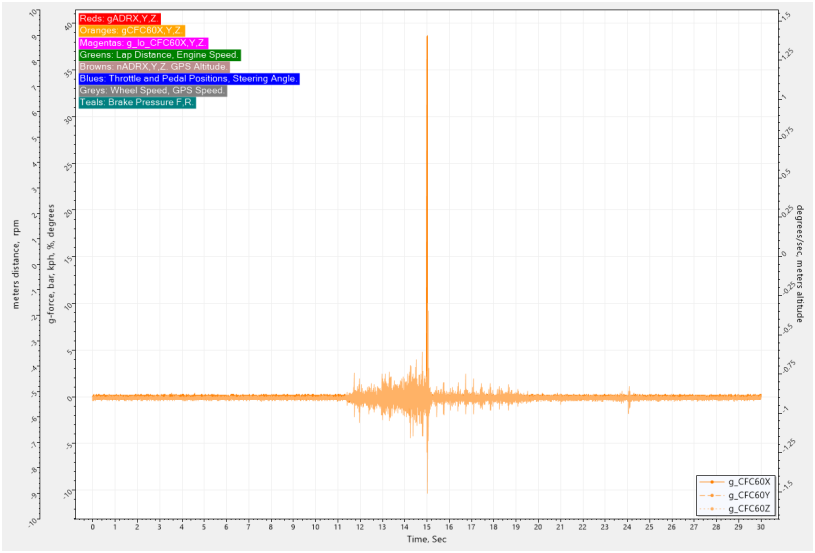


Selecting 'From ADR' instead of 'From File' moves to the Event Download tab, to allow you to first download events.

6.3 Event Structure

All events are 30 seconds in duration, and in normal cases the event captures 15 seconds of data prior to the trigger, and 15 seconds after the trigger. The image below demonstrates this; the ~40g impact in the middle of the display plot, is at 15 seconds, thus the event contains both pre and post trigger data.

Figure 6 - Event Trigger Location



Note however, that there are exceptions to this, described in Special Conditions.

6.4 Channels and Properties

During an event the ADR captures numerous **data channels**, which are continuously sampled and logged throughout the event, i.e. these data channels contain time history data.

In addition to the data channels, additional **event metadata** is captured. This metadata is comprised of parameters which do not change over the duration of the event, but rather are a snapshot in time at the point of event triggering. This metadata includes:

- Event properties, a collection of parameters related to the event itself, such as timestamps, ADR serial number, firmware version etc
- Event faults, a record of any fault codes set during the event
- Channel properties, parameters such as units, min/max values, and per-channel error checking CRC-32 fields
- ADR configuration, a full copy of the ADRs configuration as it was at the time of the event

Each of these channels and properties are described below.

6.4.1 Channels

The ADR logs either 12, or 26 channels depending on whether it is used in standalone or networked mode, as per the table below.

Table 5 - Event Channel Descriptors

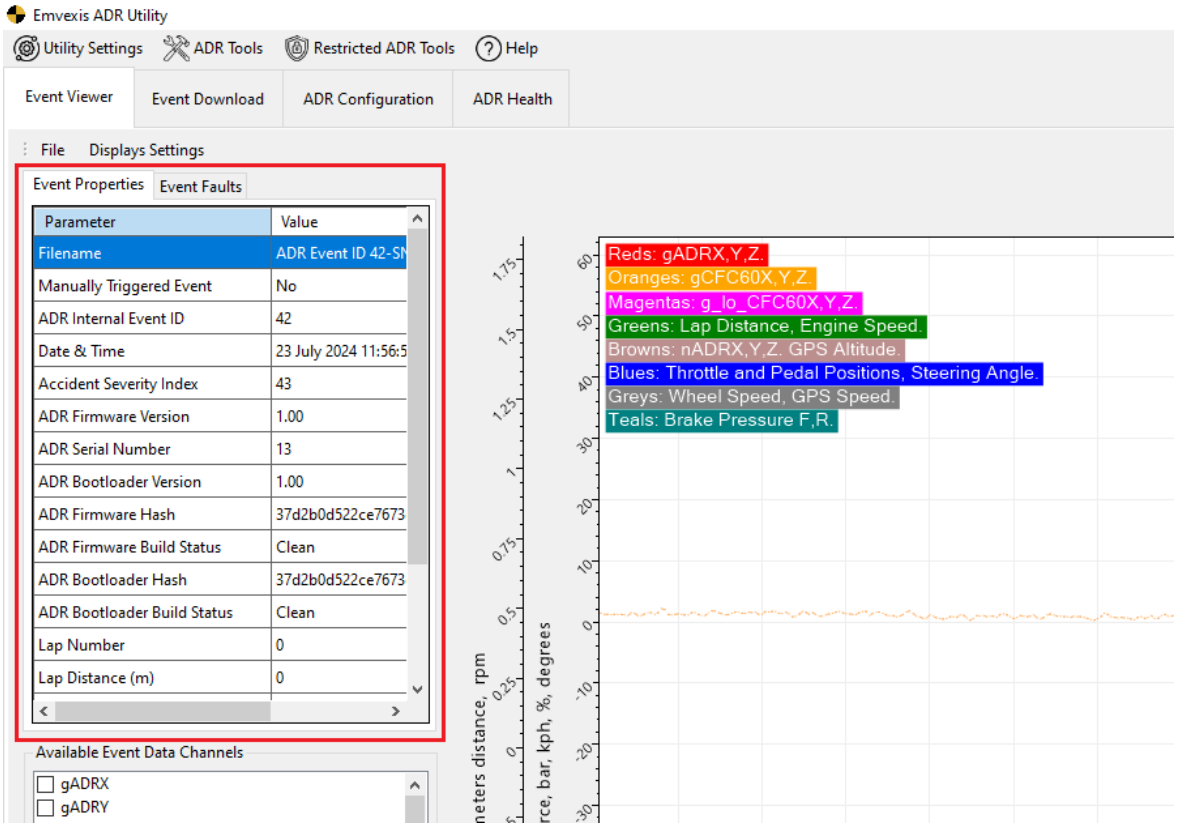
Channel Name	Channel Description	Source	Logging Rate, Hz	Units
gADRX	High range acceleration, anti-aliased, no further filtering, vehicle XYZ	ADR internal	1000	g
gADRY				
gADRZ				
gCFC60X	High range acceleration, anti-aliased & digitally filtered to ISO 6487 CFC60, vehicle XYZ			
gCFC60Y				
gCFC60Z				
g_lo_CFC60X	Low range, high resolution acceleration, anti-aliased & digitally filtered to ISO 6487 CFC60, vehicle XYZ			
g_lo_CFC60Y				
g_lo_CFC60Z				
nADRX	High range gyroscopic rate, anti-aliased, no further filtering, XYZ			°/sec
nADRY				
nADRZ				
brake_pres_f	Brake hydraulic pressure		100	bar

brake_pres_f		Vehicle systems via CAN		
lap_distance	Distance travelled on current lap			meters
lap_number	Current lap number			n
engine_speed	Engine rotational speed			rpm
v_car_wheel	Vehicle speed calculated from wheel speed			kph
throttle_pedal	Throttle **pedal** demand			%
steer_angle	Steering angle			°
throttle_actuator	Throttle **actuator** demand			%
gps_speed	Ground speed as measured by GPS		10	kph
gps_altitude	Altitude as measured by GPS			meters
gps_lat	Latitude as measured by GPS			1e7°
gps_long	Longitude as measured by GPS			
gps_status	Connected (via RS-232) GPS module status			Module specific

6.4.2 Event Properties

Each event file contains a set of Event Properties, viewable under the Event Properties tab in Event Viewer.

Figure 7 - ADR Utility Event Properties



These parameters relate to both the ADR itself (for example, serial number that captured the event), and to the event (for example, date and time stamp).

Each of the parameters included in Event Properties are described in the table below.

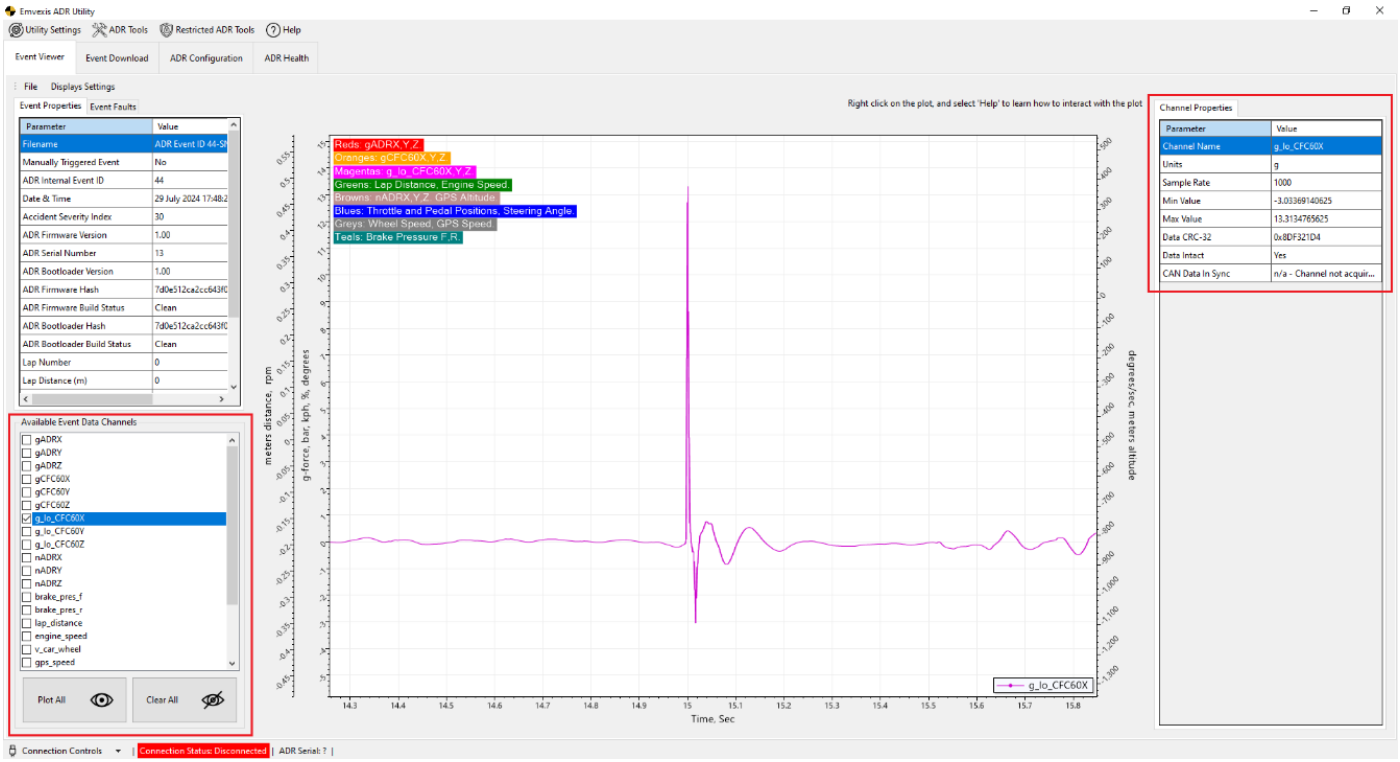
Table 6 - Event Property Parameter Descriptions

