Colour Displays & Data

TRAINING CONFERENCE 2015

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Race smart.

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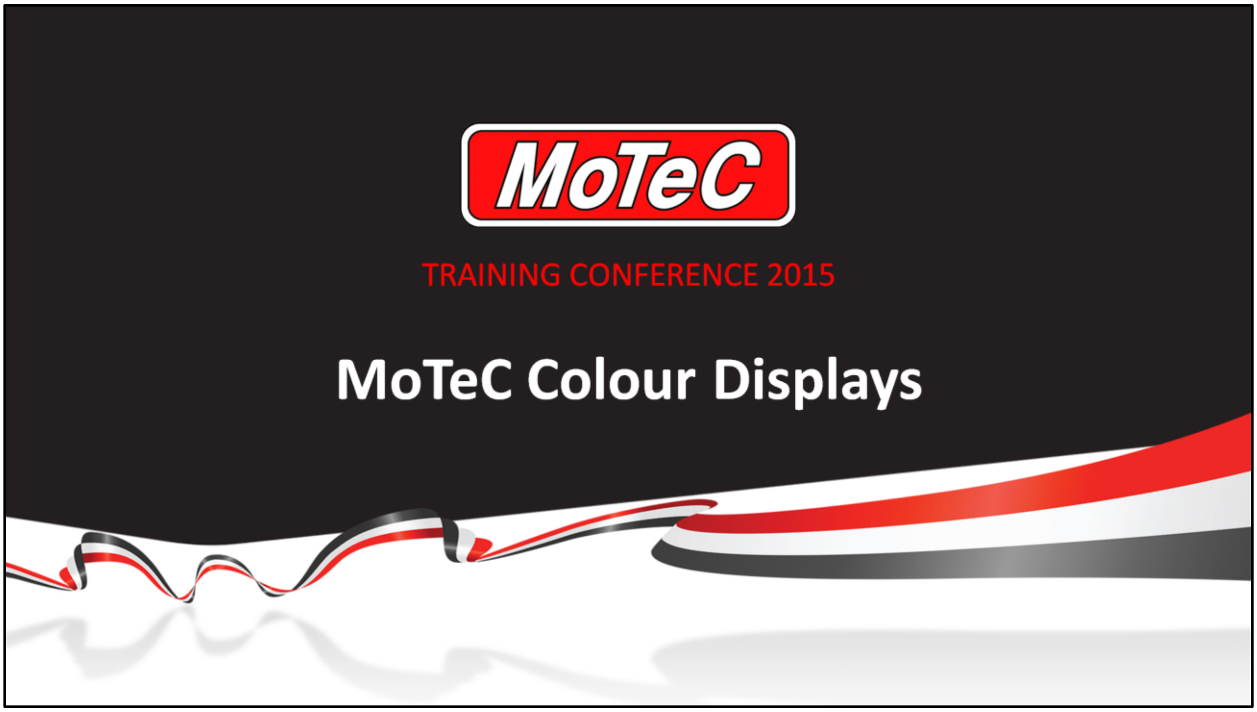
Appendix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MoTeC Colour Displays

Overview

- Introduction to Colour Displays
- Creating a New Configuration
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- Functions/Tables/Condition Setup
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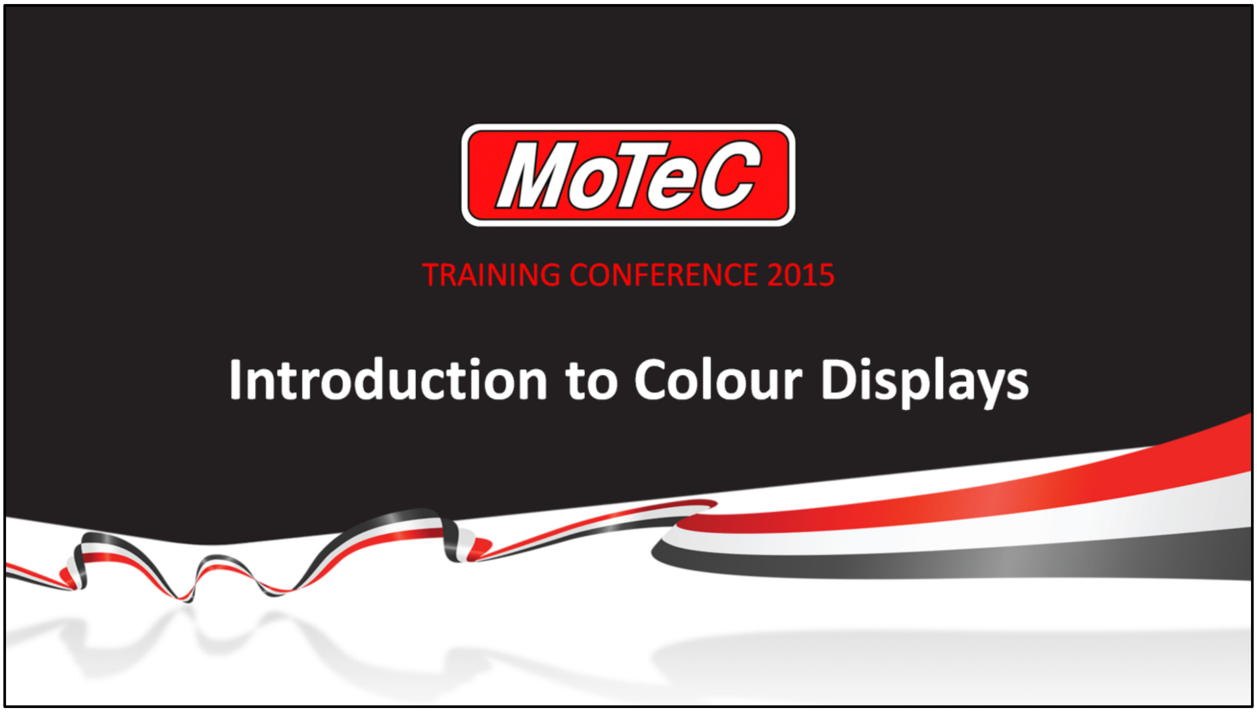
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Introduction to Colour Displays

Types of Colour Displays

D Series (D153/D175)

- Display only
  - No logging hardware
  - Switch and dial inputs
  - CAN communications

C Series (C125/7 and C185/7)

- Display Loggers
  - 120MB to 500MB memory
  - Range of inputs
  - Replaces CDL3/SDL3/ADL3

D Series Displays

D153

- Designed specifically for steering wheel integration
- Flying lead connection
- 8 Analogue and 6 Switch Inputs

D Series Displays

D175

- 22 Pin Autosport connector
- 10 multicolour LED Shift Lights
- CAN connection
- 8 Analogue inputs

I/O Features

2 expanders max, no limitations on using them (like the CDL3 had)

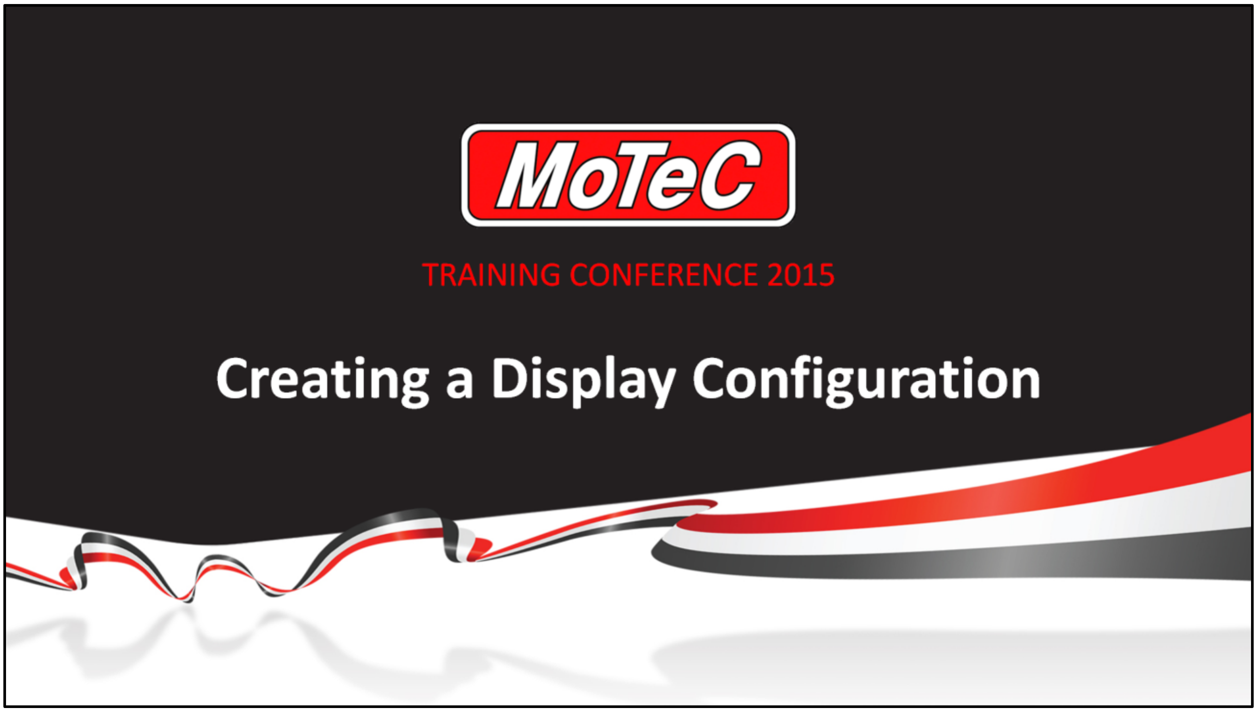
Race Logging Kit:

- 10Hz GPS
- Two button loom
- Network Cable
- Terminated race loom

Standard 250MB

30 I/O standard 44 optional

T2 Upgrade available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Creating a Display Configuration

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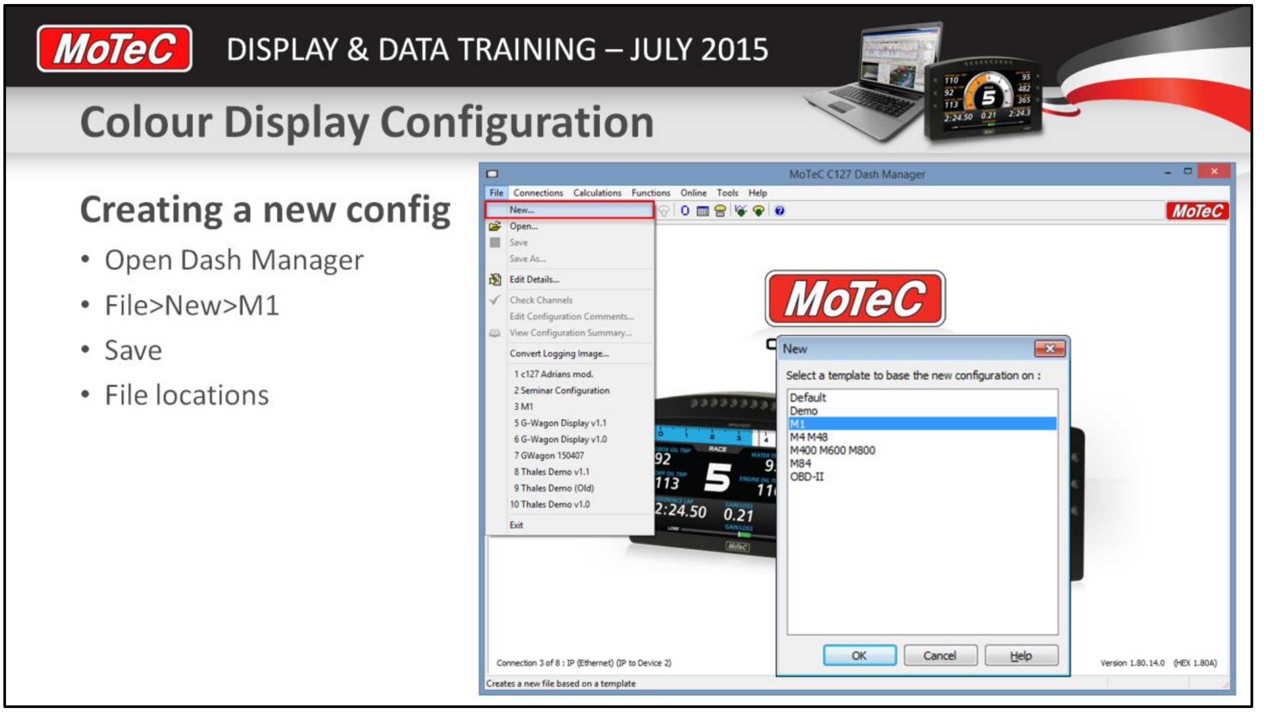
Configuration Overview

- Create a New File/Open Existing File
- Inputs - Physical & Communications
- Logging Setup
- Display Setup
- Alarms
- Vehicle Details
- Connecting to the Display
- Sending the Configuration



Open the correct Dash Manager for the Display you have.

Locale File

After installing Dash Manager software, the first time the software is run a dialogue will appear asking you what 'locale' file you want to use, with a choice of:

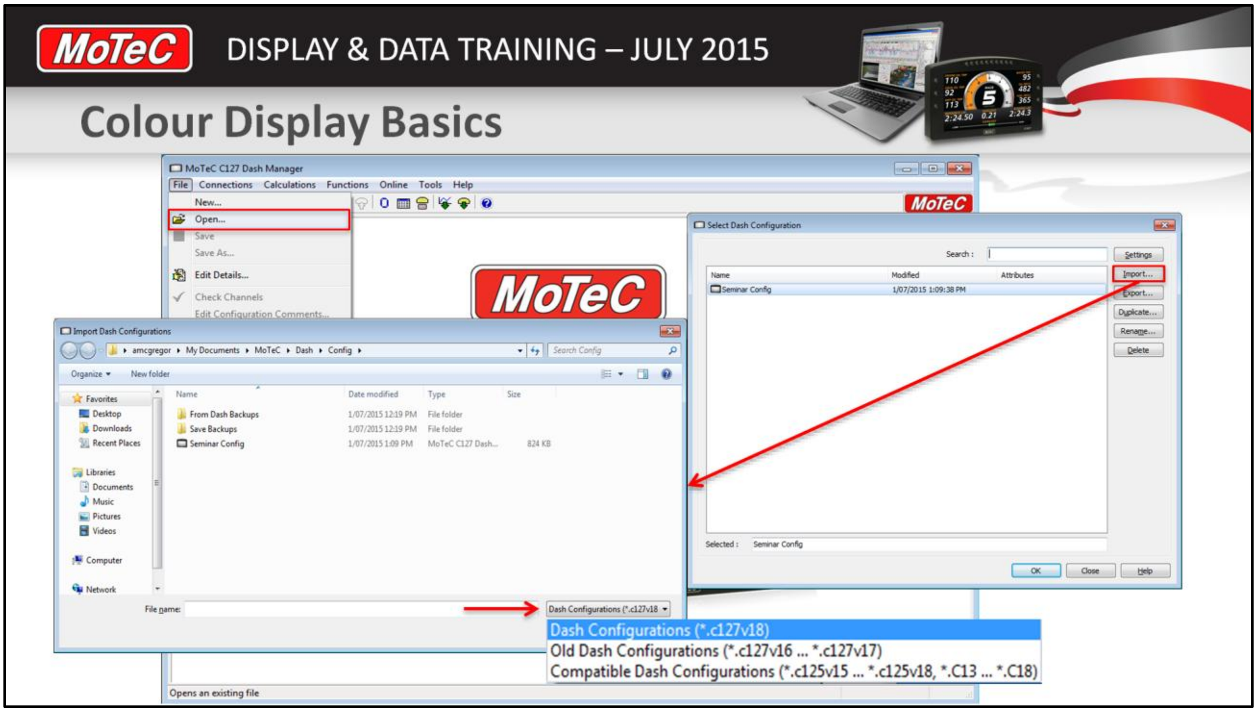
- All channels metric
- Common channels in PSI, F, MPH, In
- Common channels in PSI
- Drag Racing

By default all channels in the Dash are treated as Metric. While it is possible to change the units used for any particular channel by using the 'Edit channel' feature, the locale file offers a way to change the units for a large group of commonly used channels and select the one most appropriate to your application. The selection can be changed at a later date by going to 'Tools – Options' and selecting a different locale file.

Click on File>New and then either select Blank to start from scratch or select the ECU you are using. In this case I will be connected to an M1.

Click on File>Save and call the config an appropriate name. It's always good to include either dates or version numbers so changes can be easily tracked.

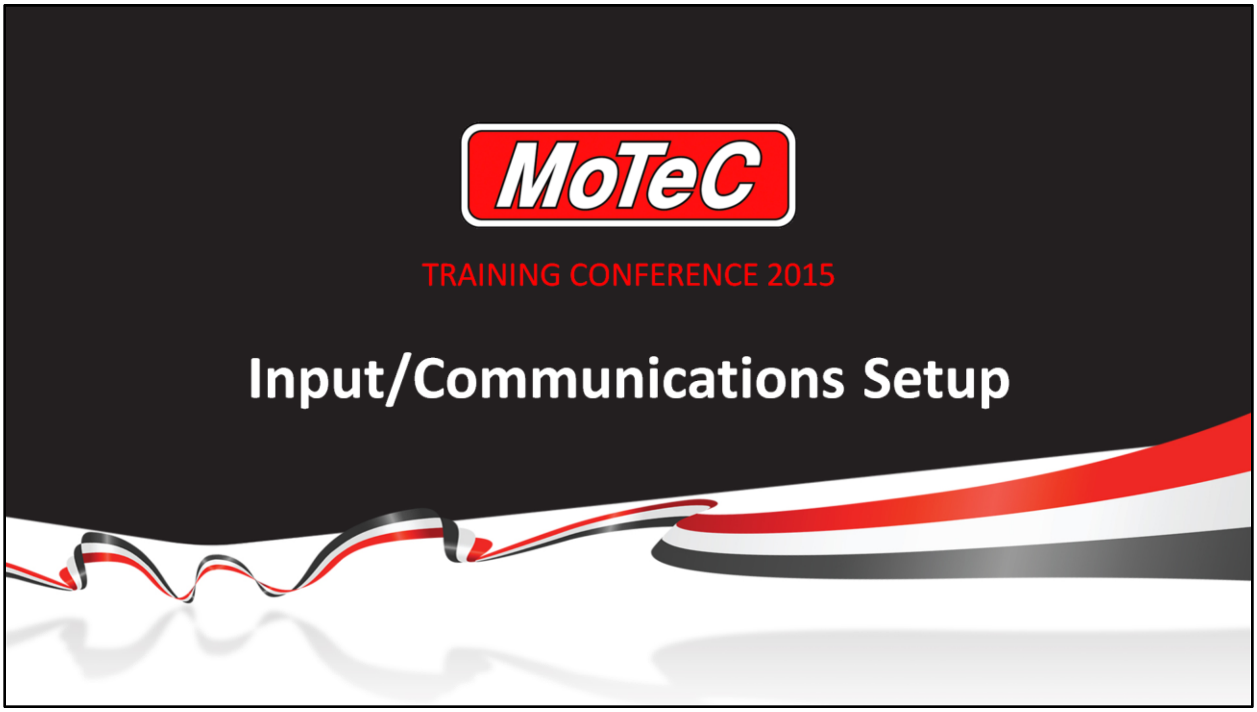
Files are by default saved to 'user'\document\MoTeC\Dash\Config



Click on File>Open to display a window listing all previously saved configs.

If you have a config created with an older version of Dash Manager you can import it using the import button.

You can also select compatible Dash configurations, in this case you can import a C125 config to create a C127 config. C185 to C187 is also possible.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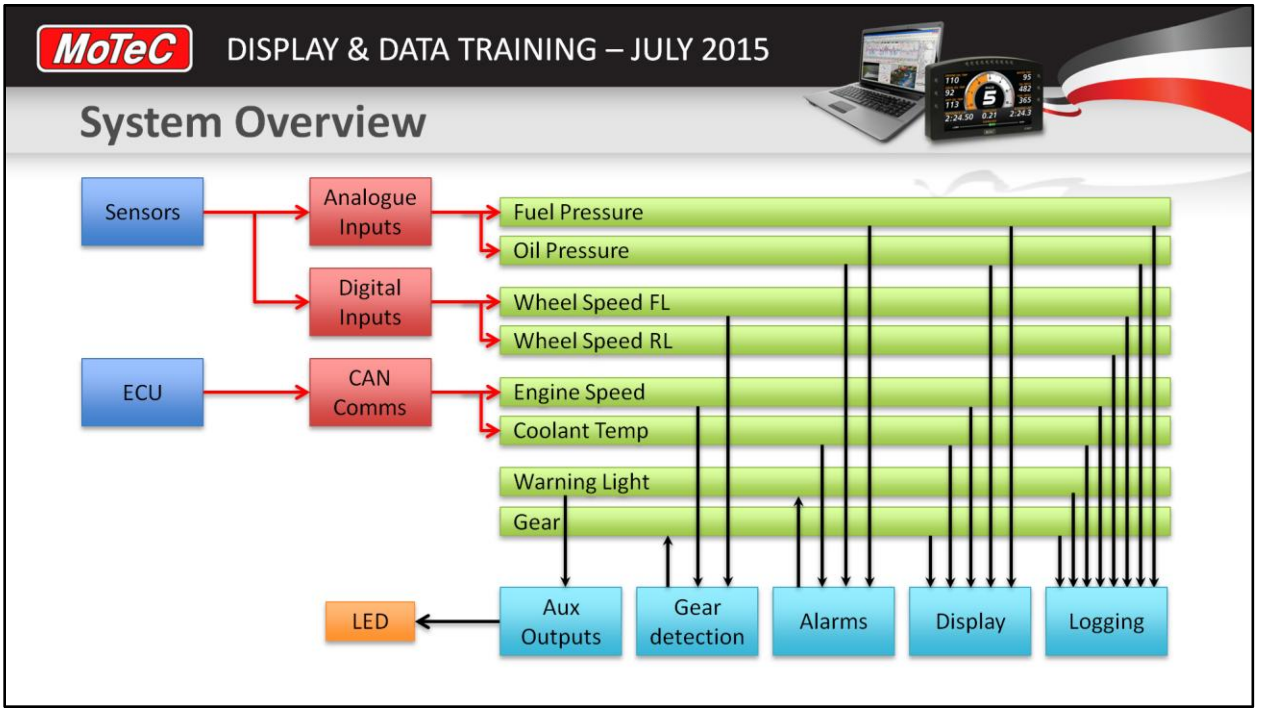
Input/Communications Setup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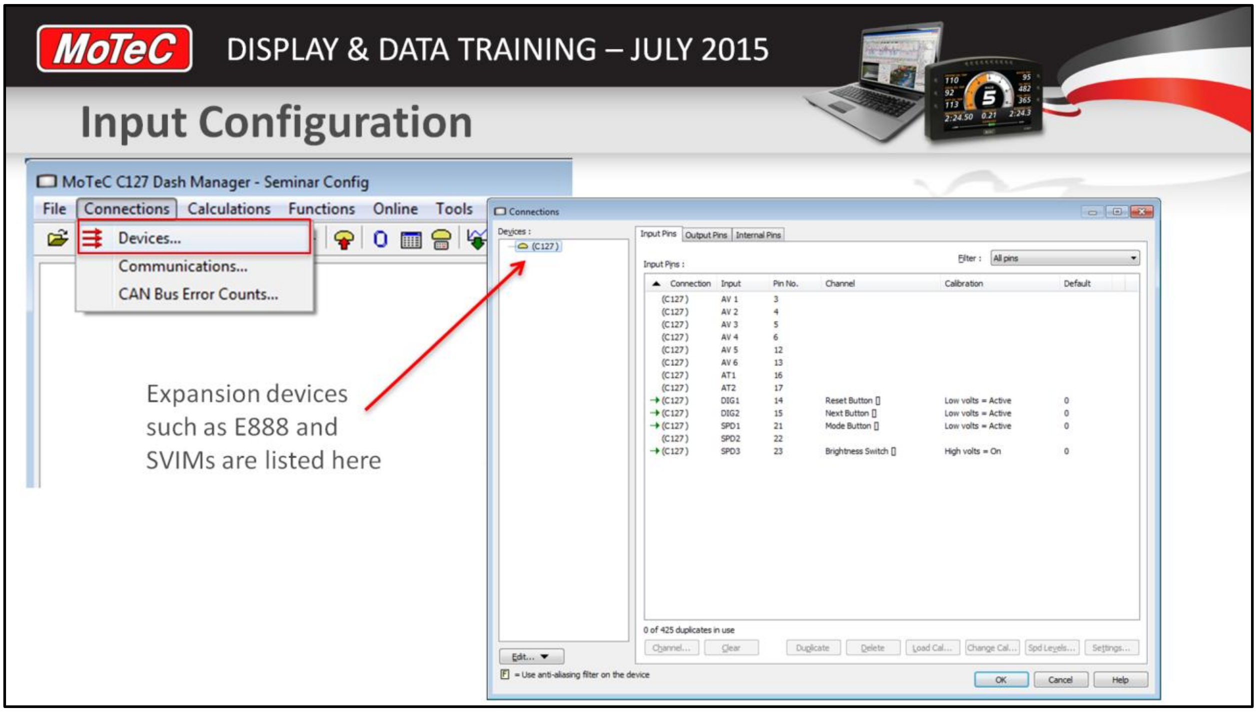
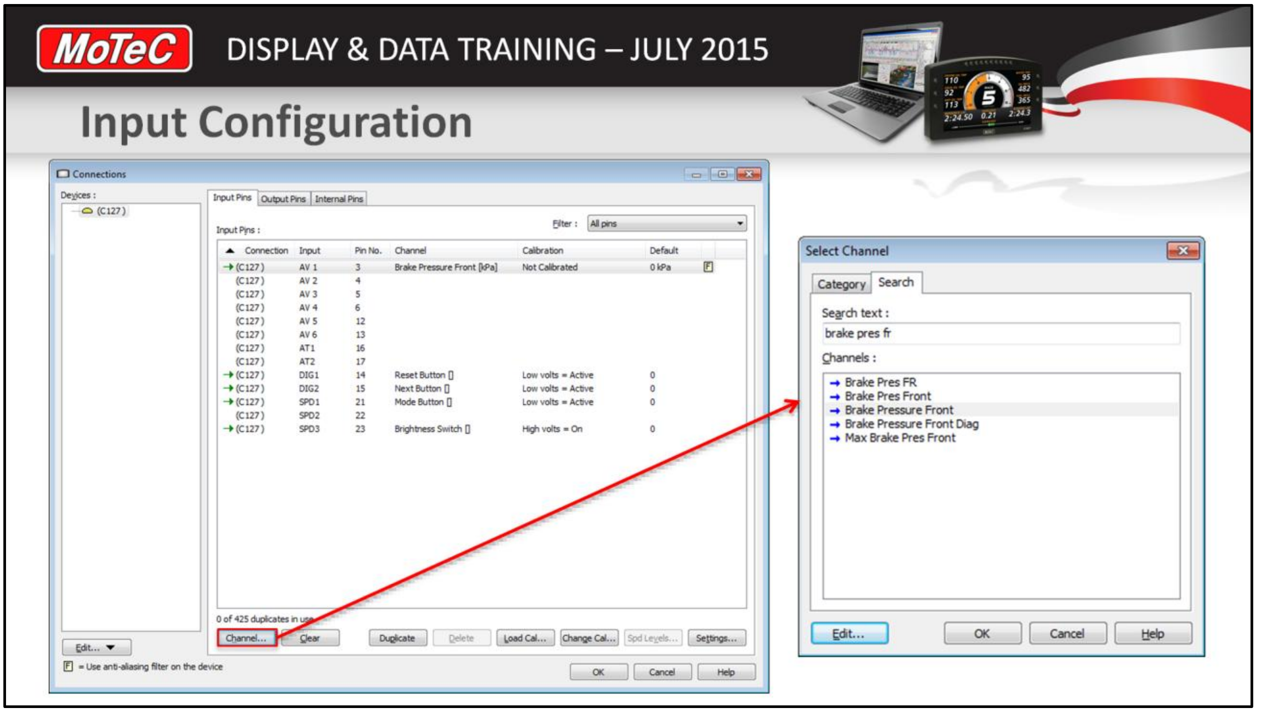
System Overview
Sensors
ECU
Analogue Inputs
Digital Inputs
CAN Comms
Fuel Pressure
Oil Pressure
Wheel Speed FL
Wheel Speed RL
Engine Speed
Coolant Temp
Warning Light
Gear
LED
Aux Outputs
Gear detection
Alarms
Display
Logging



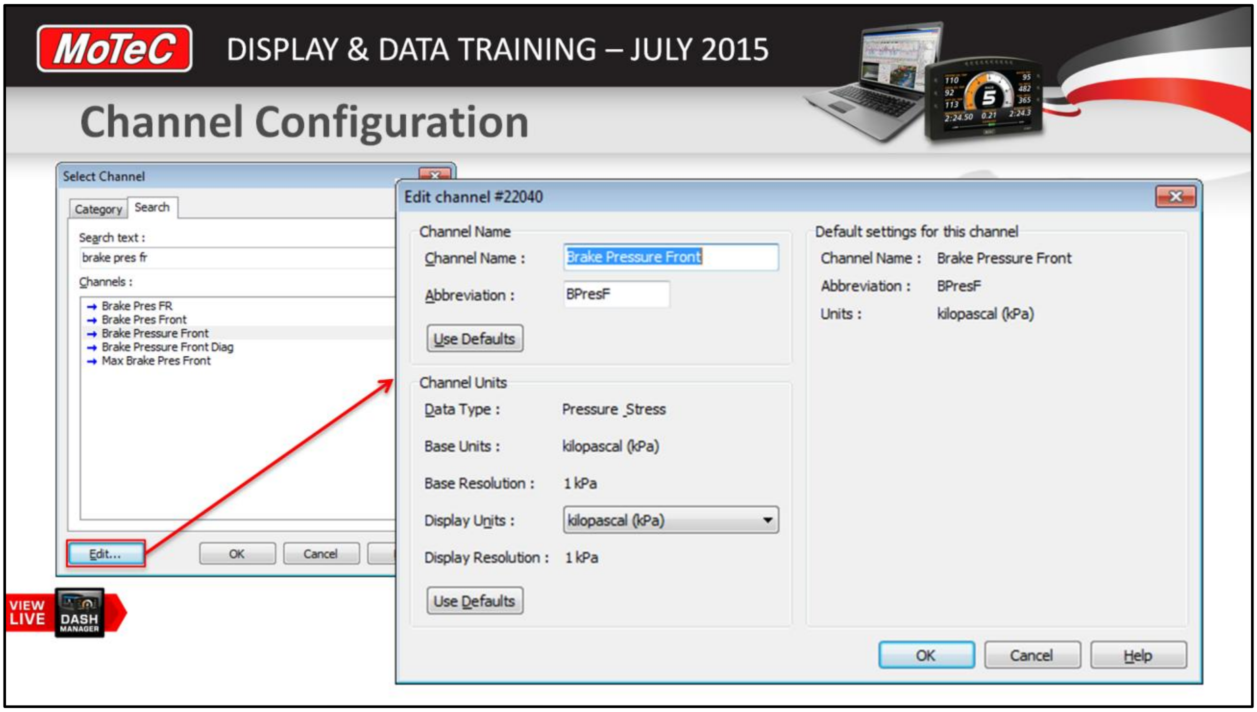
This is where all of the physical inputs and outputs are setup, as well as expanders if available.

When using the M1 setup, a number of inputs are preconfigured for display control such as the mode button/alarm acknowledge and brightness adjustment.



To select a channel, either double click the input line or highlight it and click channel.

We are going to set up a front brake pressure sensor on AV1. Start typing in the search bar until ‘Brake Pressure Front’ is displayed. Either double click it or highlight it and press OK.



Editing Channel Details

In the channel selection window click Edit. This will allow you to change the name of the channel and its displayed unit.

It is important to note the base resolution of the channel cannot be changed. All calculations within the Dash are done in the base unit of the channel and then are converted afterwards to the display unit. This is especially important when configuring CAN templates or using Advanced Maths.

As an example, let’s say you have have an M800 that is set to use PSI for Engine Oil Pressure which you want to display on your C127 in PSI. The base resolution of Engine Oil Pressure in the ECU will be 0.1PSI and it will be 0.1kPa in the Dash.

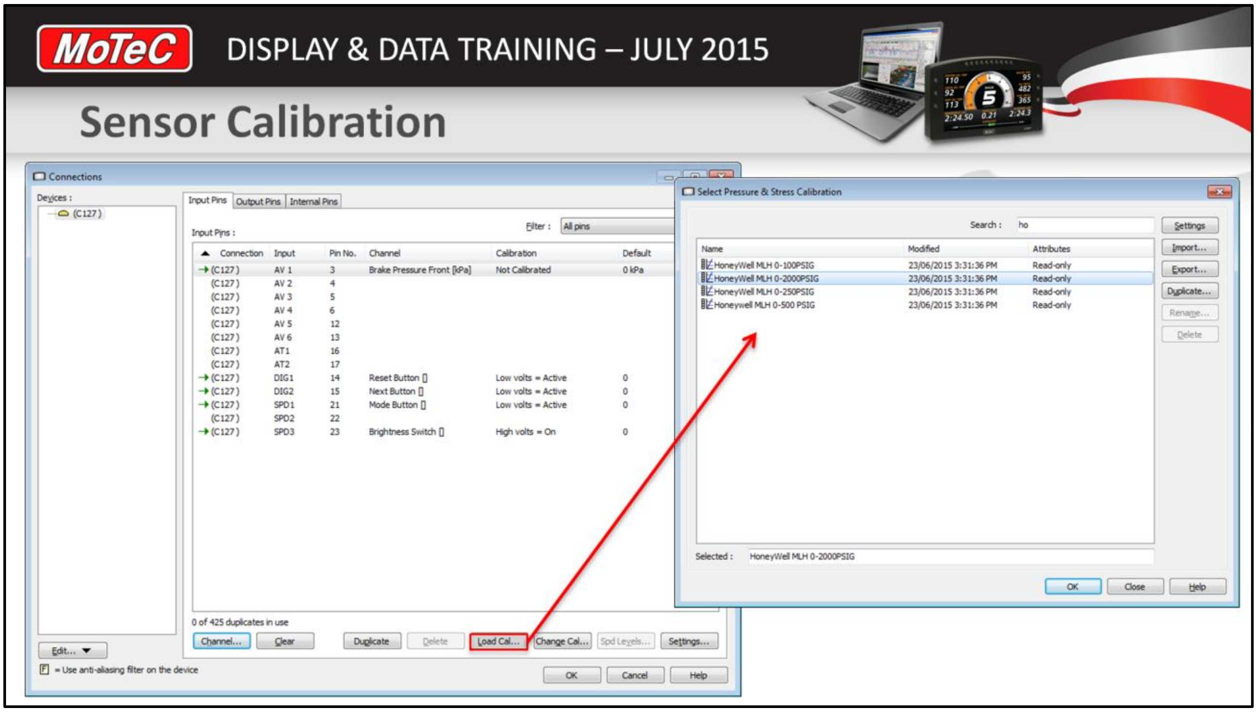
So in the CAN setup you have to convert from 0.1PSI to 0.1kPa.

0.1PSI = 0.6895kPa

The Dash only uses whole numbers in the communications setup so you have to multiply the input channel by 6895 and then divide by 1000

0.1*6895/1000=0.6895

Now the Dash will have the correct channel value and will convert it to the selected displayed units in the background.

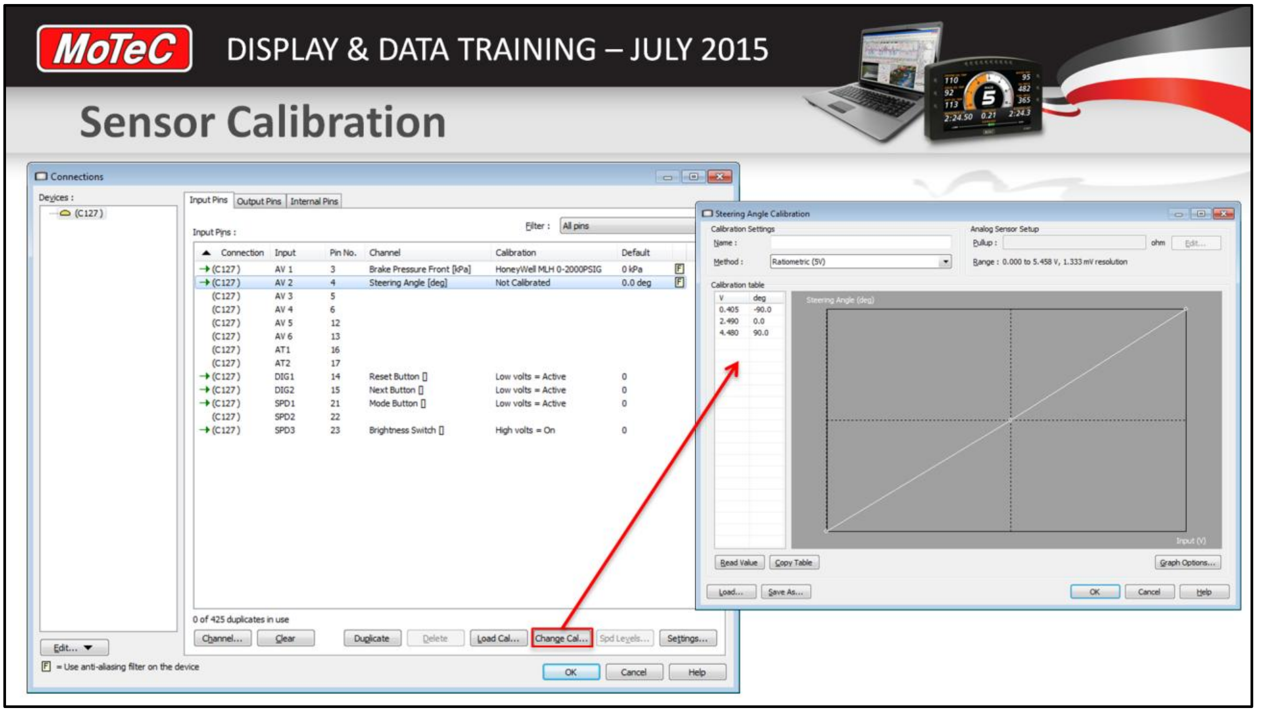


There are two ways to calibrate the input, either with an existing calibration file or manually.

To load an existing calibration click on load Cal:

In the search box begin typing until the file you want is visible.

Either double click it or highlight and click OK.



Manual Calibration

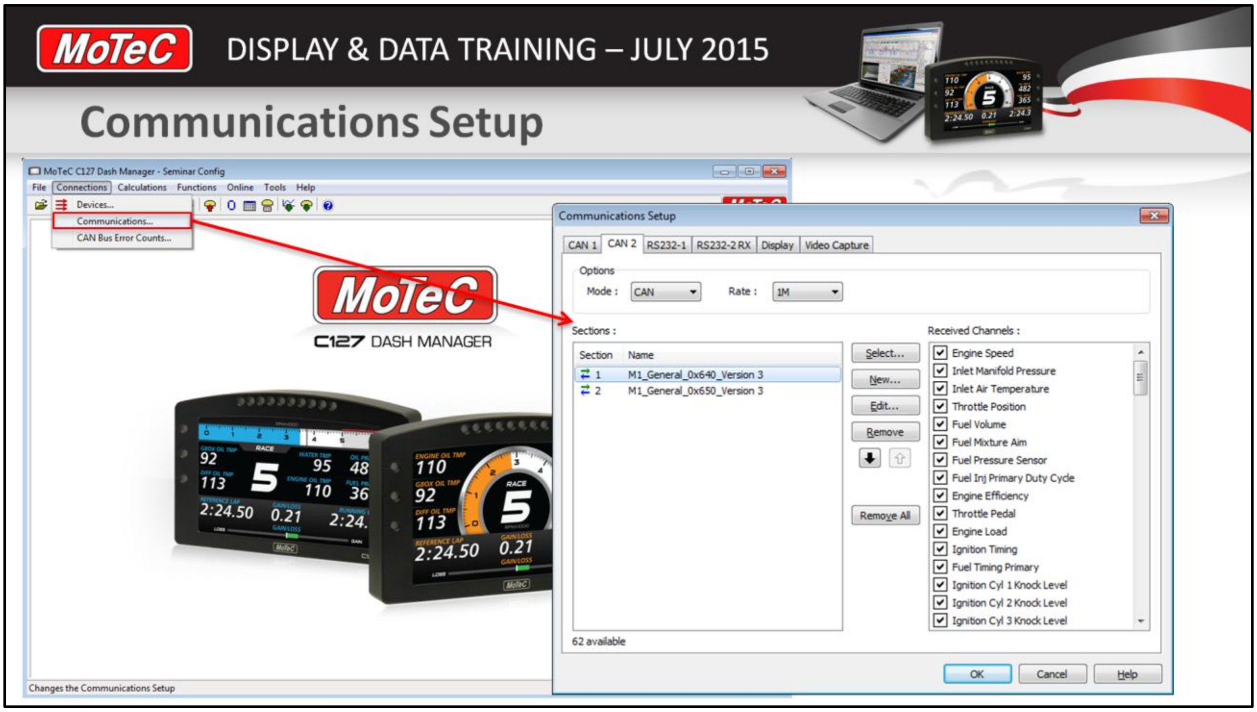
There are two ways to insert values. You can either go through each position on the table if you have a data sheet from the sensor manufacturer, or in this case where we are calibrating a steering potentiometer, you can use the read value button.

Point the steering wheel straight ahead, click read value and then enter 0 deg in the adjacent box.

Turn the wheel 90 deg to the left, click read value and enter -90 deg. Repeat for 90 deg to the right from centre.

This sensor is rotary pot with a 5V supply so the method needs to be set to Ratiometric (5V).

Absolute voltage is used when the sensor has its own internal regulation and its output voltage is not proportional to its input voltage.



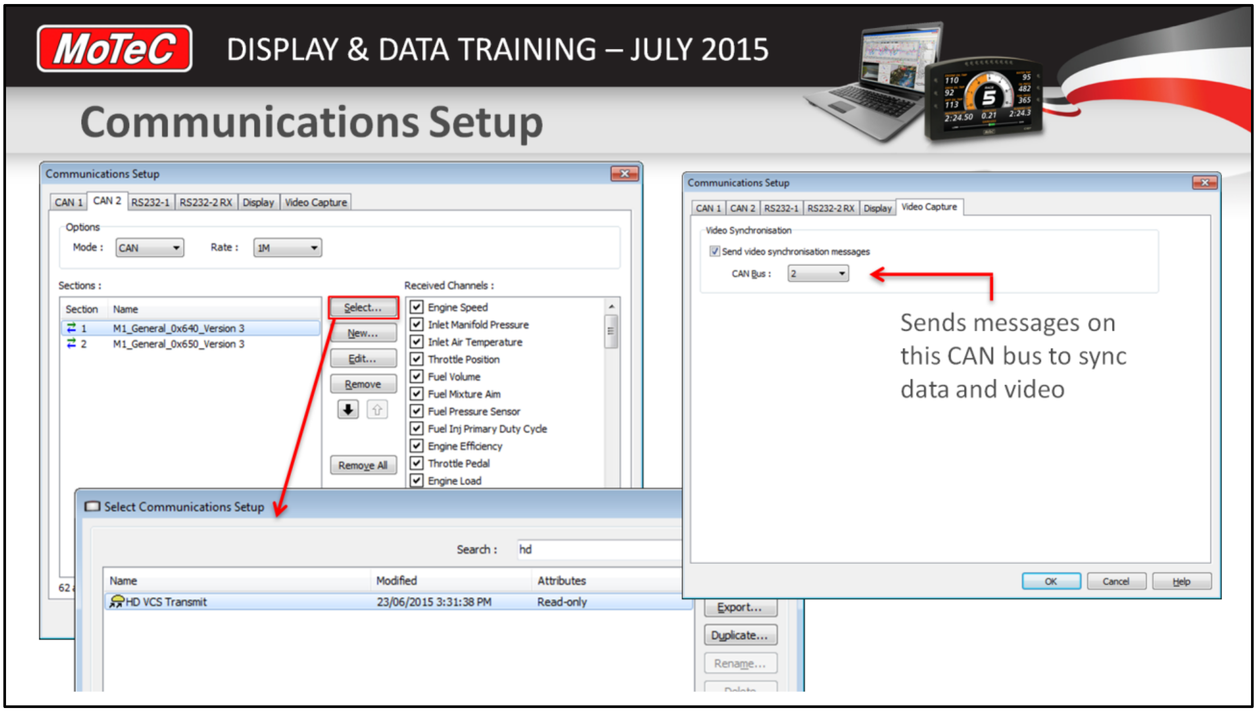
Communications Setup

This is where all CAN/Serial communications are set up to communicate with any other device.

As we started an M1 config, the comms templates are already loaded for the channels that are sent out of the M1 with a GPA/GPR Package.

CAN rate can be set to a number of different values, MoTeC devices default to 1M, some can be changed others are fixed. Typically vehicle factory CAN buses will be at 500k, heavy vehicles (J1939) at 250k. All devices on the CAN bus must be at the same rate otherwise they will not work.

Some of the CAN buses can be repurposed as additional serial ports if necessary by changing the mode in the drop down menu.



We want to add an HD-VCS camera to our comms setup. To do this, click Select and in the search bar start typing HD-VCS until the template comes up. Click OK and it is set up, ready to go.

The next thing to do is set up the video synchronisation messaging. Click on the Video Capture tab and tick the ‘Send Video Synchronisation Messages’ box. Select the correct CAN bus from the drop down menu and click OK.

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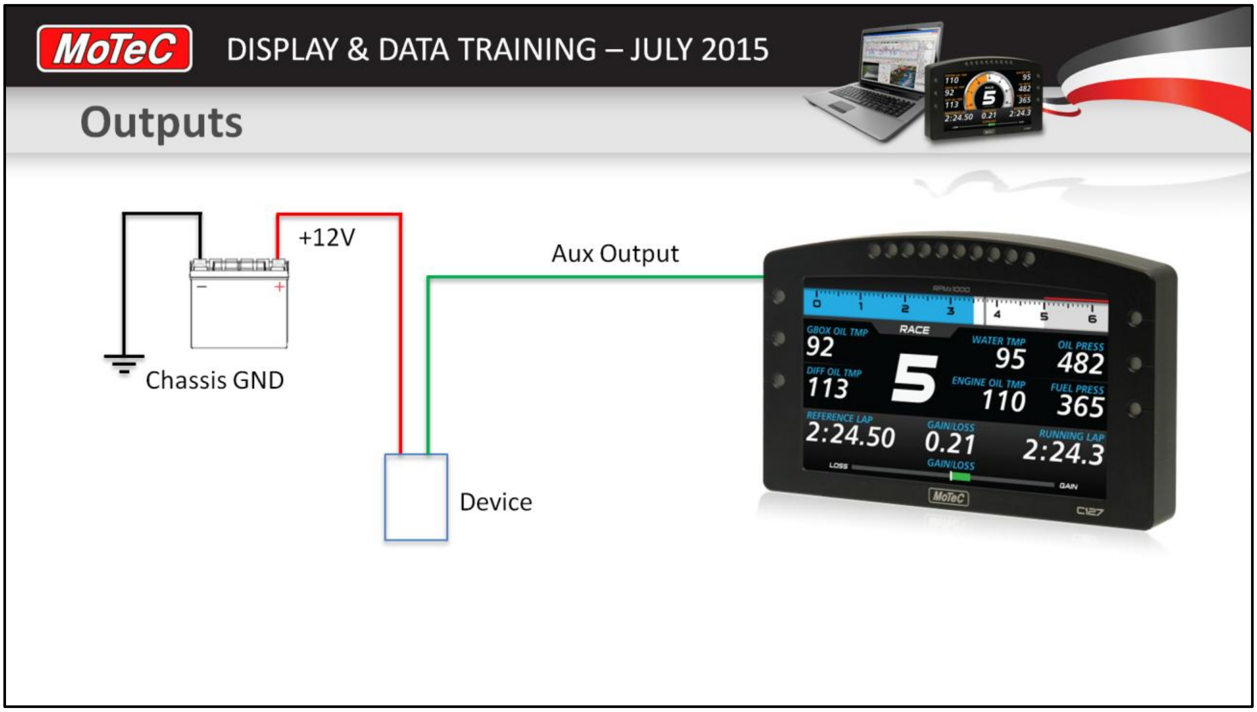
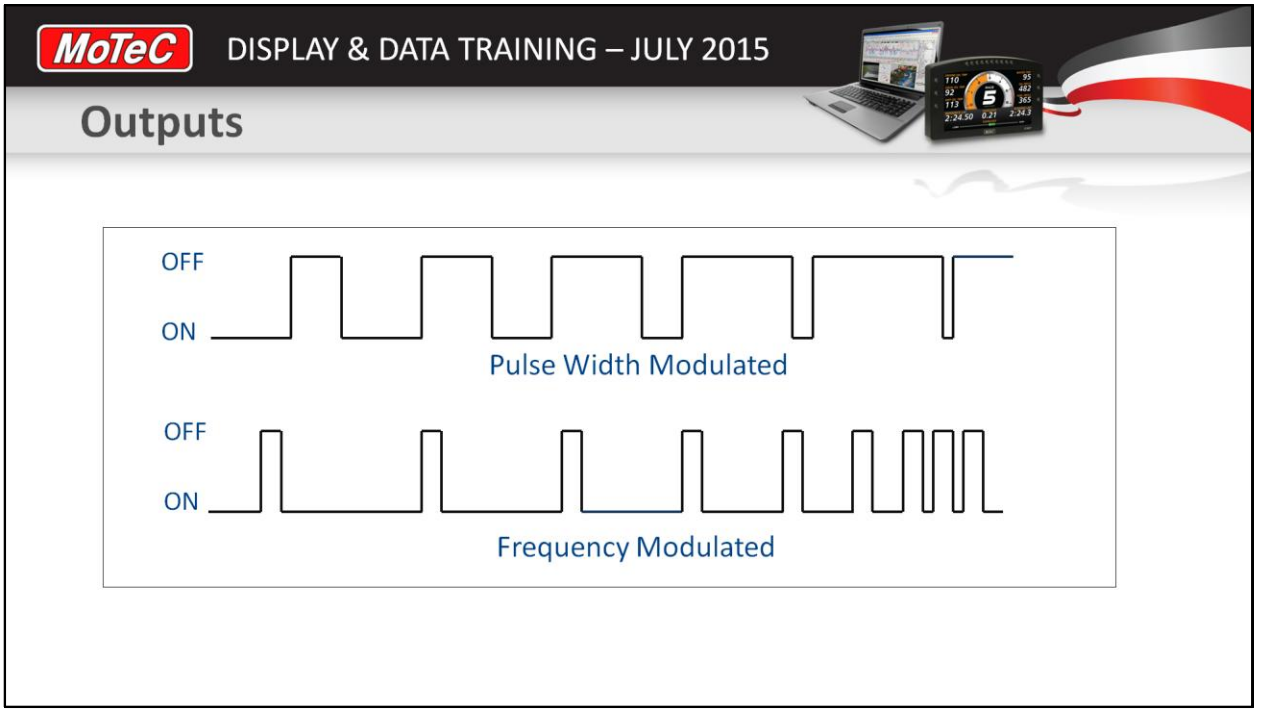
Output Setup



The Aux outputs are open collector and driven to ground. They have a max current of 0.5A so are only suitable to directly control small loads. Solid state relays are required when controlling higher current devices.



Electrical Specifications

The Auxiliary Outputs switch to ground and may drive up to 0.5 Amps.

On/Off Output:

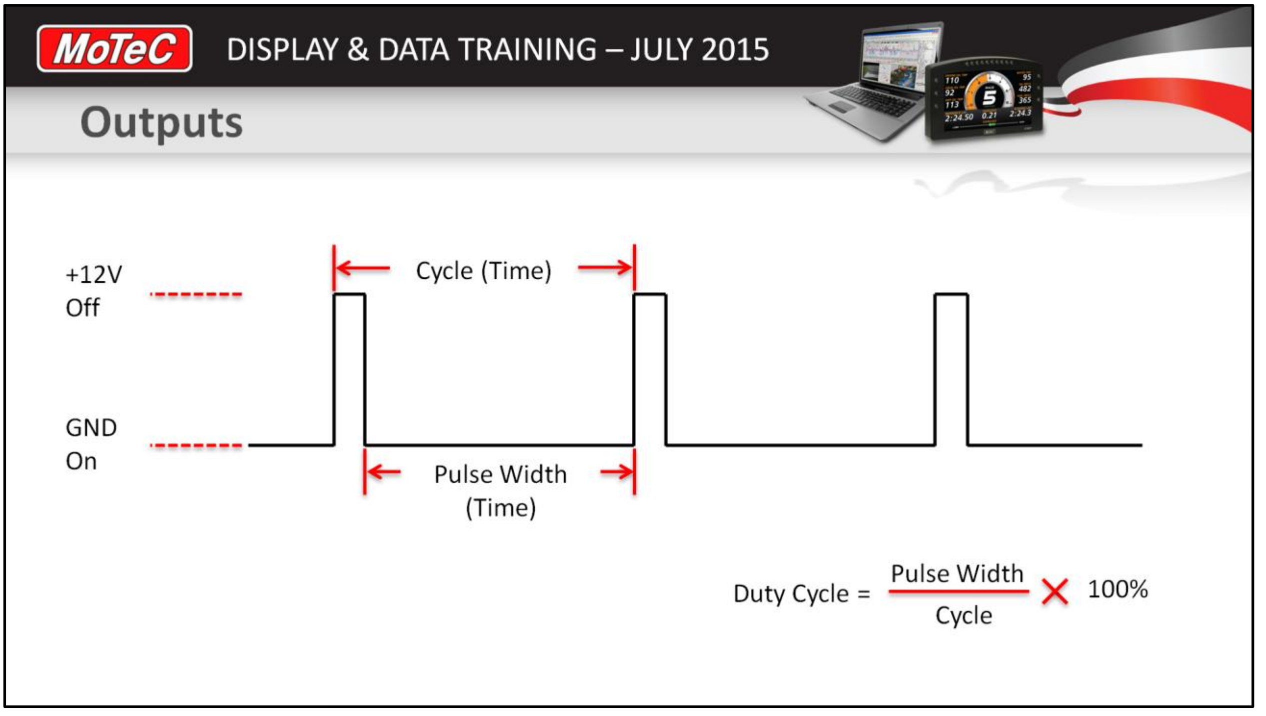
- Fuel Pump
- Shift Light
- Thermo Fan

Duty Cycle

- Boost Control

Frequency

- Tachometer



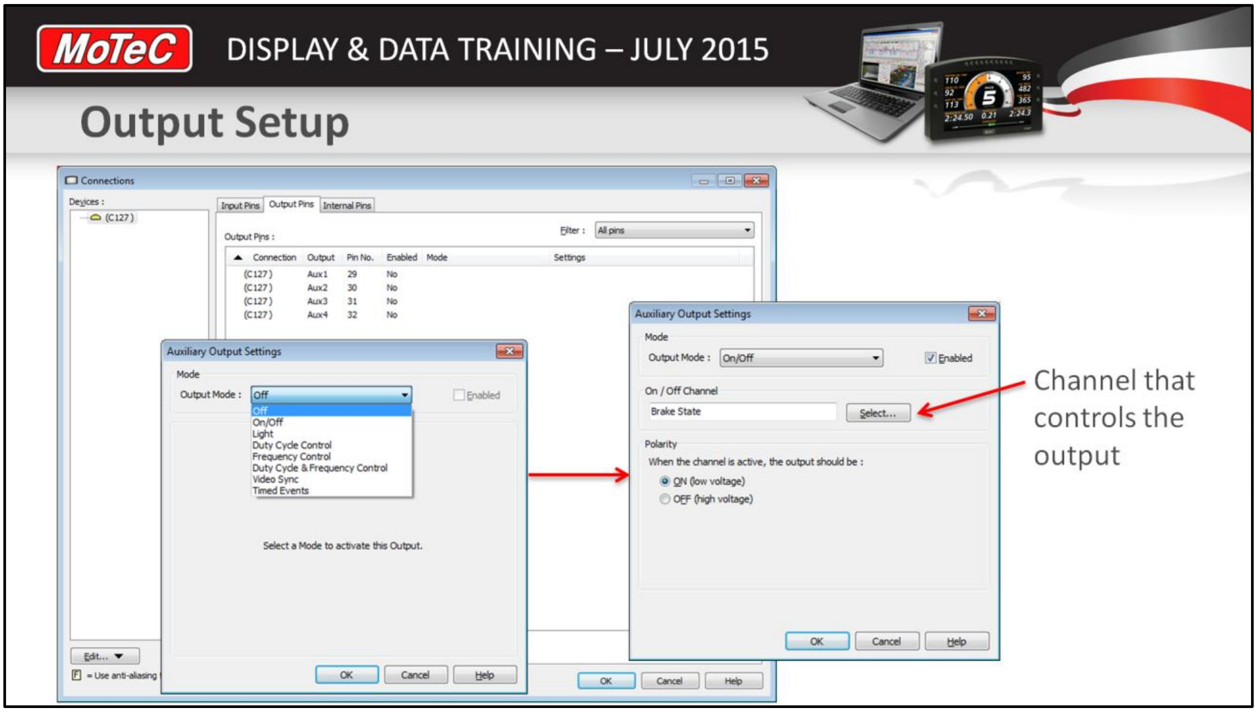
A device is normally continuously powered. The Dash output is switched to ground to turn the device 'on'.

Frequency: Number of complete cycles in one second, measured in Hertz.
1 Hz = 1 cycle/second.

Cycle: Time from when a device is turned 'on' until the next time it is turned 'on'.

Pulse Width: The time in seconds the device is 'on'.

Duty Cycle: Percentage of time the device is 'on' in one cycle.



Each digital output can be controlled in one of several modes:

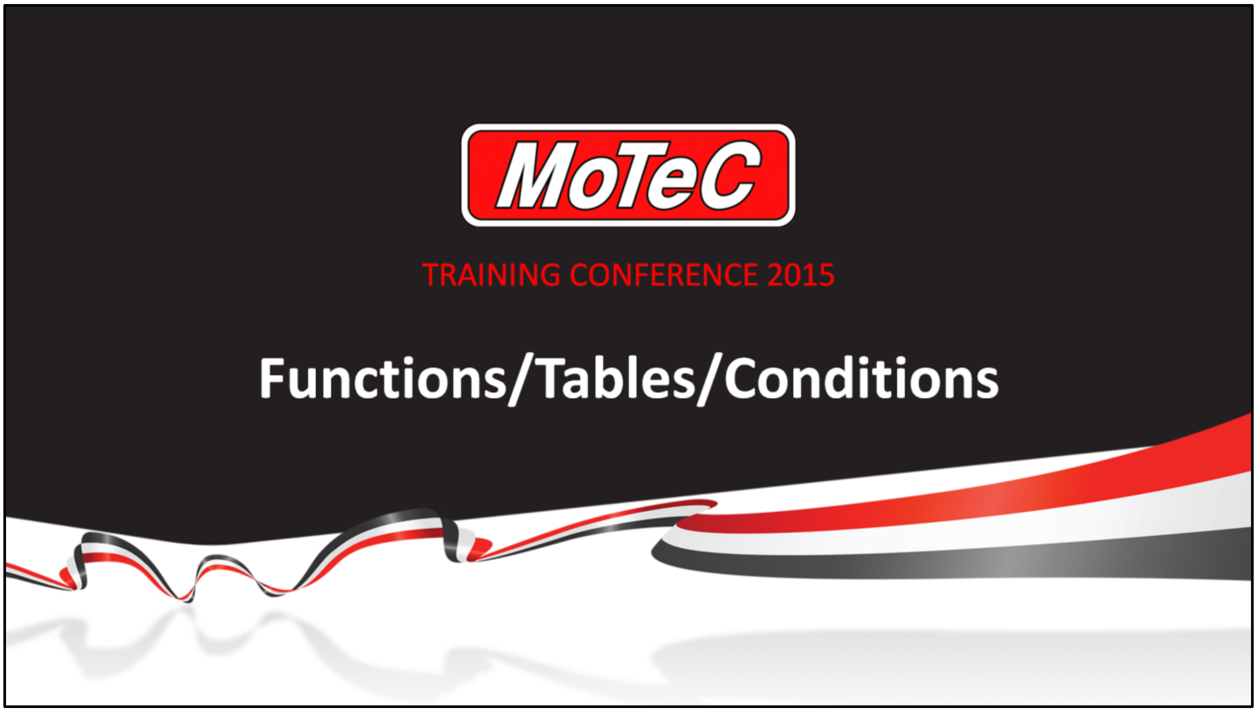
On/Off only output available in an older SDL.

Light: If the light is on, it is driven with a programmable duty cycle to vary its intensity

Frequency: the output is driven at a programmable frequency (Note: 22Hz minimum)

Duty Cycle: the output is driven at a programmable duty cycle

Frequency and Duty Cycle: Both the Frequency and Duty Cycle of the output can be varied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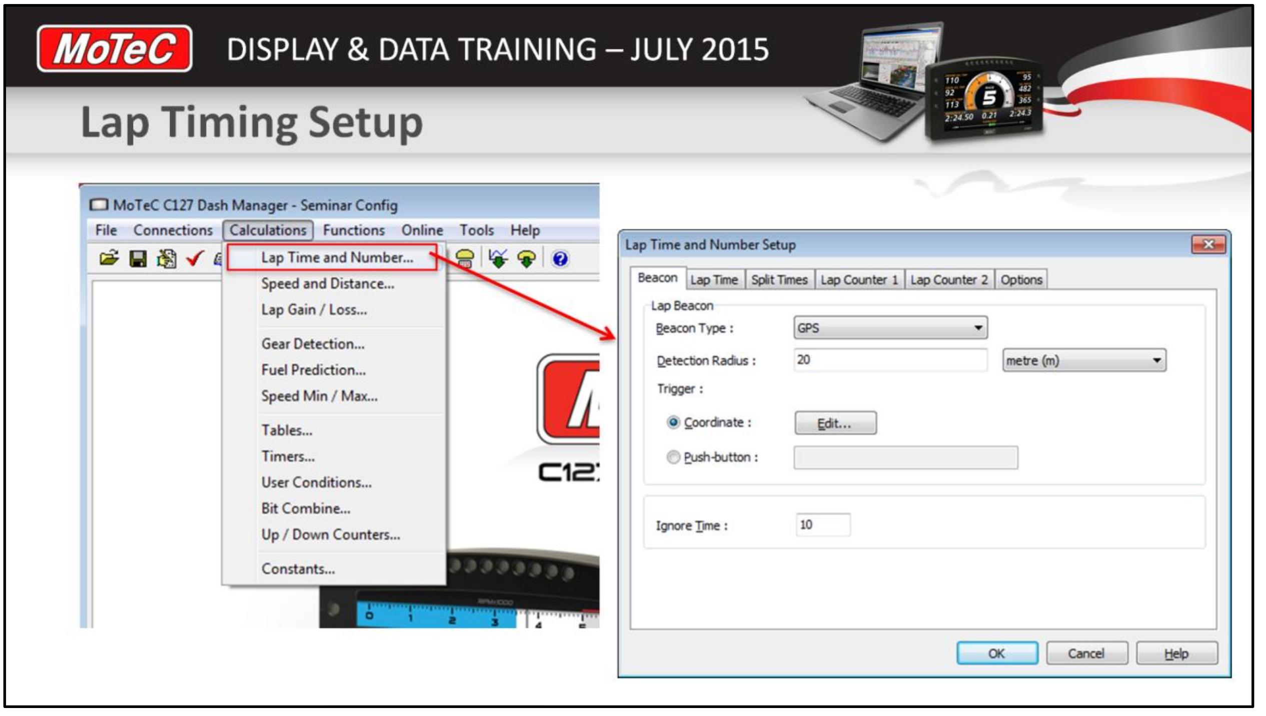
Functions/Tables/Conditions

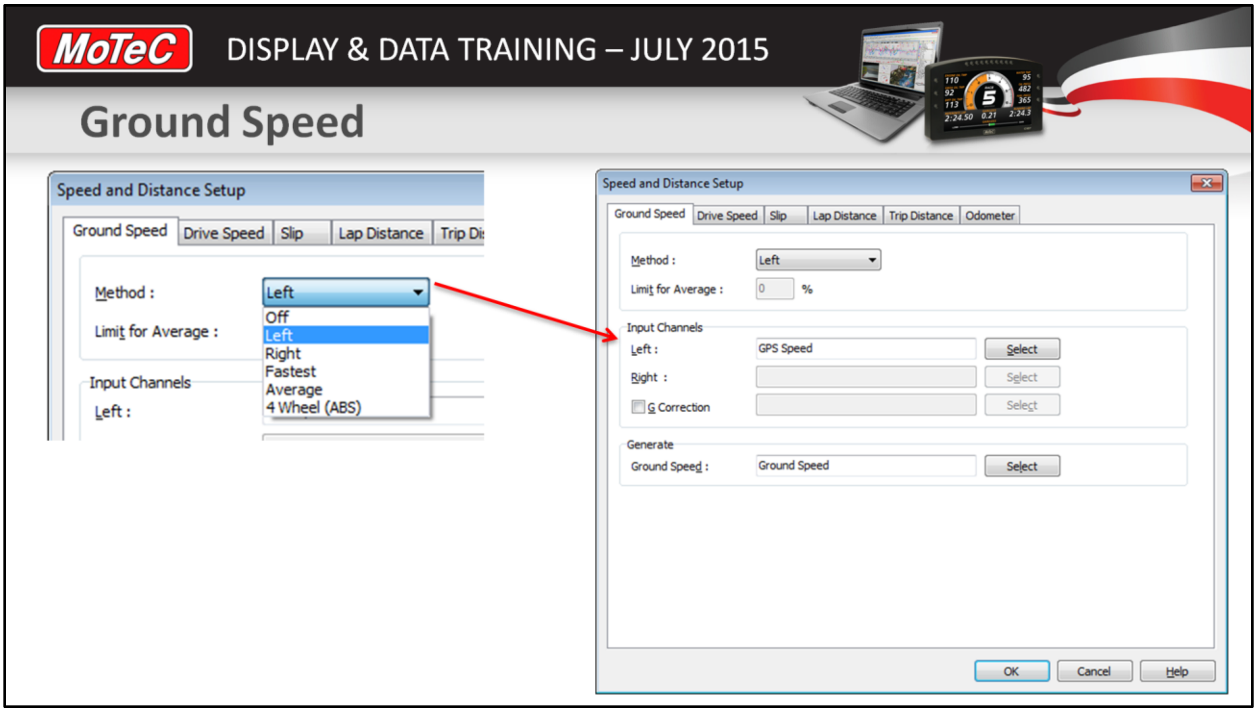


Beacon Types

GPS: Uses a connected GPS unit and GPS coordinates of the start/finish line to trigger the start/end of lap. The detection radius is used to ensure that the lap is triggered whether you are on the far right or far left of the track. Also accounts for drift. The beacon triggers when the vehicle passes at 90 degrees to the start/finish location, so making the detection radius larger should have no effect on the accuracy of the timing. Only the drift will cause inaccuracy. Coordinates set the location of the start finish line. This is tied to the venue file.

Button/Internally Generated: Can set up a switch to trigger the beacon or internal maths calculation on other conditions . Can simply be an on/off signal sent from another device on CAN.

BR2: CAN signal from a MoTeC BR2 module. Need to add CAN template to correct CAN bus and set the Mode and ID to match beacon. Can specify an ignore time; beacon will not be triggered within this time period even if a beacon signal is received.



Ground Speed Tab

Calculates vehicle Ground Speed from either the left or right wheel speed, or from one of a number of methods that help to avoid wheel lockups giving incorrect readings. Correction of wheel lockups is particularly important for the Lap Distance calculation which is derived from the Ground Speed.

Method

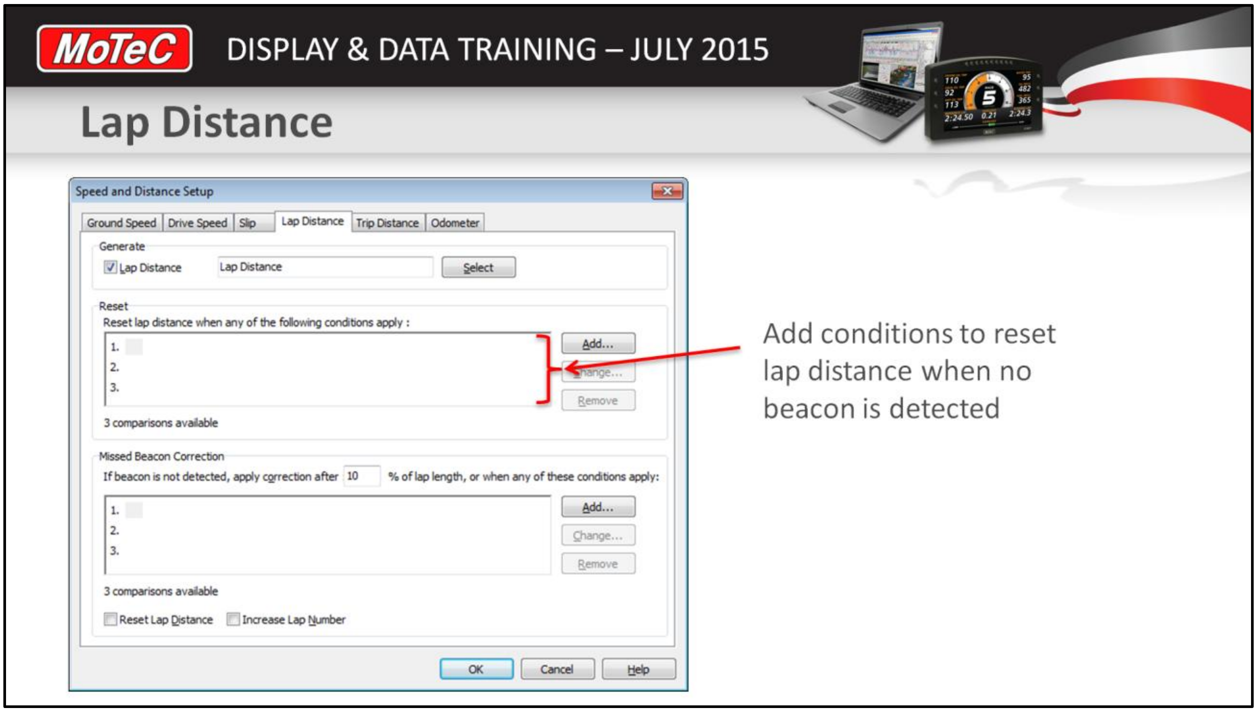
Specifies the method for calculating the Ground Speed.

- Left - Uses the Left wheel speed channel.
- Right - Uses the Right wheel speed channel.
- Fastest - Uses the fastest of the two wheel speeds to avoid errors due to wheel lock.
- Average - Uses the average of the two wheel speeds until the difference between the two exceeds a limit value, at which point the fastest of the two wheel speeds is used to avoid errors due to wheel lock.
- 4 Wheel (ABS) - Uses the fastest of up to four wheel speeds, including the wheel speeds defined in the drive speed calculation.

G Correction

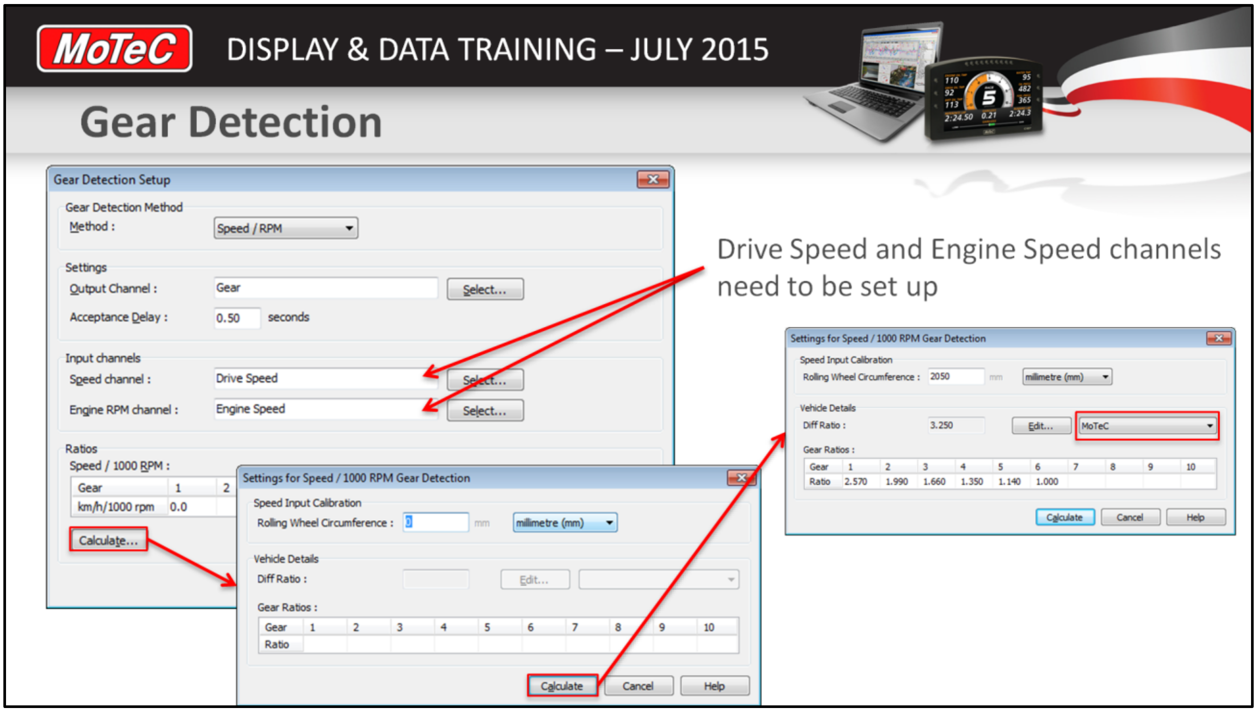
G Correction is used to correct for wheel lockups during braking. It predicts the wheel speed during braking using the Longitudinal G Force sensor to detect and correct wheel lockups.

This can be used when only one wheel speed sensor is allowed. It may also be used when measuring more than one wheel speed, which is particularly useful for ABS systems; they tend to have erratic wheels speeds as the wheels partially lock during ABS activation.



Representative lap distance is important for a number of calculations, so it is useful to set other conditions that will reset lap distance for when the vehicle enters the pits or misses a beacon.

Beacon correction uses the lap length set in the venue file.



Requires Speed, RPM or Gear sensor

Requires ratios of gearbox in details

MUST be updated each time a different tyre or gear ratio is used.

1. The Output Channel ‘Gear’ is selected.

2. The acceptance delay applies a filter, otherwise (especially for speed/RPM method) the fluctuations in RPM during the change will cause it to attempt to show more than one gear.

3. The method can be either derived from speed and an RPM signal or purely from a sensor.

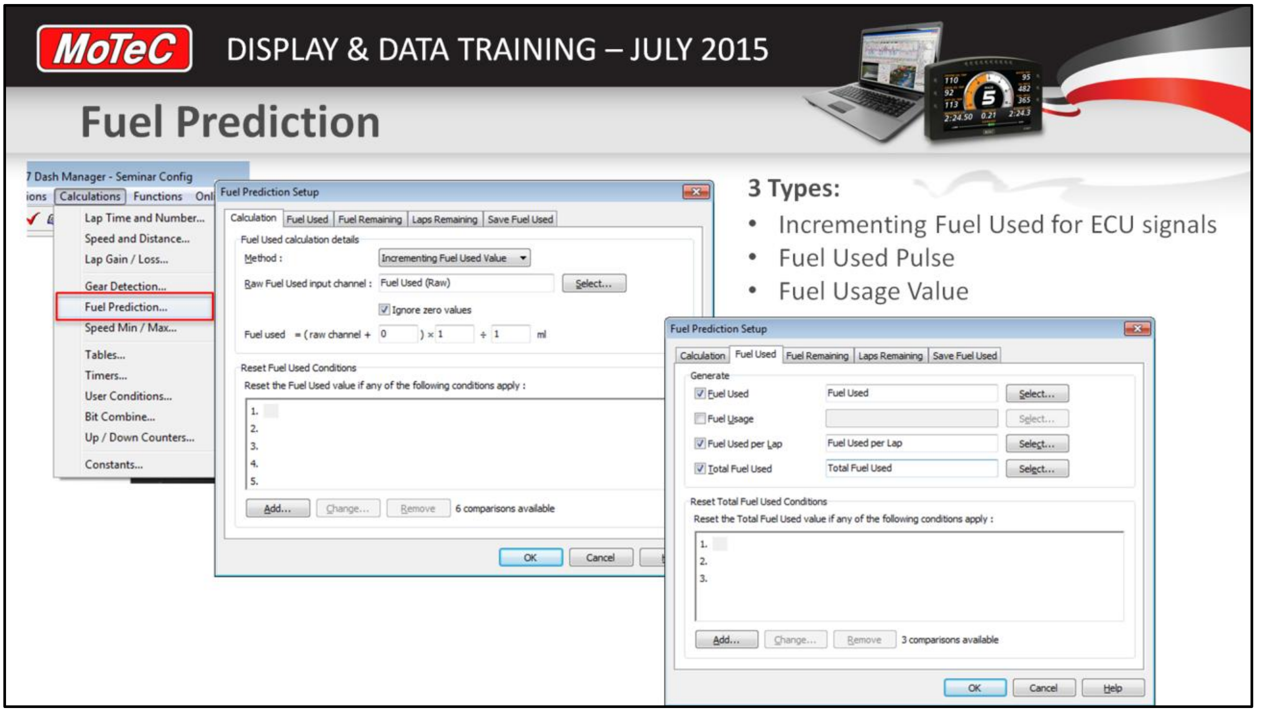
4. If the details are entered (as shown on previous page) for the ratios and the correct circumference of the tyre is entered, pressing the Calculate button will update the speed/RPM ranges for the Dash.

5. A dialog appears asking the user to confirm the details – pressing on Calculate (again) then updates the information in the Gear Detection screen.

The Gear Detection often causes the most problems as people forget that each time a tyre is changed and ratios are changed the Dash must be updated and the NEW configuration sent to the Dash – assuming gear is being calculated from speed/RPM and not directly from a voltage sensor.

Gear will only be displayed if:

- The correct tyre size is entered (correct wheel speed calibration)
- The correct Ratios are entered in the details editor [File Menu] [Edit details] Gears Tab
- You have gone to the gear detection page and clicked [Calculate]



The Dash can calculate fuel consumption figures using either a channel from an ECU, or from a fuel level sensor. There are three calculation methods, each slightly different with 'Incrementing Fuel Used Value' being the most common and widely supported by different ECUs.

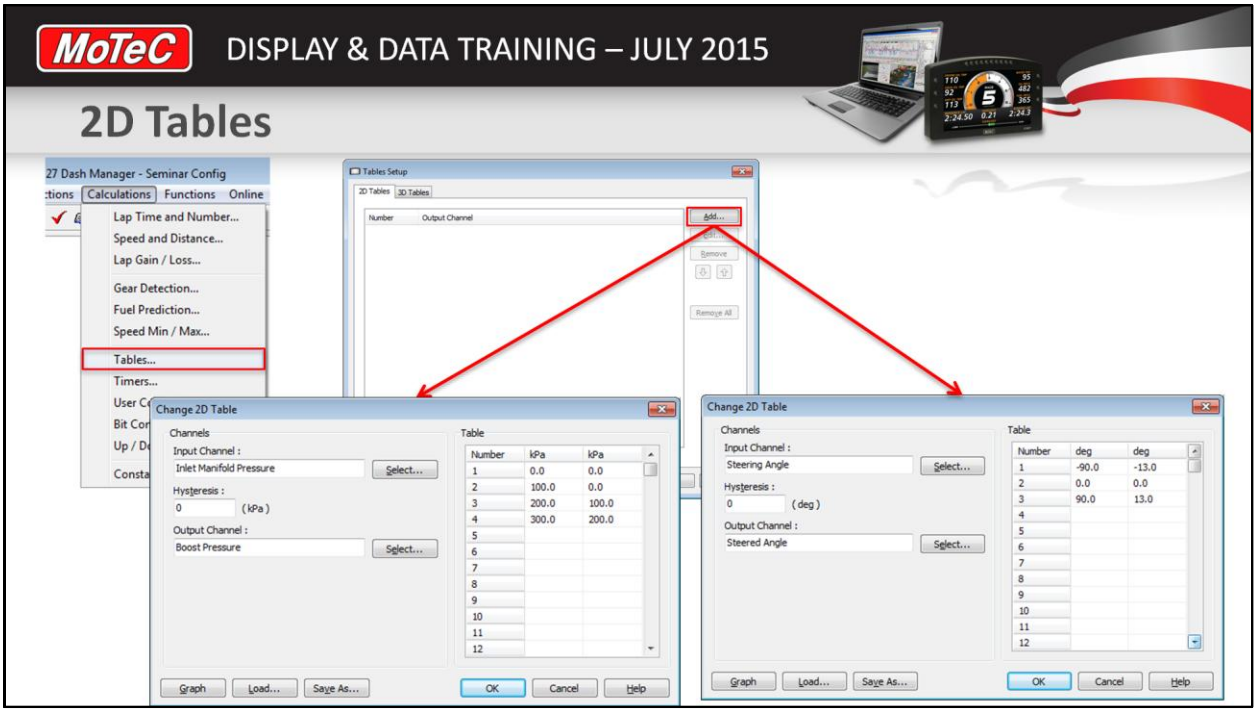
MoTeC ECUs transmit Fuel Used (RAW) in 10ml units, e.g. a value of 15 on the input channel corresponds to 150ml. As the calculation is done in mls, this means that the RAW Fuel Used value must be multiplied by 10, giving a scaling of (+0)*10/1

The Fuel Used value is stored in permanent memory so that if the Dash power is removed, the Fuel Used value is maintained at next power on. If the fuel used figure stops updating for 4 seconds and it has been at least 10 minutes since it was last saved, then it will be saved. RPM is not used in determining when to save the fuel used.

The Fuel Used is only zeroed when the reset condition becomes true.

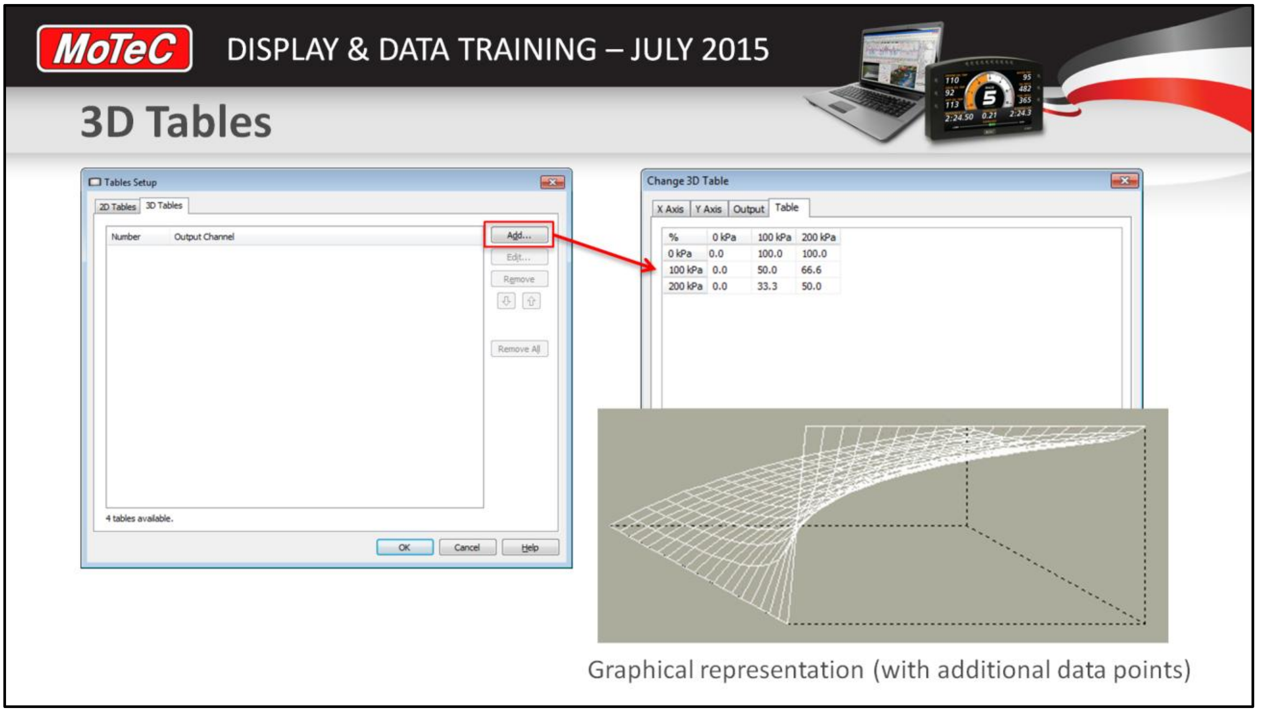
Check the boxes under the other tabs to select the channels you wish to have calculated, e.g. Fuel Used per Lap, Fuel Remaining.