Property	Type	Description
Filename	Text	Filename of the event .XML file
Manually Triggered Event	Yes/no	Determines whether this event triggered manually using the Trigger Manual Event function in *ADR Utility,* or was it a real event
ADR Internal Event ID	Value	ID assigned to the event by the ADR, this ID combined with the ADR serial number uniquely identifies an Emvexis ADR event file
Date & Time	Datetime	Date and time stamp of the first sample within the dataset
Accident Severity Index	Value, g	Maximum absolute acceleration recorded at any time point within this event, in any axis
ADR Firmware Version	Version, X.Y	Version of the ADR application firmware in use at the time this event was captured
ADR Serial Number	Value	Unique hardware serial number of the ADR that captured this event
ADR Bootloader Version	Version, X.Y	Version of the ADR bootloader firmware in use at the time this event was captured
ADR Firmware Hash	SHA-1 hash	Cryptographic hash used to uniquely identify the ADR application firmware build with absolute certainly
ADR Firmware Build Status	-	Internal use only
ADR Bootloader Hash	SHA-1 hash	Cryptographic hash used to uniquely identify the ADR bootloader firmware build with absolute certainly
ASH Bootloader Build Status	-	Internal use only
Lap Number	Value	Current lap number when the event was triggered
Lap Distance	Value, meters	Current lap distance when the event was triggered
ADR Internal Pressure	Value, mBar	Pressure of the ADR internal air volume when the event was triggered
ADR Internal Temperature	Value, °C	Temperature of the ADR internal components when the event was triggered
Event Format	Value	Reserved for future use; identifies format of the event file to allow newer format versions of event files to be recognised by *ADR Utility*, to support new features
Number of Channels	Value	Number of Channels included within this event
Event Length	Value, seconds	Number of seconds of data within this event

6.4.3 Event Channel Properties

Event files contain properties specific to each data channel, as shown below. As each channel is selected in the Available Event Data Channels list (bottom left), the Channel Properties (top right) view will update to show the properties, for the selected channel.

Figure 8 - ADR Utility Event Channel Properties



Each of the channel properties, and their associated meanings are described in the table below.

Table 7 - Event Channel Property Descriptors

Property	Description
Channel Name	Name of the currently selected channel, from the list of Channels
Units	Units of the parameter in this channel, for example g, °/sec
Sample Rate	Number of samples per second, in this channel
Min Value	Minimum numerical value in this channel, in this event
Max Value	Maximum numerical value in this channel, in this event
Data CRC-32	Error-detecting code, calculated by the ADR for this channel only, when the event was stored. Used by *ADR Utility* to compare against when recalculating this channels CRC-32, to determine whether data corruption has occurred

Data Intact	See above, if a freshly calculated CRC-32 of this channel matches the saved CRC-32, the data has not been corrupted
CAN Data in Sync	For channels obtained via CAN, if any CAN faults occurred during capture of this event, this property warns for this

6.4.4 Event Configuration

Within each event file is a copy of the ADRs configuration that was in use at the time when the event was captured.

A good example of why this configuration data is included is, for example; even if it is known with certainty which orientation an ADR was installed in a vehicle at the time of a given event, if it is not known which orientation setting was configured, then it is impossible to know with certainty if the X,Y and Z channels are correctly mapped to the vehicle coordinate system.

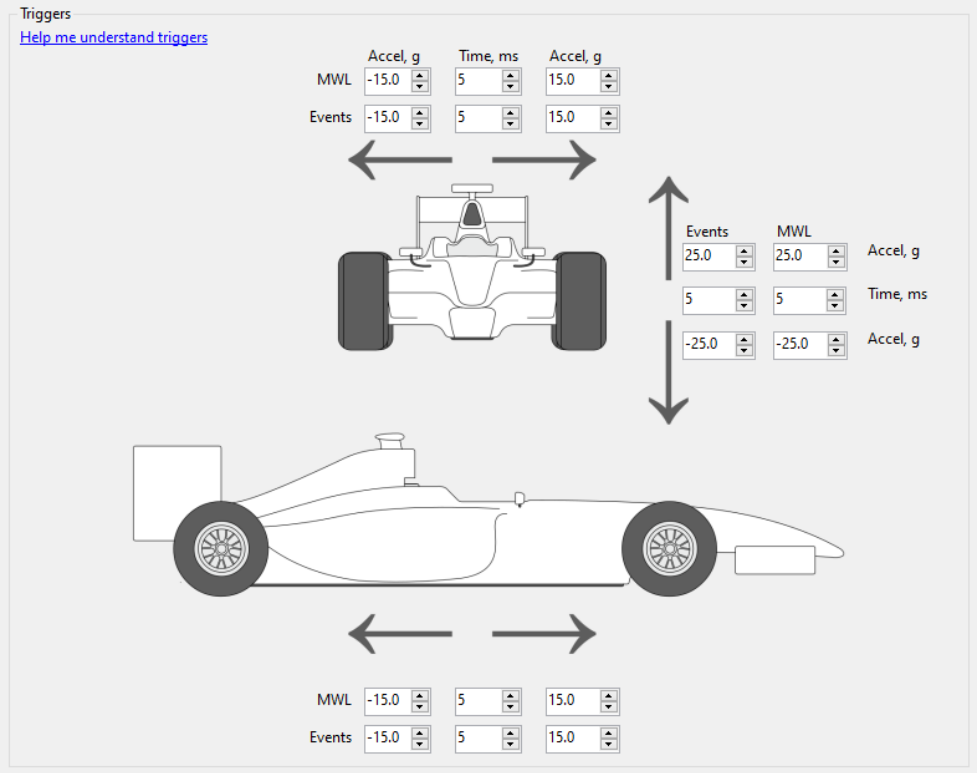
6.5 Triggers

As described above, a **trigger** is what causes an **event** to be captured. There are independent triggers for each axis, and each axis direction has an independent trigger.

In addition, there is a secondary set of triggers used to independently trigger the External Medical Warning Light, allowing the MWL and events to be triggered at separate acceleration and time thresholds.

The image below shows a screenshot from the ADR Utility PC Software, where the triggers may be configured.

Figure 9 - ADR Utility Trigger Configuration



Each trigger is comprised of 2 parameters: acceleration, and time. For a trigger to be triggered, the measured acceleration in that axis must exceed the configured acceleration threshold, for **more than** the time specified.

The acceleration must be consecutive, for example if there are 4ms of 18g but the next millisecond is 14g, the time counter is restarted and the acceleration would need to be measured above 15g for another full 5ms.

Finally, the acceleration is treated as an absolute value, whilst considering the thresholds as signed. For example, 4ms of 18g, followed by 2ms of -18g **will** still trigger, as the absolute acceleration was above both the positive, and negative triggers, for more than the trigger duration.

Once an event is triggered, event detection is **disabled** until it is reenabled towards the end of the current event as described in Special Conditions. This is to prevent multiple events being triggered due to multiple closely space impacts, in for example a vehicle rollover condition.

6.5.1 Special Conditions

As described above, events are **always** 30 seconds, and typically contain 15 seconds of pre-trigger data, and 15 seconds of post-trigger data.

The 15 second pre/post-split is not always true however, when:

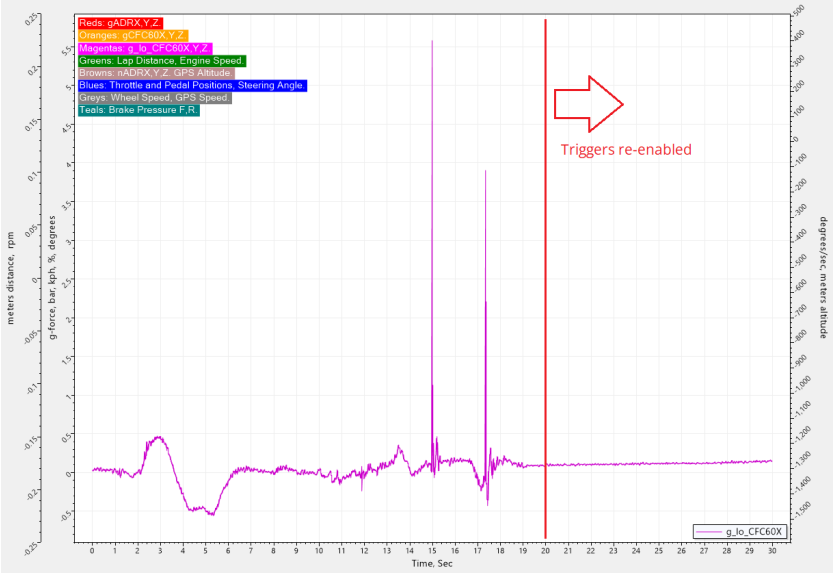
1. An event is triggered less than 15 seconds after the ADR is powered on and starts sampling, the event will still be 30 seconds long, but the trigger will not be at 15 seconds. For example if there is only 5 seconds of data available, the event will contain 5 seconds of pre-trigger data, and 25 seconds of post-trigger data, per the below image.

Figure 10 - Early Event Trigger

2. Once an event is triggered, further event triggering is disabled until 10 seconds before the end of the current event. That is, triggering is re-enabled at 20 seconds into the current 30 second event.

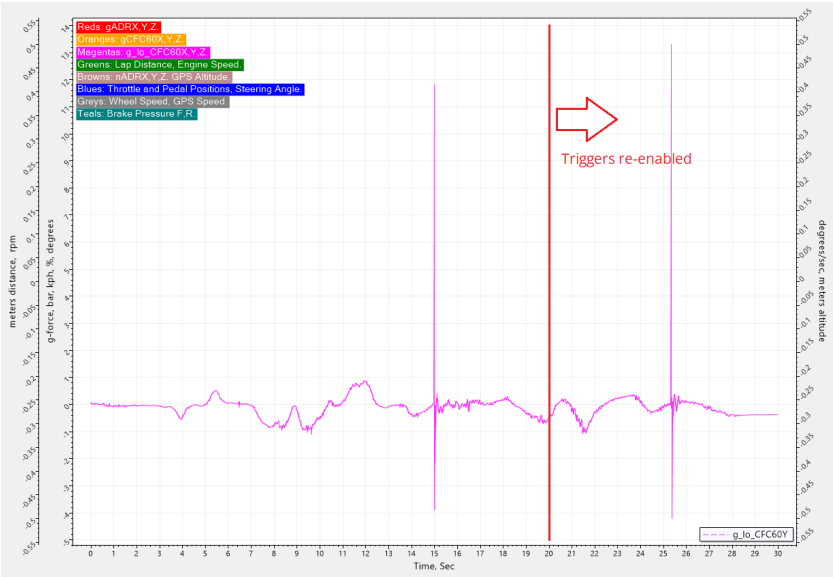
   If an impact triggers an event after the trigger re-enable point, a **back-to-back** event is triggered, meaning that once the current event ends, a second event follows on immediately. In practice, this means the trigger point is not within the second event, and thus the entire second (or third, fourth etc) event is purely post-trigger data. Therefore in the below image, the second acceleration pulse will **not** trigger a back-to-back event, because it occurs before the trigger re-enable point.

Figure 11 – Disabled Triggers



In the below image, the second impact pulse **will** trigger a back-to-back event, because it occurs **after** the trigger re-enable point.

Figure 12 – Back-to-back Event Trigger



6.5.2 Exporting Events to CSV

In some cases it may be desirable to export an event file to CSV, for use in other software. ADR Utility supports exporting to CSV, with the channel order defined by FIA 8872-2018.