Fuel Usage is the fuel flow rate.



The tables are a good way of converting channels. In this case we have Inlet Manifold Pressure but we want to be able to display Boost Pressure. The 2D table allows us to convert from one to the other.

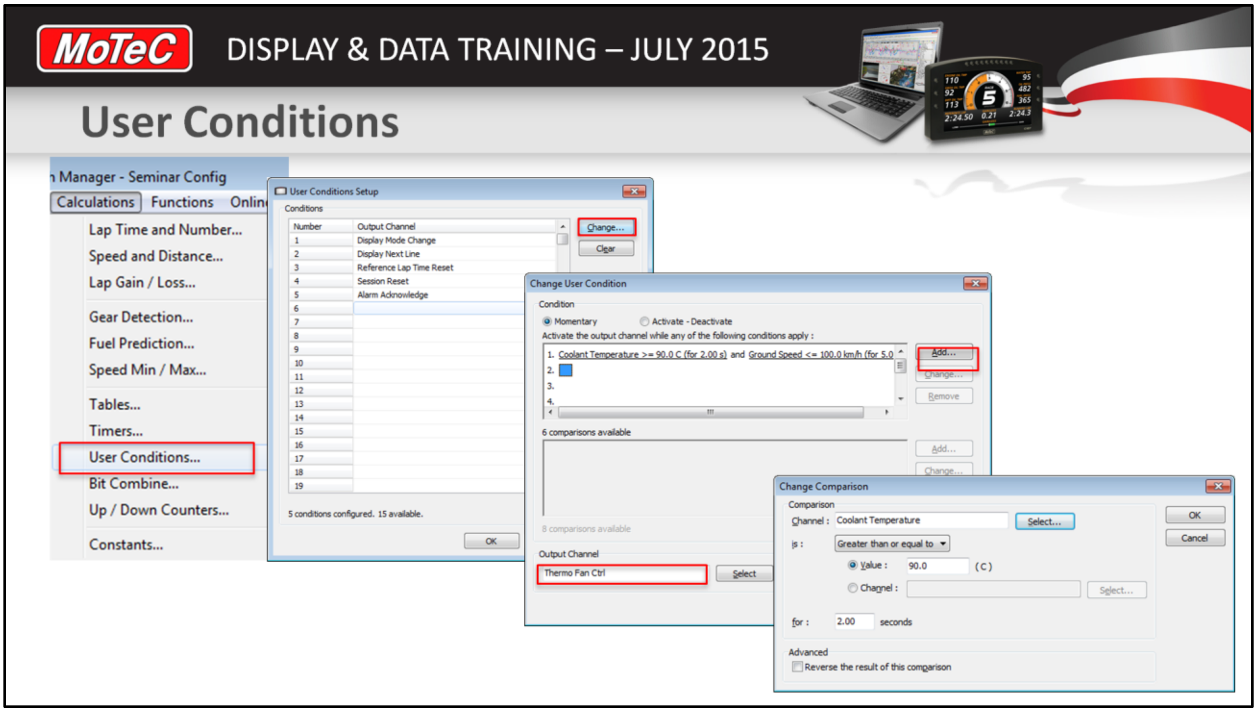
Another example is Steering Position. If you have steering wheel position sensor and want to convert to actual steered angle you can use a 2D table.



Populate Table

In this example, the Brake Bias channel is calculated from Front and Rear Brake Pressure. When front brake has a high pressure value and rear brake pressure has a low value, then the output of the table will indicate more front brake bias.

The tables (both 2D and 3D) linearly extrapolate between points and off both ends. The graph shown used a number of additional data points.



The example above shows the setup for a channel that will be used for controlling a thermo fan.

Conditions are used for many purposes throughout the setup of the Dash. This function allows you to set up a single comparison or combinations of comparisons to generate an On/Off (True/False) output channel. These can then be fed into other parts of the config, for example to control an output, or start a timer. Especially useful if the same condition is used more than once – saves defining it again. They are also useful for setting a smart display.

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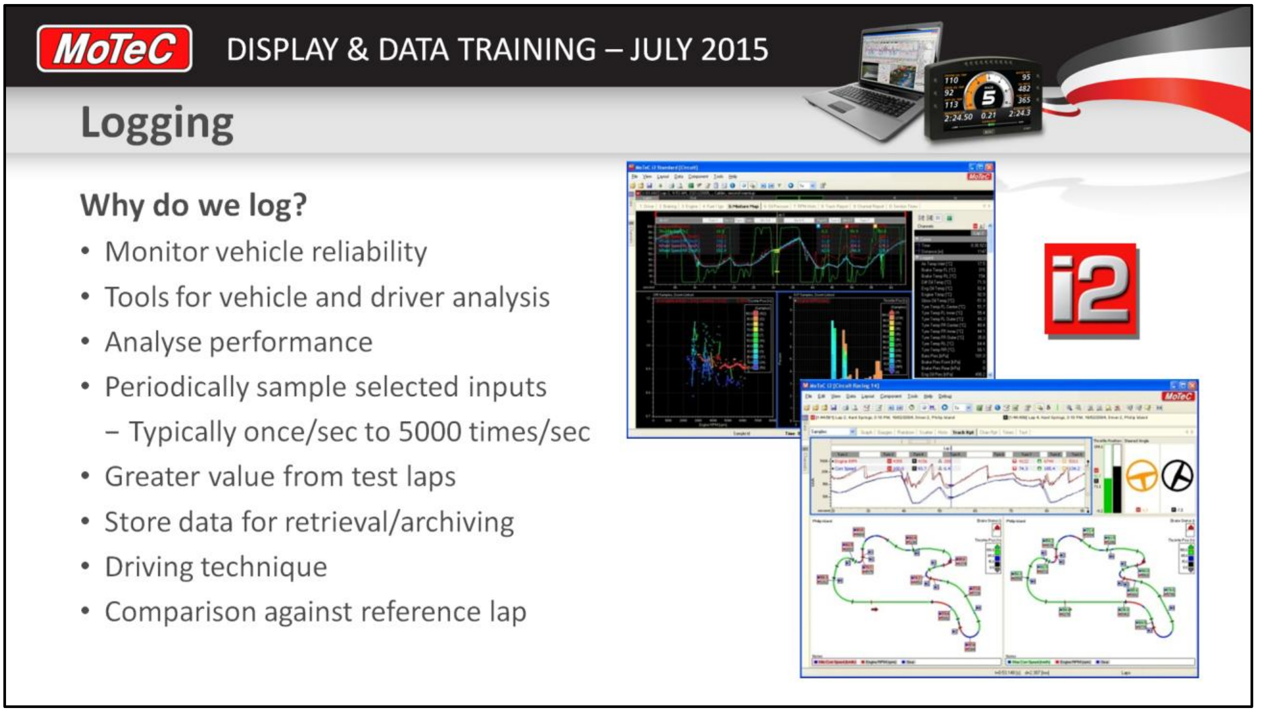
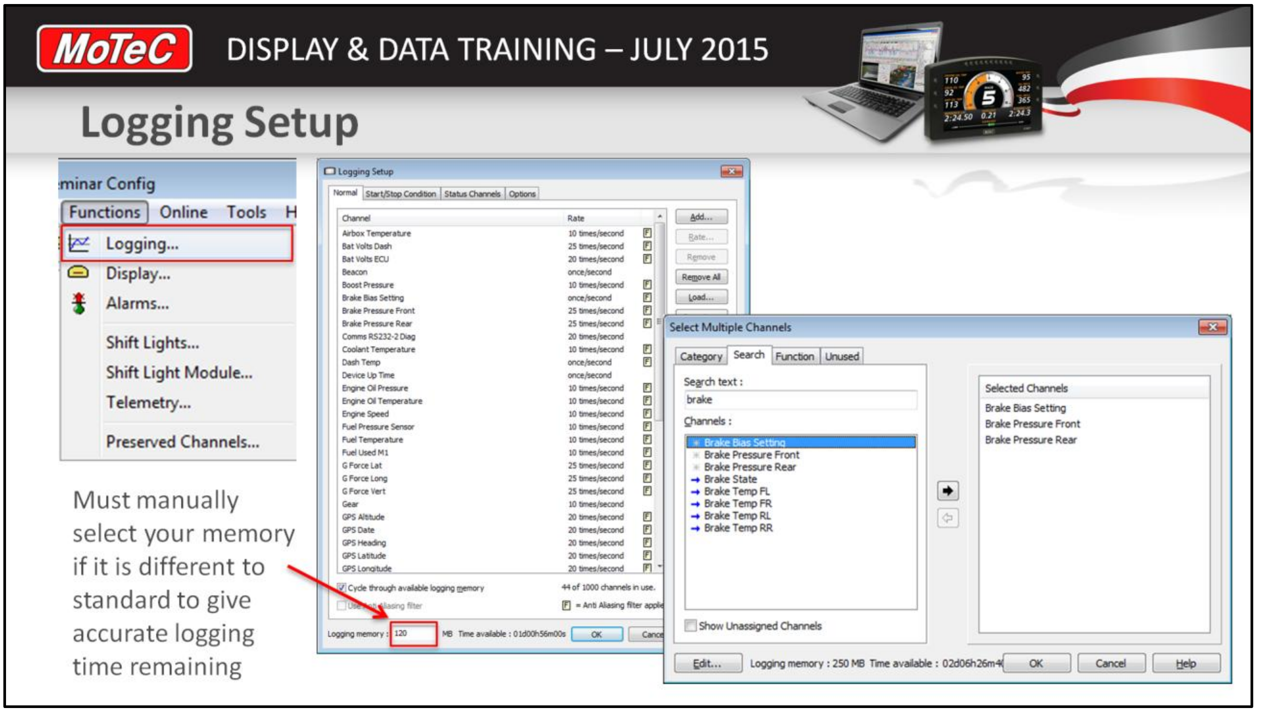
Logging/Display/Alarms

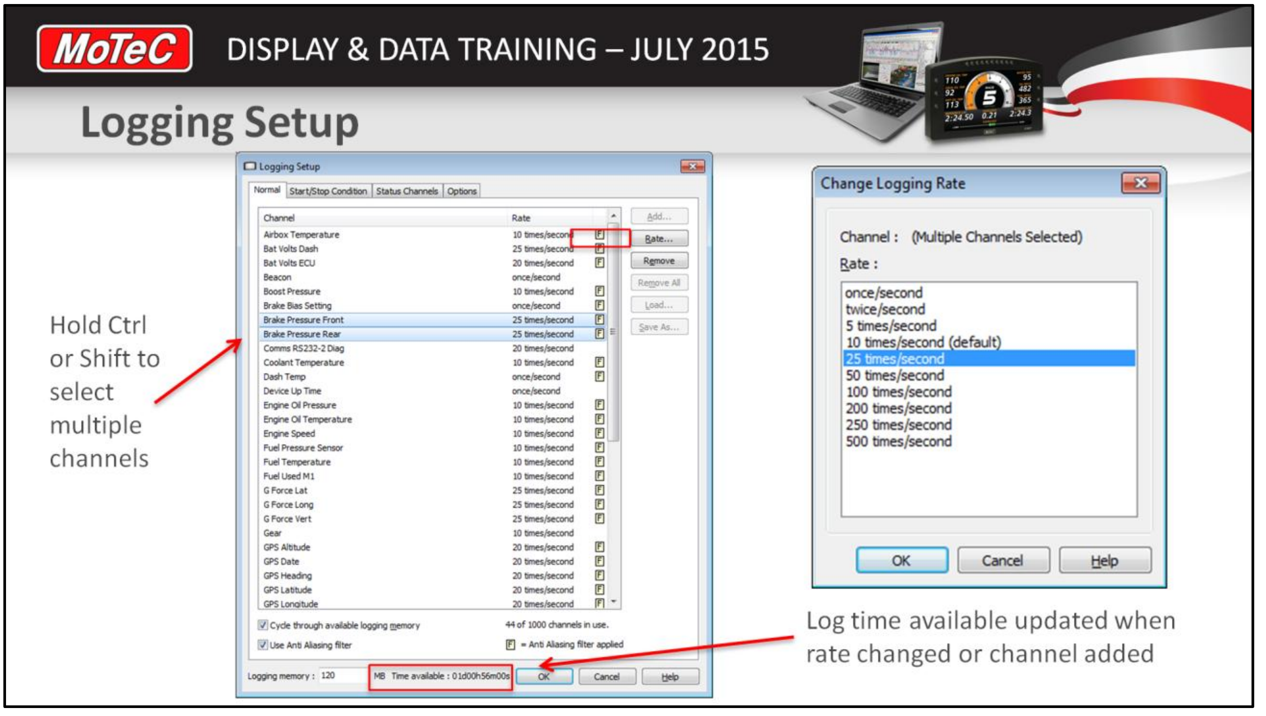


- Data Logging is used to record quantitative data (facts) about vehicle performance (drive train and chassis).
- Monitor the drive train in all parts of a lap to look for unusual changes
- Confirm ‘gut feel’ and driver feedback about what is happening in the vehicle
- Sampling rate is determined by the sensor being logged - must log fast enough to record important data variations
- Maximise information available in a test session. Data logging will record everything that happens.
- Data can be used for future setups and as comparison with other drivers.
- Help diagnose faults and optimise performance, e.g. check fuel and oil pressure are stable during the session - no surges.
- Overlay speeds before and after a chassis change
- Measure oversteer/understeer at individual corners for planning chassis adjustments
- Measure braking ability of vehicle (and driver)
- Compare all elements of a lap against a Reference Lap to understand chassis changes, driver technique, tyre performance etc.



The available logging time is displayed based on memory size, and as you add channels or change the logging rate for a channel, the logging time is updated automatically.

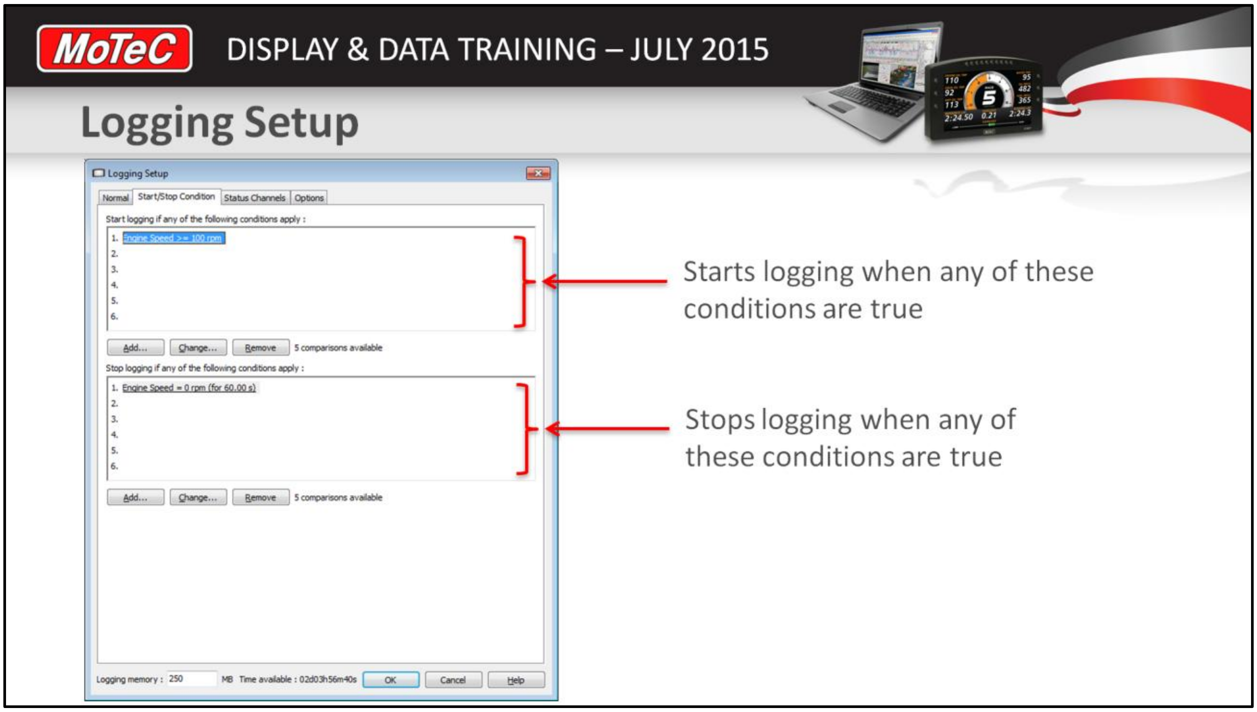
The Dash Manager software performs an estimation of how long the memory will last based on the actual logging rates you have defined. This calculation is displayed in the logging screen instantaneously as the changes are made.



By highlighting a channel and then clicking on the 'Rate' button, the logging rate may be individually set for each channel between 1 to 500 times per second (1000Hz for C185/C127).

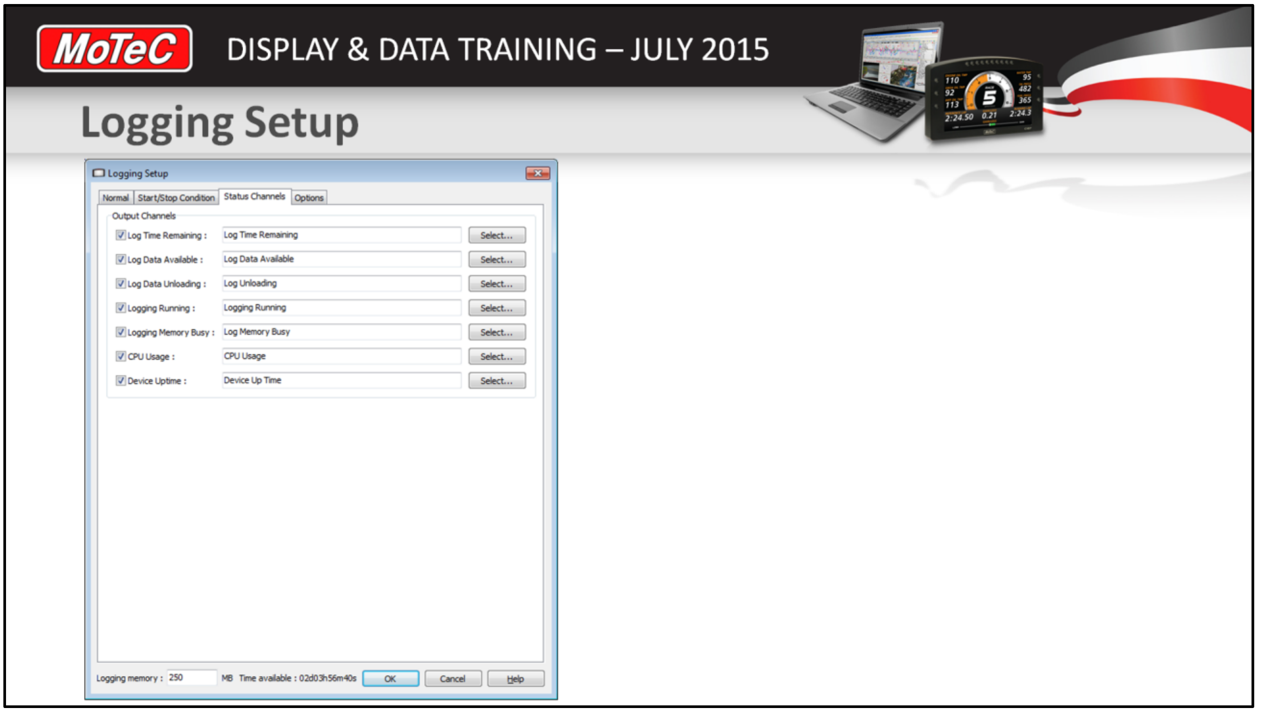
Some of the channels are marked with an 'F' to indicate that they are filtered by an anti-aliasing technique.

Channels are sampled at their maximum rate and then averaged to match the chosen logging rate.



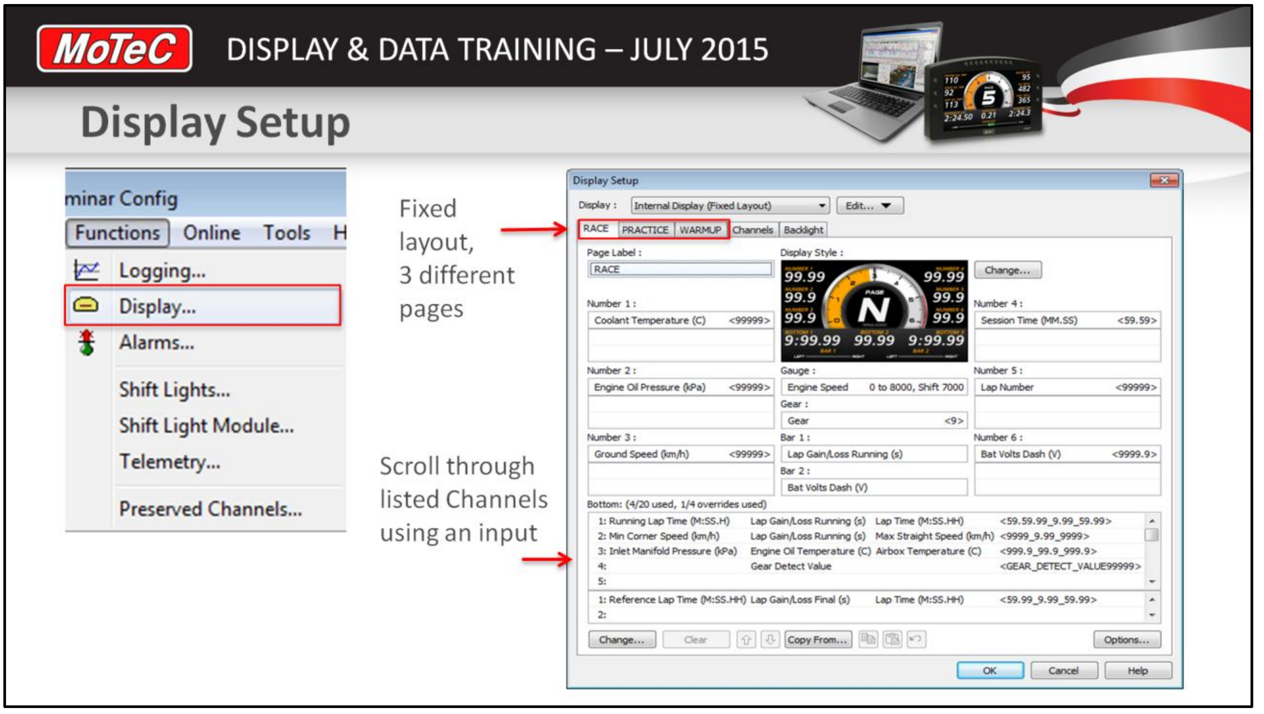
The Start/Stop conditions are used to determine when the display is actually logging data. Any channel and multiple conditions can be used to set when the logging starts and stops.

The stop condition overrides the start condition, so if a stop condition is true then the logging will stop irrespective of the start condition.



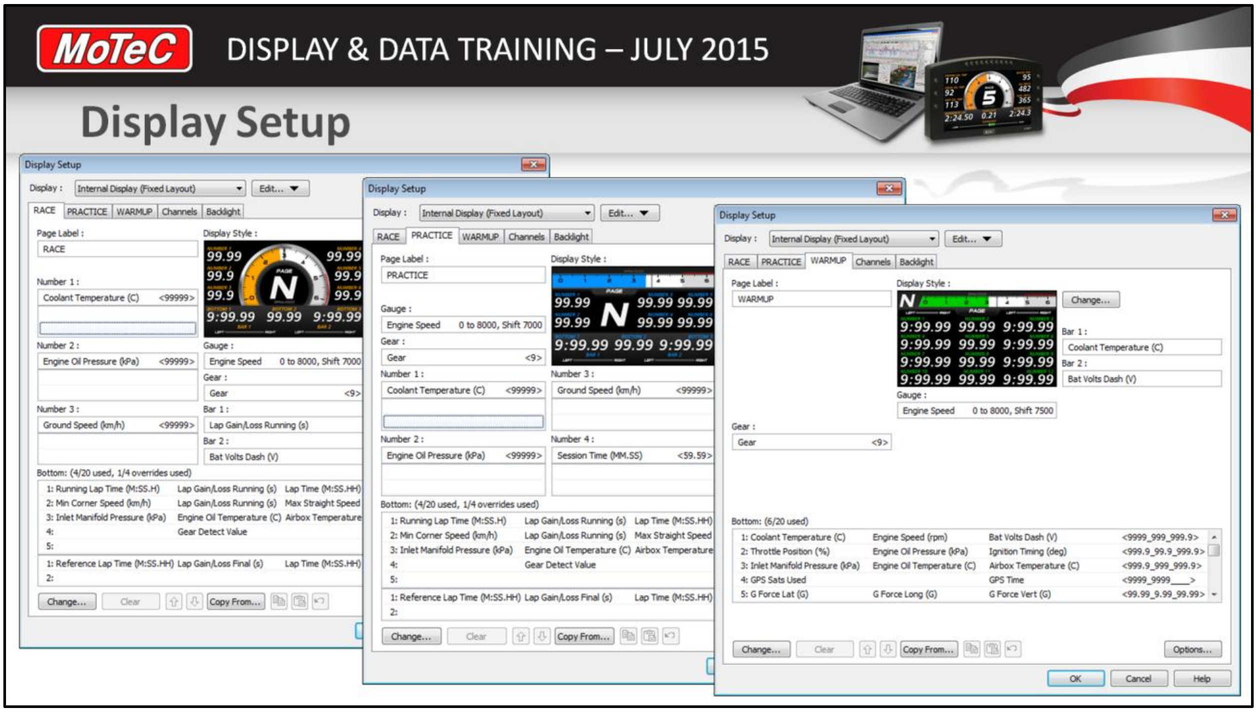
Useful for diagnostic purposes.

Using 'Logging Running' in a start logging condition is a good way of starting logging as soon as the Dash is powered up, i.e. 'Logging Running' = False for 0.5sec will start the logging straight away and, as long as you don't have a stop condition, it will continue until the power is turned off.



Fixed layout, similar setup to previous Dashes. Set positions for channels, channels can be selected.

Three individually configurable pages, with selectable styles.

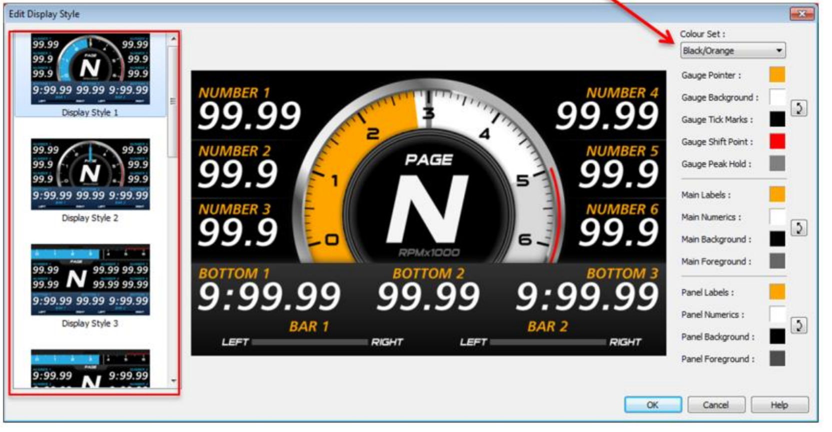


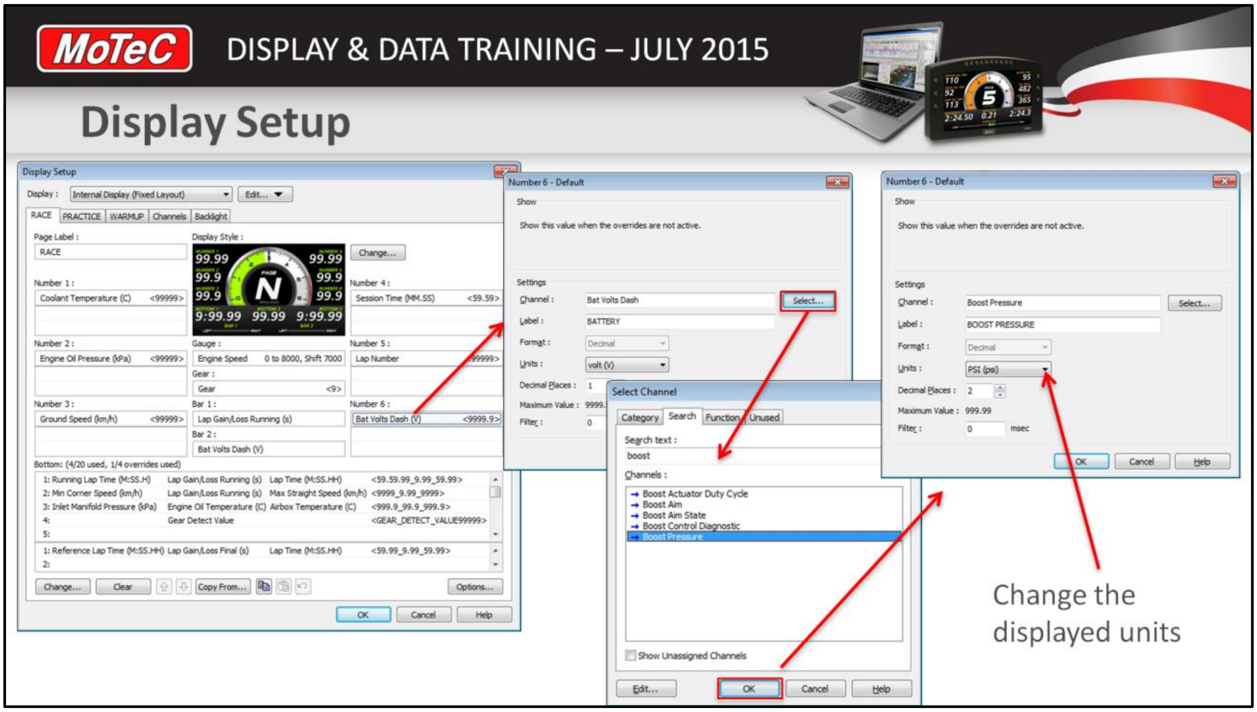
Three pages with different colours/layouts/channels. Switch between them with a button.

Display Setup

Select a colour set from the drop down menu or customise each colour individually

Select the style you want to use

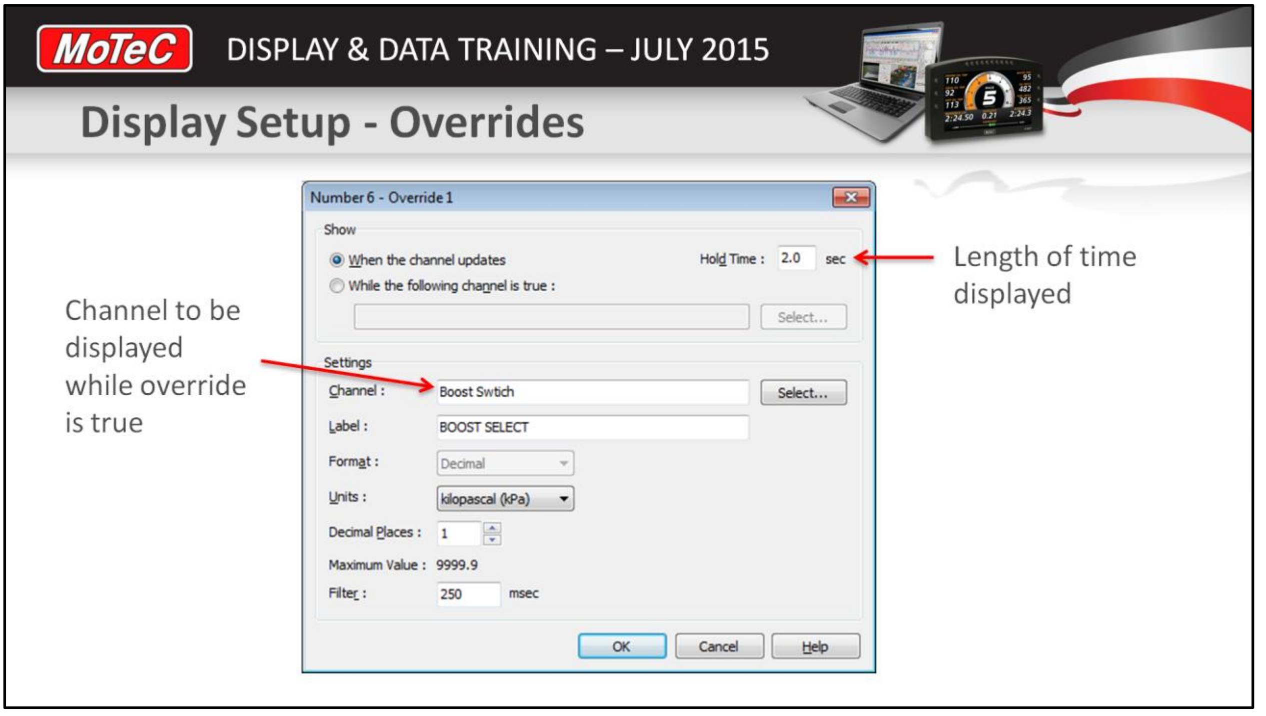




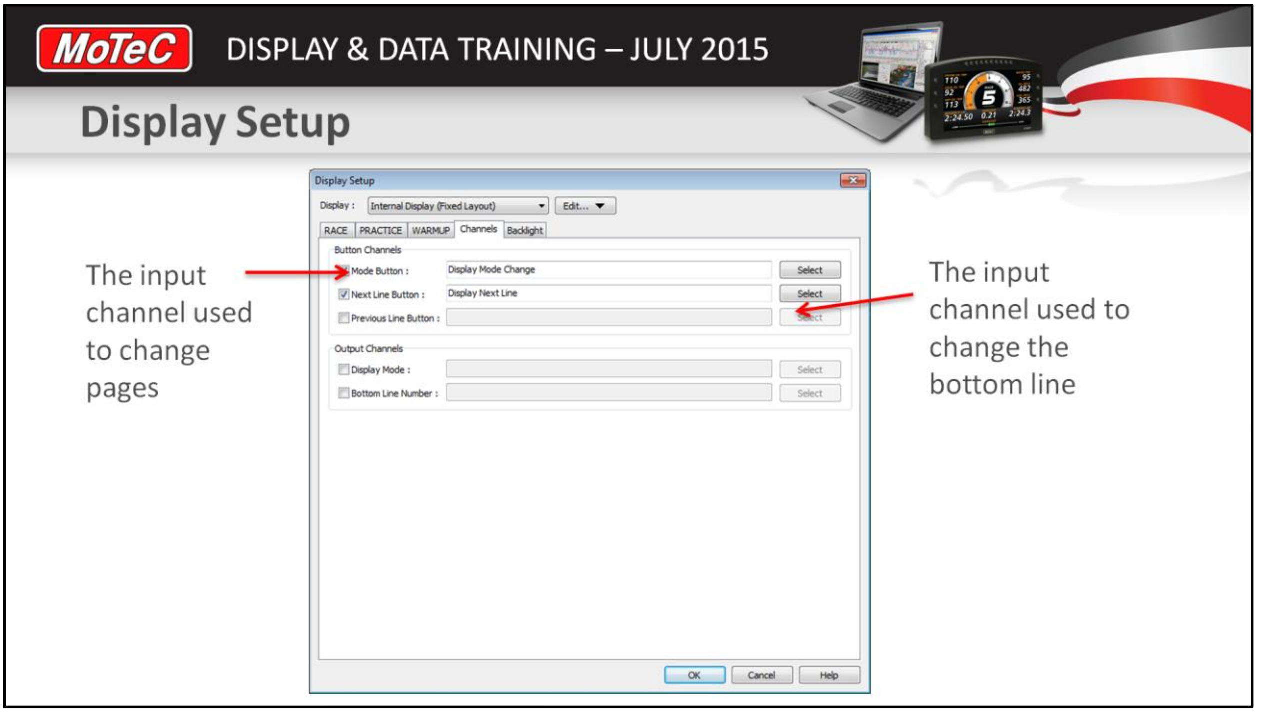
Changing the displayed units in the Display Setup does not change it in the logging.

Take note of the number of decimal places and the maximum value that can be displayed. If a larger number is required the resolution will need to be reduced.

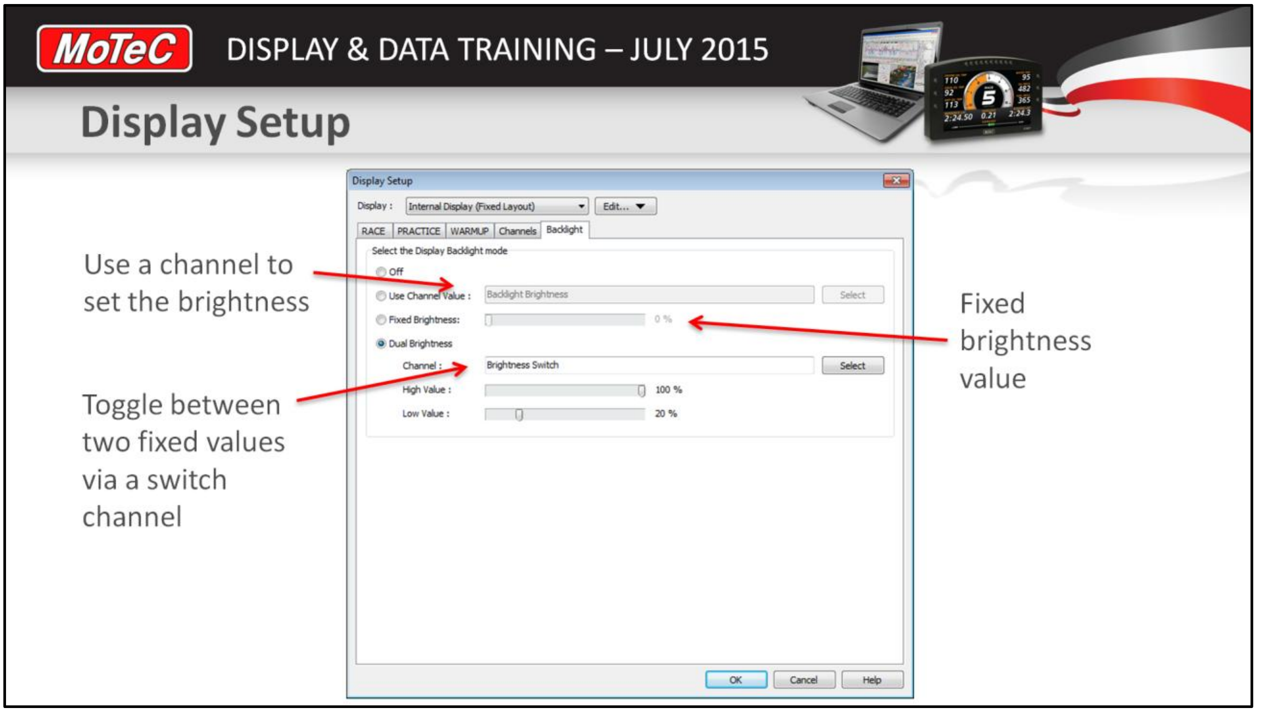
Filter: Helpful for channels that are updated very quickly, allows you to actually read the value without it jumping up and down by small amounts all the time. 250 milliseconds is usually enough.



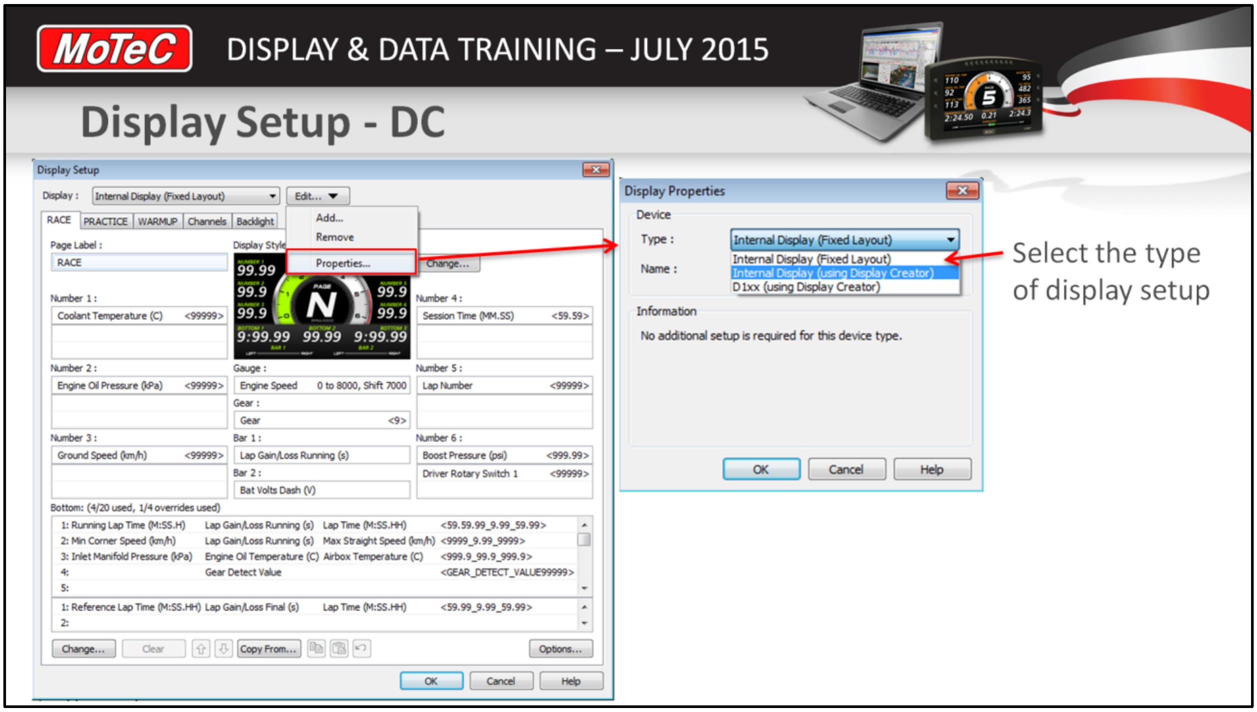
Let's say we have a rotary switch set up in the M1 to set the boost level. Every time the dial is rotated the value boost aim will be displayed.



This is where we set up the channels that control the toggling of the pages and which of the bottom lines is displayed. There are also output channels to indicate which page and what bottom line is displayed.

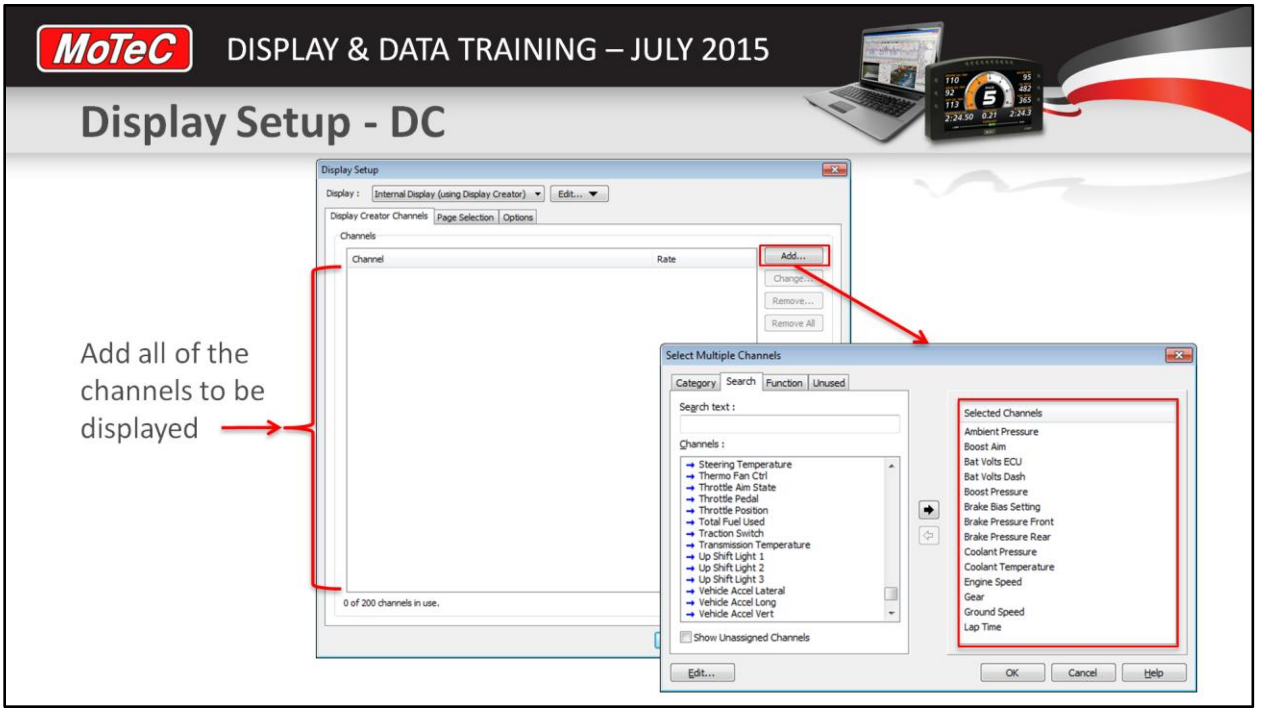


The backlight brightness can be controlled in a number of ways, either by a percentage channel, a fixed set brightness or two levels that are switched between via a switch such as a headlight switch.

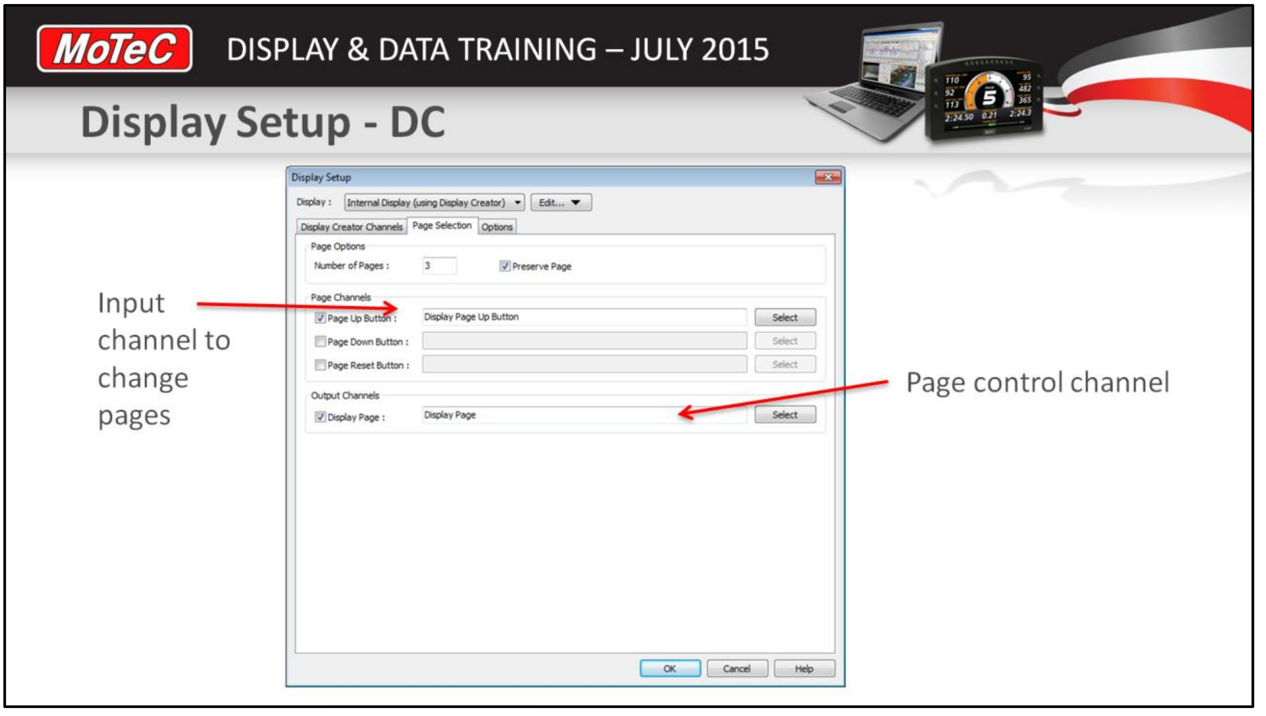


If Display Creator is being used instead of the fixed layout then we can also configure it from here. Change the display type to an 'Internal Display' (using Display Creator) as shown.

It is also possible to add a setup here if you have an additional D-Series Dash that you want to configure with a fixed layout.



Each of the channels you want to use in your Display Creator project needs to be added here. Think of the Logger and the Display as two separate devices. This sets up the transmit template and creates a DBC file that can then be loaded into Display Creator as the receive template.



Display Page: Number used in conditions to control which page is displayed.

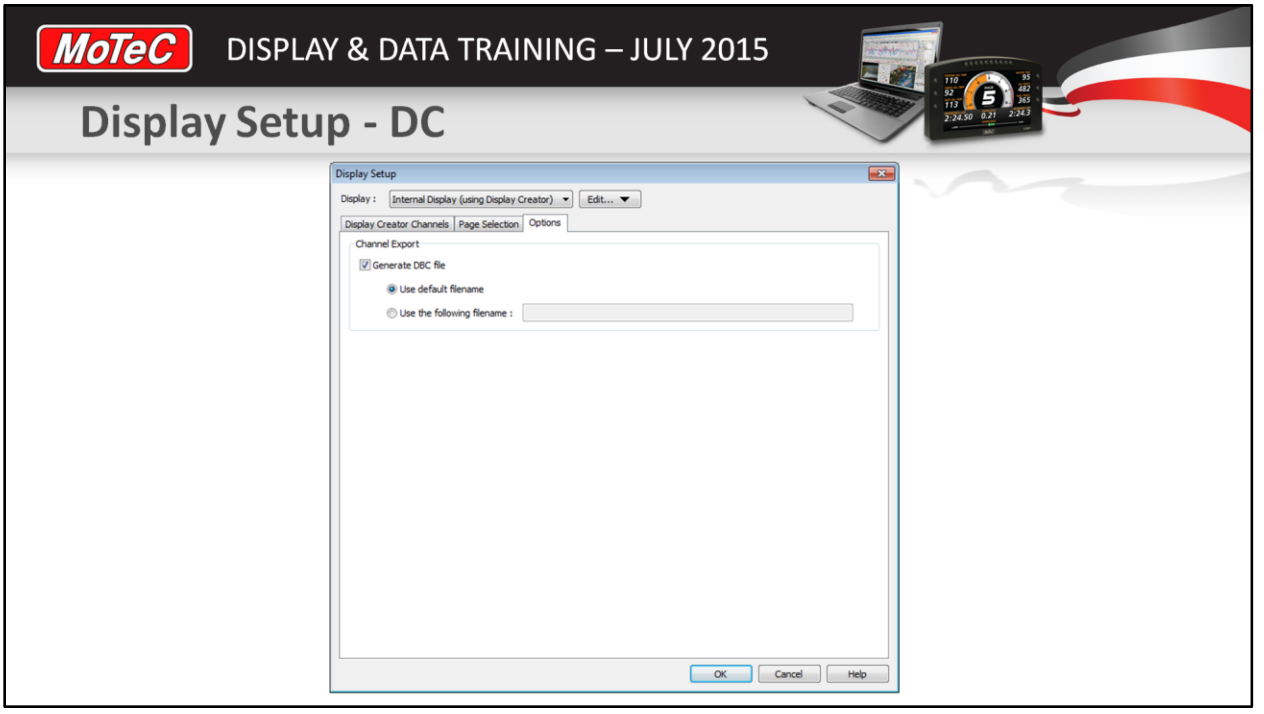
Number of Pages: Number of pages you will be using in your Display Creator project. Note the first number is zero, so for 3 pages Display Page has a range of 0-2.

Page Up Button: Channel used to increment Display Page by one

Page Down Button: Channel used to decrement Display Page by one

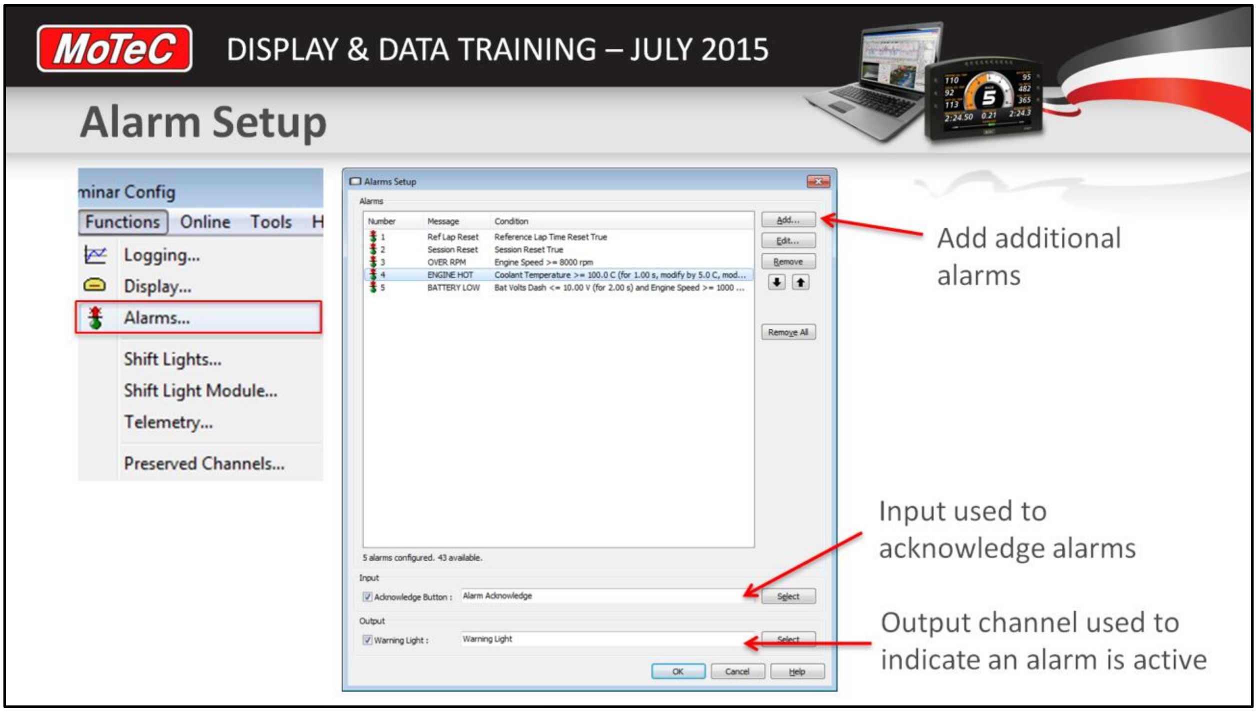
Page Reset Button: Channel used to reset Display Page to zero

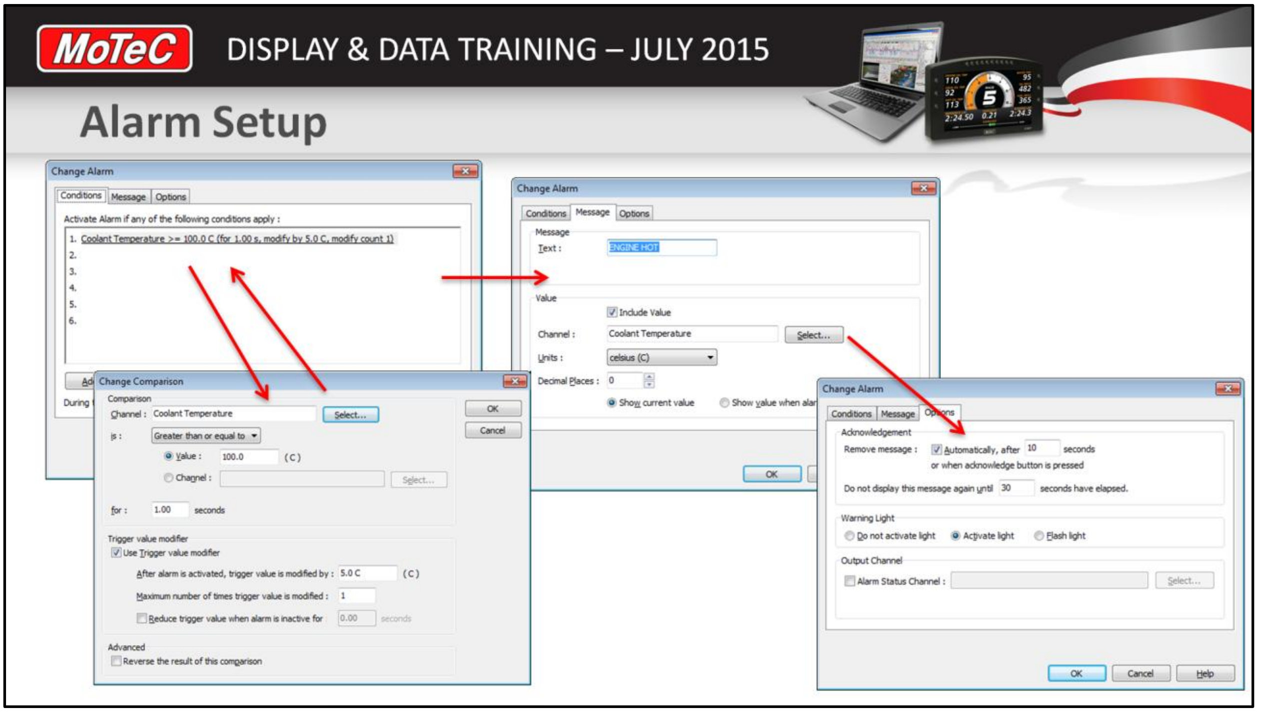
Preserve Page: If ticked will save the value of Display Page when the display is turned off. Whatever page the Display was on before powering off will be displayed on power on.



DBC file name: Generally easiest to leave as the default name.

When a Display is set up to use Display Creator it will create a DBC file to be imported into your DC project. This is all of the communications information required for the channels you select to send to the Display.


MoTeC
DISPLAY & DATA TRAINING – JULY 2015
Alarm Setup
minar Config
Functions Online Tools H
Logging...
Display...
Alarms...
Shift Lights...
Shift Light Module...
Telemetry...
Preserved Channels...
Alarms Setup
Alarms
Number Message Condition
1 Ref Lap Reset Reference Lap Time Reset True
2 Session Reset Session Reset True
3 OVER RPM Engine Speed >= 8000 rpm
4 ENGINE HOT Coolant Temperature >= 100.0 C (for 1.00 s, modify by 5.0 C, mod...
5 BATTERY LOW Bat Volts Dash <= 10.00 V (for 2.00 s) and Engine Speed >= 1000 ...
Add...
Edit...
Remove
Remove All
5 alarms configured. 43 available.
Input
Acknowledge Button : Alarm Acknowledge
Select
Output
Warning Light : Warning Light
Select
OK
Cancel
Help
Add additional alarms
Input used to acknowledge alarms
Output channel used to indicate an alarm is active

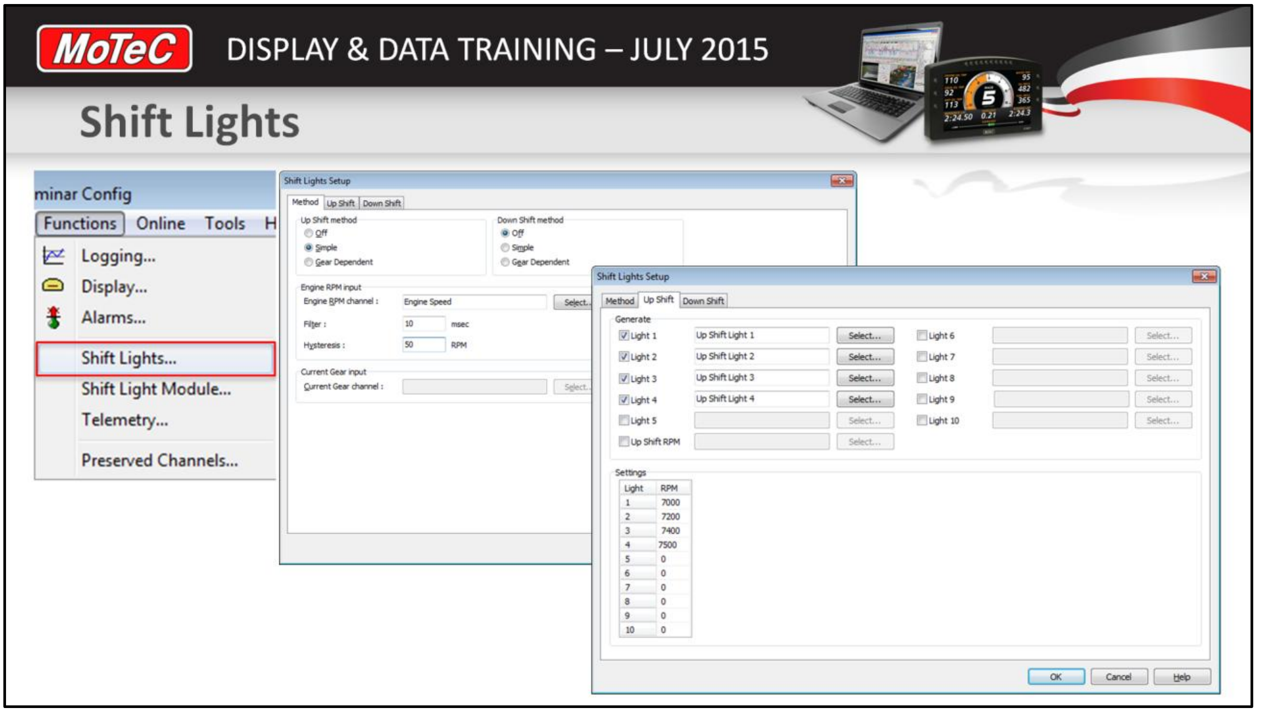


Alarms allows us to create a warning based on certain conditions. In this case we are creating an engine temp alarm. When the coolant temperature exceeds 100 degrees celcius for 1 second the alarm will be triggered.

We are also able to modify the value once it has been triggered. In this case, if the coolant temperature exceeds 100 degC the alarm comes on. Once this is cleared it will now have to exceed 105 degC to trigger the alarm.

A message needs to be added and will be displayed at the bottom of the screen when an alarm is active. The current value of the channel can also be set to be displayed.

It can be set to automatically acknowledge the alarm after a set period of time and an on delay can be set. An output channel can be set for each individual alarm to allow display of specific alarms, such as on a SLM.



Shift Light Setup

The Shift lights are set up by a two stage process. The menu is accessed from Functions then Shift Lights as shown above in the first picture.

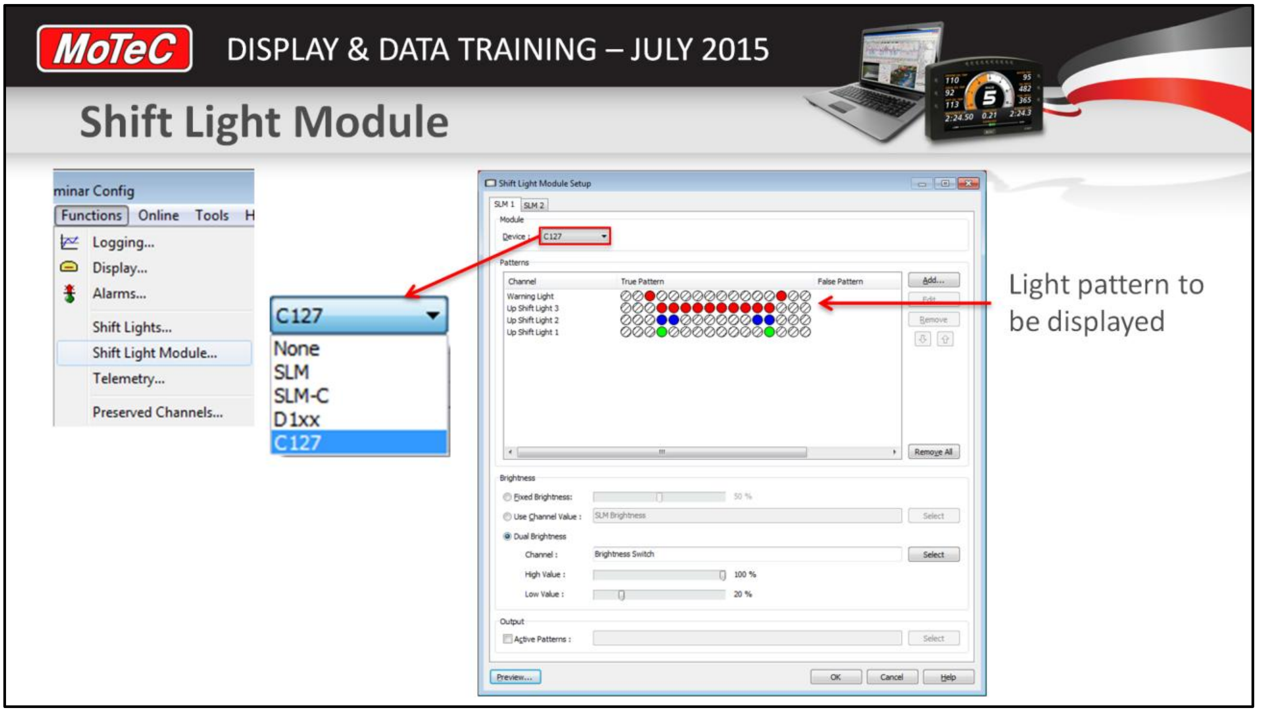
Next choose which channel drives the lights. This is most likely to be RPM**,** however, if you wish to have the lights as a boost gauge for testing a turbo engine or inline G for deceleration, then this channel could also be assigned a channel for a light. (Not in the Shift Light setup, however.)

Try to remember to put the RPM signal lower than the actual RPMyou wish to shift at.

Why? The main reason is the driver will always need to see the light before he knows to change gear. If you want to shift at 6700 RPM for example the light should come on 100 RPM less (more for a new driver)

Hysteresis is to stop potential 'flickering' of the shift light if RPM is around the shift point.

The shift lights can also be set to Gear Dependant. This requires a Gear signal from either the gearbox, or can be calculated by using Speed and RPM. The gear channel must first be set up under 'Calculations – Gear Detection'. Using a Gear channel, the RPM that triggers the shift lights can be modified for the higher gears.



SLM is a CAN communications-based shift light with eight individual LEDs that can each emit eight different colours at user defined brightness. The lights can be driven by the Up Shift Light channels, as well as the Warning Light channel or any others.

When used with a Dash, the SLM can be configured as a four stage shift light as well as having patterns based on up to four User Condition channels and a Warning Alarm option. The number of lights, and the colour and brightness for each, can be individually set for each display configuration.

The ability to pick individual items out of status groups and error groups. It is also possible to have a light flash, as well as changing between two colours when active; each colour is up to the user.

The ability to have certain colours displayed when any condition is false is also available as an alternative to simply having the lights 'off' when nothing is triggering them.

Patterns are arranged in priority order, with the top of the list having the highest priority. This means that if a pattern has a high priority, e.g. Warning Lights, it cannot be affected by another pattern condition lower in the list becoming true.

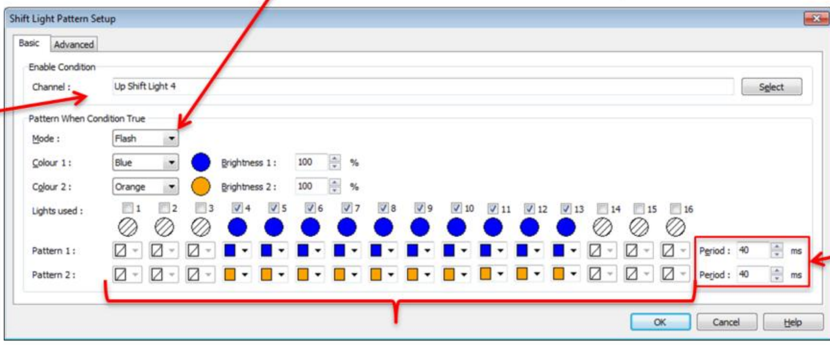
Use of SLM over CAN will free up Aux Outputs to be used for other functions.

DISPLAY & DATA TRAINING – JULY 2015

Shift Light Module

Select Mode - Either Flash/Static

Select the channel to control the lights



Flash timing

Select which lights will be used

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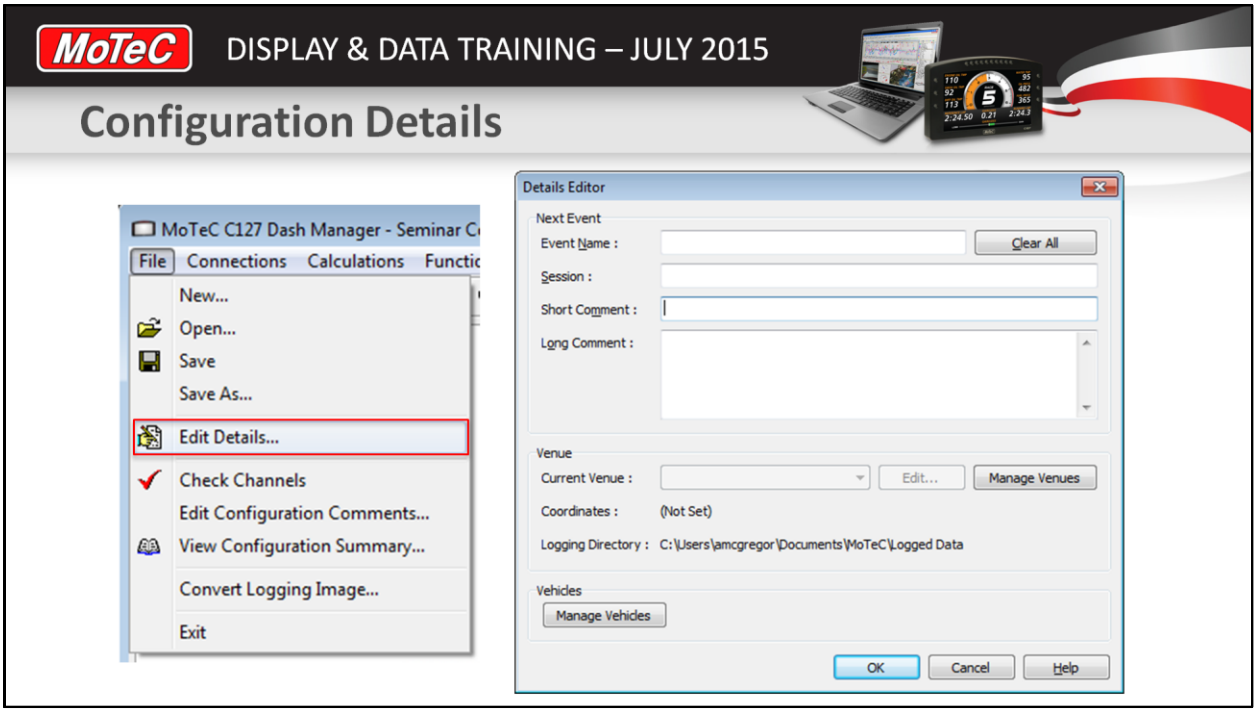
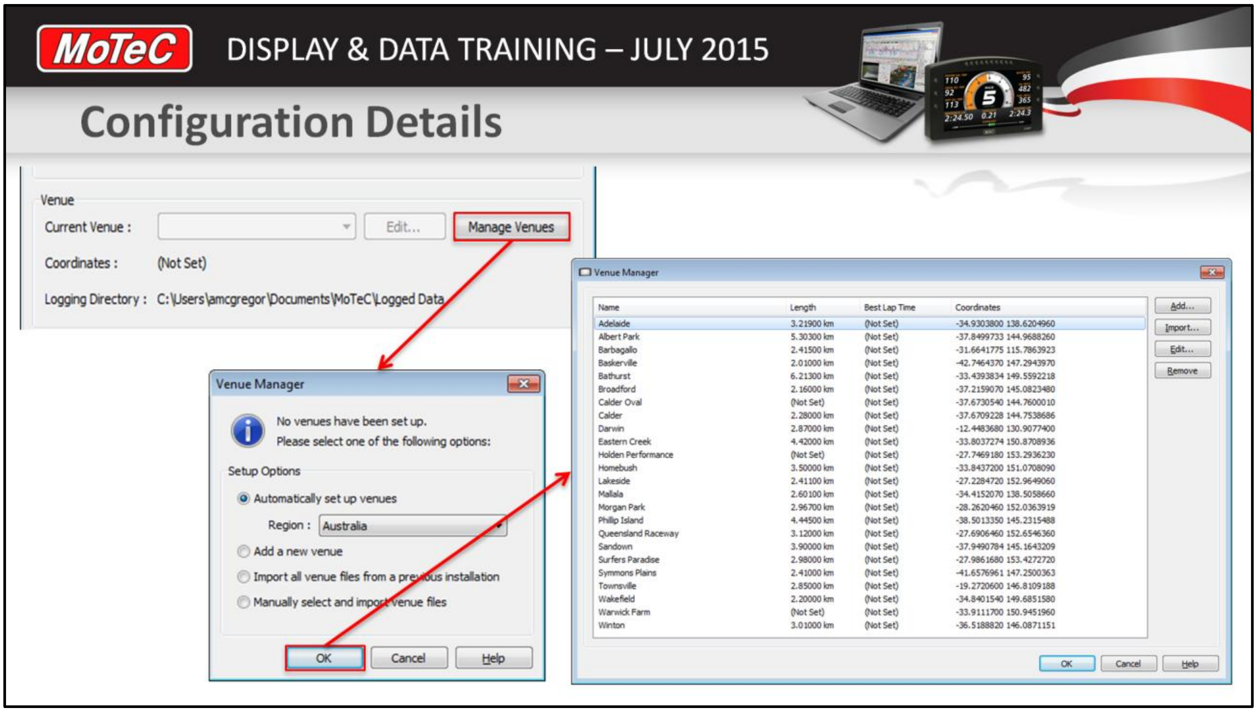
Vehicle Details



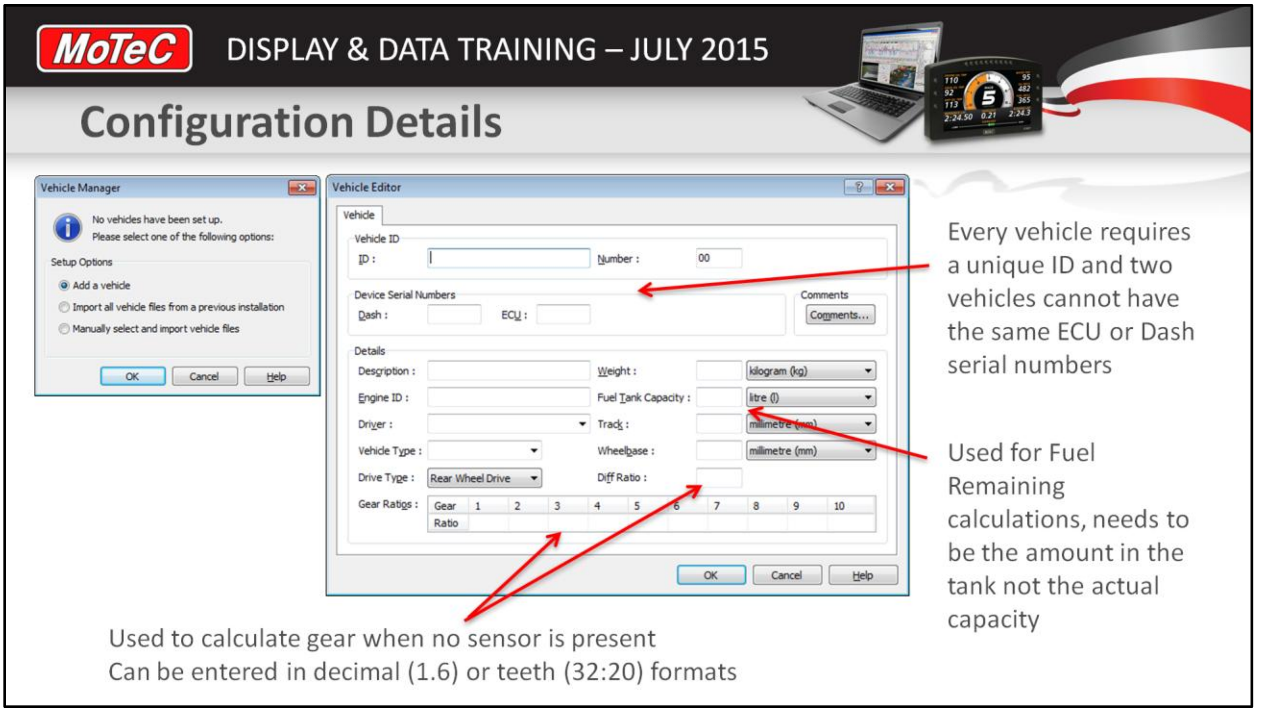
The details can be filled out either before sending the configuration or when downloading the data. This is often overlooked but is very important when trying to identify data later on.



Clicking on the Manage Venues button for the first time will bring up a window to automatically import venue files.

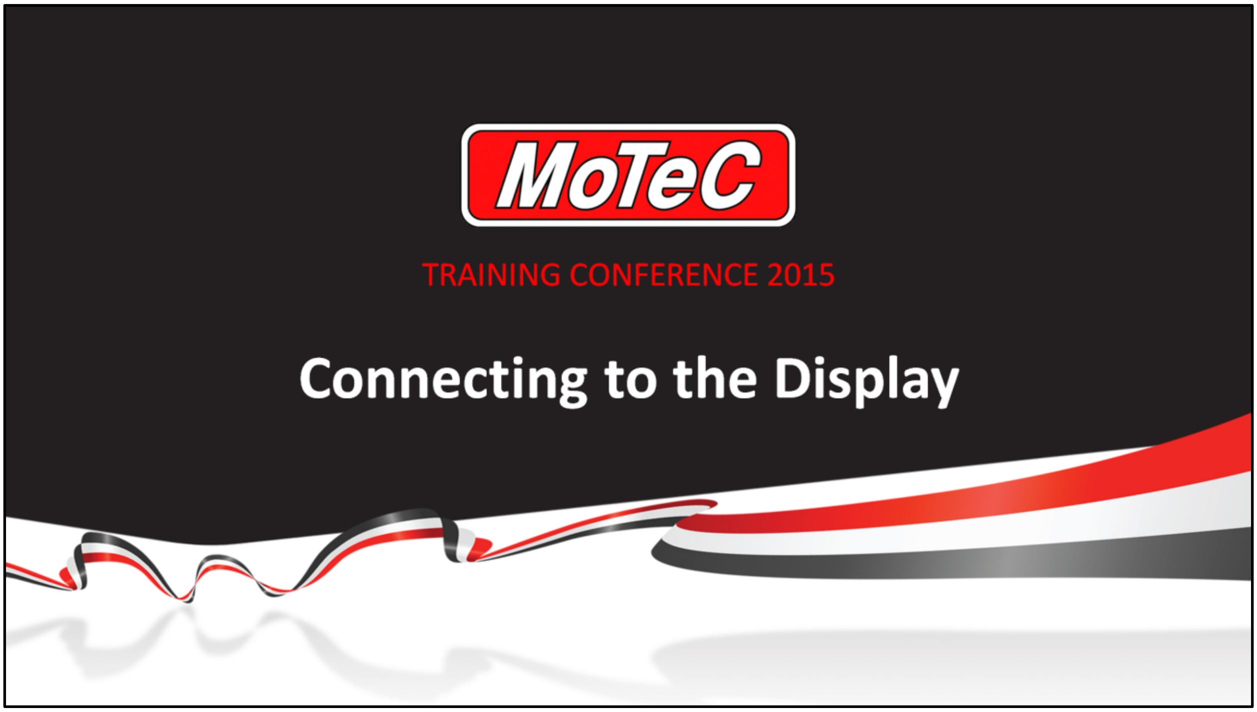
Additional tracks can be added manually using either the import button to bring in tracks that have already been setup by MoTeC or by clicking Add and filling in all of the details manually.

Every track in the Venue Manager is loaded into the display, meaning that if you have GPS beacons set up you can turn up to any of those tracks and get lap times without having to change the config.



- **Vehicle Number and Dash Serial Number**: These are the parameters the Dash looks for when sending or retrieving configs or data from the Dash. It will match up this page with the Dash serial number. If you wish to upload and download on multiple computers, this information should match and be on all computers used.
- **Description:** Usually the style of vehicle, e.g. Formula Ford or V8 Superboats
- **Engine ID:** If you are running a sealed engine, log the serial number and the install date. Most people ignore it and when they come to talk with their supplier they have forgotten these details.
- **Weight/Fuel Tank etc**: Useful for when you're back in the office and forgot what run 23 Friday afternoon was. Also note the units can be metric or imperial. 100 gallons will not fit in a 100 litre fuel tank.
- **Driver**: This will be displayed in i2 as the name along with the log file. Leaving it blank may save time but wastes valuable post processing time matching your laps up to the official timing and scoring sheet to work out who was driving.
- **Comments section:** This will be added to the Log file. It's your main hope of remembering which run was with fresh tyres, different springs etc.
- **Track**: Used by i2 for its Vehicle Roll calculation
- **Wheelbase:** Used by i2 for its Oversteer calculation
- **Fuel Tank Capacity** is used for Fuel Remaining calculations
- **Gear Ratios**: For the record and used if calculating Gear from Speed and RPM.

Most of the errors in missed details on laptops etc. come from users not having the details for the car they download on their computer.