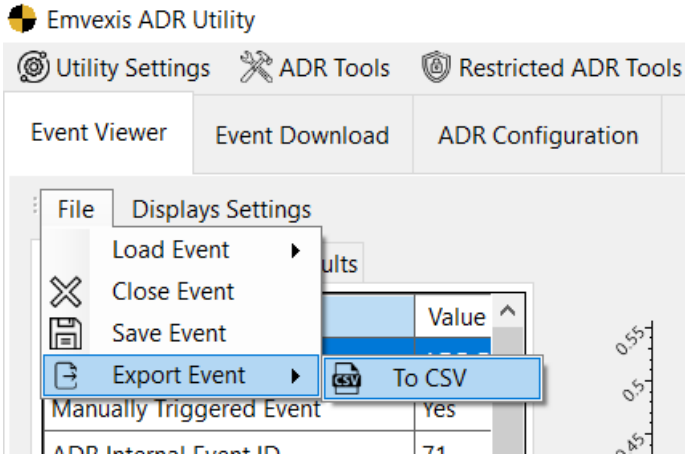
Unless absolutely necessary, Emvexis advises against exporting to CSV, as much of the accompanying event metadata is lost, such as:

- Event properties
- Event fault information
- ADR configuration information

CSV file sizes are notably larger than the XML file from which they were created. The filename, channel order, and CSV headers included in the file are all defined by FIA 8872-2018 and are not configurable.

To perform an export:

1. Open the event .XML file in ADR utility that you wish to export to CSV
2. Click File > Export Event > To CSV
3. Choose the location to save the file to, in the dialog that is displayed



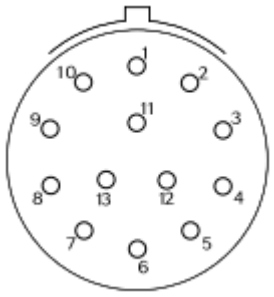
7 Electrical Connector Pinout

The ADR follows the pinout convention required by FIA 8872-2018, and uses either of the following connectors:

- Souriau 8STA2-1035PN, mates with 8STA6-1035SN, or
- Deutsch AS210-35PN, mates with AS610-35SN

Note that both connector options are interchangeable, and ADRs may be shipped with either Souriau or Deutsch connectors.

The pin physical positioning follows the diagram below, relative to the single master keyway slot in the connector shell. The diagram below is looking **into** the male-pinned ADR connector, not the female-socket cable plug.



The pinout functional mapping corresponds to the table below.

Table 8 - Connector Pinout

Pin Number	Pin Function	Notes
1	RS-232 RX	
2	External Medical Warning Light	See External Medical Warning Light
3	CANH	
4	CANL	
5	External Status Light	See External Status Light
6	RS-232 TX	
7	USB V_{BUS}	$+5V_{DC}$ USB supply. Only used when connected via USB
8	USB D+	
9	USB D-	
10, 11	Not used	Reserved for future use
12	Battery positive	
13	0V	

Emvexis supplies USB only ADR Interface Cables using this connector and pinout specification, for USB connection to the ADRs.

8 Status Indicator LEDs

The ADR provides three methods of visually indicating status information:

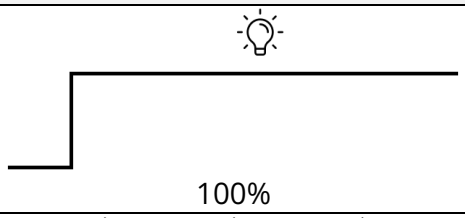
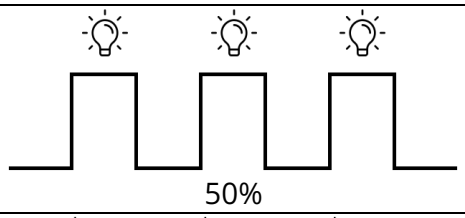
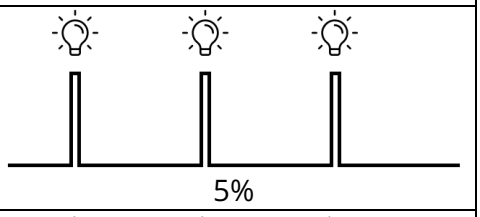
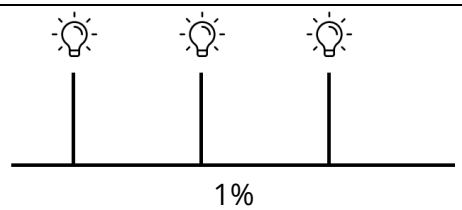
1. an on-board multi-colour LED,
2. the ability to drive two external LEDs via its constant-current driver output pins (see Electrical Connector Pinout)
3. broadcast of status information via CAN, which may be received by a third-party device to either drive LEDs or display information on a screen

8.1 On-board LED

The ADRs on-board, multi-colour LED function is defined primarily by the FIA 8872-2018 standard and is thus fixed/not user configurable. Additional colour/flash states beyond those specified in FIA 8872-2018 are used and are not configurable.

The LED can display red, green and orange, and these colours combined with various flash states, are used to indicate the status of the ADR, as defined in the table below.

Table 9 - Onboard LED States

ADR State	Colour	Flash Frequency, Hz	Duty Cycle	Brightness, %
Normal, no faults	Green	0		50
Busy[1]	Orange	0		
Hard fault present	Red	0		
Normal, soft fault present	Green	1		100
Triggered	Green	10		
Booting	Orange	10		
Self test	Orange	2		
Event Stored	Red	4		
Low power sleep	Orange	1		

1. Busy states include event download, event erase, firmware update in progress

8.2 External LEDs

The ADR can drive 2 external LEDs, via pins 2 and 5. These pins are constant current LED drivers, and thus require no external current limiting resistor. The drivers output a constant 19mA current, regardless of the connected LEDs forward voltage. It is therefore recommended to select external LEDs rated for a forward current of at least 25mA.

The equivalent control circuit for the external LEDs, is shown below, and is duplicated for both the External Status Light, and the External Medical Warning Light.

Note ESD protection input structures are present, but not shown in the diagram.

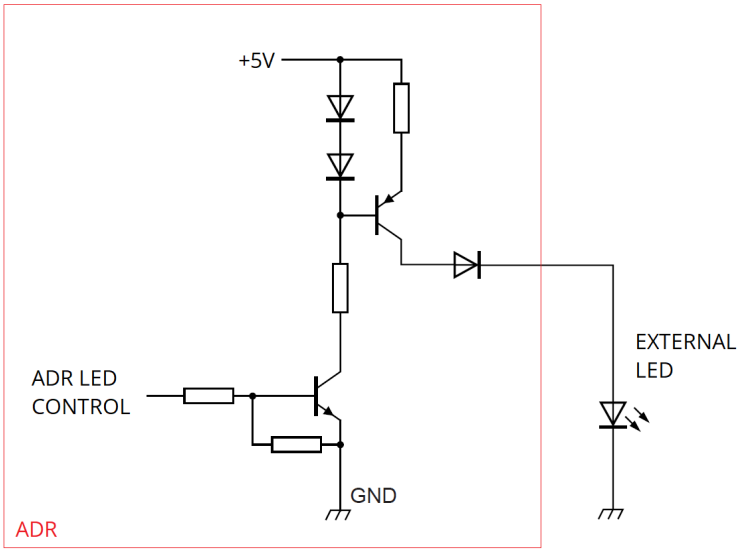
The status of the external LED is linked to the On-board LED states, as shown in the table below.

Table 10 - External LED States

ADR State	Ext Status LED[2]
Normal, no faults	On
Busy[1]	Off
Hard fault present	Off
Normal, soft fault present	On
Triggered	On
Booting	Off
Self test	Off
Event Stored	On
Low power sleep	Off

1. Busy states include event download, event erase, firmware update in progress
2. External status LED disabled in low power mode

Figure 13 - LED Driver Equivalent Circuit



8.2.1 External Status Light

The external status light is a simplified duplication of the on-board status LED. It has only 2 states, on or off. Table 9 - Onboard LED States details when the external status LED is illuminated, or not.

The external status light may be enabled, or disabled via the ADRs configuration, using the *ADR Utility* software.

8.2.2 External Medical Warning Light

The external Medical Warning Light (MWL) is a configurable indicator light used to inform trackside staff attending an incident (for example, medical crews), that an impact of a certain severity has occurred, which is used to trigger appropriate medical procedures for example.

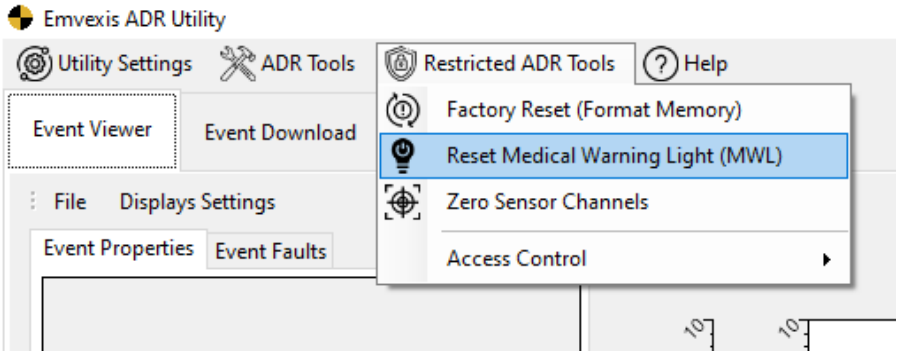
The MWL is triggered in the same way events are triggered, but must be configured equal to, or greater than the threshold used for event triggers, and any attempt to configure otherwise will be rejected by *ADR Utility*. This is to guarantee that any impact that triggers the MWL, will also trigger an event.

The MWL may be enabled, or disabled via the ADRs configuration, using the *ADR Utility* software. Once triggered, the MWL is cleared by 1 of 3 different mechanisms:

1. A power cycle of the ADR (including full discharge of the internal backup supply)
2. Erasing **all** events currently stored in the ADR
3. Manually resetting the MWL via ADR Utility

Note that for options 2 and 3 above, these are passcode protected functions that require either the FIA or authorised delegate to perform these.

To reset the MWL, first unlock the ADR, and then click Restricted ADR Tools > Reset Medical Warning Light (MWL)



Alternatively, erasing all events from the ADR will also reset the MWL.

8.3 Special case – low power mode

In the case of external power supply to the ADR having been lost, the ADR automatically switches to using its own internal backup power supply, which allows the ADR to continue operating normally for approximately 5 minutes.

During backup operation, to extend the period the ADR is able to operate from its backup supply, the LED behaviour is altered, specifically:

- The external status LED is disabled
- In the 'Normal, no faults' ADR state, the LED brightness is reduced from 50%, to 25%

9 Configuration

The ADR is configurable by the user to suit the application in which it is being used. Some of the configurable parameters must be configured by the vehicle manufacturer, or installer of the ADR, whilst other parameters may only be configured by the FIA, or authorised delegate, as per requirements of a given championship, such as event triggering thresholds.