MoTeC
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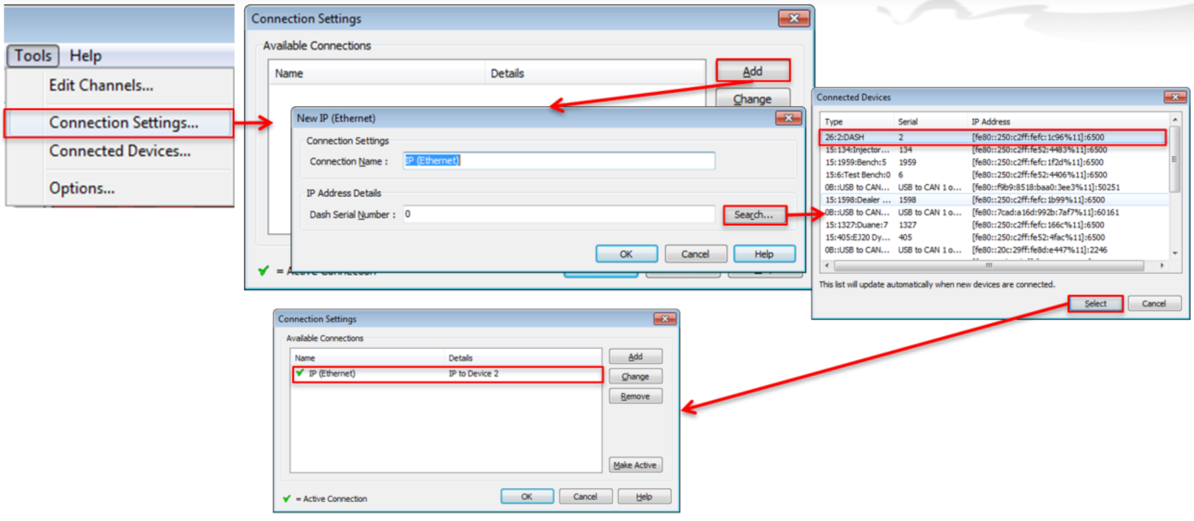
Connecting to the Display

MoTeC DISPLAY & DATA TRAINING – JULY 2015

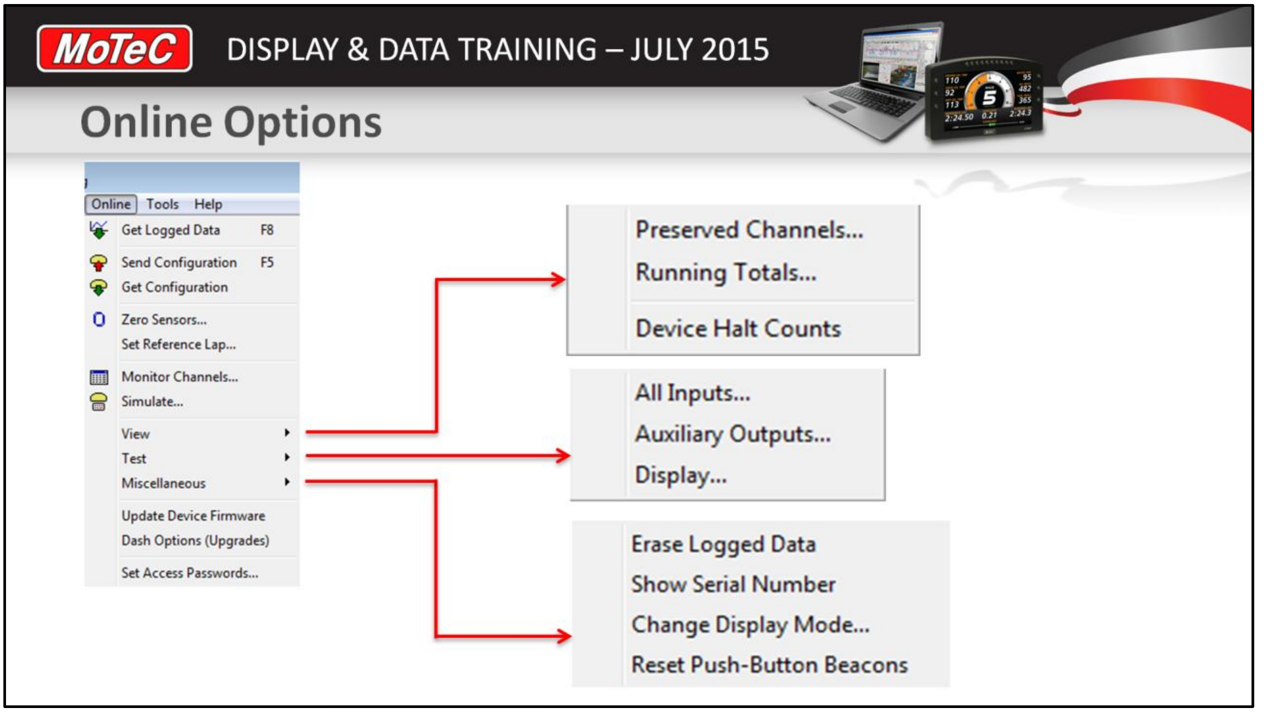
Connection Settings



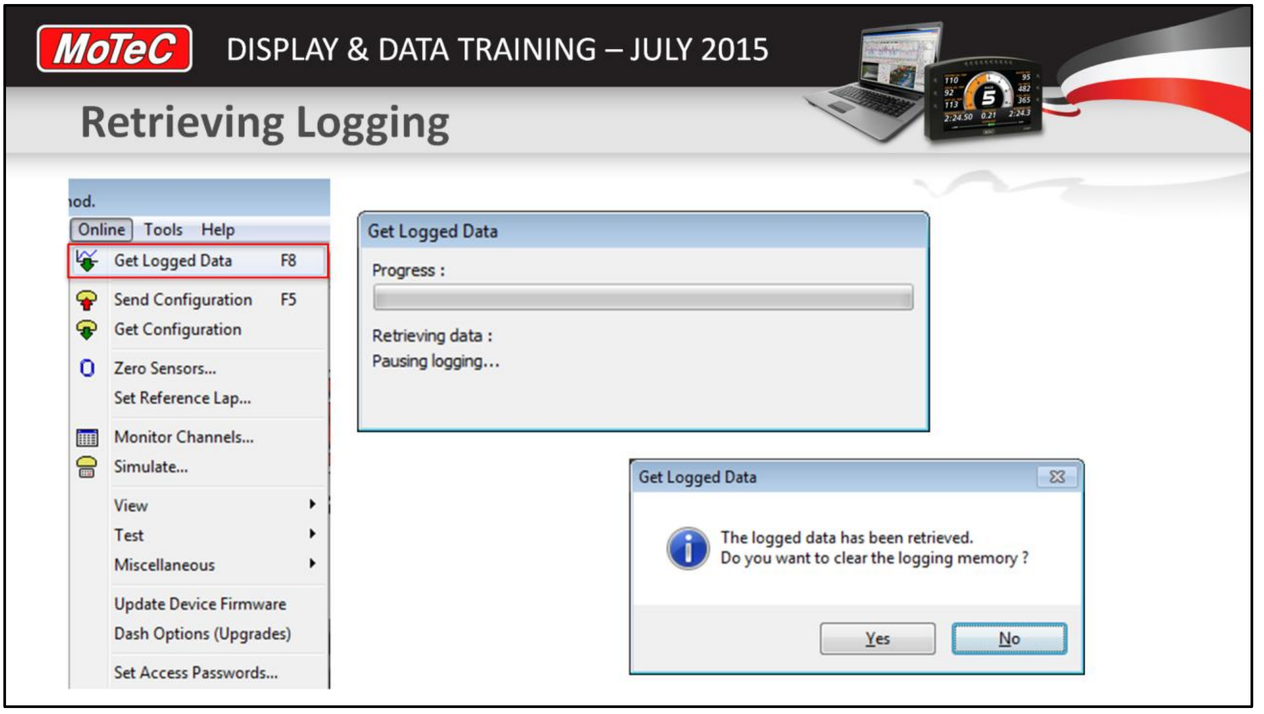
All of the Colour Display Loggers (C-Series) use Ethernet to communicate with the PC.

The Display-only devices (D-Series) require a CAN connection.

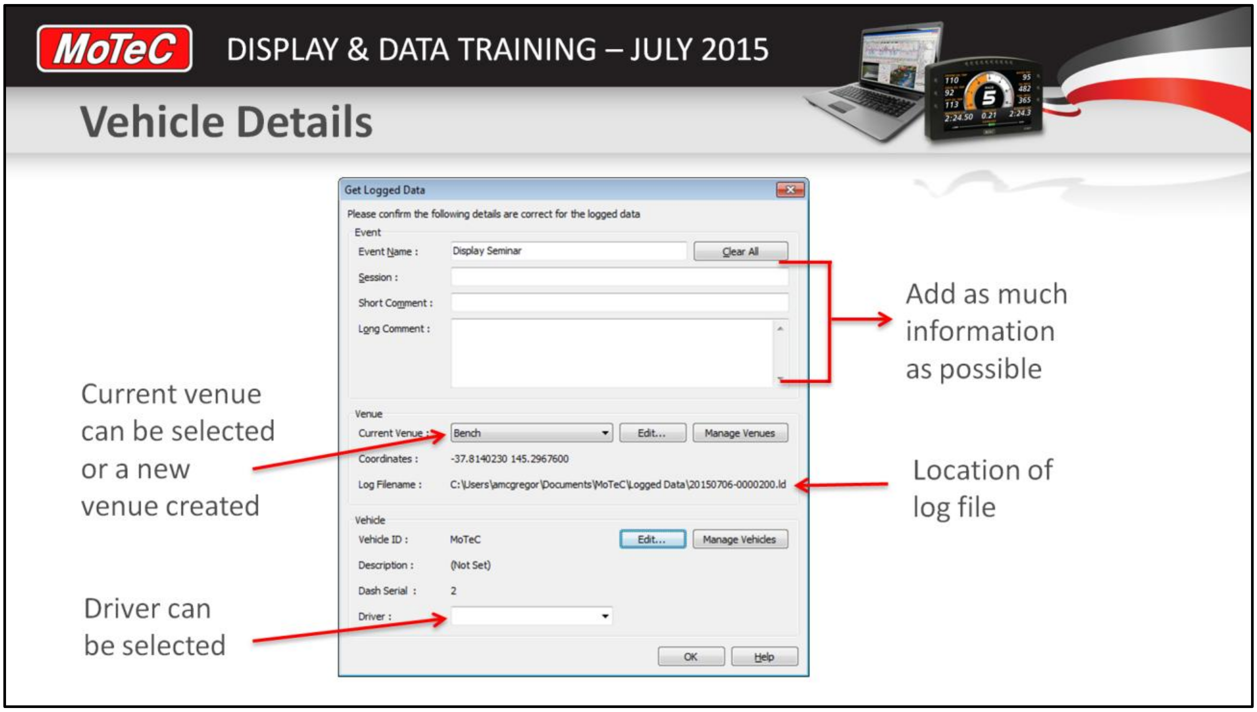
- Add a new connection, click Add.
- Either enter the serial number directly or click search. If using search it will list all connected devices.
- Double click or highlight and click Select on the device with which you want to connect.
- If you have more than one device in your available connections, highlight the one you want to connect to and click 'Make Active'. There will be a green tick next to the active one.



- Send/Retrieve Configs
- Get Logged Data
- Real time viewing of sensors
- Zero Sensors
- Simulate conditions with engine/vehicle off
- Enable options in the Dash
- Upgrade the firmware in the field
- Test inputs/outputs, raw voltages/diagnostics
- Send Reference Laps
- View History Logs



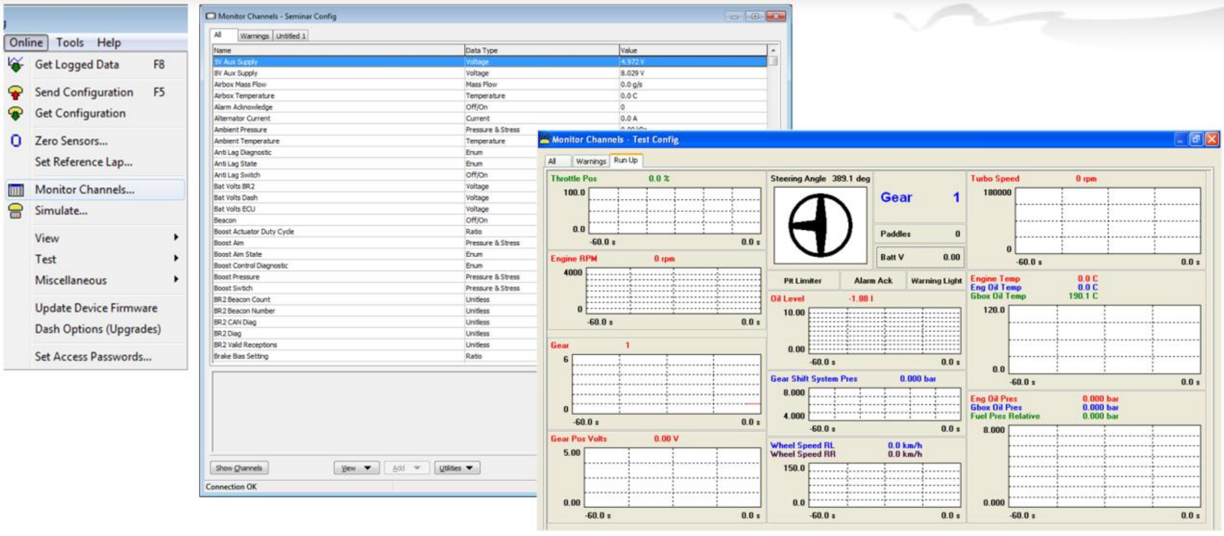
Clicking on Get Logged Data or pressing F8 will download the data from the logger (if the upgrade is enabled). Once the data is retrieved it will ask if you want to clear the logging from the device.



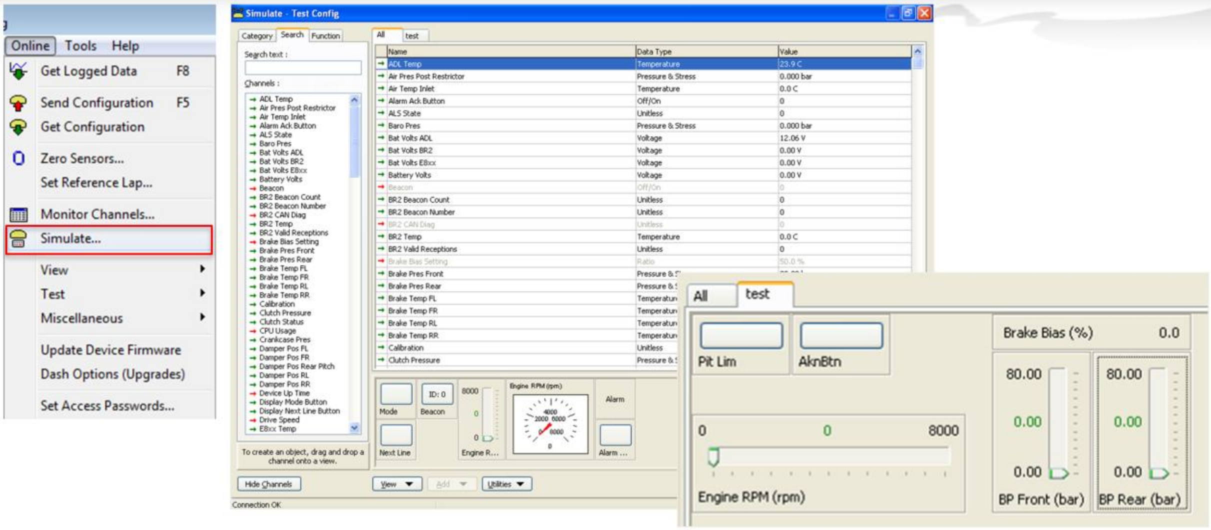
Vehicle details: When the download is complete you will be asked to fill out details about the logged data. It is important to put in as much information as possible to allow easy search at a later date. It is very difficult to find a specific log file months later if these details are not filled in correctly.

Log file location can be edited in the Manage Venues window.

Monitor Channels



Simulate


Online
Tools
Help
Get Logged Data F8
Send Configuration F5
Get Configuration
Zero Sensors...
Set Reference Lap...
Monitor Channels...
Simulate...
View
Test
Miscellaneous
Update Device Firmware
Dash Options (Upgrades)
Set Access Passwords...
Simulate - Test Config
All
test
Pit Lim
AknBtn
Brake Bias (%)
0.0
80.00
0.00
0.00
0
8000
Engine RPM (rpm)
BP Front (bar)
BP Rear (bar)

Questions

- If you need assistance, feel free to drop us a line at support@motec.com.au
- If you have suggestions on possible improvements or feature requests, email us at the same address and we can look into it for you

Dash Options

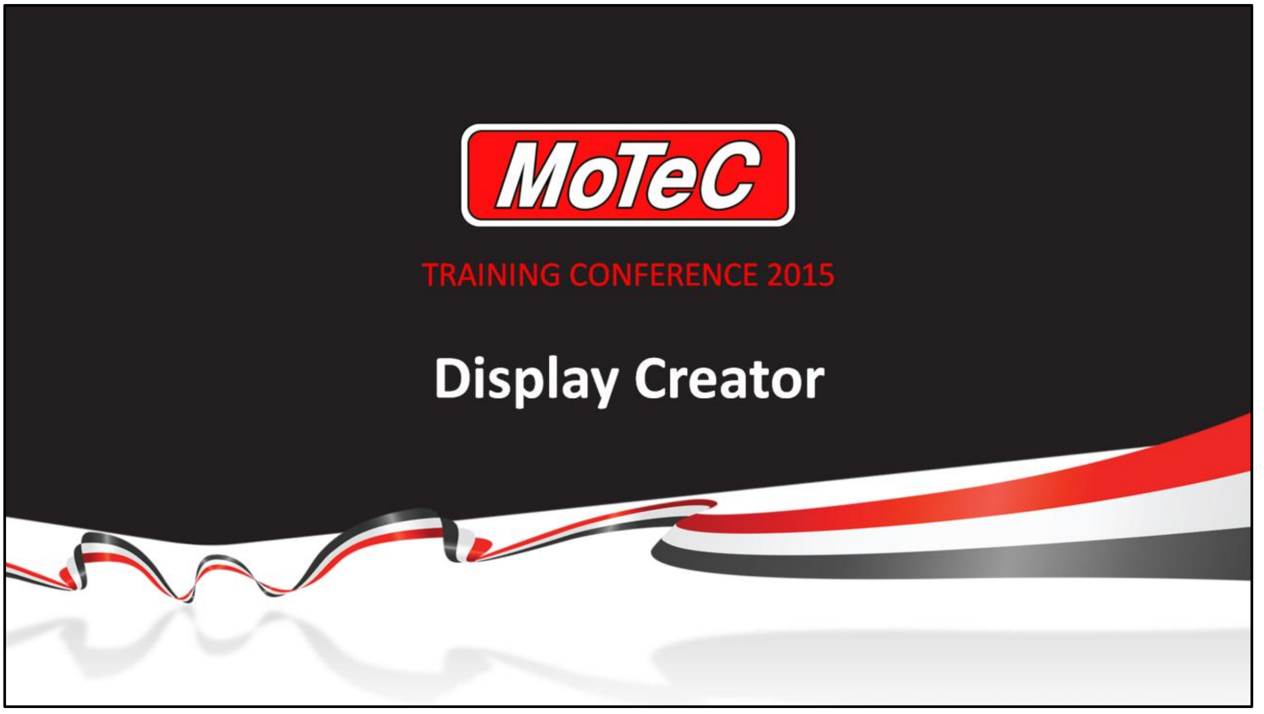
C125/C127

- Data logging – 120MB
- I/O
- Pro Analysis
- T2 Telemetry
- Display Creator

C185/C187

- Data logging – 500MB
- I/O
- Pro Analysis
- T2 Telemetry
- Display Creator
- Advanced Functions

	C125/C127		C185/C187	
Input Type	Standard	I/O Upgrade	Standard	I/O Upgrade
Analog Volt	0	6	10	20
Analog Temp	0	2	4	8
Digital	2	2	4	4
Switch	0	0	2	2
Speed	1	3	4	4
Aux Out	0	4	6	8


MoTeC
TRAINING CONFERENCE 2015
Display Creator

DISPLAY & DATA TRAINING – JULY 2015

Overview

- Introduction to Display Creator
- Creating a New Project/Initial Setup
- Input/Communication Setup
- Page Layout
- Enumerators/Switches
- Alarms/Conditions
- Sending a Configuration
- Preloaded Projects
- Additional Features
- Questions

Introduction

- Full control of the layout – optimise for your application
- Create custom graphics/icons
- Import images and illustrations
- Incorporate sponsors/team logos
- Number of pages only limited by overall project size
- Custom fonts
- Animation

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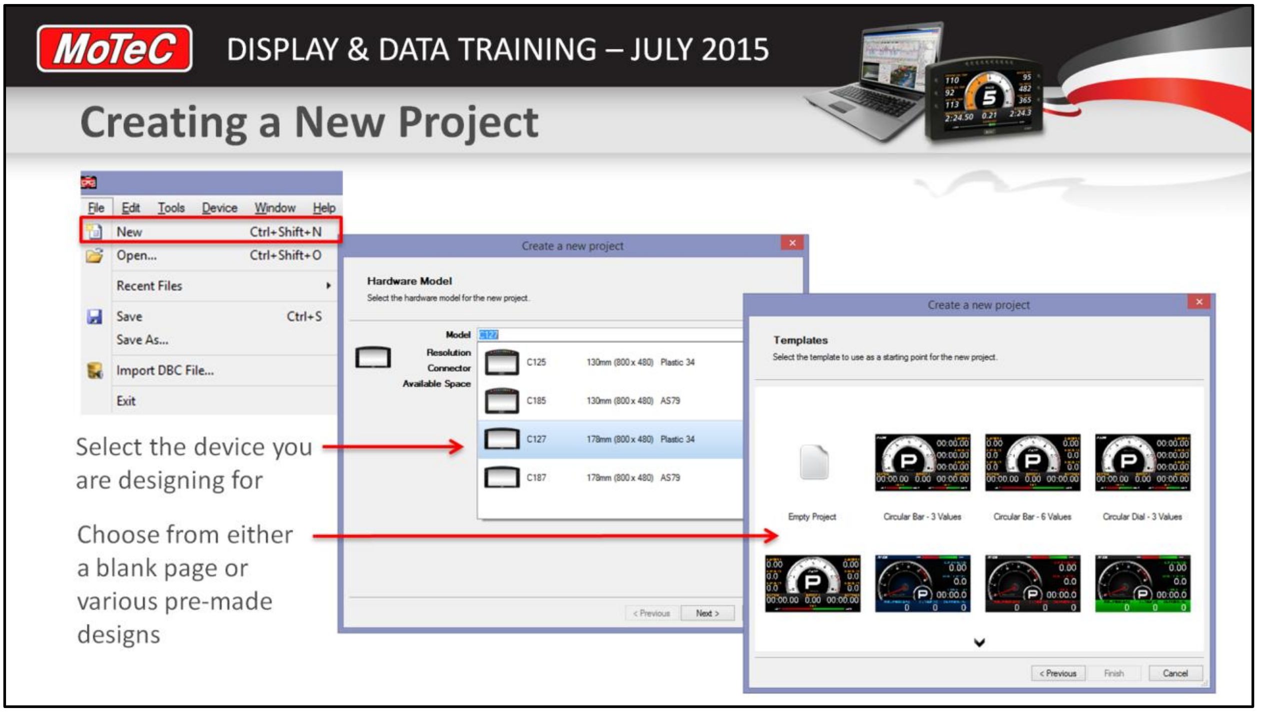
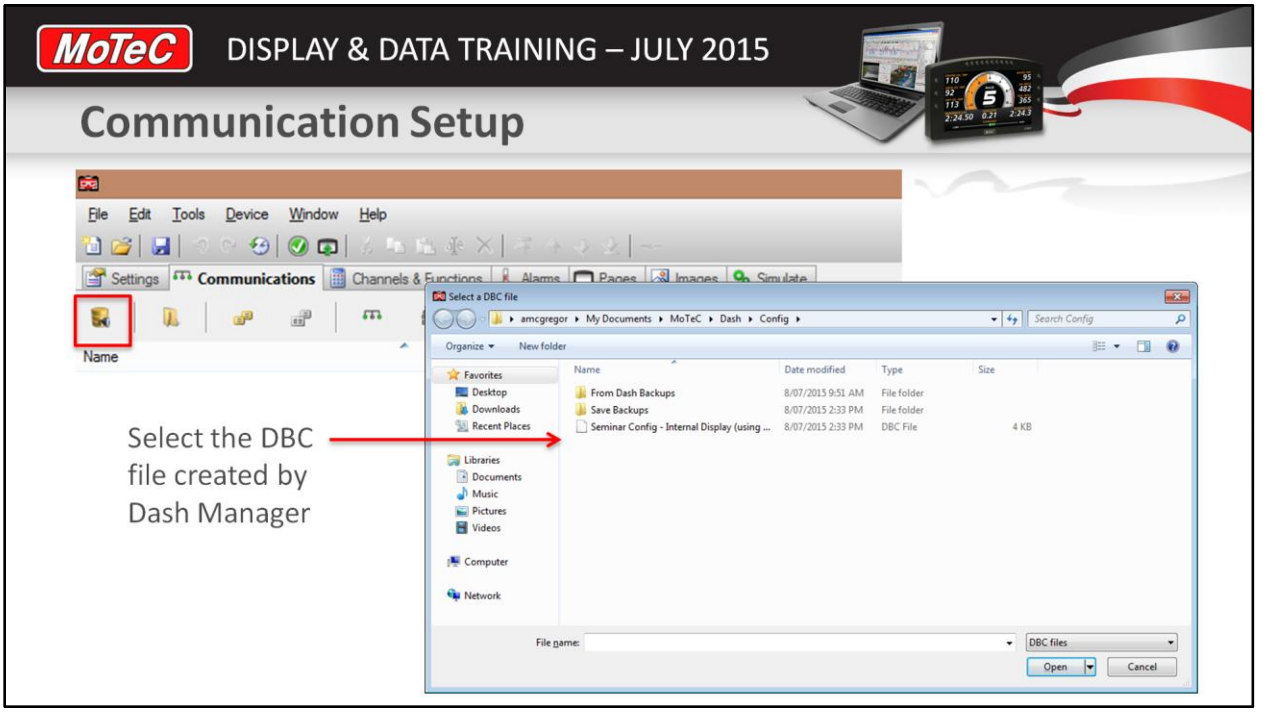
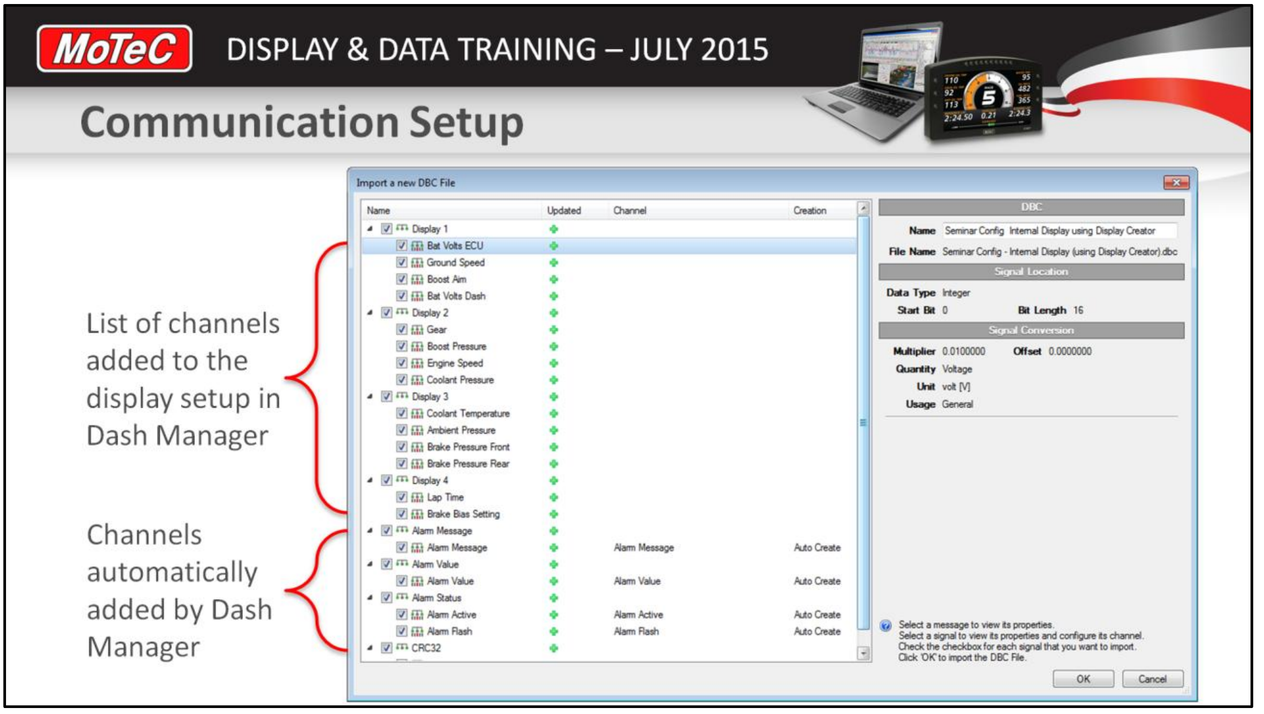
Creating a New Config/Initial Set Up


MoTeC
DISPLAY & DATA TRAINING – JULY 2015
Creating a New Project
File Edit Tools Device Window Help
New Ctrl+Shift+N
Open... Ctrl+Shift+O
Recent Files
Save Ctrl+S
Save As...
Import DBC File...
Exit
Select the device you are designing for
Choose from either a blank page or various pre-made designs
Create a new project
Hardware Model
Select the hardware model for the new project.
Model
Resolution
Connector
Available Space
C125 130mm (800 x 480) Plastic 34
C185 130mm (800 x 480) AS79
C127 178mm (800 x 480) Plastic 34
C187 178mm (800 x 480) AS79
< Previous
Next >
Create a new project
Templates
Select the template to use as a starting point for the new project.
Empty Project
Circular Bar - 3 Values
Circular Bar - 6 Values
Circular Dial - 3 Values
< Previous
Finish
Cancel

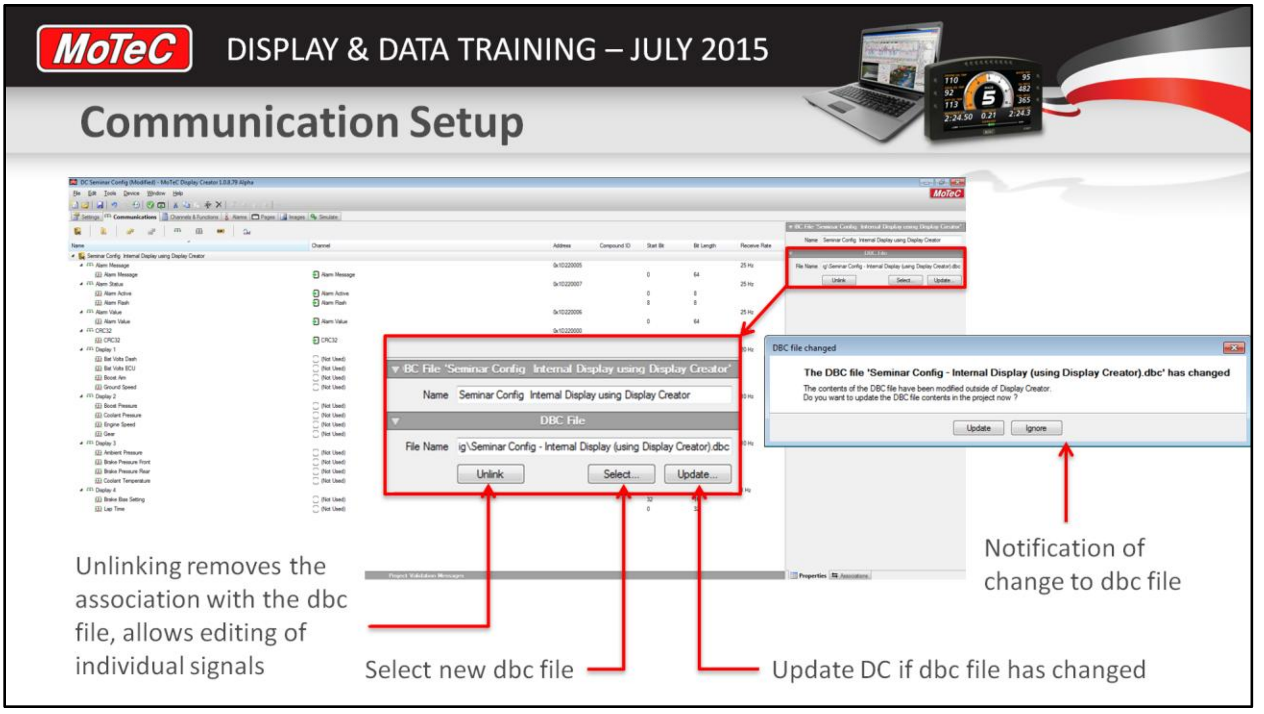


The DBC file must match the Dash Manager Configuration loaded into the Display.

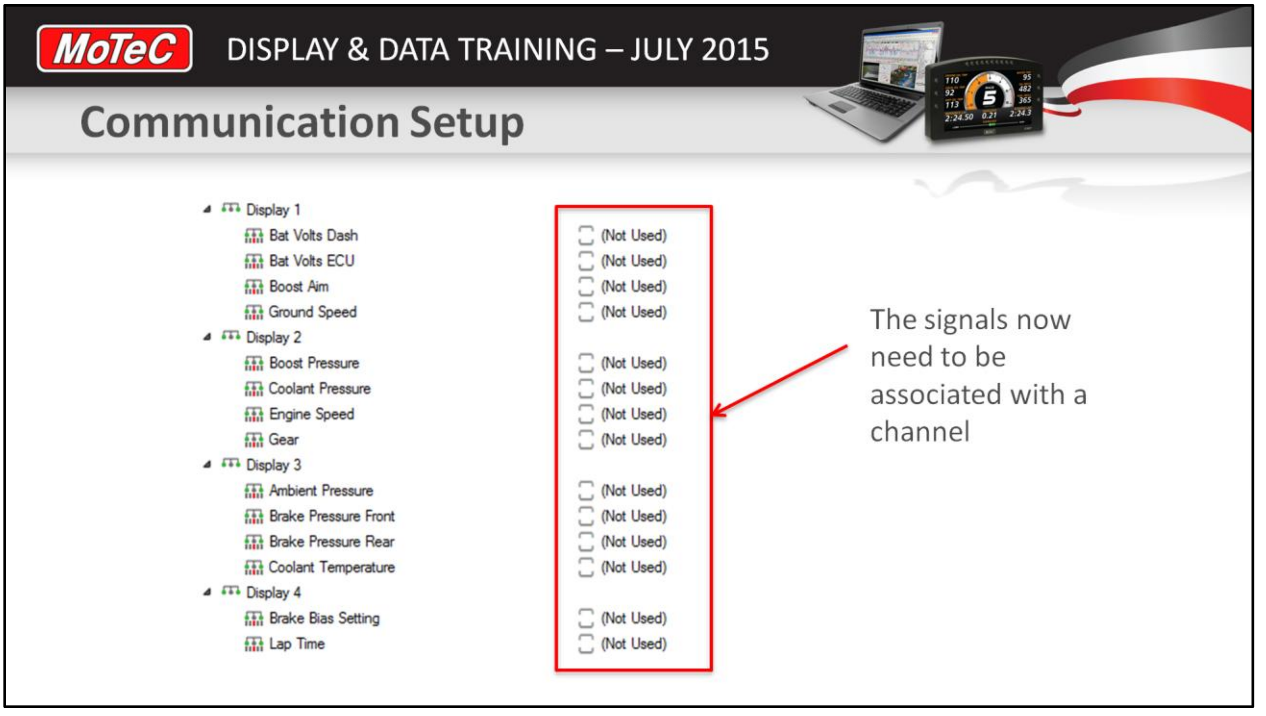


This is a list of all of the channels in the dbc file created by Dash Manager.

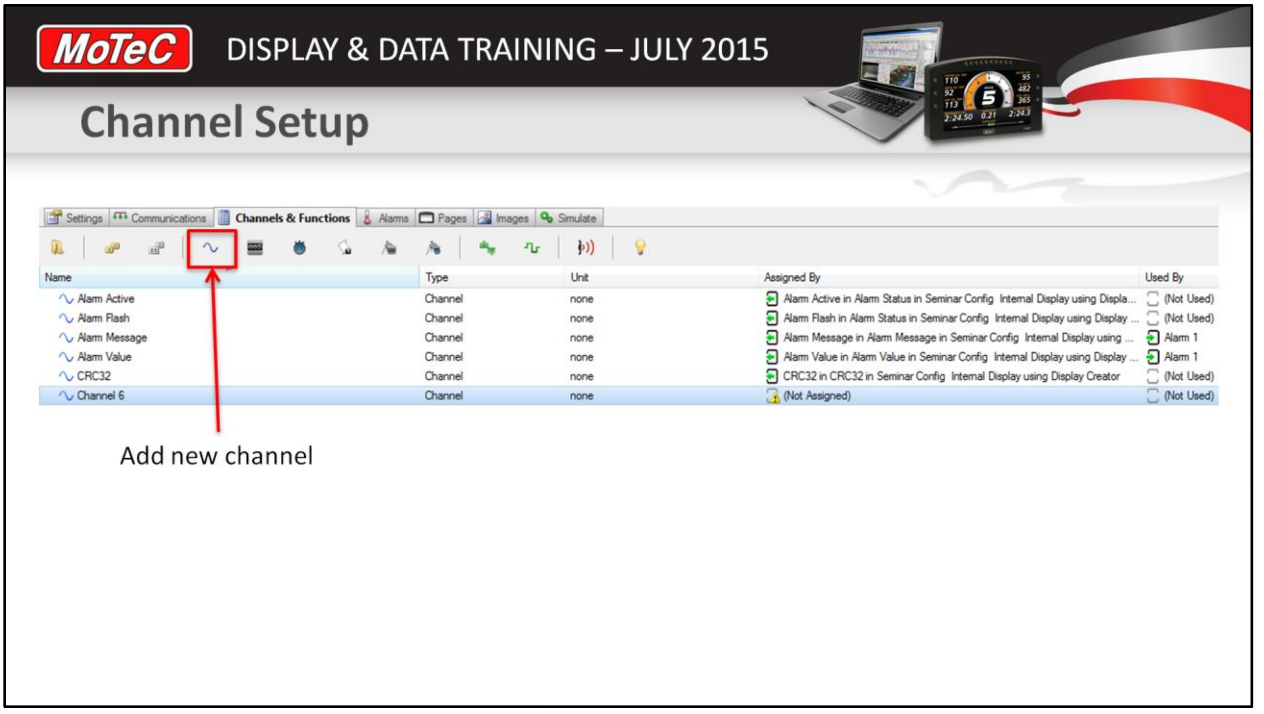
It is possible to untick channels that are not needed in the Display setup, which is usually more useful when importing a dbc file from an external source in which there are a number of channels that you don't require to be displayed.



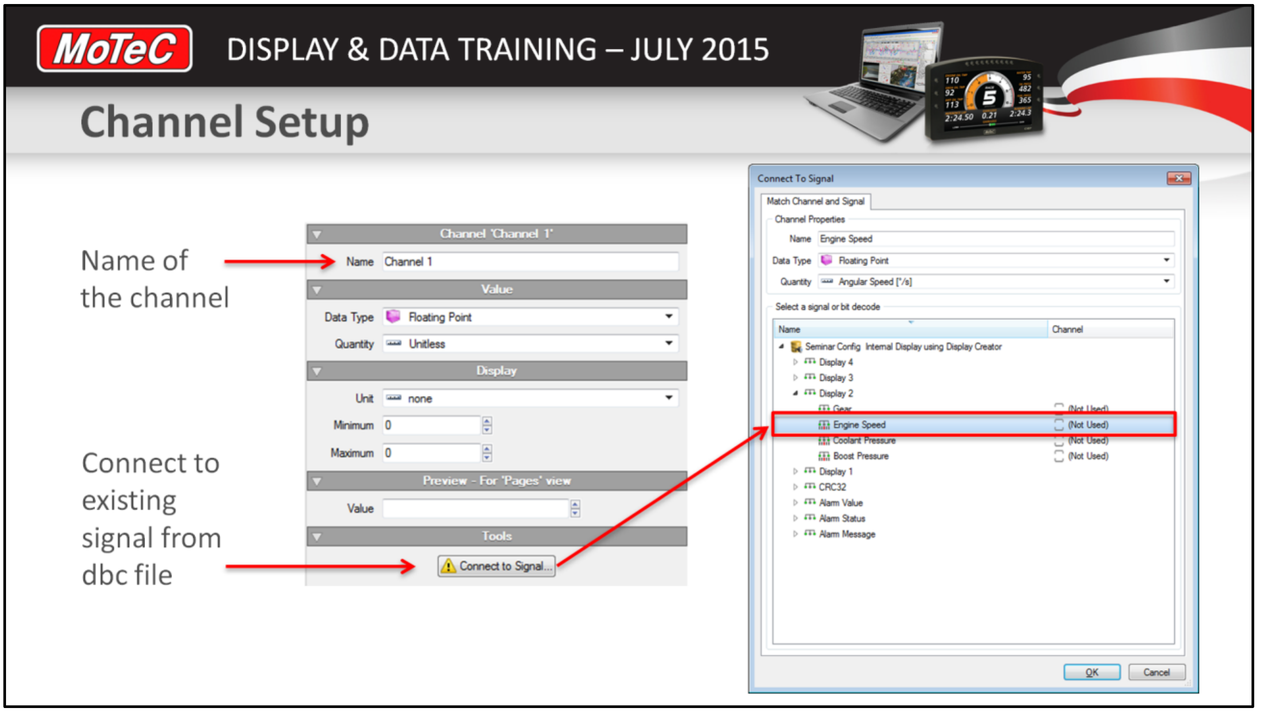
When using a dbc file created by Dash Manager, if the Display setup is modified and the dbc file is changed, DC will automatically notify you that changes have been made to a linked dbc file.



Each of the input signals need to be assigned to a channel in Display Creator. There are two methods of doing this, the first is create all of the channels and link them to the input signals. The second is to create both the channel and link to the signal when creating the display element.

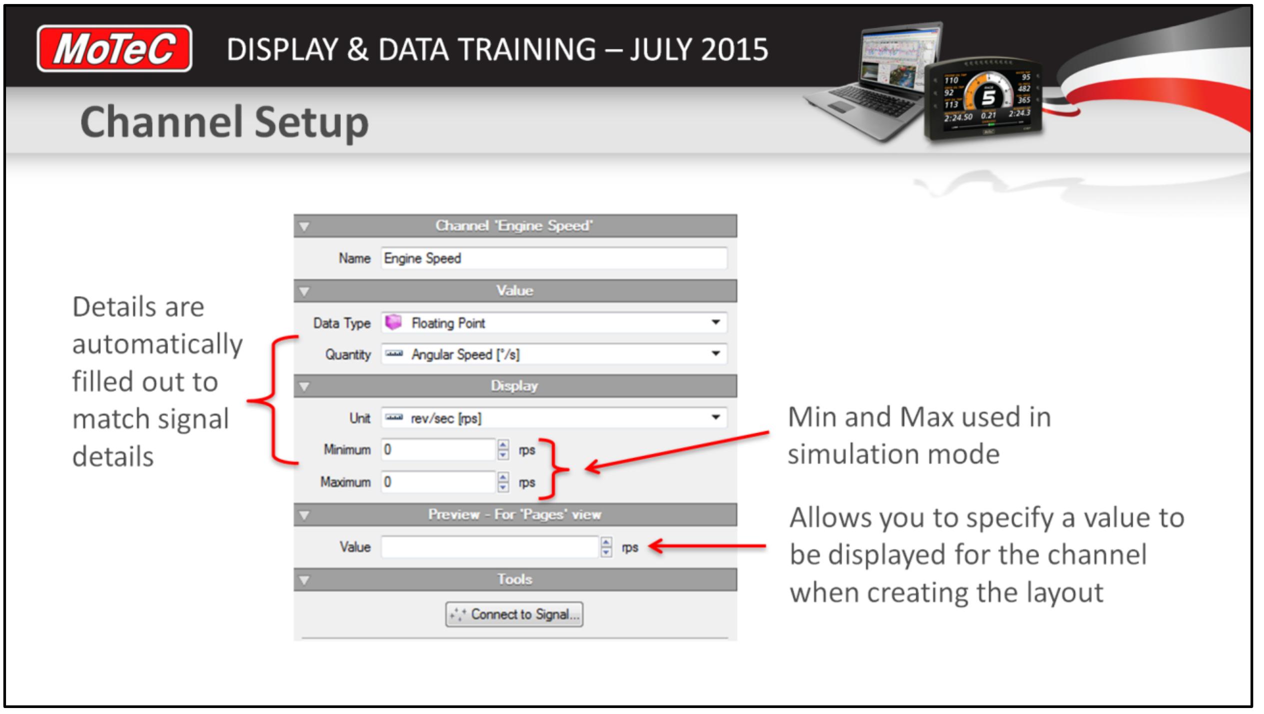


Click the ‘Add New Channel’ button to create a new channel.