All configurable parameters are grouped into two categories:

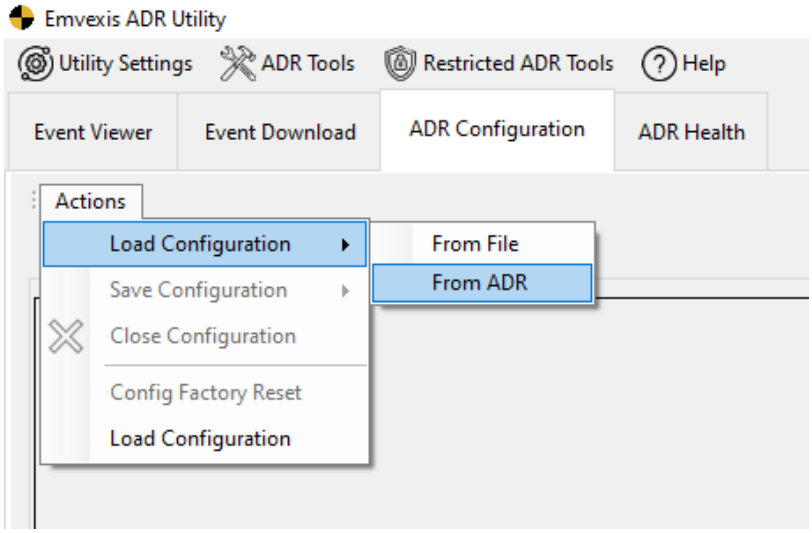
1. User Parameters – these are parameters that any user can configure at any time
2. Restricted Parameters – these are parameters that only the FIA, or its authorised delegates may configure, and are passcode protected

9.1 Loading Configuration from ADR

To edit the configuration in an ADR:

1. Connect the PC to the ADR using an ADR Interface Cable
2. Open the ADR Configuration tab in the main user interface
3. Click Actions > Load Configuration > From ADR

Figure 14 - Opening an ADRs Configuration



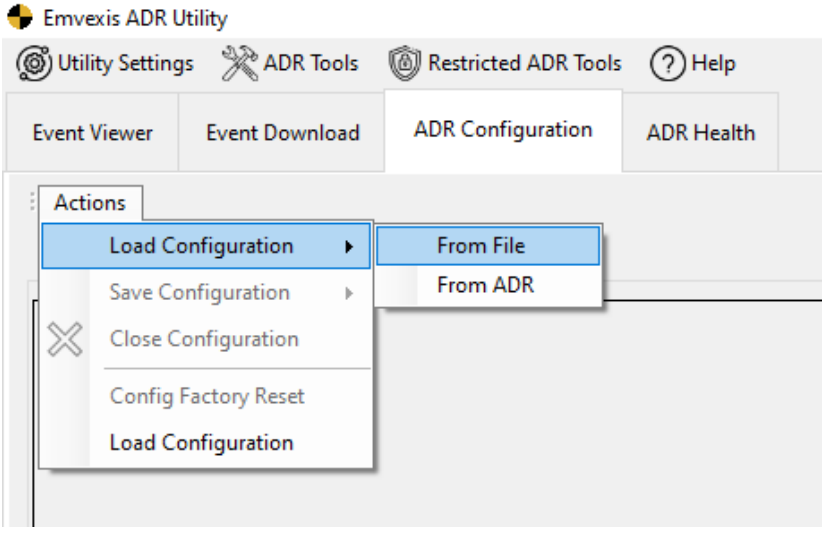
9.2 Loading Configuration from files

Instead of loading a configuration directly from an ADRs memory, it is possible to load a configuration from a file stored on the PC.

This is useful where the same configuration needs to be applied to multiple ADRs quickly; whilst the ADR stores its configuration file in internal memory, if the same configuration is to be used for multiple ADRs, the configuration may be opened from file, and then saved into each ADR.

The configuration files are saved as human readable .XML files.

Figure 15 - Opening an ADR Configuration File



9.3 Saving Configuration to ADR

Once changes are made to a configuration that has been loaded from an ADR, or from a file, the configuration needs to be saved back into the connected ADR, using Actions > Save Configuration > To ADR.

It is possible that the ADR may reject the configuration, if invalid configuration settings are applied, such as setting the MWL thresholds lower than the event thresholds. Whether the configuration is accepted or rejected, ADR Utility will notify you.

If the configuration update is successful, the ADR performs a soft reboot whereby all of the configuration settings are applied as if the ADR is powering up from cold, which includes performing a sensor zeroing, as the orientation settings may have been changed.

Figure 16 - Saving a Configuration to ADR

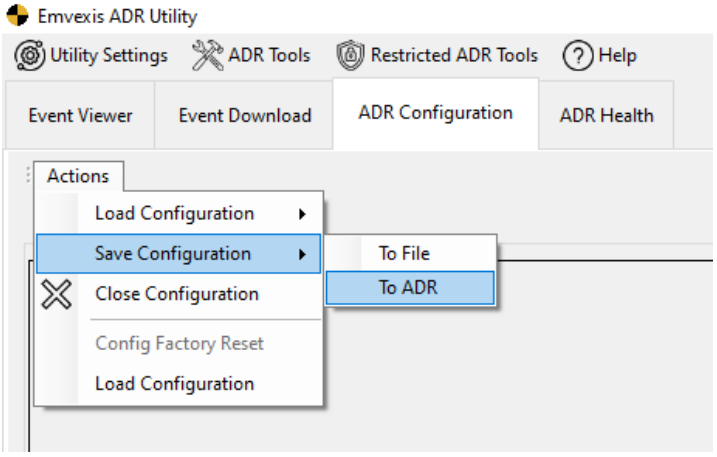
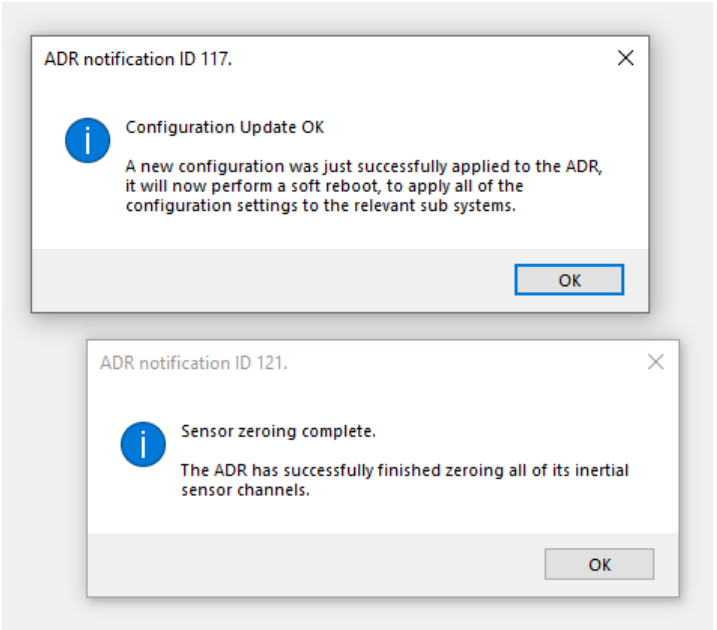


Figure 17 - Successful Configuration Update Notifications



10 Fault Handling

The ADR incorporates an extensive fault management system, which at the time of homologation monitors more than 80 possible fault conditions. The fault management system is designed to achieve several key objectives:

1. **Prevent physical damage to the ADR** – some conditions require software interaction from the ADR, for example latching off CAN bus termination resistors under persistent thermal overload conditions due to damaged CAN bus wiring
2. **Maximise availability of the ADR system** – if subsystems or specific functions of the ADR become faulty, but the ADR is able to continue functioning with a degradation in performance, or loss of a particular function, the fault management system enables this
3. **Maximise fault information to the user** – allows an informed decision to be made as to the validity of captured event data. For example, if an ADR is heated above the maximum operating temperature, the accuracy of the internal sensors is degraded

10.1 Hard vs Soft Faults

Faults are categorised into 1 of the 2 following severity categories:

1. **Hard faults** – these are high severity faults, which the ADR cannot recover from and results in a total loss of ADR function. The number of possible hard fault conditions is limited.
2. **Soft faults** – these are low severity faults, which if present do not fundamentally prevent the ADR performing its function but may impact quality or correctness of data captured. For example, a fault with the backup power supply system may impact the ADRs ability to power itself should the main vehicle supply is lost, but so long as this external supply remains present the ADR is able to continue performing all of its functions

10.2 Inclusion in Events

Every event captured by the ADR includes within its event file a list of any faults that were set at any point during the event. This allows an informed assessment to be made as to the impact any faults may have on the validity of event data.

For example, a fault set due to intermittent reception of steering angle data via CAN, as opposed to a steady stream of data, informs the user that the events steering angle data is unreliable.

10.3 Viewing in ADR Utility

There are 2 different contexts in which ADR faults may be viewed in ADR Utility:

1. As a record of faults captured as part of an event
2. As a list of faults currently set within an ADR currently connected to *ADR Utility*, including historic fault information, via the ADR Health tab.

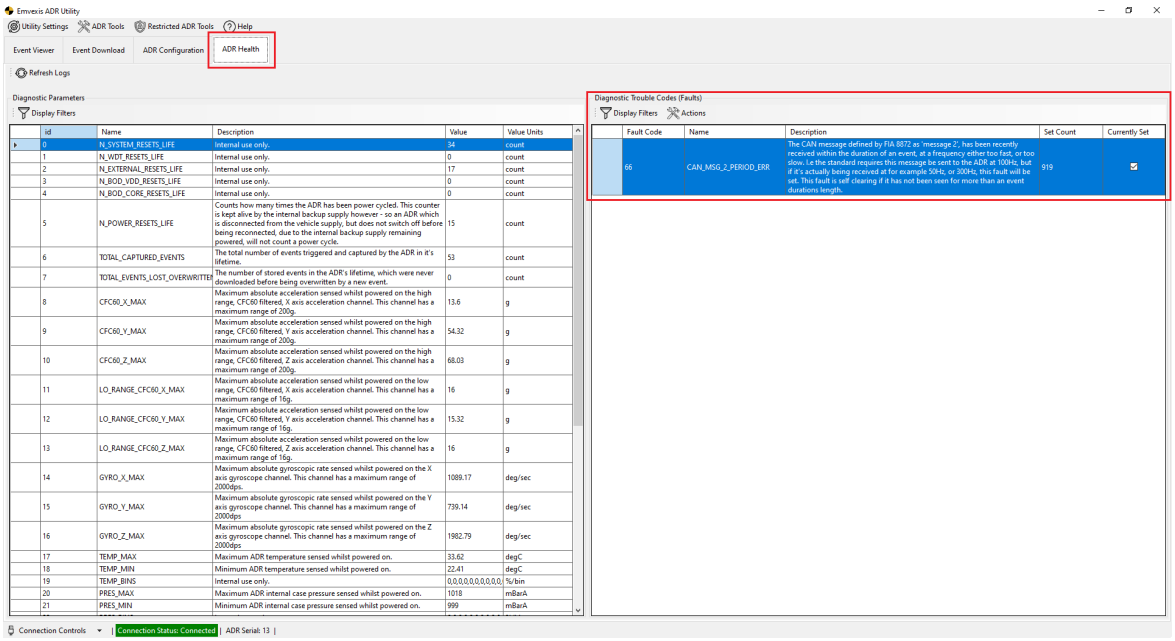
Both current, and historic faults are displayed viewed, including a count of the number of times a given fault code has been set.

Fault set counts may only be cleared (under the Actions menu) by the user for CAN related faults, as these faults are set due to external factors (such as damaged bus wiring), whereas all other faults relate to internal functions of the ADR.

In the image below, ADR Utility shows the current fault information for an ADR configured to communicate via CAN, but is receiving FIA message 2 at an incorrect frequency, thus raising a CAN_MSG_2_PERIOD_ERR fault.

A description of what each fault code means, and its associated implications is displayed directly in the fault list.

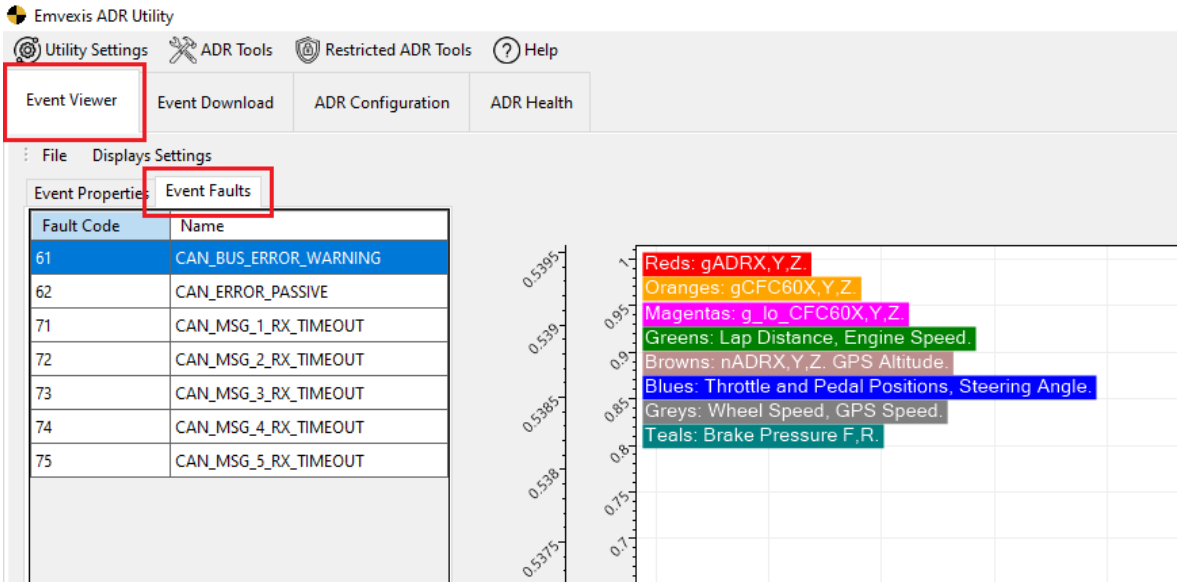
Figure 18 - ADR Utility Connected ADR Fault Information



Faults captured as part of an event, are displayed within Event Viewer under the Event Faults tab, per the image below. Capturing of this fault information is extremely important when it comes to assessing the validity of captured data.

For example, if data on one or more of the CAN channels appears to contain nonsensical data, but the internal channels appear OK, and the event contains CAN related faults, it is possible to determine that there was an issue with CAN communication during the event rendering the CAN channels untrustworthy.

Figure 19 - Event Faults



11 Diagnostics

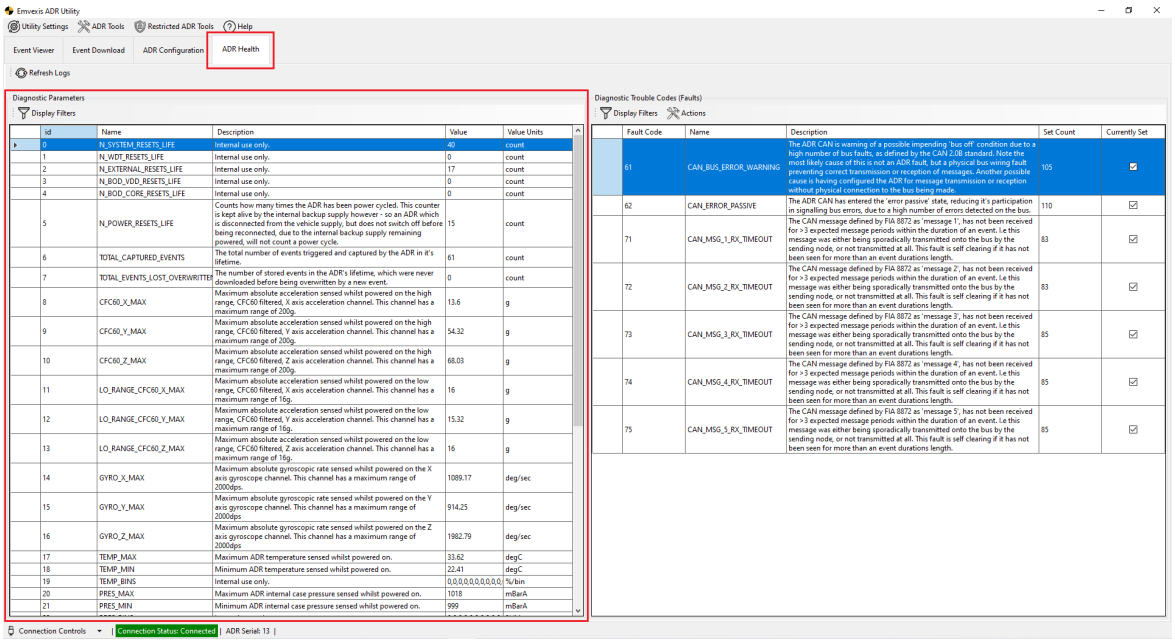
At all times whilst the ADR is powered on, a diagnostic record is maintained, monitoring parameters such as temperatures, uptime duration, and number of events captured.

There are nearly 40 different diagnostic parameters monitored. The diagnostic record is viewable in ADR Utility, in the 'ADR Health' tab, similar to viewing fault codes.

The diagnostic record **cannot** be reset by the user.

As per the fault code information, a descriptor of each diagnostic parameter is displayed in the user interface.

Figure 20 - ADR Utility Connected ADR Diagnostic Information



12 Power Supply

The ADR can be powered via 3 separate voltage sources:

1. Main vehicle supply
2. USB 5V supply
3. Internal backup power supply

12.1 Main Vehicle Supply

This is the power source most commonly used; supplying the ADR via the Battery Positive and 0V pins. This supply is heavily filtered and protected against typical automotive transients, including reverse polarity connection.

When powered from the main supply the internal backup power supply may charge at its maximum rate of approximately 3.3W (if configured to do so).

12.2 USB 5V Supply

To allow a user to connect to the ADR using only an ADR Interface Cable, with no additional power source required, the ADR capable of being powered solely by a USB connection.

The only restriction is that the charging rate of the internal backup power supply is limited to approximately 0.4W, however in practice this is no real limitation, as once the ADR is re-connected to the vehicle harness and power supply, it will resume charging at maximum configured power.

The ADR otherwise behaves exactly as if it were powered by the vehicle supply, allowing the user to perform all necessary functions.

12.3 Backup Power Supply

Under normal operation, the ADR is externally powered via one of the two external supplies described above.

However, in the event of an interruption or loss of the external supply (for example due to a severe accident which damages the vehicles electrical system), then to allow the ADR to continue performing all its functions, it utilises an internal backup supply.

The internal backup supply is a supercapacitor backup system, charged when connected to an external supply. These supercapacitors supply power into the input of the ADRs

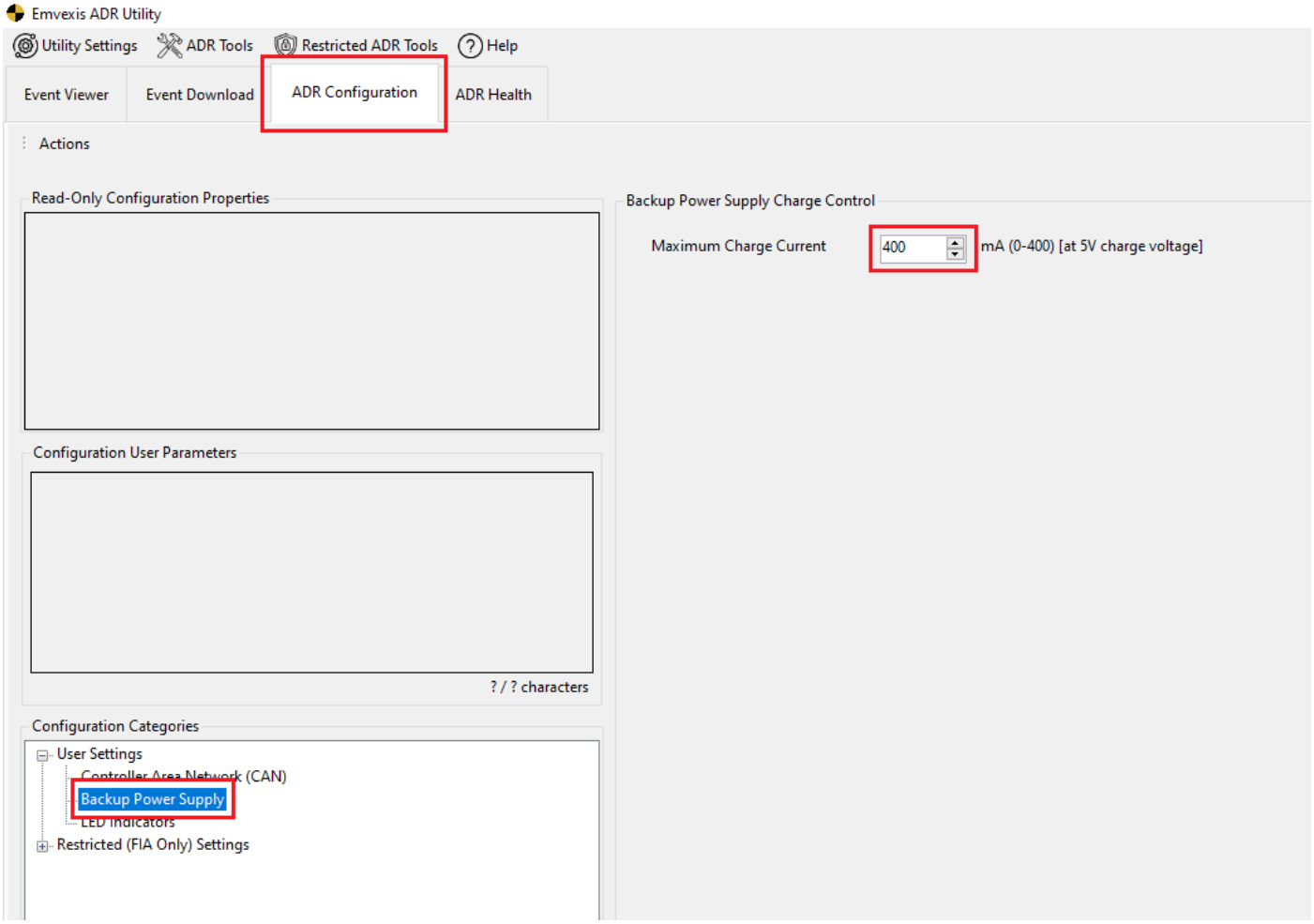
various power supplies, such that it can continue normal functioning when operating from the backup supply.

The backup supply charge power is software configurable within ADR Utility.

The charge current may be configured between 0 and 400mA – note this is current at 5V, not at the supply voltage of the ADR. When the ADR is powered with >5V, the current drawn by the ADR due to charging will be less than the configured current, approximately in accordance with the formula `power = voltage x current.`

See Table 3 - Current Consumption for the current drawn at 13.8V supply voltage, for a 400mA configured charge current.