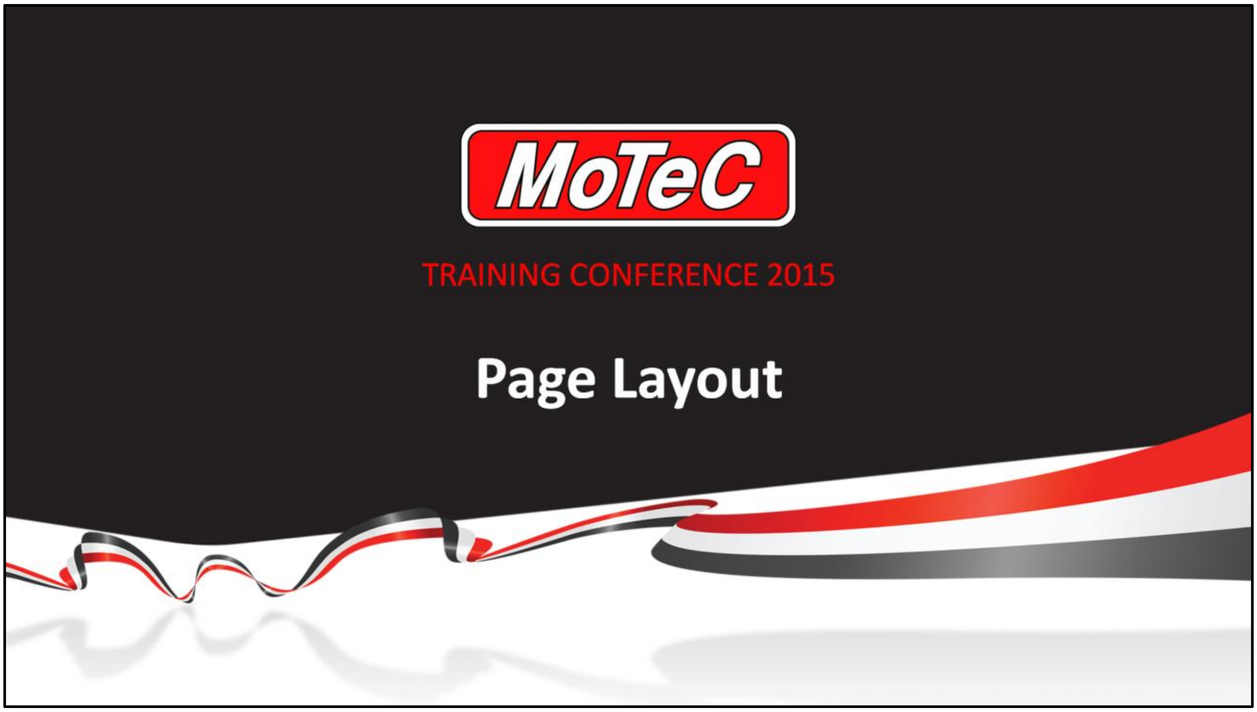
Once you have created a new channel, make sure it is selected and click Connect to Signal.

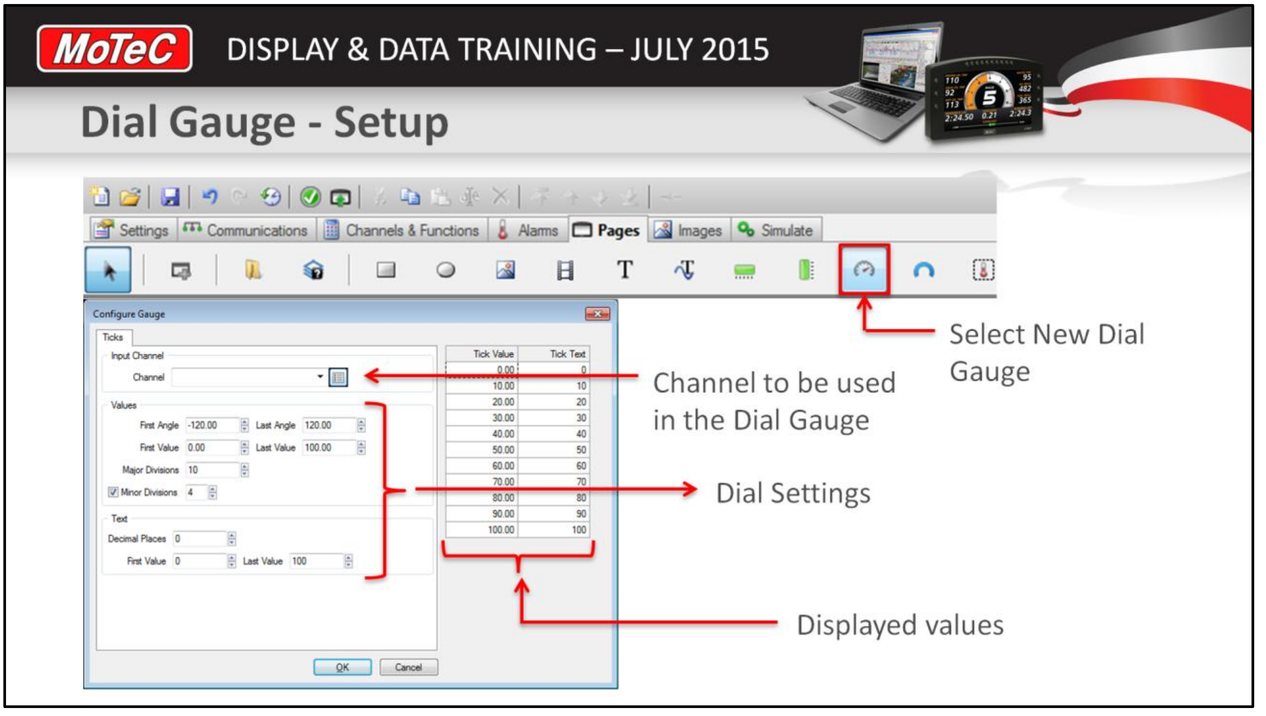
Select a signal from the DBC file to link it to the new channel. The name, data type, quantity and unit are all updated to match the signal automatically.



It is important to check the units; this will default to the base units sent by the Dash. In the case of Engine Speed this is Hz, or rev/sec, which is almost of no use so should be changed to RPM.

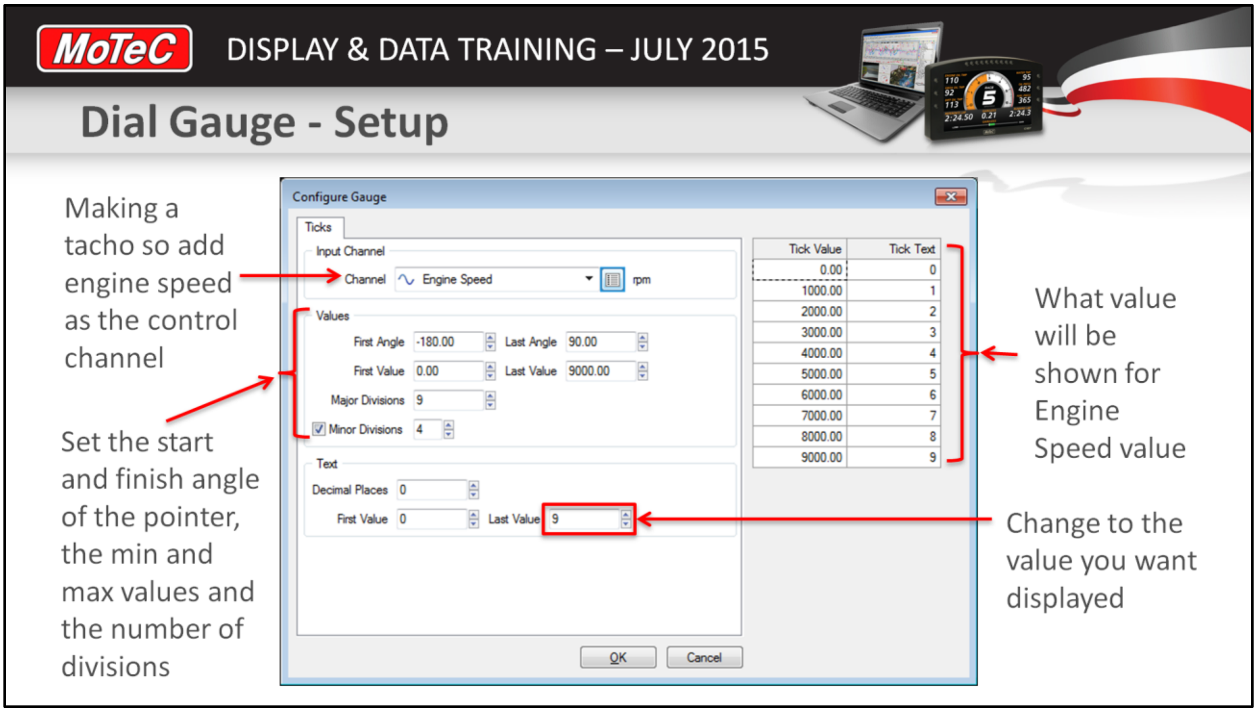
Minimum and Maximum are useful when using the simulate function but otherwise do not affect the actual functionality of the channel when used in a Display.


MoTeC
TRAINING CONFERENCE 2015
Page Layout



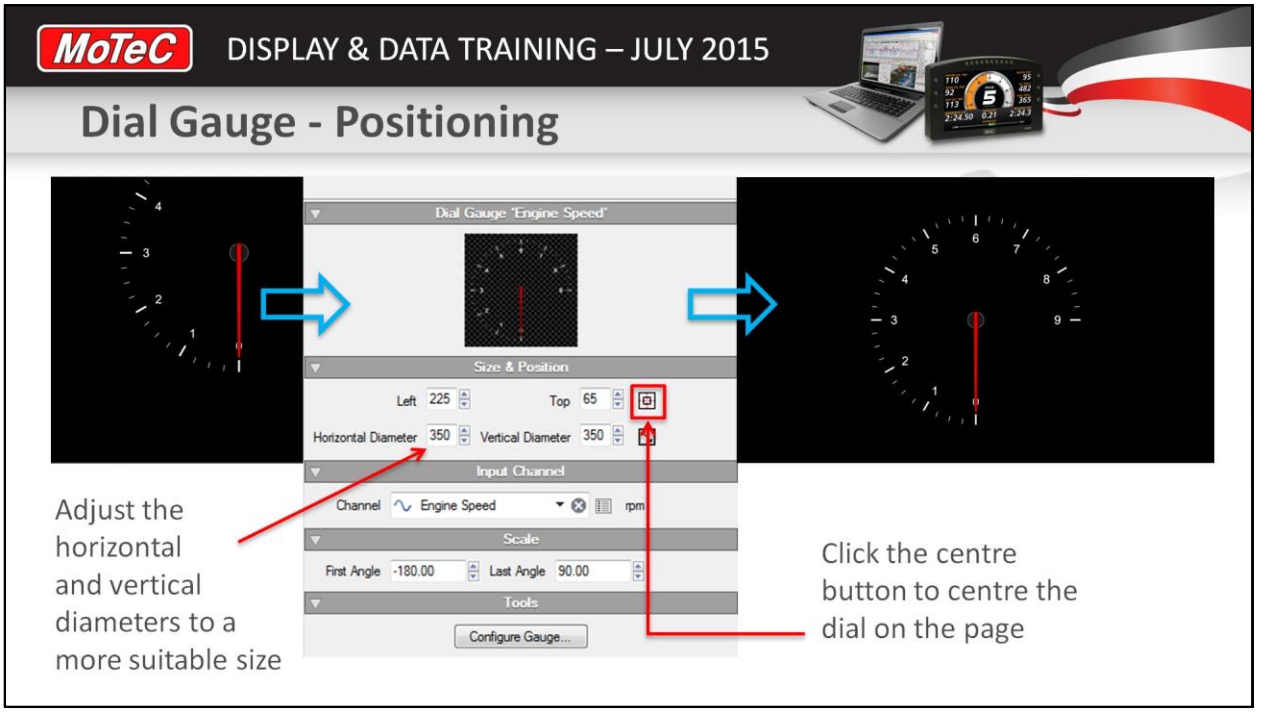
The first thing we want is a tacho. We create a new dial gauge and select 'Engine Speed' as the channel.

The start/finish angles for the gauge can be set; the number of divisions and the text that is displayed can all be configured from this window.

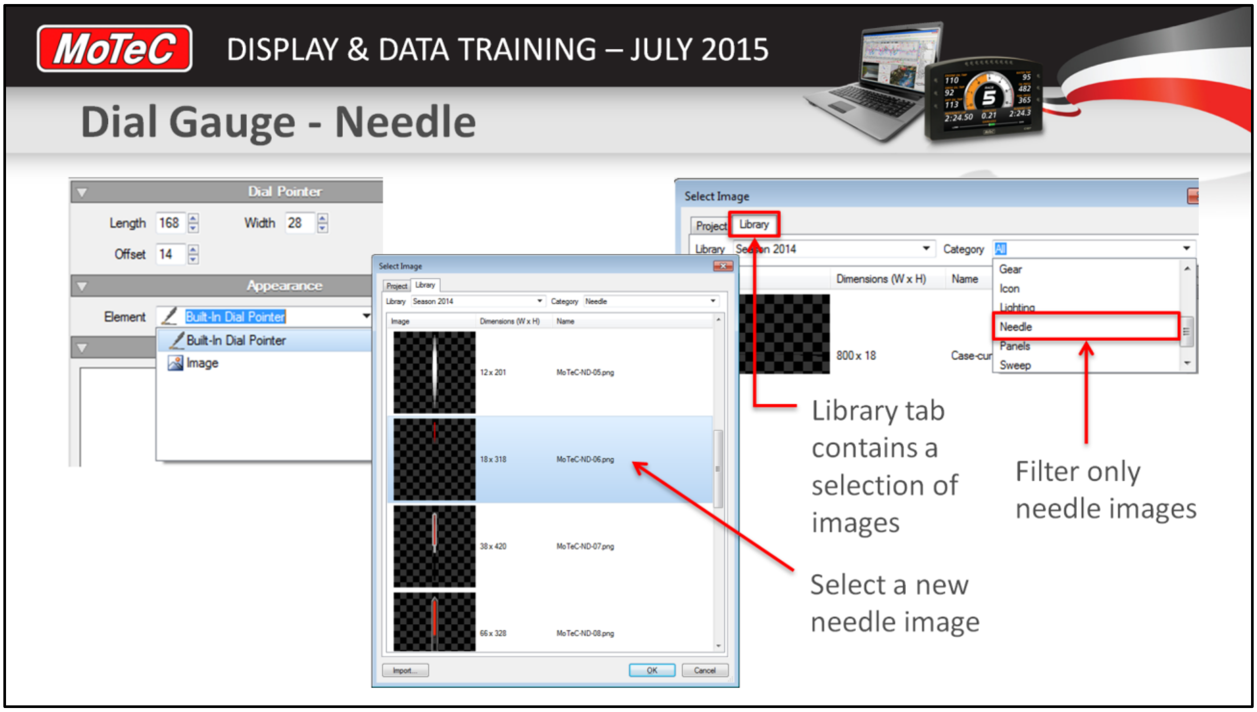


0 degrees is top centre. Positive is clockwise to bottom centre and negative is anti-clockwise to bottom centre. The Minor and Major divisions set the number of tick marks on the dial.

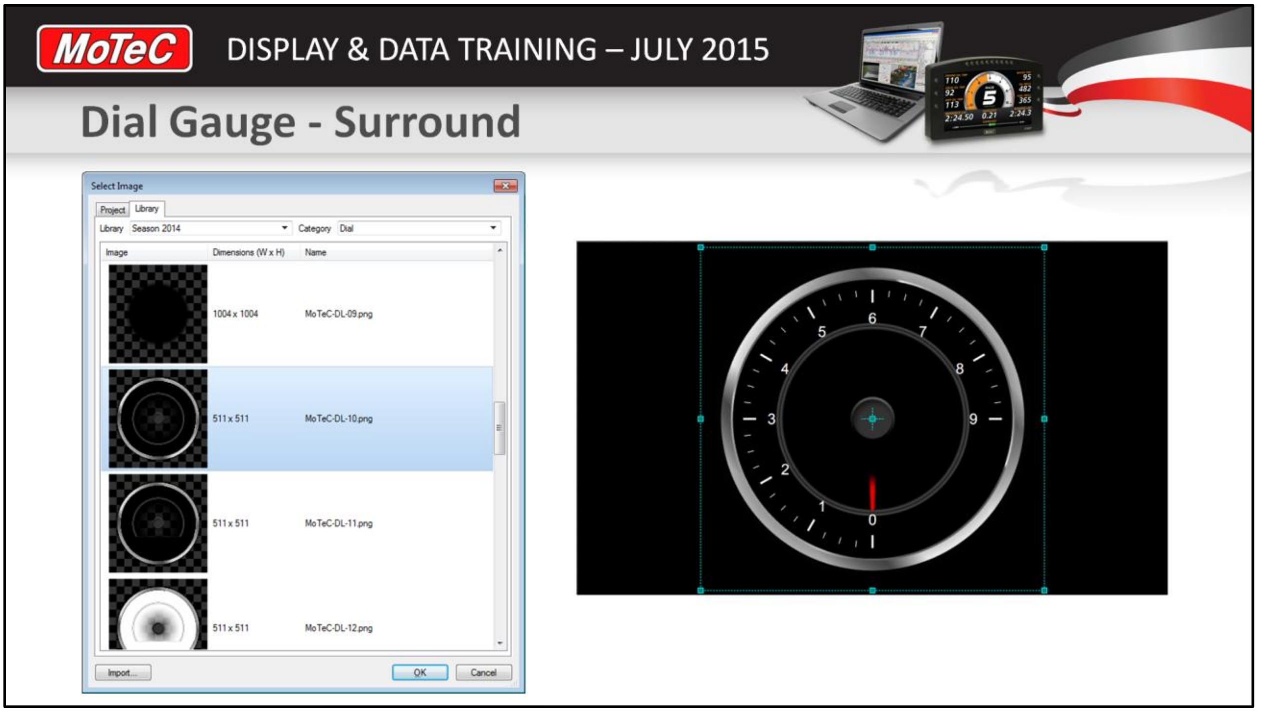
The text is what is actually displayed on the dial. We want the tacho to show 0-9 rather than 0-9000 so we make the change in this section.



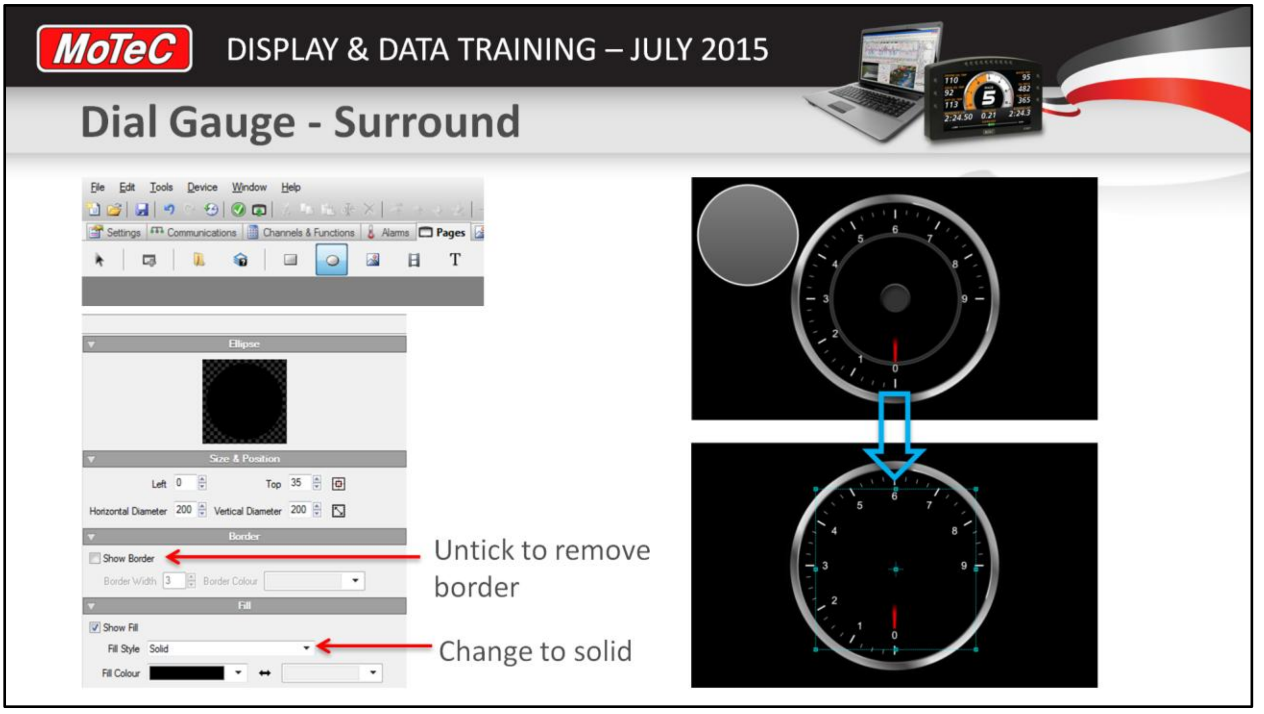
We now need to position and size the dial correctly. We want to reduce the size slightly to allow room for additional channels and we want it centred on the page.



The dial can be changed from the default to any custom image. There are a number of preloaded images that can be selected from the library tab or your own image can be loaded by clicking on Import.

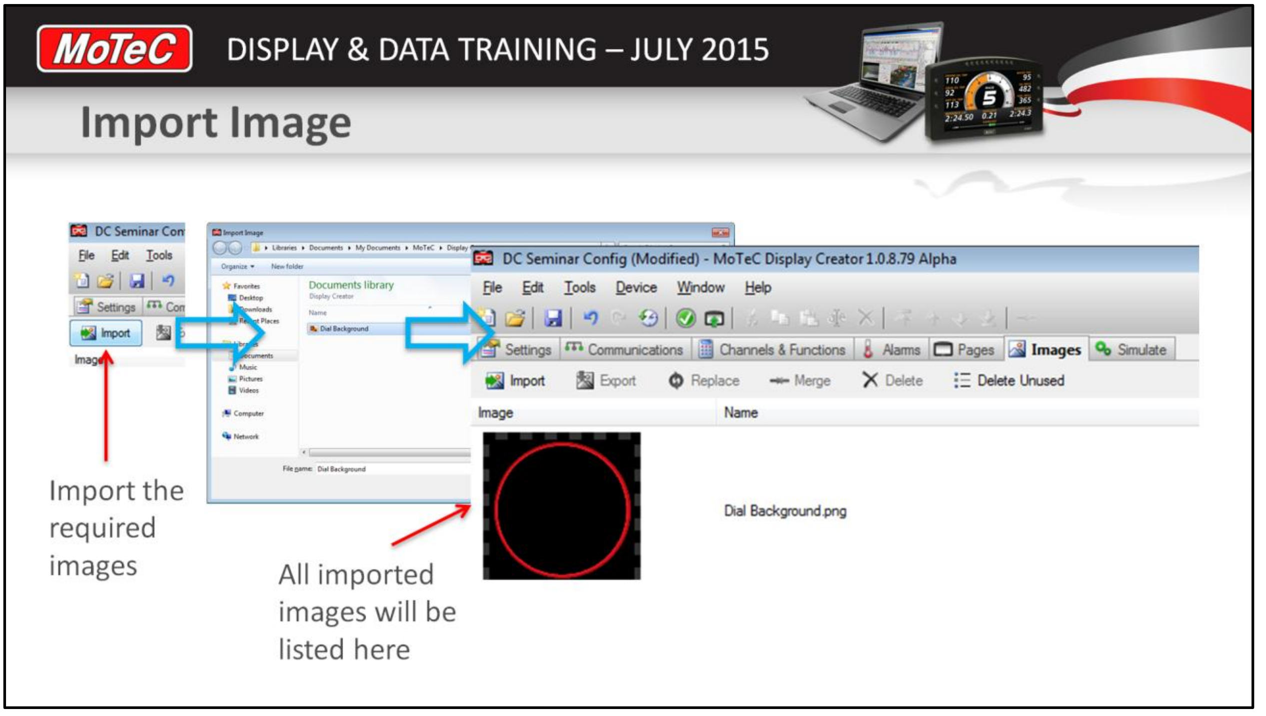


To give the dial gauge a more defined edge we will add some images. Again we can select from a number of preloaded images or import our own. In this case we will use a preload image. The sizing and positioning need to be adjusted to fit our gauge; this is done in the same way as positioning the dial gauge.



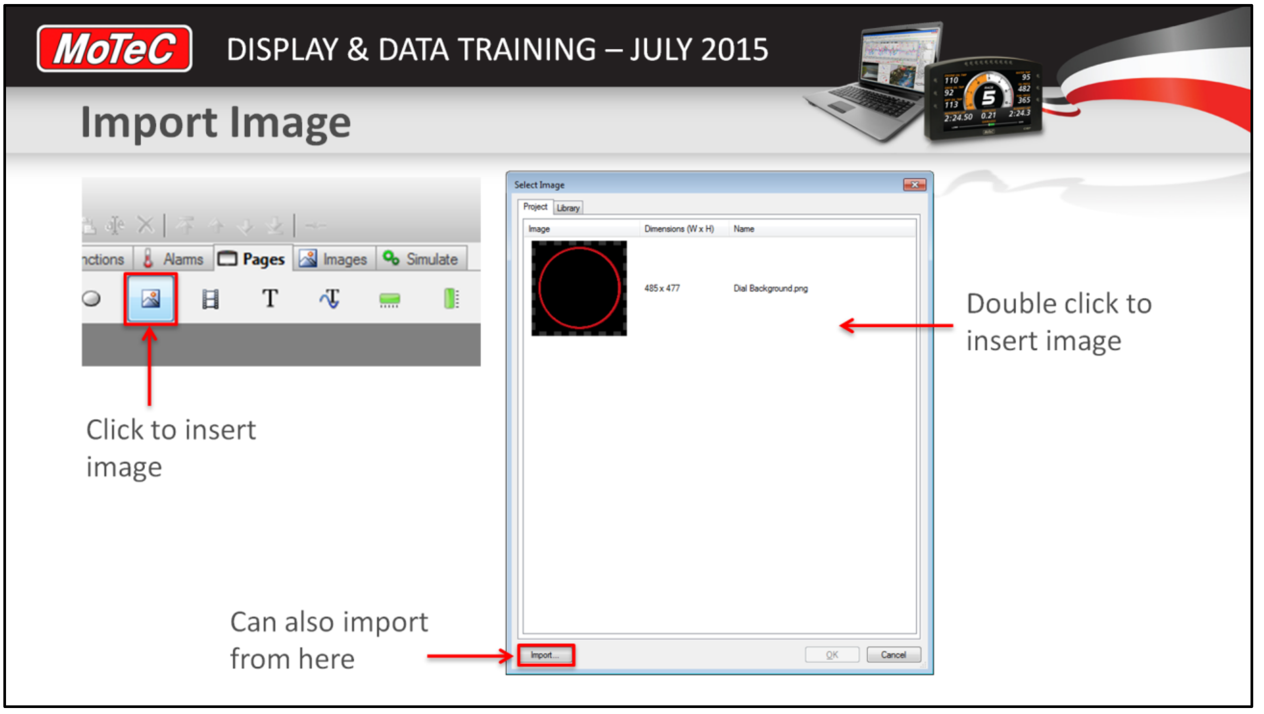
The preloaded image isn’t quite what we wanted ; we want to hide the inner rings and insert our own. To do this we create an oval that will cover the rings, allowing us to put our own over the top.

Remove the border, change the fill to solid and the colour to black. We now centre the oval and resize it to cover the rings. The Z-Order needs to be correct so that the inner rings are covered but the dial numbers are not.

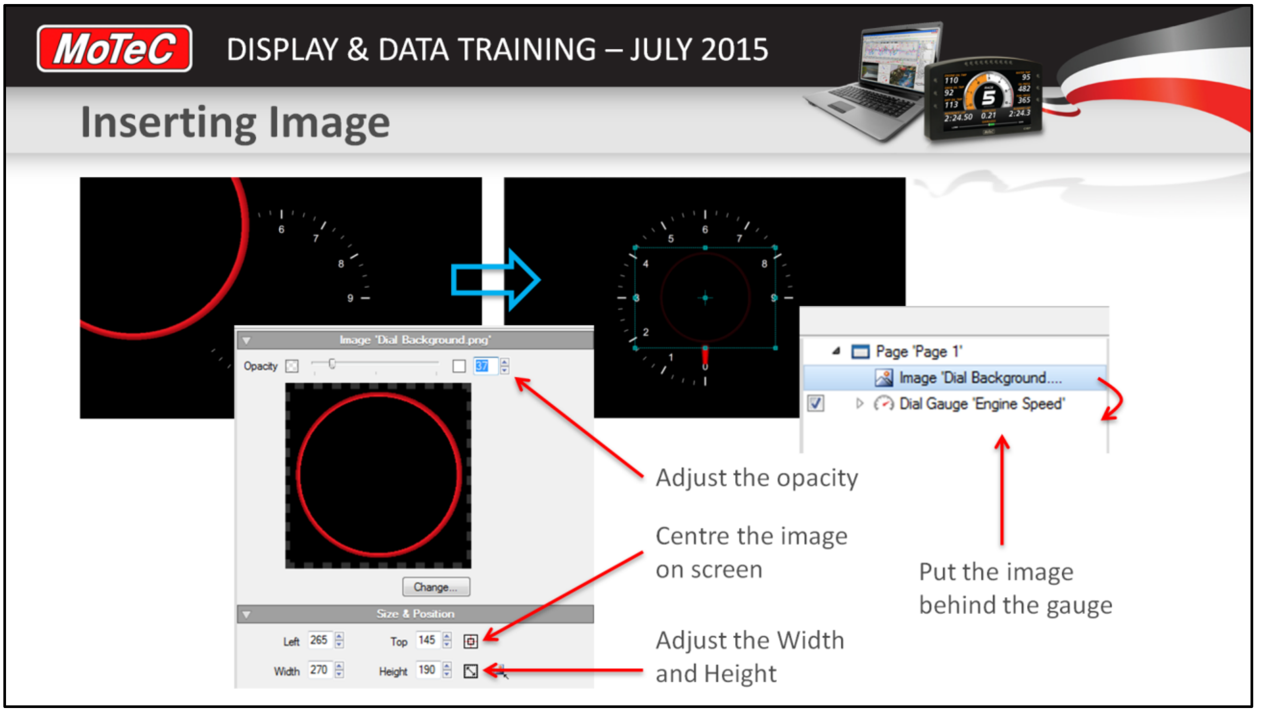


We can import our own images in two ways, the first is in the 'Images' tab. Click on the 'Import' button, browse to the location of the image you want to import and click ok.

The image will now be selectable from the image insertion window.

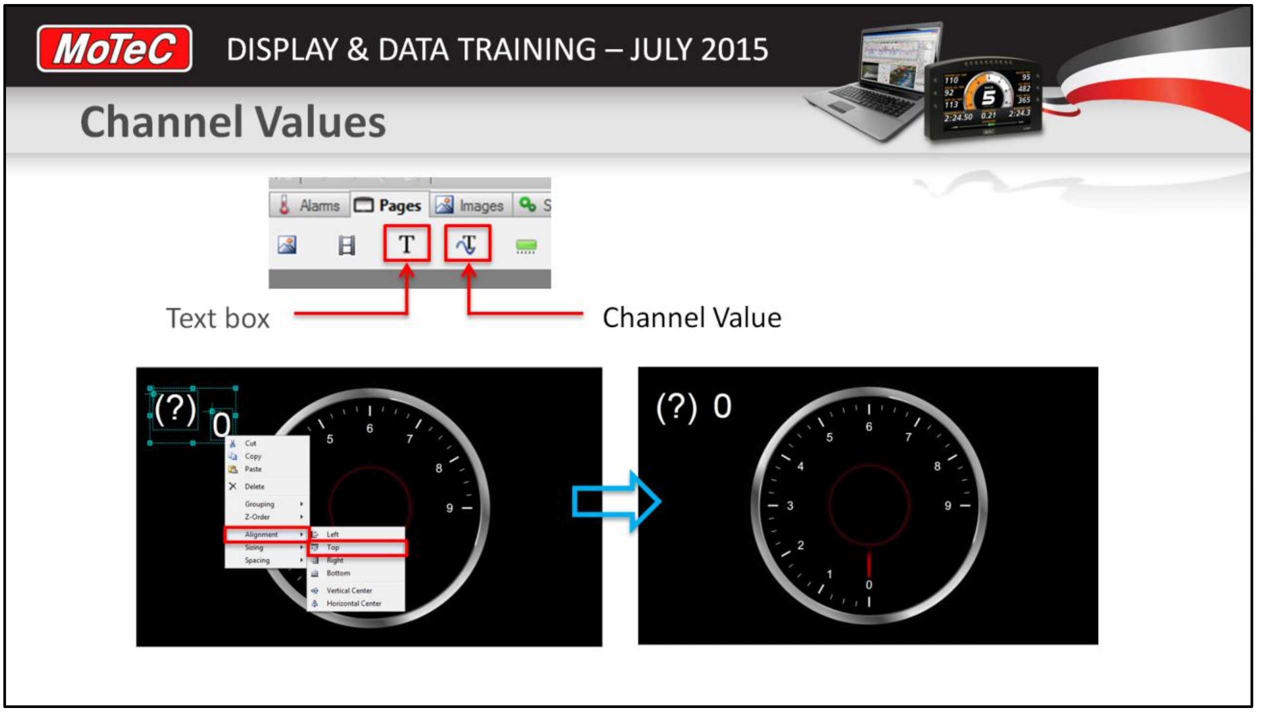


The second method is to click the 'Import' button from the Insert image window.



Positioning and sizing the image is done in the same way as all other elements. In this case we want to decrease the opacity so that you get more of a glowing effect.

It is also important to ensure the images are in the right order. You can click and drag the image above or below the dial gauge. The higher up the list, the further 'forward' the element is.

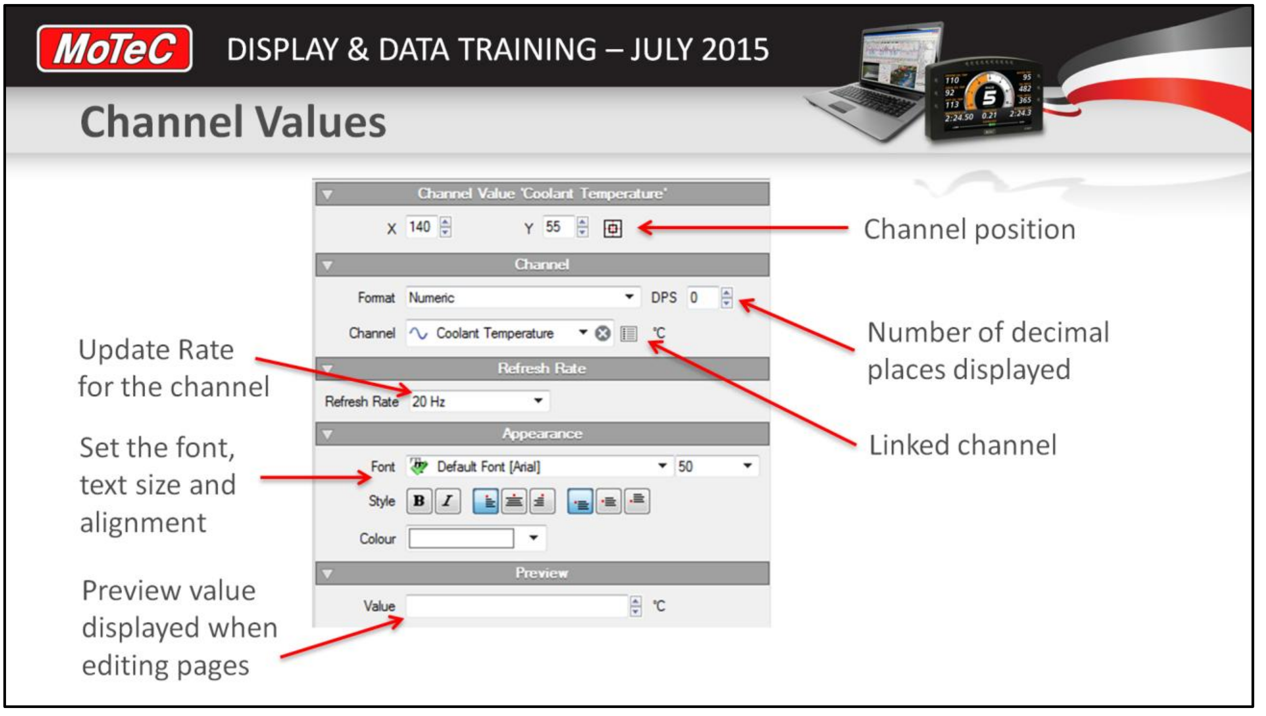


We now want to add a number of numerical channels and text labels to display the rest of our channels. Once we have a text element and a channel value we want to align them correctly.

To align two objects, select the them both either by left clicking and dragging the selection window over both of them, or by holding control and clicking on them individually.

Once selected, right click on one of the objects, highlight 'alignment' and then select Top. The two objects will now be aligned at the top.

Note: the object that is selected first becomes the reference, all other objects will move to align with it.

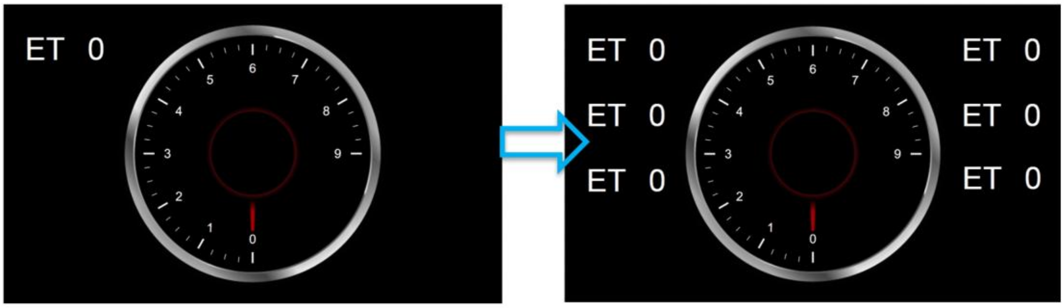


We want this channel to be 'Coolant Temperature' so we select it from the drop down box.

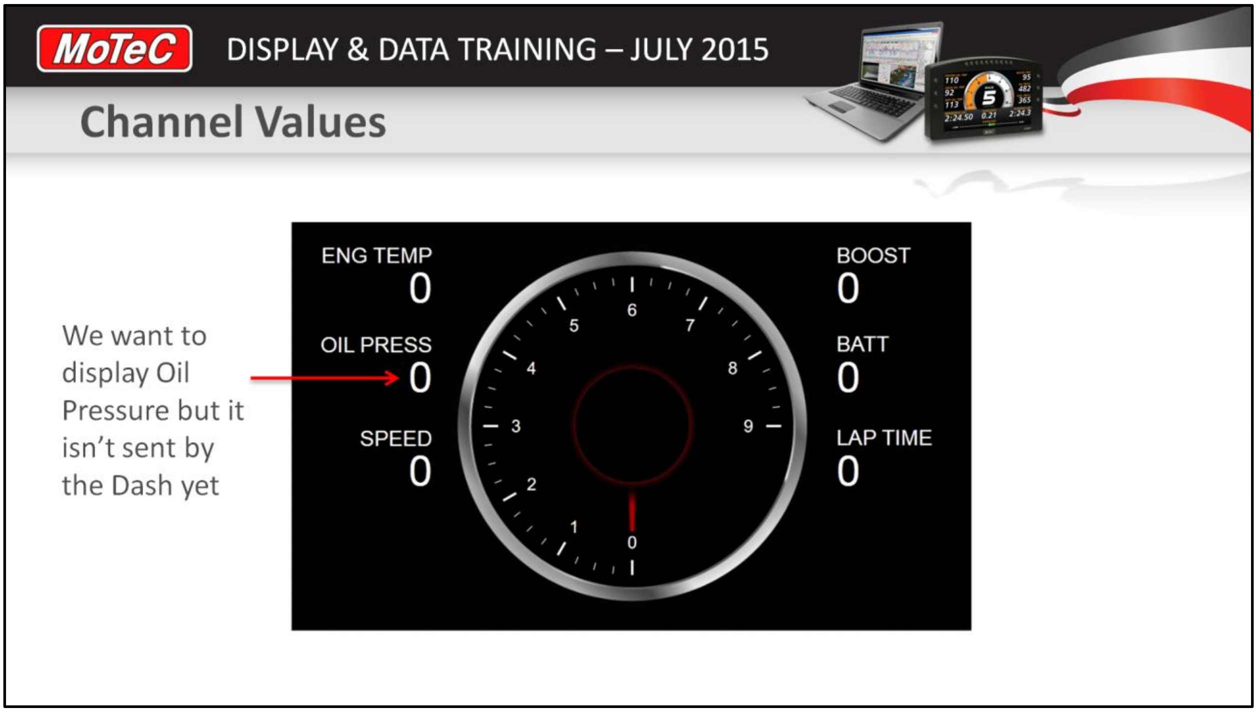
It is often useful to reduce the refresh rate for channels that update very quickly to make it easier for the driver to read. This is not usually the case for temperature channels so we will leave this as the default.

DISPLAY & DATA TRAINING – JULY 2015

Channel Values



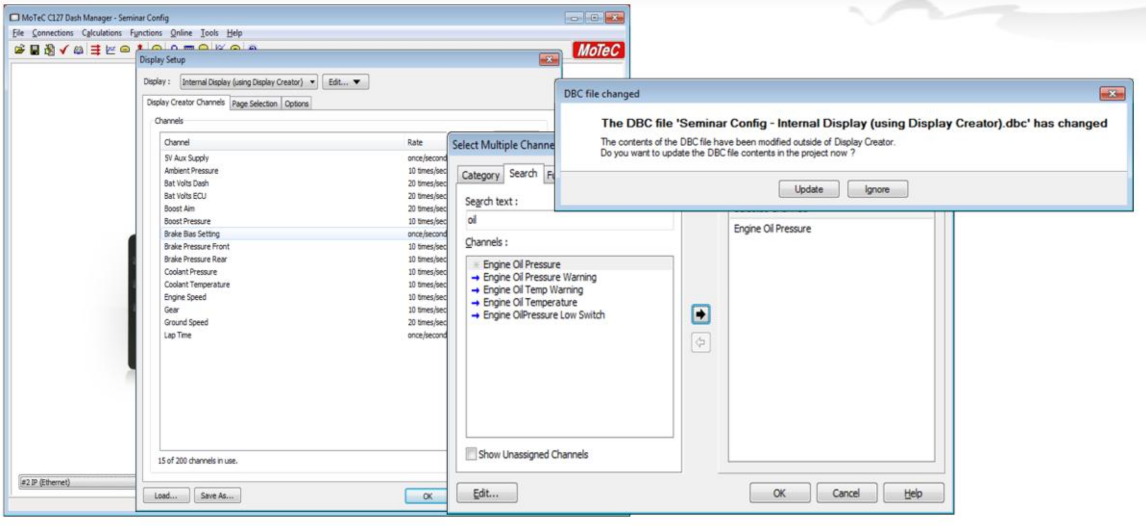
The easiest way to replicate a number of channels is to copy the text and channel value multiple times to quickly set out where you want your channels displayed. Then go through each of them, change the text and link to the correct channels.