Figure 21 – ADR Utility Configuring Charge Current



13 Real Time Clock

The ADR features an internal real time clock used to keep track of the current year, month, day, weekday, hour, minute and second, for the purposes of timestamping events.

The RTC automatically handles calendar exceptions such as leap years.

A dedicated internal backup battery ensures the clock remains continuously powered and is sized to last longer than the FIA homologation validity period of the ADR and is thus not user serviceable.

The battery is replaceable by Emvexis if required.

14 Communication

The ADR features multiple communication interfaces, for the following purposes:

1. Setup and configuration of the ADR
2. Capturing of additional data from the vehicle's communication networks
3. Broadcasting of data from the ADR, onto the vehicle's communication networks
4. Providing 'expansion' capability to interface with other devices, such as external GPS receivers

14.1 USB

The ADR features a USB 2.0 interface, used for both configuration and event download. No special software drivers are necessary, all the necessary drivers are built into Windows®.

14.2 CAN

The ADR hardware supports both classical CAN, and CAN-FD according to ISO 11898-1:2015, but implements only classical CAN, to comply with the requirements of FIA 8872-2018.

The physical interface is designed to be electrically robust, with multiple layers of fault protection and tolerance, in addition to extensive application-software level diagnosis to detect conditions such as missing messages, or incorrect message reception frequency.

Configuration of the ADRs CAN functionality is limited due to the requirements of the FIA 8872-2018 regulation. For example, the number of, frequency and contents of messages are all strictly defined by the regulation, and thus are not configurable.

CAN may be entirely enabled or disabled on an ADR, to account for the fact that some ADR installations will not make use of CAN, and disabling CAN will prevent the ADR raising soft faults indicating that CAN communication is not active.

Configurable settings include:

- Bus termination options
- Which incoming, and outgoing messages are enabled
- Single, configurable out message for external MWL triggering

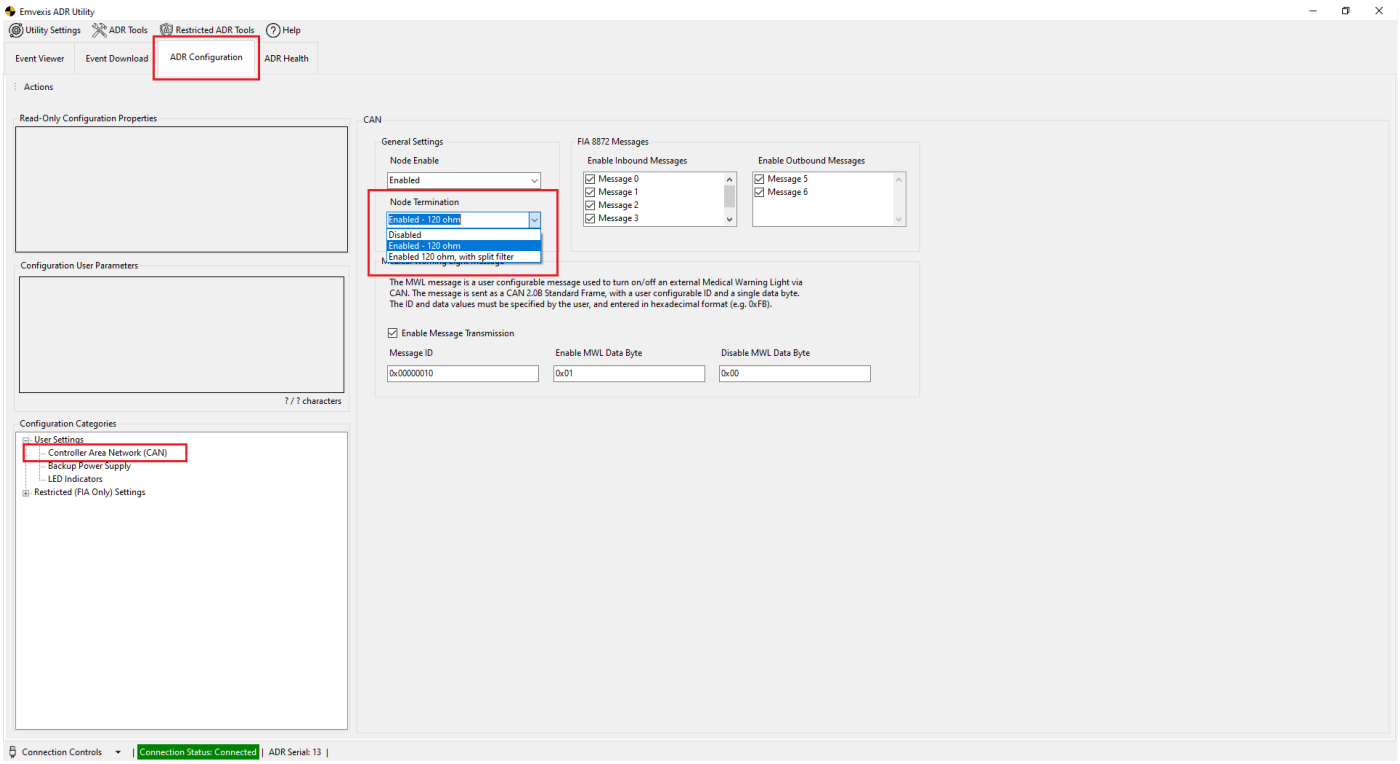
14.2.1 Software Selectable Bus Termination

If bus termination is required at the ADR, no external termination resistors are required. The ADR features internal, software selectable 120Ω termination, comprised of two series 60Ω resistors with software selectable, center tap, split termination filtering.

The termination resistors are protected from thermal overload during short to VBAT and short to 0V conditions, at $24V_{DC}$.

Configuration of the termination is performed using *ADR Utility*, as per below. The CAN must be enabled for the ADR, **even if no messages are enabled**, for the option to enable termination to become available.

Figure 22 - CAN Bus Termination Configuration



14.2.2 FIA Standard Messaging Protocol

The FIA 8872-2018 standard defines a set of messages that must be sent to the ADR by the vehicles other systems, including the message IDs and data formats, in addition to the messages that the ADR transmits.

It is permissible for other messages to be present on the bus, the ADR will simply not accept those messages.

All multi-byte fields use big-endian byte order.

Message 1, **ID:** 0x200, **Rate:** 100Hz, **Direction:** Input to ADR

Byte	Description	Scaling	Type
0-1	Engine rotational speed	1 rpm/bit	16-bit unsigned
2	Front brake pressure	1 bar/bit	8-bit unsigned
3	Rear brake pressure		
4-5	Lap distance	1 m/bit	16-bit unsigned
6-7	Throttle actuator position	0.1 %/bit	16-bit signed

Message 2, **ID:** 0x204, **Rate:** 100Hz, **Direction:** Input to ADR

Byte	Description	Scaling	Type
0-1	Vehicle wheel speed	0.1 kph/bit	16-bit unsigned
2-3	Steering angle	1 °/bit	16-bit signed
4-5	Throttle pedal position	0.1 %/bit	
6-7	Not used	-	-

Message 3, **ID:** 0x680, **Rate**: 10Hz, **Direction:** Input to ADR

Byte	Description	Scaling	Type
0-3	GPS latitude	1e7 degrees	32-bit fixed point (7dps) value
4-7	GPS longitude		

Message 4, **ID:** 0x681, **Rate:** 10Hz, **Direction:** Input to ADR

Byte	Description	Scaling	Type
0-3	GPS time	HHMMSSsss[1]	32-bit unsigned
4-5	GPS speed	0.1 kph/bit	16-bit unsigned
6-7	GPS altitude	0.1 m/bit	16-bit signed

1. GPS time encoding example: 23hrs 30mins 40secs 999millisecs, encoded as unsigned numerical integer whose value is 233040999, or 0xDE3EC67. Value is transmitted to ADR as:
    a. Byte 0: 0x0D
    b. Byte 1: 0xE3
    c. Byte 2: 0xEC
    d. Byte 3: 0x67

Message 5, **ID:** 0x682, **Rate:** 10Hz, **Direction:** Input to ADR

Byte	Description	Scaling	Type
0-2	GPS date	DDMMYY[1]	24-bit unsigned
3-7	unused	-	-

1. GPS date encoding example: 18th June 2024, encoded as an unsigned numerical integer whose value is 180624, or 0x2C190. Value is transmitted to ADR as:
    a. Byte 0: 0x02
    b. Byte 1: 0xC1
    c. Byte 2: 0x90.

Message 6, **ID:** 0x7B, **Rate:** 10Hz, **Direction:** Output from ADR

Byte	Description	Scaling	Type
0	Accident Severity Index	0 = no accident 1-255 = maximum absolute acceleration of last accident detected since power on	8-bit unsigned
1	ADR firmware version	10 (e.g. version 3.7 = 37 = 0x25)	
2-3		See table below	bitmapped
4-5	ADR serial number	1	16-bit unsigned

Table 11 - Message 6 Status Bitfield Descriptor

Bit	Description	State
0	Logging in progress	**1** if an event has been triggered, completed, and is now currently writing to flash. I.e. this bit only goes to 1 for a few seconds **after** an event has completed, else **0**. Bit 4 is more likely to be useful for use by another system.
1	ADR configuration OK	**1** if the ADRs configuration is OK (did not fail CRC-32 integrity check) and is in use, else **0** and the ADR is using factory default configuration settings.
2	CAN communication OK	**1** if CAN is enabled, and no CAN Protocol Faults are set, else **0**
3	Accident stored	**1** if ADR contains at least one stored event, else **0**
4	Accident active	**1** if an event is currently triggered, and in progress, else **0**
5	Download mode	**1** if USB interface is connected to ADR Utility (**not** just plugged into PC), else **0**
6-15	Unused	Always 0

Message 7, **ID:** 0x81, **Rate:** 10Hz, **Direction:** Output from ADR

Byte	Description	Scaling[2,3]	Type
0-1	Gyroscope yaw rate (rate about Z axis)	7 LSB/0.060975dps	16-bit signed
2-3	Acceleration Y (gCFC60Y)[1]	16 LSB/0.098g	
4-5	Acceleration X (gCFC60X)[1]		
6-7	Acceleration Z (gCFC60Z)		

1. Note channel order of YXZ is correct per FIA 8872-2018. YXZ means lateral, longitudinal, vertical, as would typically be expected from a vehicle coordinate system.
2. Gyroscope field increments and decrements in steps of 7 LSBs, i.e. never will 4 LSBs be set for example, only 0, 7, 14, 21 etc. This CAN channel contains a nominal 0.35% error due to scaling, and resolution limitations of the CAN channels. This error is **not** present in event files downloaded from ADRs.
3. Acceleration fields increments and decrements in steps of 16 LSBs, i.e. never will 9 LSBs be set for example, only 0, 16, 32 etc. Accelerometer calibration values are **not** applied to data broadcast on these channels, therefore these channels contain data accurate only to +/- 10%. These channels contain a nominal 2.1% error due to scaling, and resolution limitations of the CAN channels. This error is **not** present in event files downloaded from ADRs.

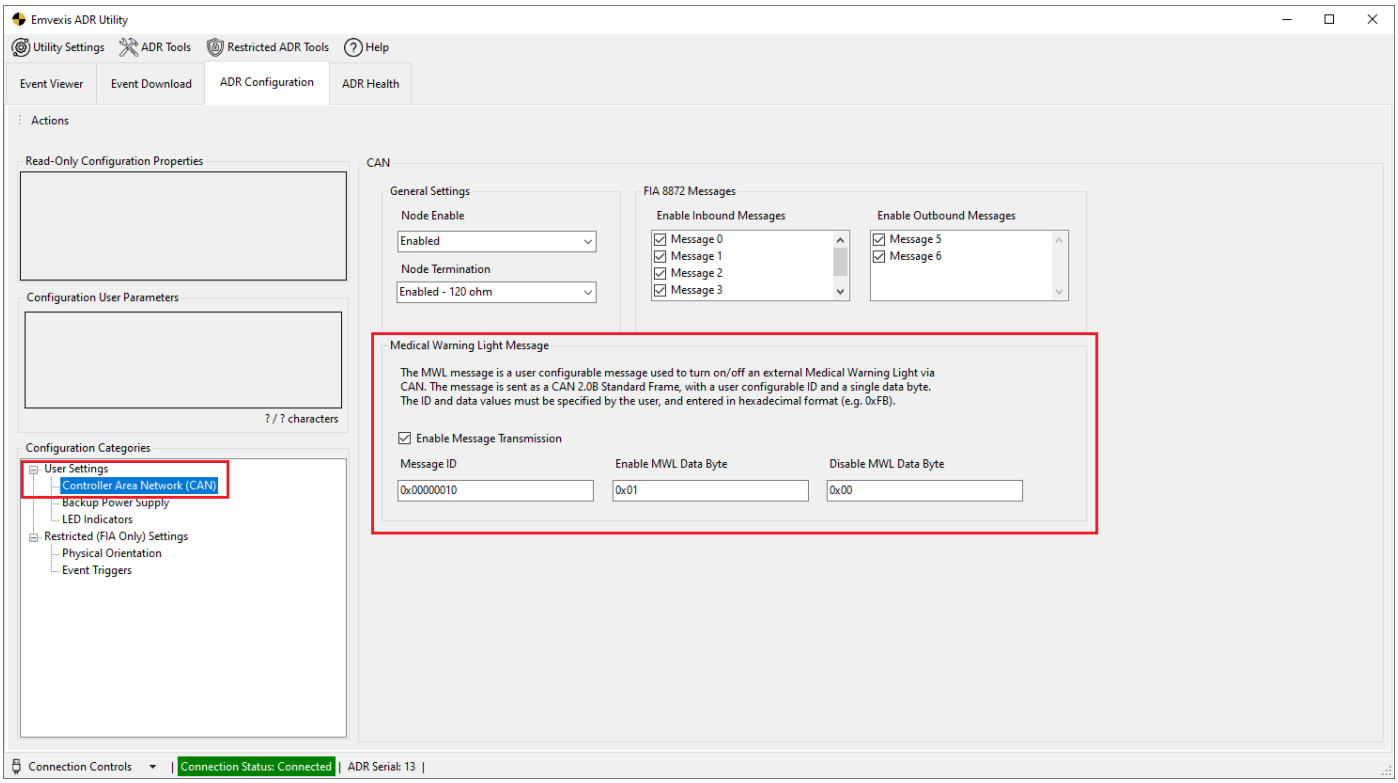
14.2.3 User Configurable MWL Trigger Message

In addition to the standard FIA messages described above, the ADR supports 1 user configurable outbound message, used to control an external Medical Warning Light via CAN.

To use the message, CAN must be enabled, and the 'Enable Message Transmission' option enabled underneath Medical Warning Light Message.

The message is a CAN 2.0B standard length frame, with a single data byte. The message ID must be set to avoid ID collisions with other CAN traffic in the vehicle.

The 'Enable MWL Data Byte' and 'Disable MWL Data Byte' are the values transmitted in the messages single data byte, that indicate when the MWL should be active, or not. Typically a value of 0, and 1 is used to indicate off/on, but they may be any value between 0-255. The device receiving and acting upon this message needs to be configured accordingly.



14.2.4 CAN Protocol Faults

The ADR features extensive diagnostic of faults related to the CAN system, at both the hardware and communication protocol level. Whilst all of these faults are described in ADR Utility where they appear, the CAN Protocol Faults require special attention.

There are 2 types of CAN fault in particular that are particularly informative: period error faults, and timeout faults, displayed in ADR Utility with the following naming format:

- FAULT_CAN_MSG_n_PERIOD_ERR (fault codes 65-69)
- FAULT_CAN_MSG_n_RX_TIMEOUT (fault codes 71-75)

Period error faults indicate that whilst CAN message traffic is being received, it is being received either sporadically, or at the incorrect frequency. For example messages may stop being received in short bursts, resulting in 'windows' of missing CAN data.

Timeout errors indicate CAN messages have stopped being received altogether. In this case valid data may have been being received, until it stopped.

The two types of faults can co-exist, which would indicate sporadic reception of CAN messages, followed by the messages no longer being received.

14.3 RS-232

A full duplex RS-232 port is provided, with robust electrical protection. This port allows the ADR to interface with any other device implementing RS-232.

However, no software provision is made for this at the time of writing and is provided primarily as a requirement of the FIA 8872 technical regulations, which requires the inclusion of RS-232 hardware but prescribes no requirement for software support.

However, custom functionality may be implemented upon request - please contact Emvexis to discuss your requirements.

15 Installation Instructions

The ADR must be installed in accordance with the FIA Installation Specification for FIA-Approved 8872-2018 Accident Data Recorders (ADR) document.

The FIA specification controls almost all aspects of an ADR installation, except those specific to each manufacturer's ADR. For the Emvexis ADR1, the following supplementary installation instructions apply:

15.1 Orientation

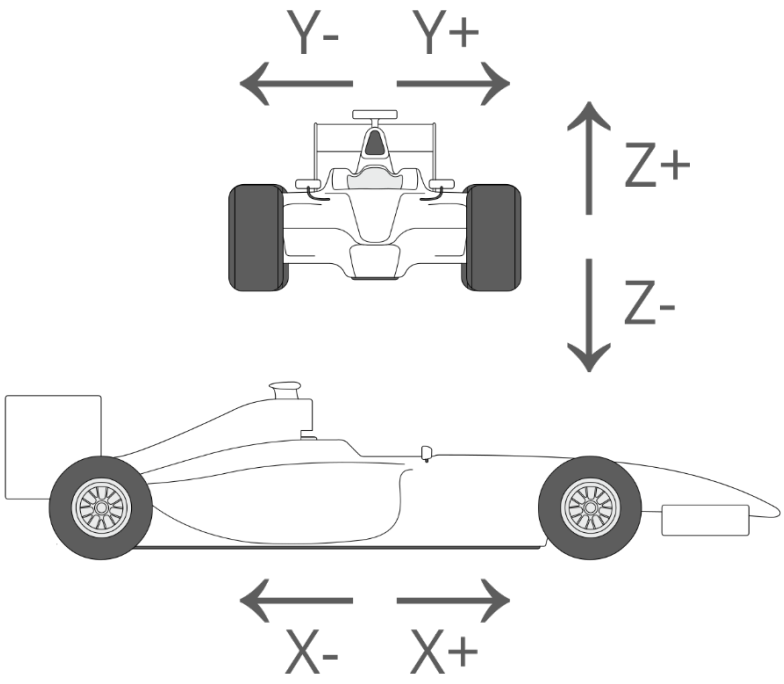
For the ADR to record acceleration and gyro data in the correct event data channels, the ADR must be physically installed within the vehicle in the orientation that the ADR is configured for.

The vehicle coordinate system is defined by FIA 8872-2018 and is different from common automotive standards such as SAE J1733.

The FIA coordinate system is in accordance with the image below. Positive values represent the direction the vehicle must be accelerated in along a given axis, for the recorded data to contain positive values.

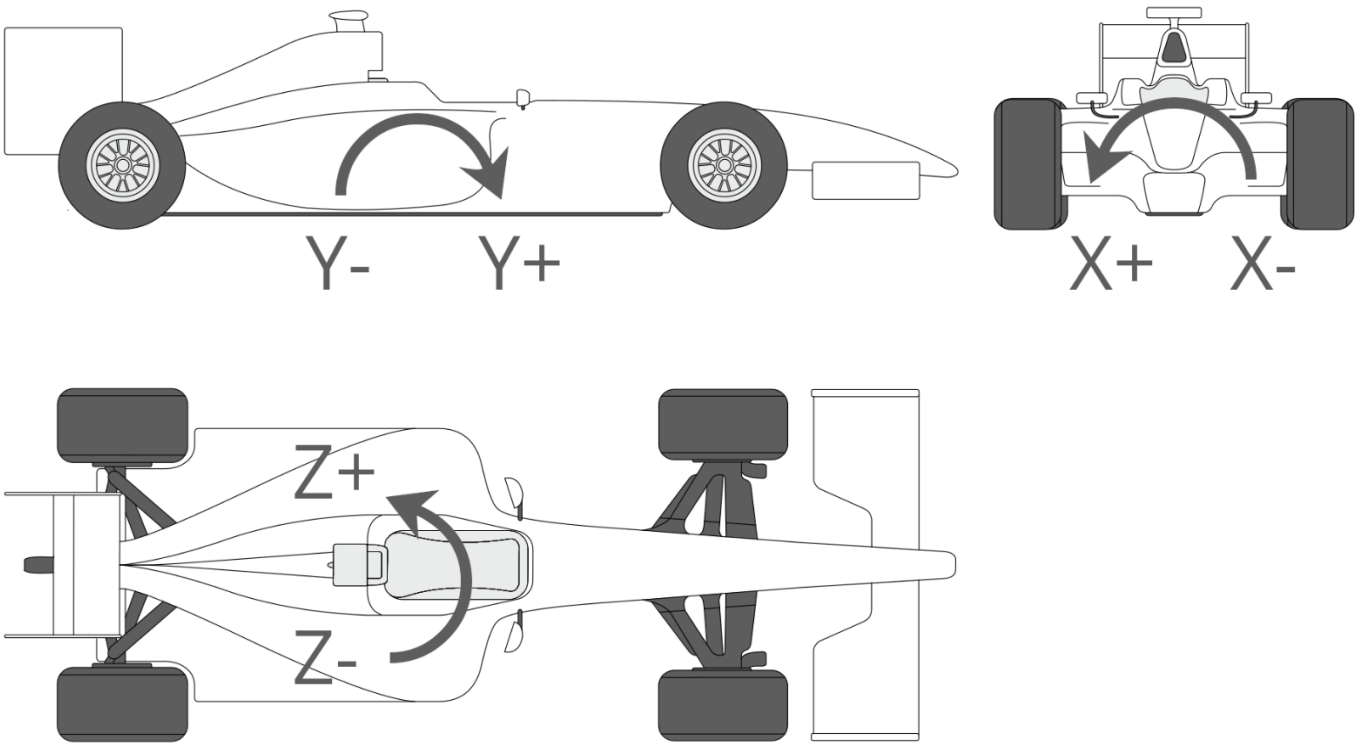
For example, a vehicle accelerating forward at a race start will capture positive X acceleration, and when braking into a corner will record negative X acceleration.

Figure 23 - Accelerometer Channel Orientations



Gyroscope orientation is aligned such that clockwise gyro rotation when looking in the direction of an acceleration axis, results in positive gyroscopic data, as per the below image.