We have decided that we want to display 'Oil Pressure', so we will need to add it to the Dash configuration as it is not currently configured.

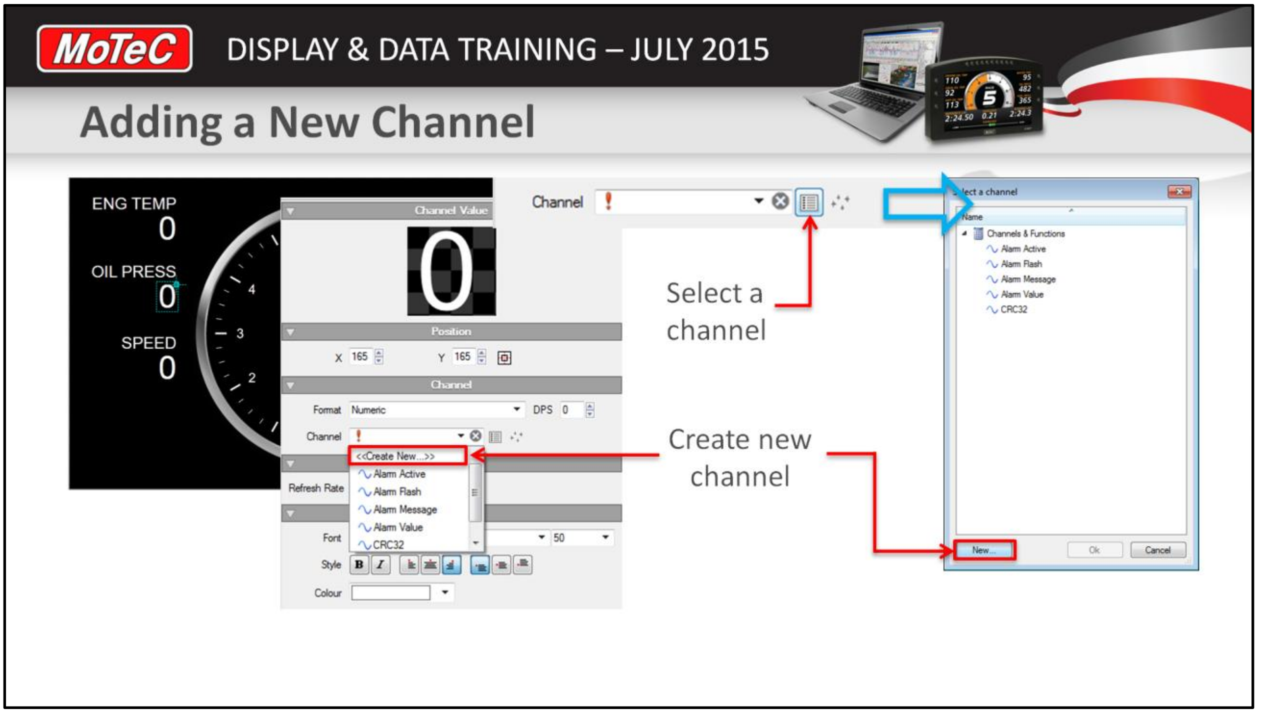
DISPLAY & DATA TRAINING – JULY 2015

Adding a Channel

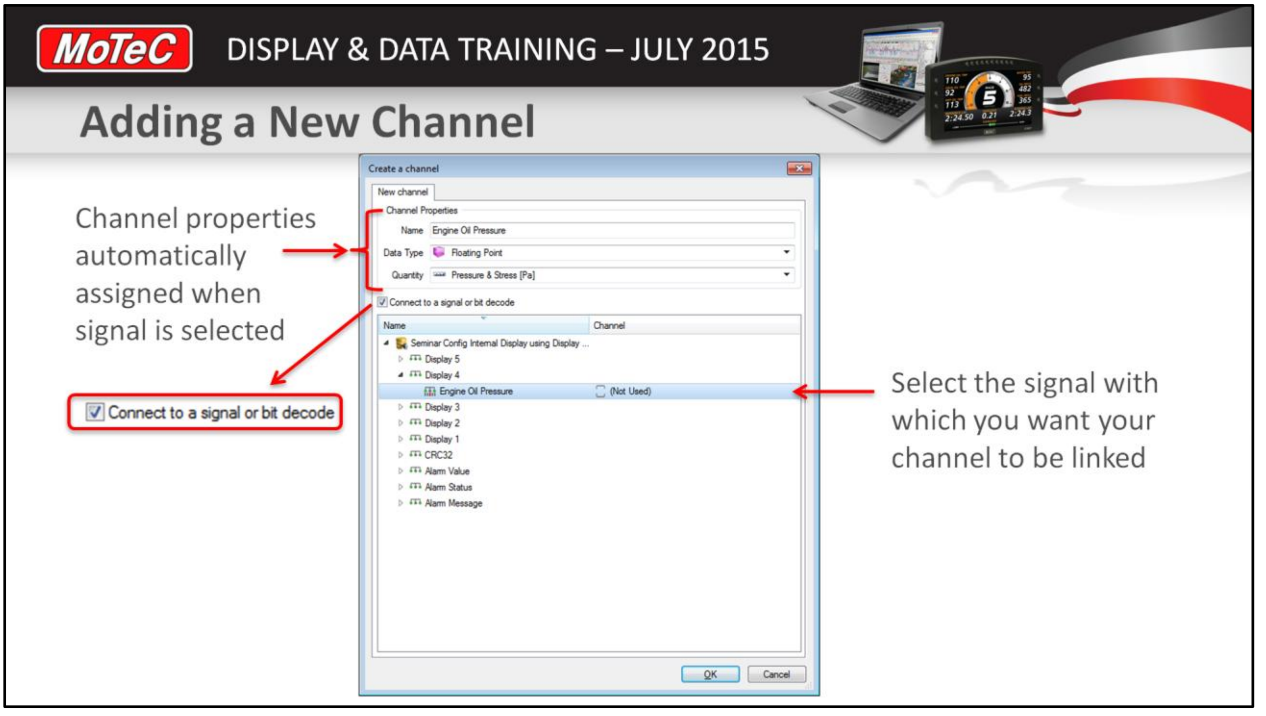


In Dash Manager we add 'Engine Oil Pressure' to the Display setup. Once the configuration is saved, we get the DBC file update message in Display Creator.

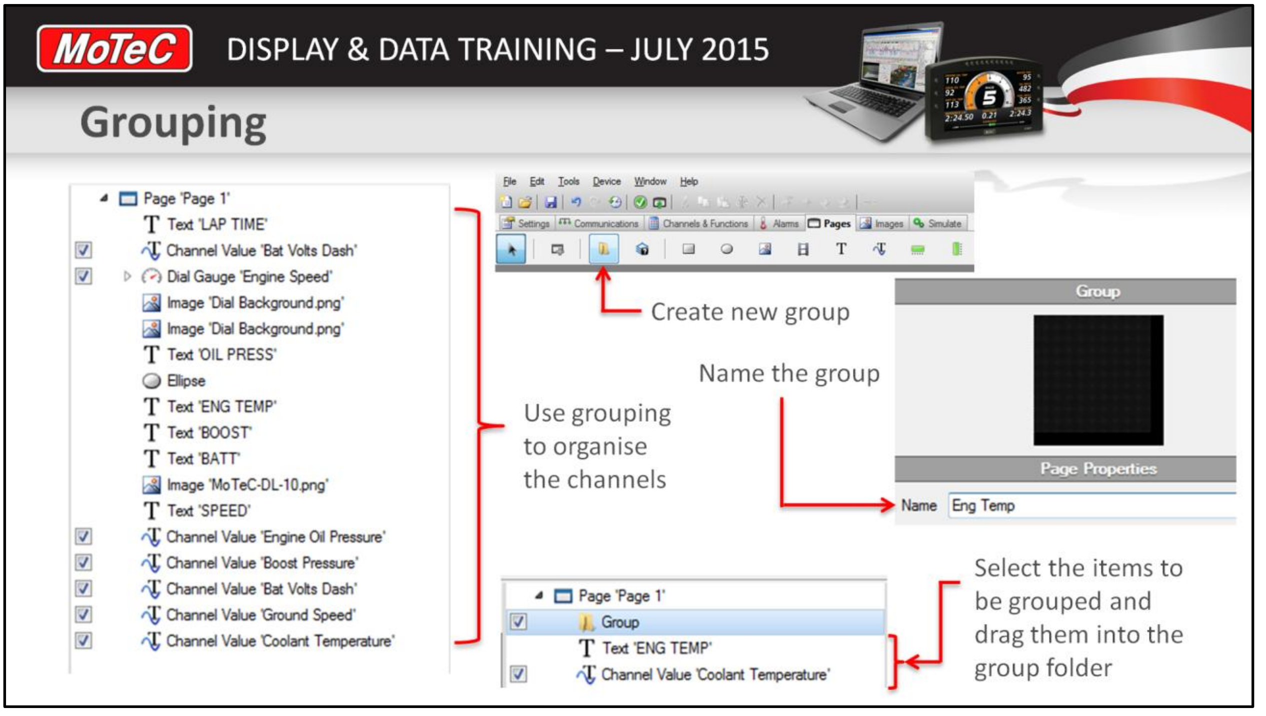
Click update to add the new channel.



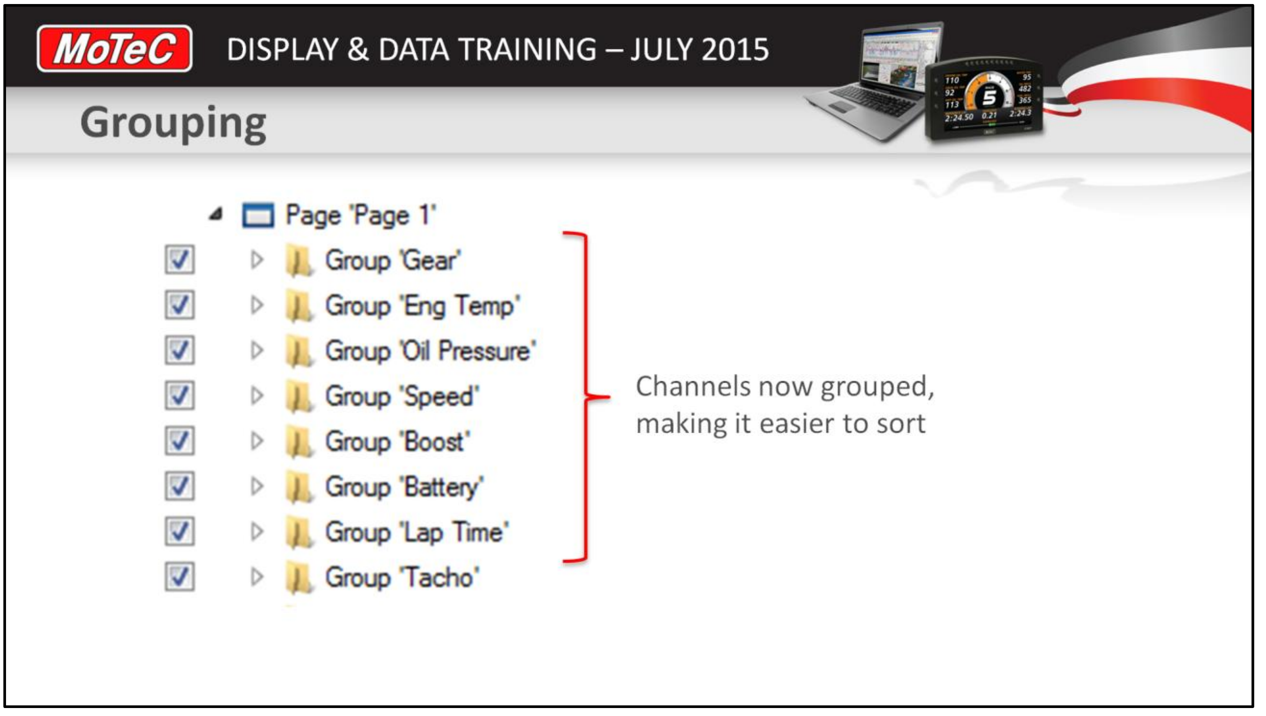
The second method of adding a channel is to do it in the ‘Pages’ tab. To do this, either select ‘Create New’ in the channel selection drop down or click the icon next to the drop down and then select ‘New’.



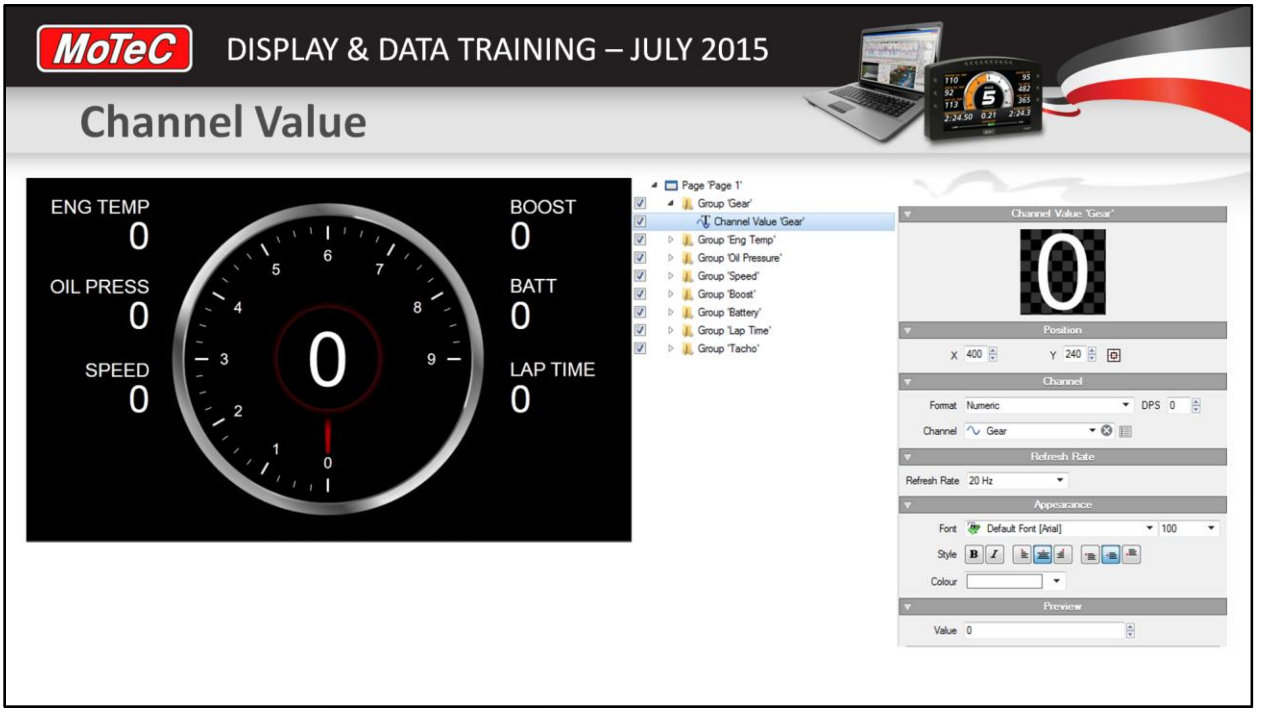
To create a new channel simply tick the 'Connect to a signal or bit decode' check button and select the signal. The name and channel properties will be populated automatically.



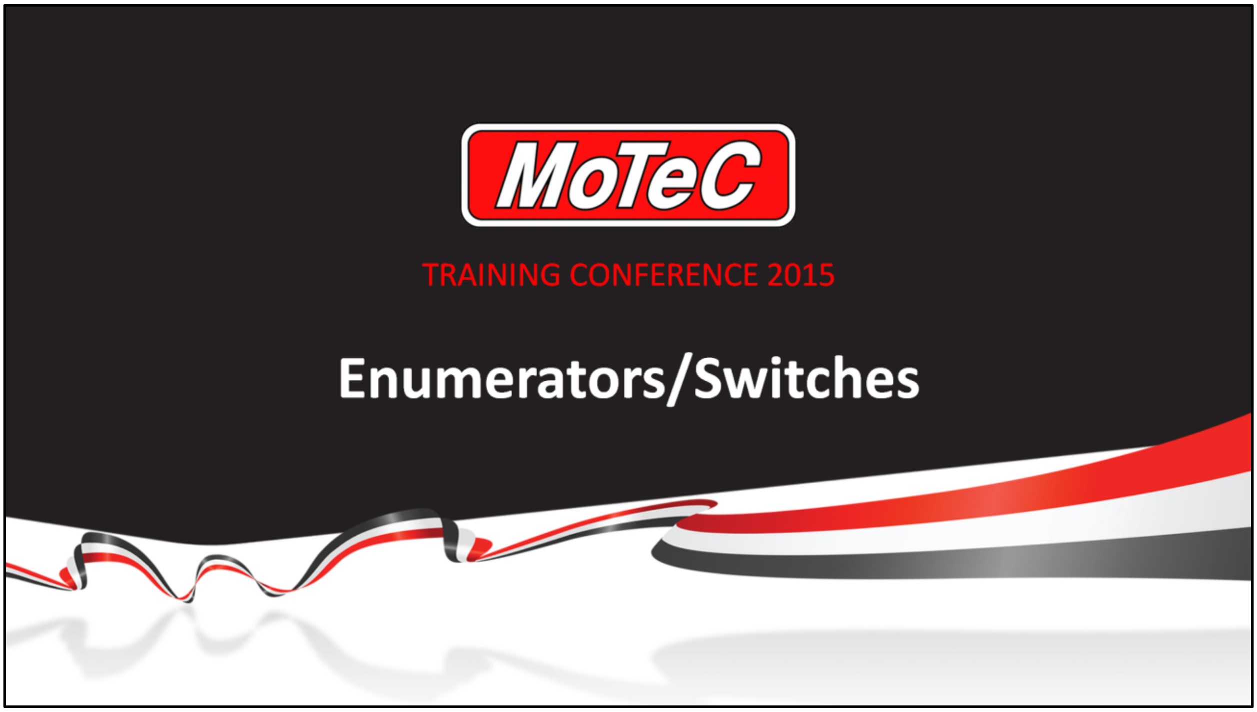
It is often a good idea to use groups to collect together parts of the project. For instance all of the images and the dial gauge can be grouped together making it easier to find/edit individual parts.

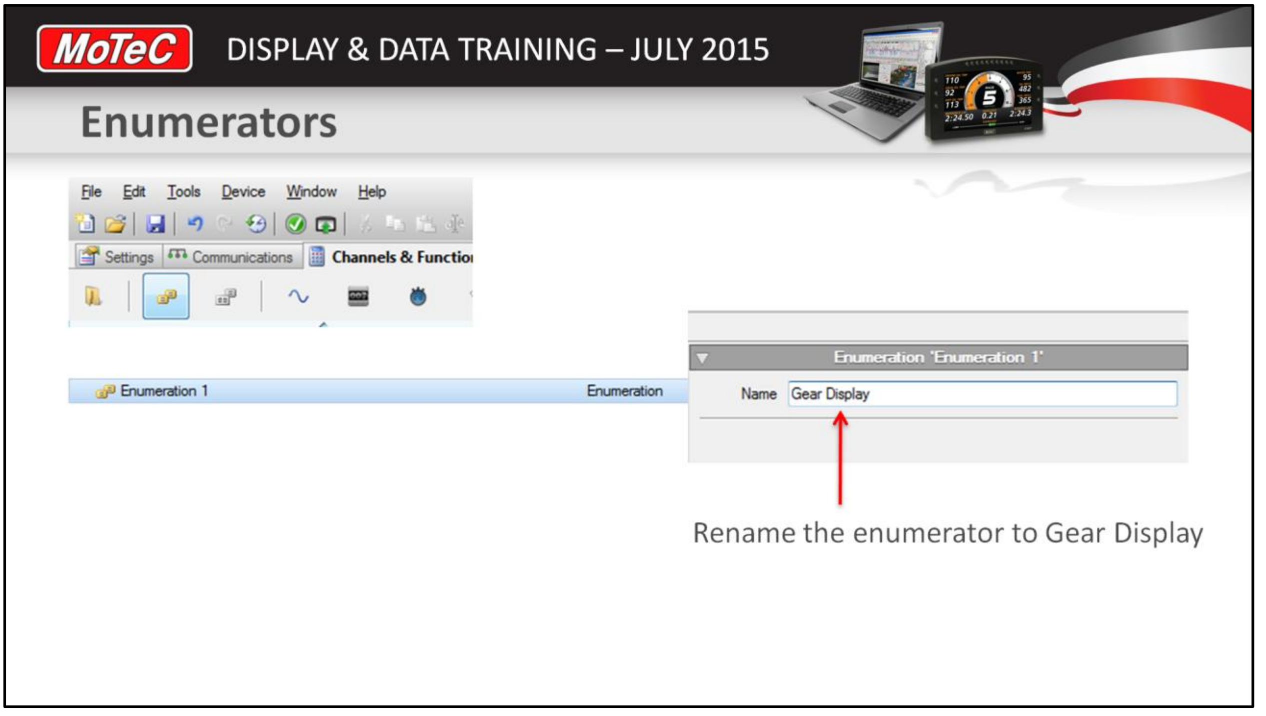


With everything grouped you can open a group and only see the individual parts for a particular element. It also allows you to hide a group and all of the elements within for testing purposes.

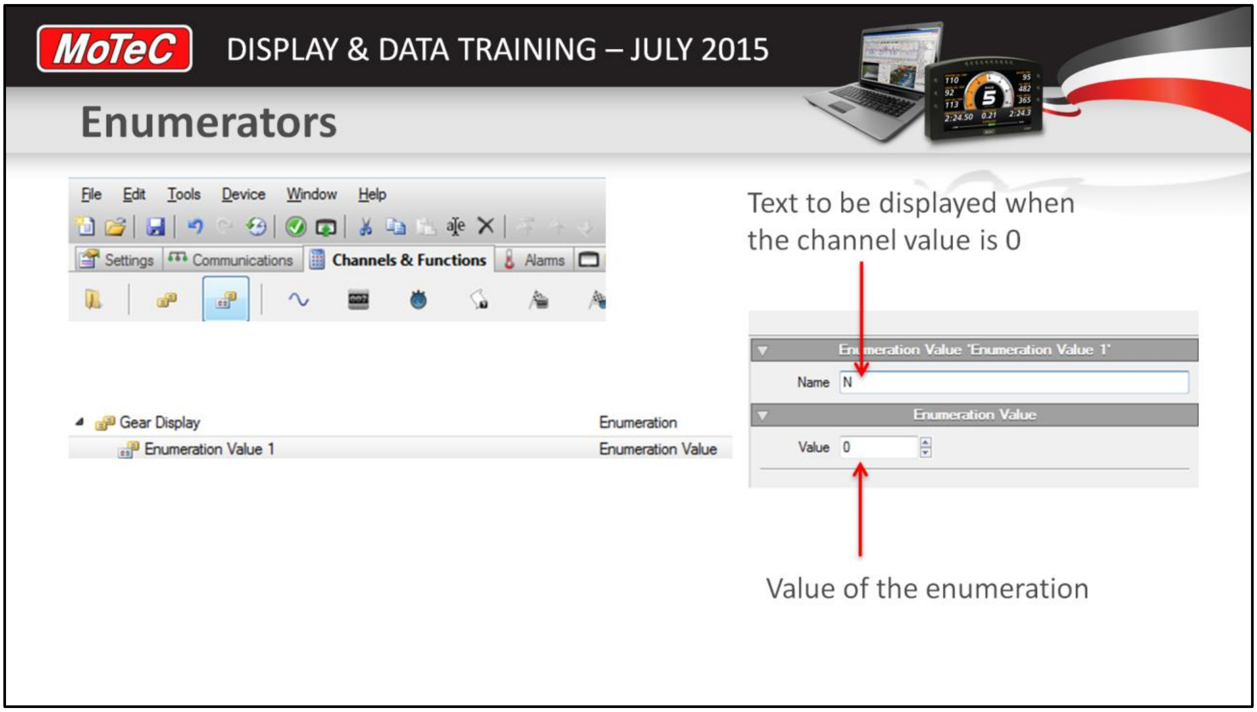


We also want to add a 'Gear' channel. The same method is used as the other channel values.

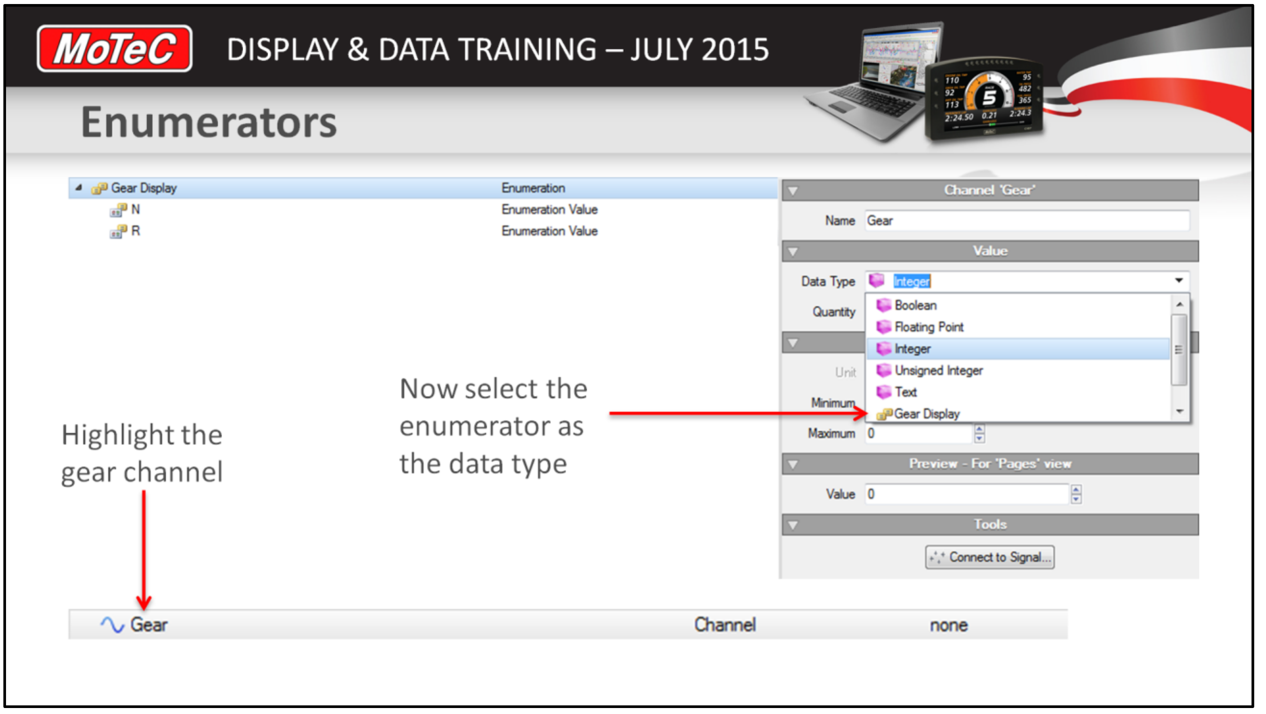

MoTeC
TRAINING CONFERENCE 2015
Enumerators/Switches



Enumerators are a way of giving a text value to a state channel. For instance, in this case when we receive 0 and -1 from the Dash for gear position we actually want N and R to be displayed.

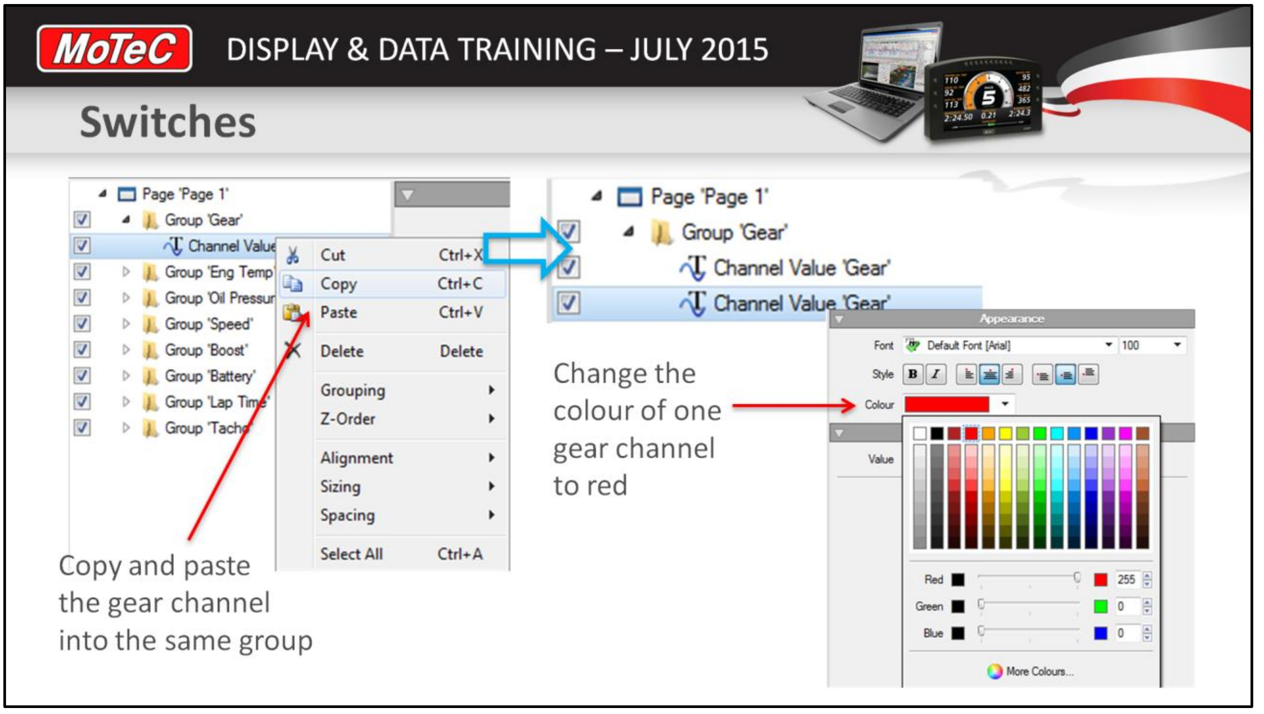


Any value that doesn't have an enumerator specified will be displayed as the raw value. In this case, with gear, we only need to specify -1 and 0 as we want forward gears to be displayed as they come from the Dash, i.e. 1, 2, 3 etc.



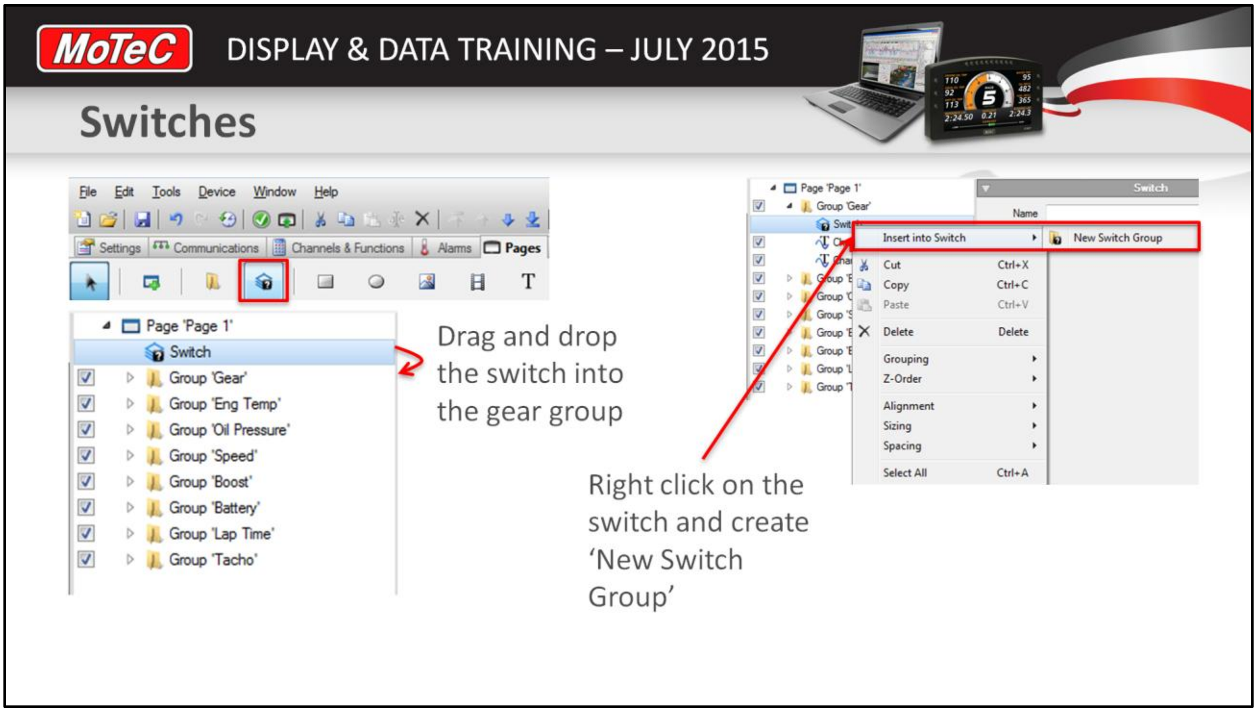
Changing the data type to Gear Display will now display the text specified in your gear display enumerator.

Can be used for any state channel that you want to display text. For instance, if you wanted to display the 'Engine Reference Speed State' channel, each of the values 0-11 can have a text description allocated to them. So instead of displaying the integer value you get a meaningful tag such as 'Cycle Lock'.

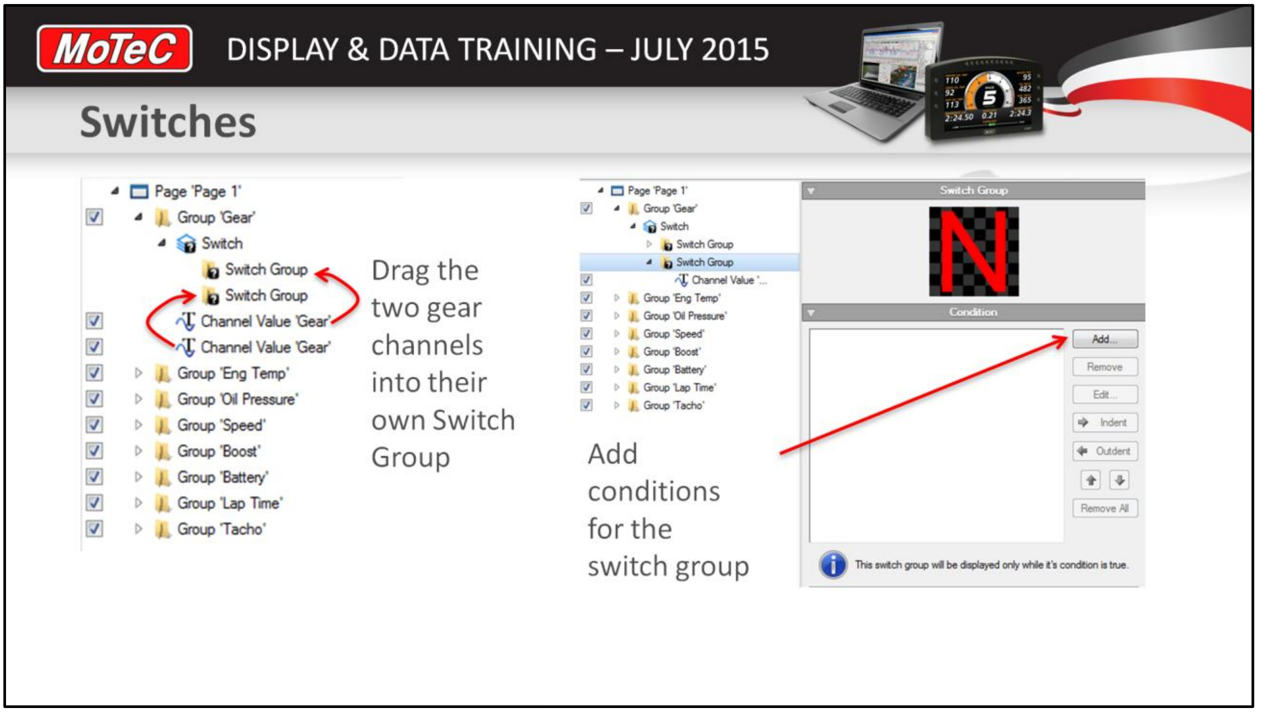


Switches allow you to switch between multiple objects with the use of conditions.

For example, we want the gear indicator to be red when it is in Neutral or Reverse and white when in any of the forward gears.



Put the new switch into the 'Gear' group to keep things tidy. Now create two new switch groups by right clicking on the switch.



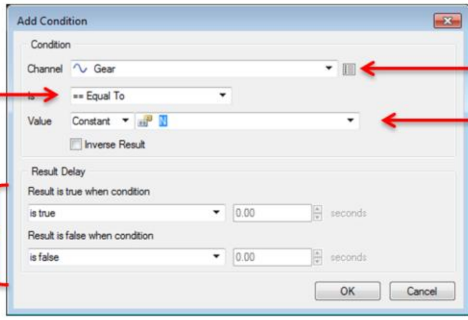
Each of the switch groups can have a number of conditions based on any channel in the configuration. Any number of groups can be added to a switch.

The switch group will only be displayed if the condition is true, otherwise it will be blank. The easiest way is to have one of the groups with no condition, that way it will always be displayed if the other switch conditions aren't true.

Switches

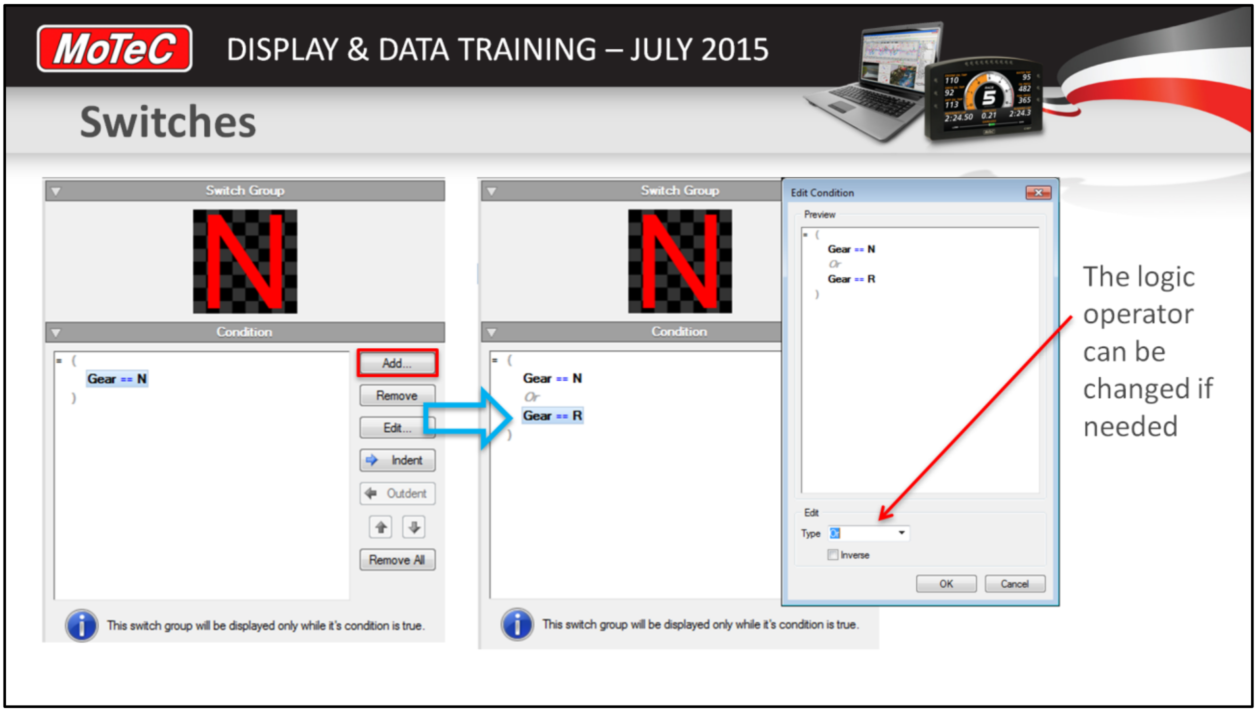
Condition operator

Add in time delays



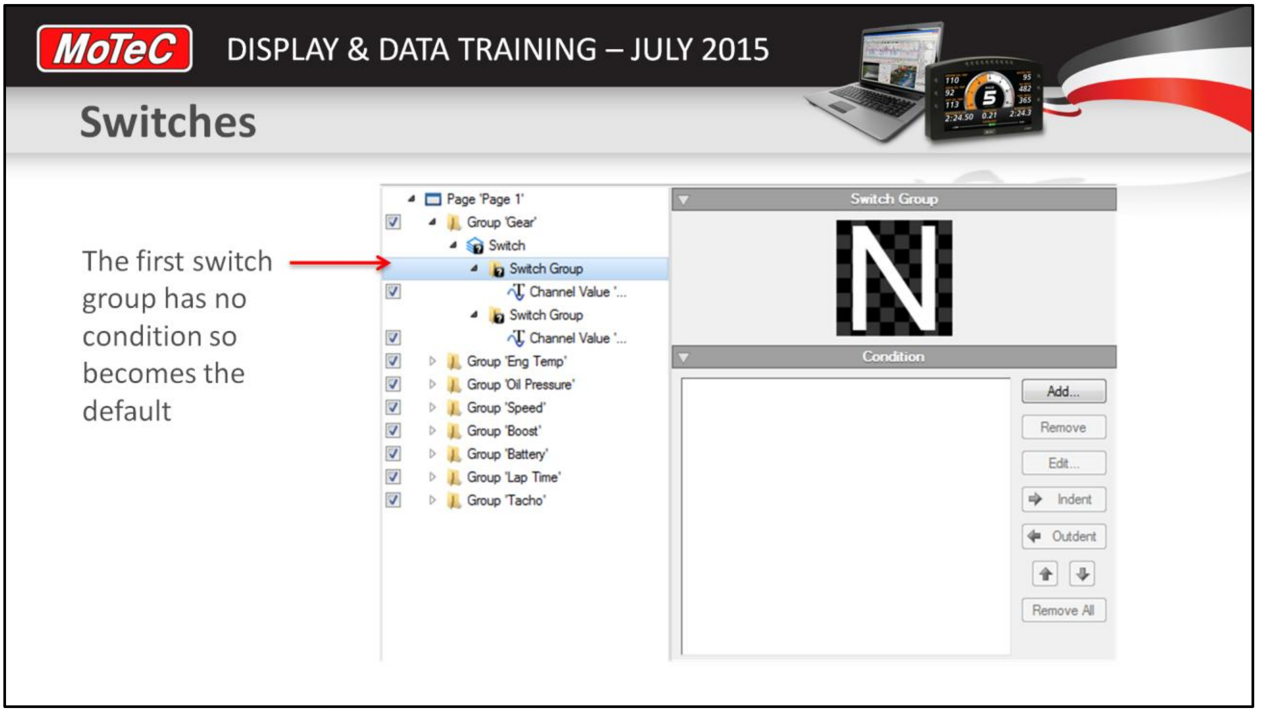
Channel used in condition

Value of condition



Add additional conditions and then edit the logic operators. In this case we want an 'or' operator but if we wanted an 'and', you simply double click on the logic operator and then change it from the drop down menu.