Figure 24 - Gyroscope Channel Orientations



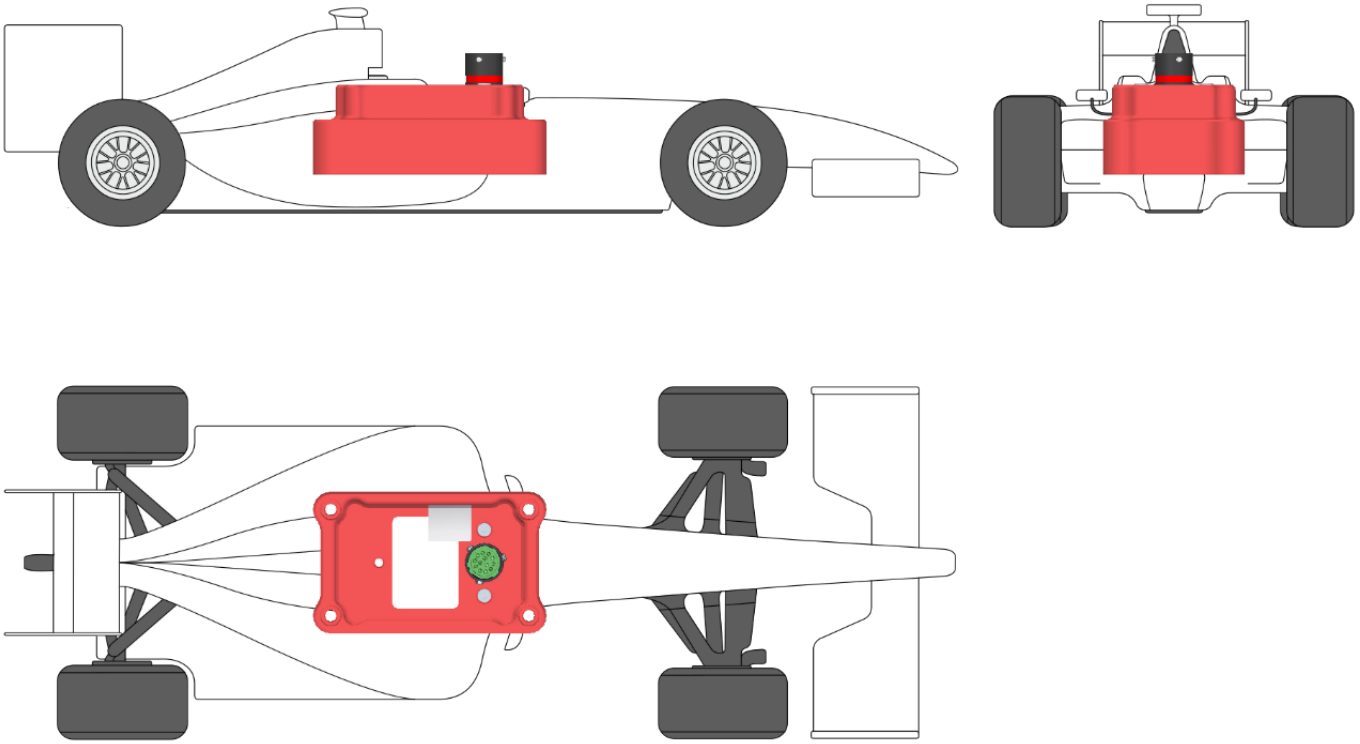
The orientation of the ADR within the vehicle is fully configurable using the *ADR Utility* software, but is a restricted configuration parameter requiring authentication by passcode to perform the configuration.

The orientation configuration ensures that regardless of the ADRs orientation within a vehicle, the event data channels always contain **vehicle aligned** data, not ADR aligned data. That is when properly configured, regardless of the ADRs orientation, the X axis acceleration dataset channel will always contain the vehicle's X axis acceleration, **not** the ADRs X axis acceleration.

In essence, the ADR itself does not have a coordinate system, per se.

The ADR shall therefore be installed in the default installation orientation as shown in the image below, unless absolutely necessary, and only with written permission from the FIA, and the ADR configured accordingly.

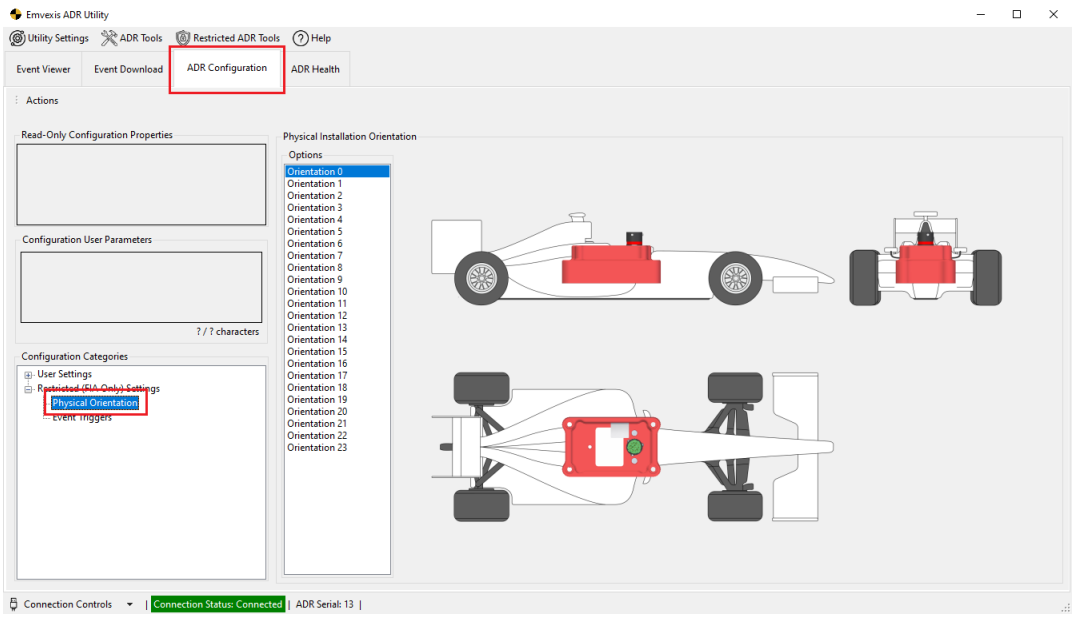
Figure 25 - Default Installation Orientation



15.1.1 Changing Orientation Configuration

As described above, only the FIA may configure the ADR installation orientation, using the tool shown below.

Figure 26 - ADR Utility Configuration Installation Orientation



15.2 Mounting

The ADR shall **always be hard mounted** within the vehicle. It does **not** require vibration isolation that is common with other electronics and **will not record accurate acceleration data if not hard mounted**.

To clarify heading 4.1 within the FIA installation requirements, the ADR does not need to be isolated from vibration to protect the ADR, but it should still not be installed in a location likely to experience high vibration, purely due to the possibility of such vibration being included in recorded event datasets.

For clarity, high frequency vibration is strongly attenuated by the ADRs internal hardware and software filters above 100Hz, but any low frequency vibration or 'panel panting' will be accurately recorded by the ADR.

15.3 Fasteners

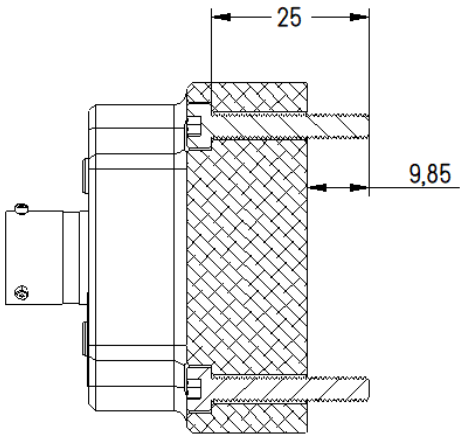
The ADR shall be installed with 4x M4 mounting screws, at an installation torque appropriate for the hardware to which the ADR is being mounted.

It is recommended to use ensure ≥8mm thread engagement into aluminium, or ≥6mm into steel. These guidelines are not definitive, as they depend heavily upon the design of the surrounding structures.

Recommended fastener specifications:

- Geometric standard: DIN 912
- Material: Stainless steel A2-70
- Length: 25mm (provides ~10mm fastener protrusion from ADR underside)

Figure 27 - Recommended Fastener Length



15.4 Power Supply

The ADR shall be powered from a DC voltage source between the minimum and maximum voltage limits defined in Table 2 – General System Specifications. It is recommended to fuse the power supply with a 0.5A fuse.

The bare minimum electrical connections required are power and 0V. See Electrical Connector Pinout.

15.5 USB port accessibility

When the ADR is installed in a position within the vehicle where it can be easily accessed without tools, as per section 15.7, then a USB connection can easily be made to the ADR for the purposes of event download and configuration.

If however the ADR is installed in a position where it is not normally possible to access the ADR, the vehicle must feature a USB 2.0 bulkhead type connector, connected to the ADRs USB pins, in a location which can be easily accessed, such as a bulkhead or dashboard.

15.6 Connecting to CAN

When connecting the ADR to the vehicle's CAN network, the following points should be noted:

- When using the ADRs software selectable, internal 120Ω termination resistors to terminate the CAN bus, the termination is only active whilst the ADR is powered and running. Termination is disabled during ADR firmware update
- The ADRs CAN must be enabled within the ADR configuration before it will participate in CAN activity
- The ADR will only accept the incoming CAN messages defined by the FIA regulation, although it will continue to ACK non-accepted messages in accordance with the CAN 2.0B specification
- The ADR will only broadcast the CAN messages defined by the FIA regulation, in addition to one user configurable message used to trigger an external Medical Warning Light

15.7 External Indicator Lights

If the ADR is installed in a position such that the onboard status light is not visible, the vehicle must be equipped with 2 dedicated indicator LEDs:

- Status light, used to indicate general status of the ADR system
- Medical Warning Light, used to indicate to medical personnel when an accident of a configured severity has occurred

Both of these lights must be in a position that is normally visible to an FIA/ASN official when the occupant(s) is(are) seated normally and must be cleared marked 'ADR Status' and 'ADR MWL'.

The LEDs may be controlled by:

- The ADR's 2 constant current LED driver output pins, or,
- A third-party device such as a Power Distribution Module, capable of receiving and interpreting information via CAN from the ADR, to set the light states

The first option is strongly recommended, to mitigate the risk of misconfiguring third party systems, resulting in incorrect or non-functional indicator lights.

16 ADR Interface Cable

The electrical connection of the ADR within a vehicle is the responsibility of the vehicle designer, builder, or operator as the design of the harness depends upon the functionality of the ADR that is used or not and where the ADR is positioned in the vehicle etc.

However for simple interfacing with the ADR, Emvexis supplies ADR Interface Cables, which are simple USB male A, to the corresponding Deutsch/Souriau connectors detailed here. These allow you to perform all necessary functions, such as:

- Configure the ADR
- View diagnostics and fault information
- Download event and configuration files
- Clearing the Medical Warning Light

The cables are available in a standard length under the following part number, and available in custom lengths on request:

Length (minimum)	Part Number
3M	PN-131

The ADR connector is overmoulded onto the cable, in-house by Emvexis to produce a low-cost, mechanically robust cable assembly. Only pins 7, 8, 9 & 13 are populated in these cables.

The ADR is fully functional when powered only by USB using these cables, with the only restriction being the backup power supply charge rate is limited when on USB power only.

Figure 28 - Standard 3 meter ADR Interface Cable

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