The conditions can be nested to allow for multiple and/or operators.



A switch group with no condition becomes the default. This group will be displayed when none of the other group conditions are true.


MoTeC
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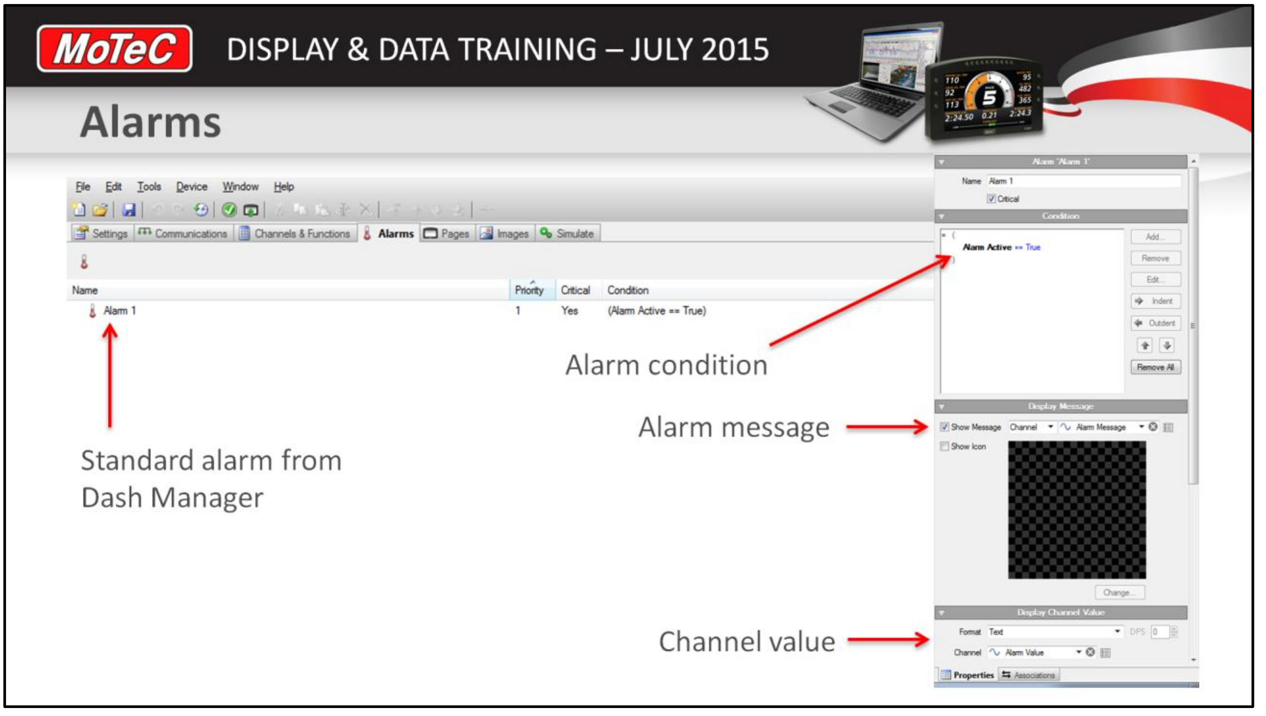
Alarms/Conditions

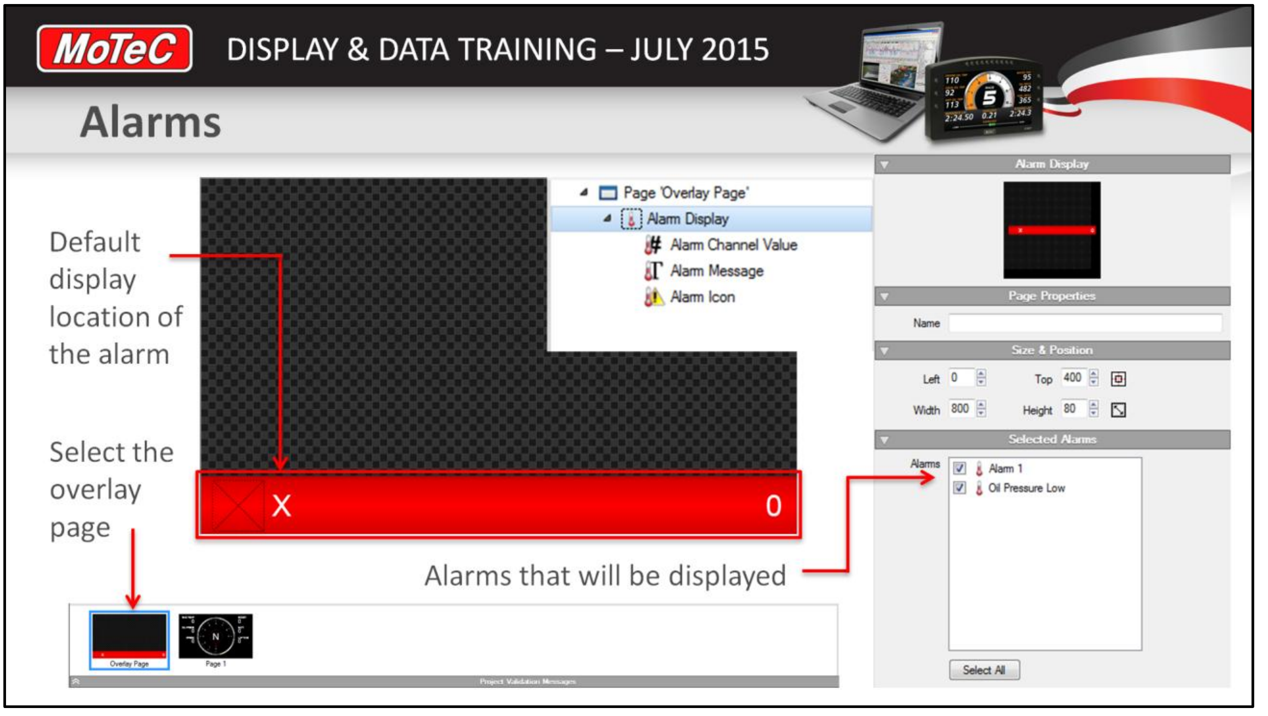


Alarm 1 is automatically added and is controlled by the alarm setup in Dash Manager. It will also display the text and value of channels that are defined in the alarm setup of Dash Manager.

Any number of additional alarms can be added for various conditions.

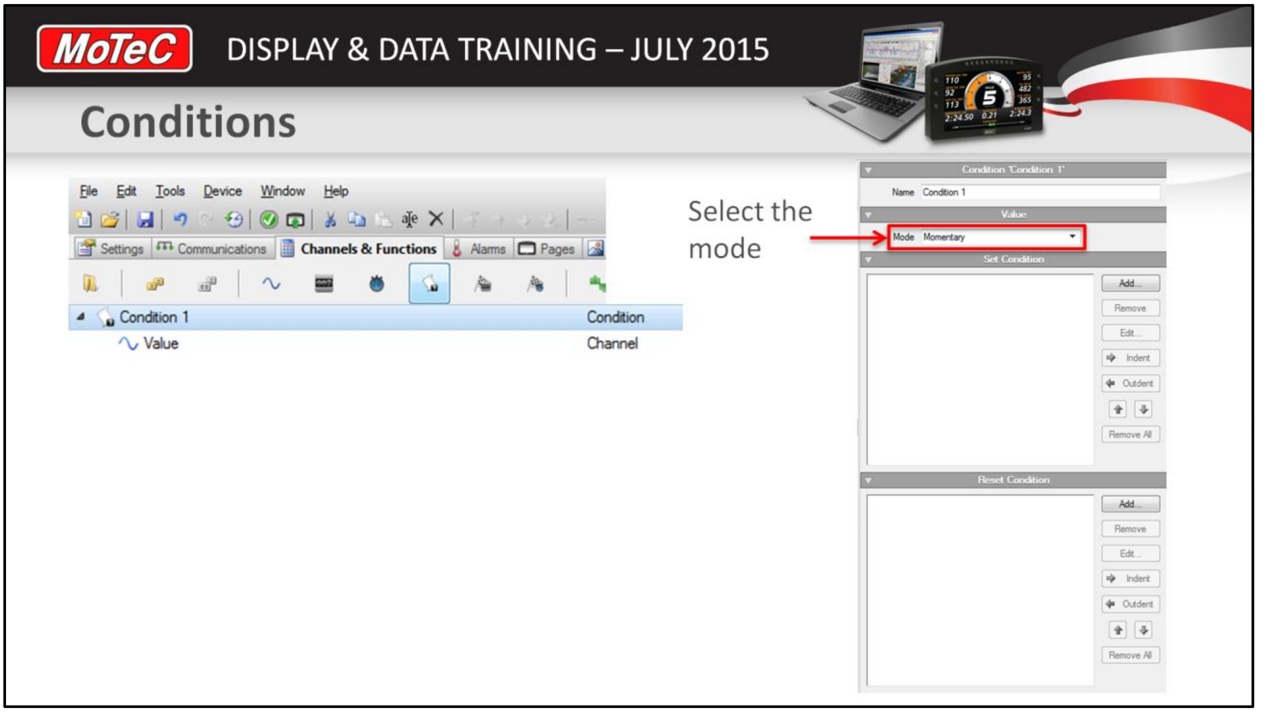
An alarm can be set up with multiple conditions. In this case we have an 'Oil Pressure Low' alarm that is active when the oil pressure is below 200 kPa and the engine speed is above 4000 RPM.

On and off delays can be set for each condition to stop transient behaviour triggering an alarm or the alarm turning off before the driver notices.



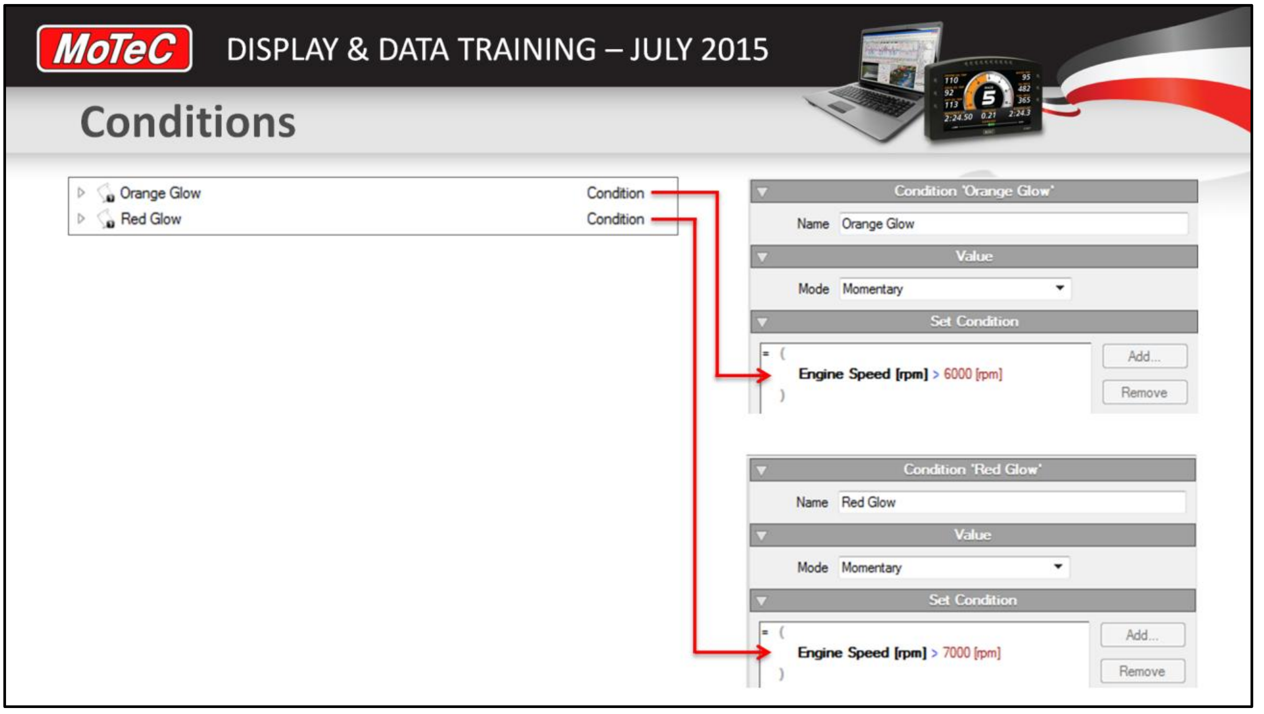
The new alarm 'Oil Pressure Low' is automatically added to alarm display list.

What is displayed when the alarm is active can be modified just like any other object on the other pages.

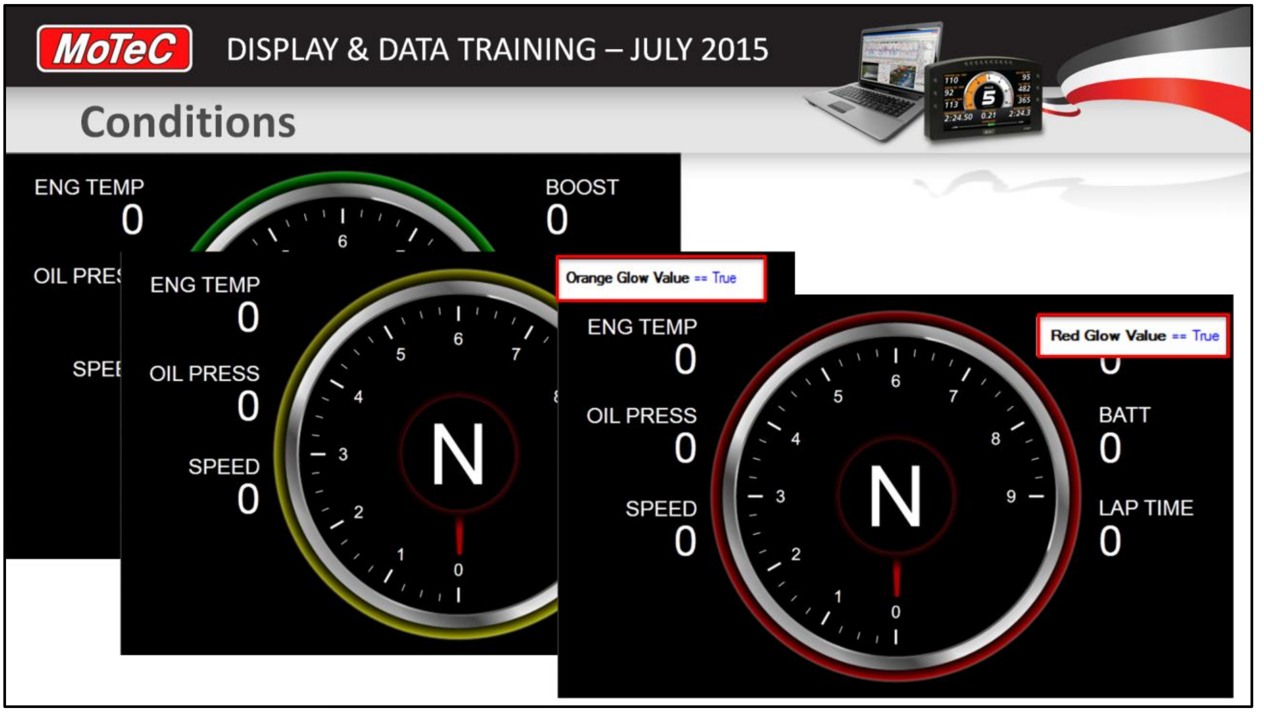


Conditions are useful when we want to use the same conditions multiple times. This way if anything changes you only have to update one condition.

Can be set as Momentary, Toggle or Set/Reset depending on how you want it to function.



These two conditions will be used in a switch based on Engine Speed.



The condition functions are used in the switch groups rather than directly putting in the logic functions. This means that if we have a number of pages with the same conditions and you want to modify them you only have to do it in one location rather than every page.

Take note of the order of the switches groups. The red ring needs to be higher up the order because when it is active, i.e. greater than 7000 RPM, the yellow ring is also active (greater than 6000). If the orange switch is higher up, the red one will never be displayed.

Only the first switch group can have no condition.


MoTeC
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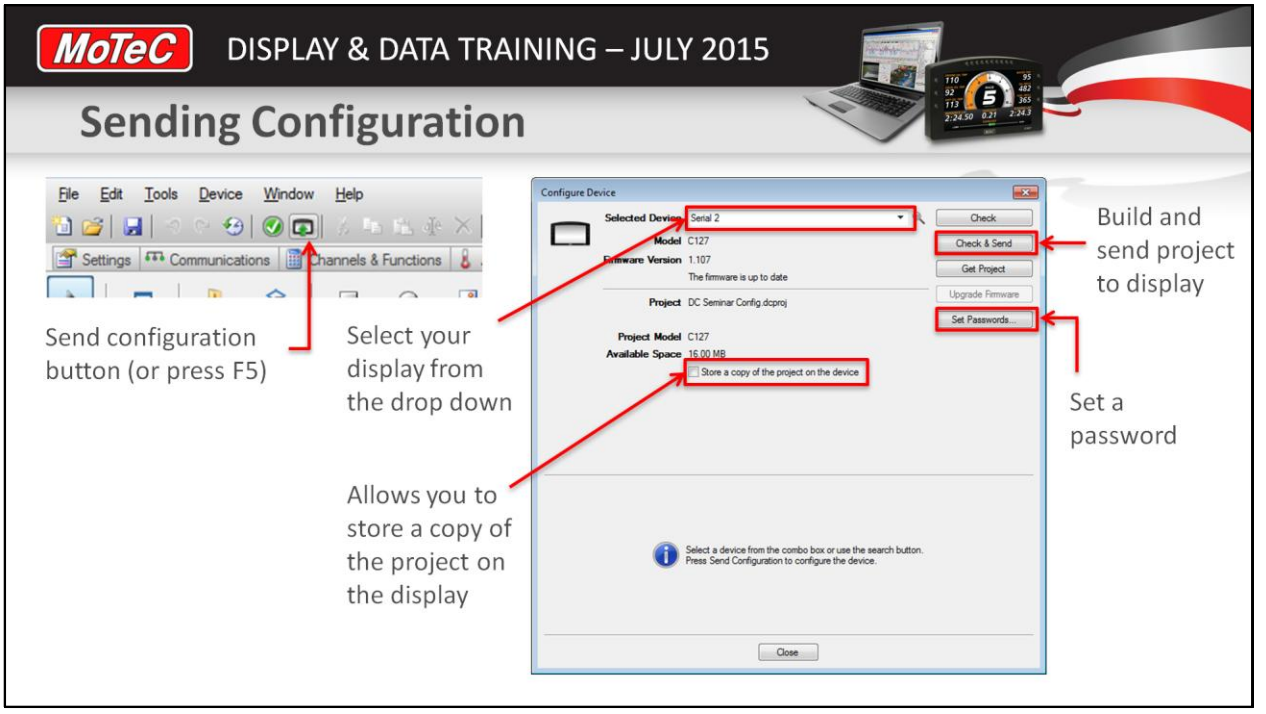
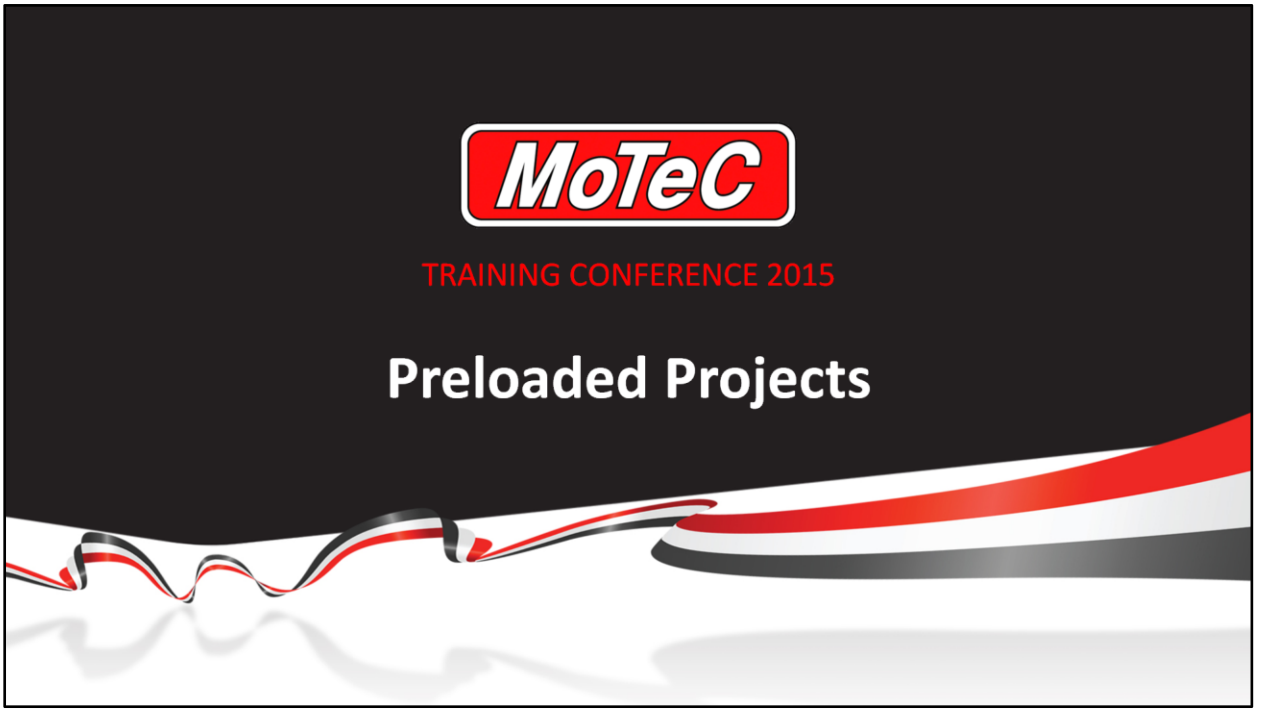
Sending a Configuration

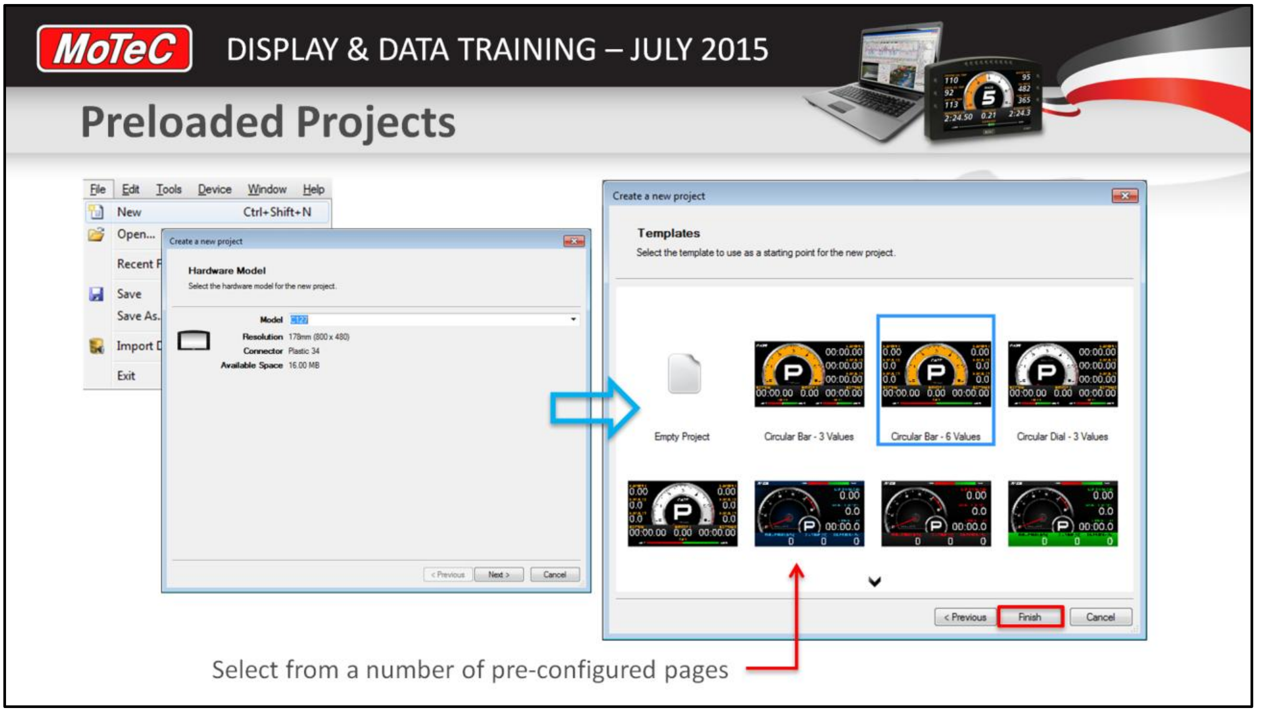


Sending a DC config is a similar process to sending a Dash config. You select the device from the drop down menu and then click 'Check & Send'.

It is possible to store a copy of the project on the device so it can be retrieved later.

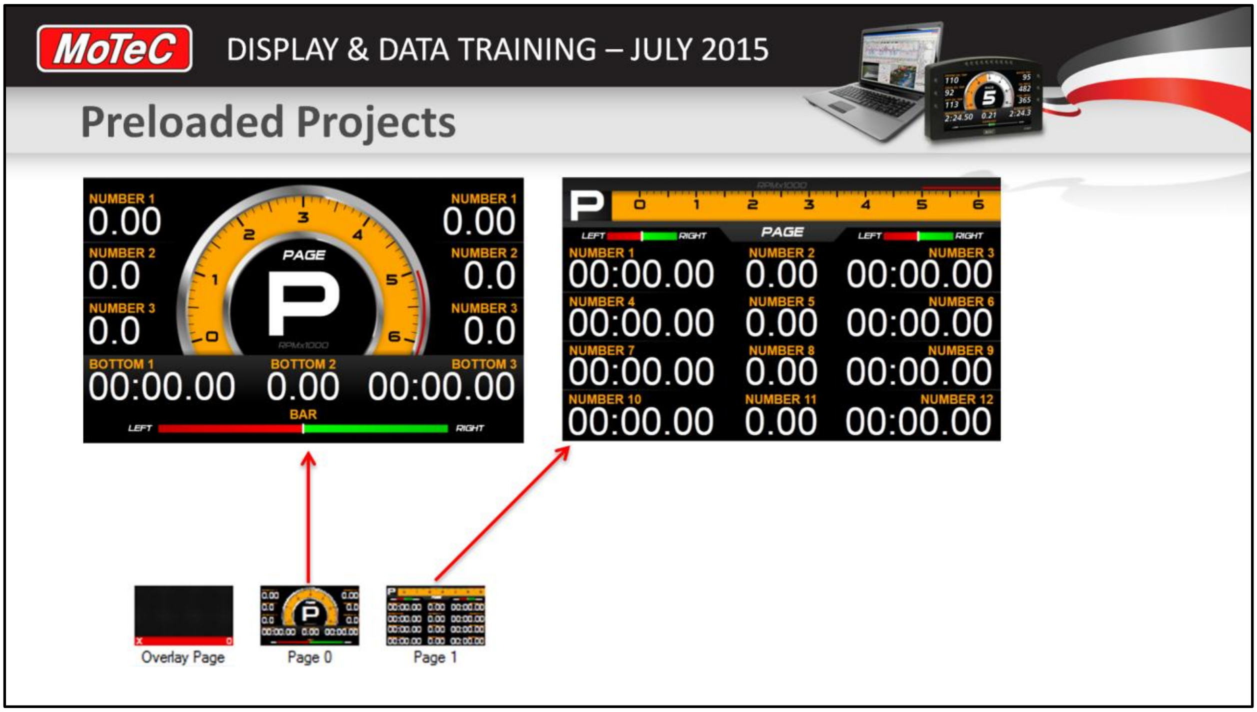
The device can be set up to require a password to send a configuration to stop unwanted changes.


MoTeC
TRAINING CONFERENCE 2015
Preloaded Projects



Display Creator has a number of pre-configured display pages that can be selected. These include the default display pages that come with the Colour Displays, allowing customisation without having to build an entire Display from scratch.

Elements or entire pages can be copied from any of the pre-configured projects into your own custom project.

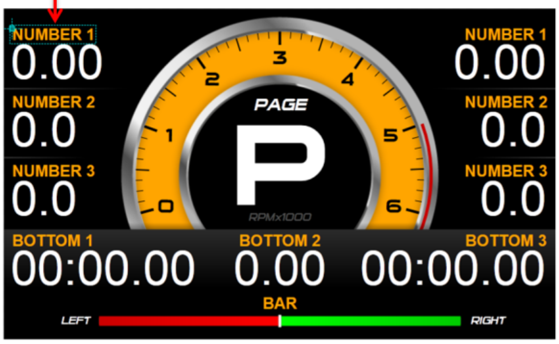


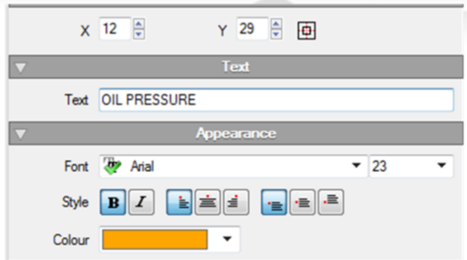
Now that we have a base to start from we add the dbc file from our Dash config in the same way as previously discussed.

DISPLAY & DATA TRAINING – JULY 2015

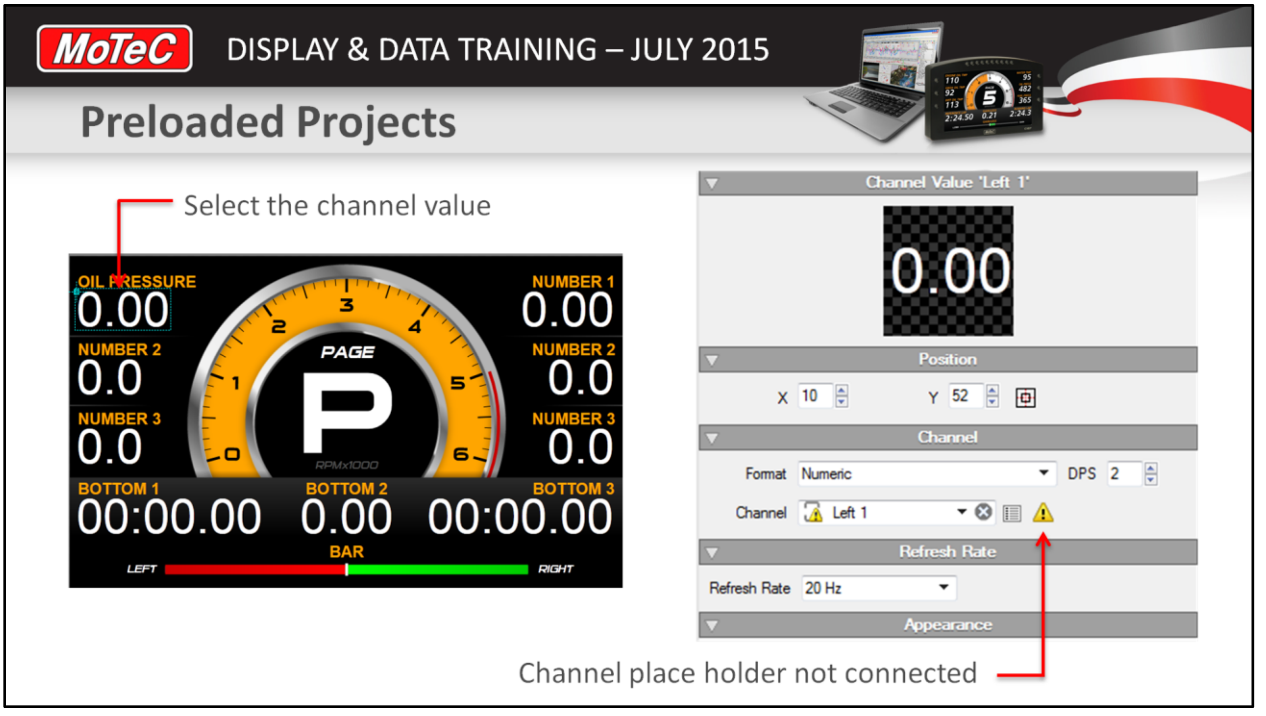
Preloaded Projects

Select the channel label

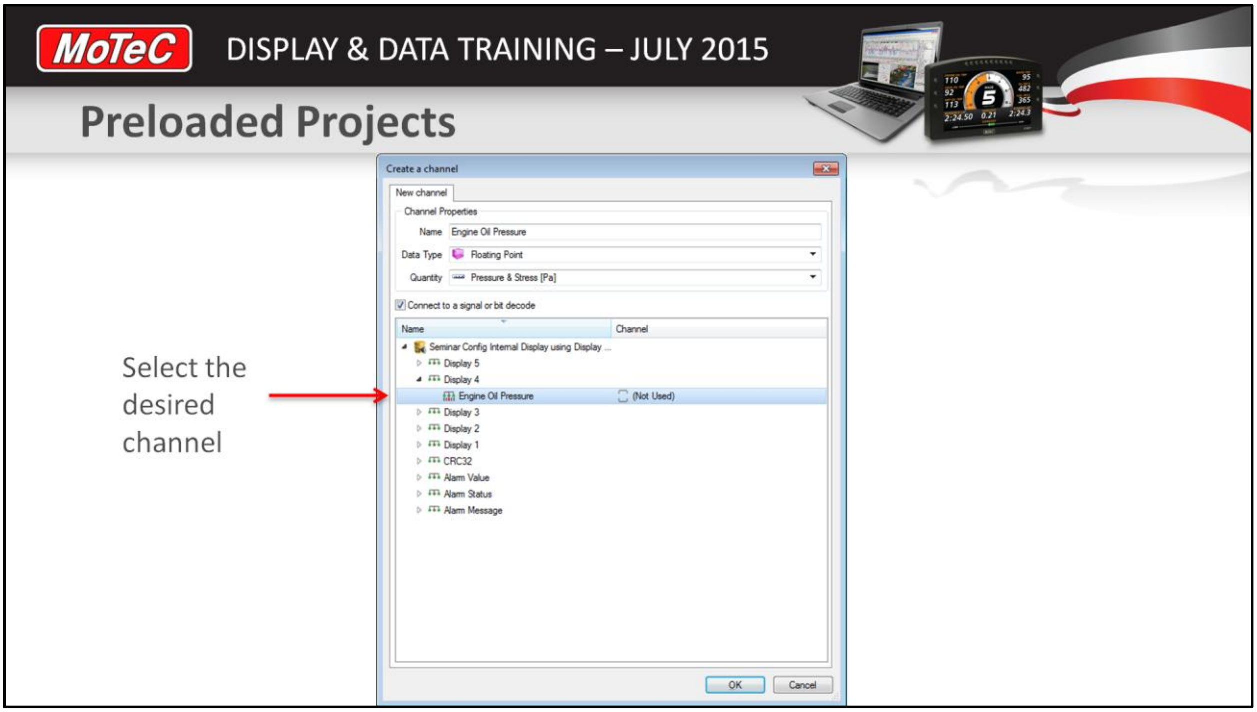




We now start by selecting the text label and renaming it to the channel we want to display in that position.



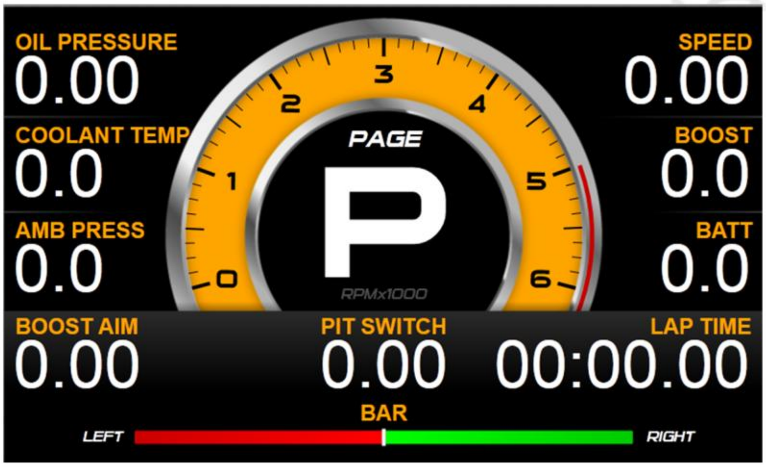
Select the channel you want to allocate, the yellow warning symbol lets you know the allocated channel can't be found. The preconfigured projects all contain channel place holders that need to be reallocated with the channels you actually want displayed.



Select the signal you actually want to be displayed and click OK. It will automatically create the channel and fill out the parameters.

DISPLAY & DATA TRAINING – JULY 2015

Preloaded Projects



VIEW LIVE

Continue through and allocate each of the channels you want displayed.

It is important to note that only one channel can be allocated to each signal. If you wish to use a channel in another location don’t reconnect to a signal, simple select the channel from the drop down menu.

DISPLAY & DATA TRAINING – JULY 2015

Additional Features

- Timers/Counters
- Animation
- Simulation
- Bit Decode
- Backlight Control
- Splash Screen

D-Series Only

- Input Signals
- Beacons/Lap timing
- M800 CAN Input

Timers/Counters: Functions similar to Dash functions. Can be used to create time based conditions.

Animation: Create animations from a number of images.

Simulation: Simulate the Display to check layouts/functions/conditions etc. before sending to a Display.

Bit Decode: Decodes a bit stream allowing you to send multiple state channels in one CAN message

Backlight Control: A channel to control the backlight brightness, can be set as a constant value or varied depending on a particular input or conditions.

Splash Screen: Set an image to be displayed when the device powers up instead of the default MoTeC screen.

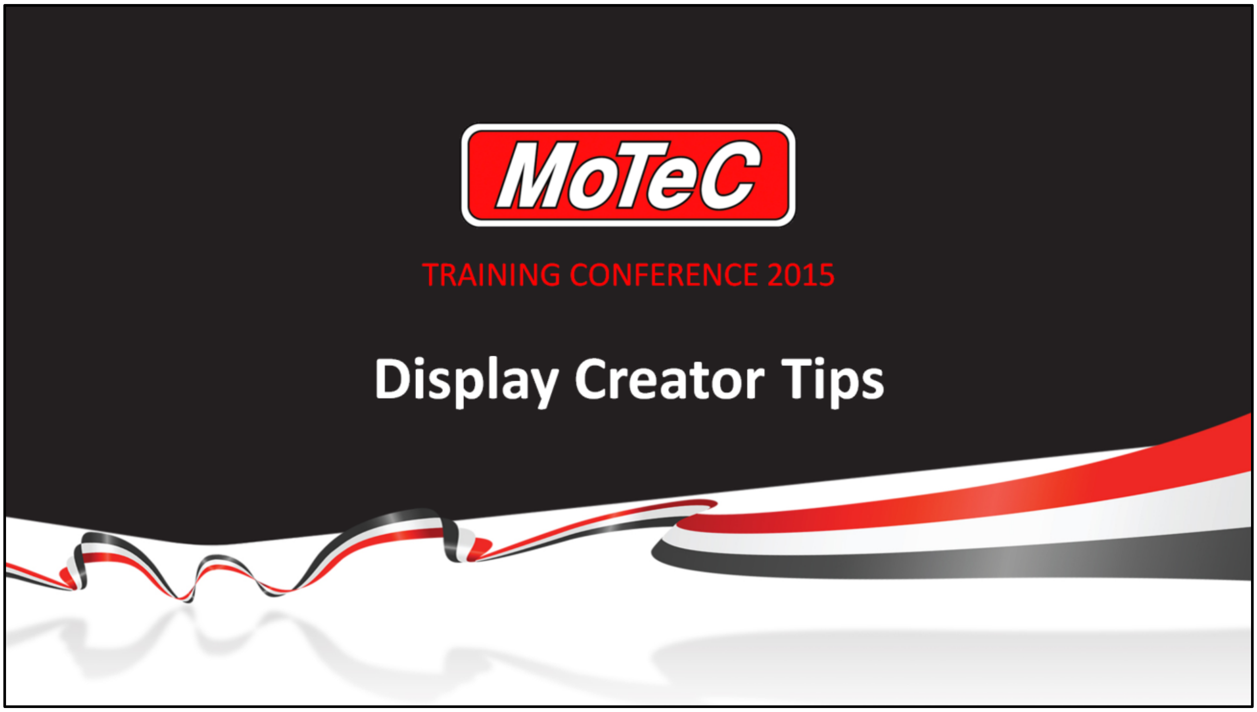
Input Signals: When using a D-Series Dash this allows you to configure the analogue and switch inputs to be used in configuration

Beacons/Lap Timing: Setup a BR2 for lap timing to be shown on the display

M800 CAN Input: Sets up standard M800 CAN messaging so it doesn't have to be done manually. (Note: If using an M1 ECU a DBC file can be provided by MoTeC on request)

Questions

- If you need assistance, feel free to drop us a line at support@motec.com.au
- If you have suggestions on possible improvements, or feature requests, email us at the same address and we can look into it for you


MoTeC
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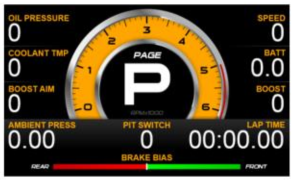
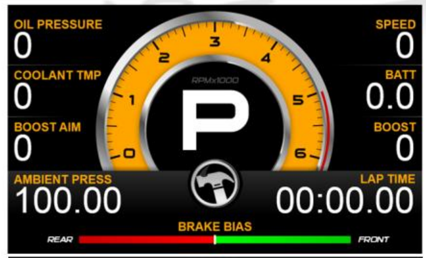
Display Creator Tips

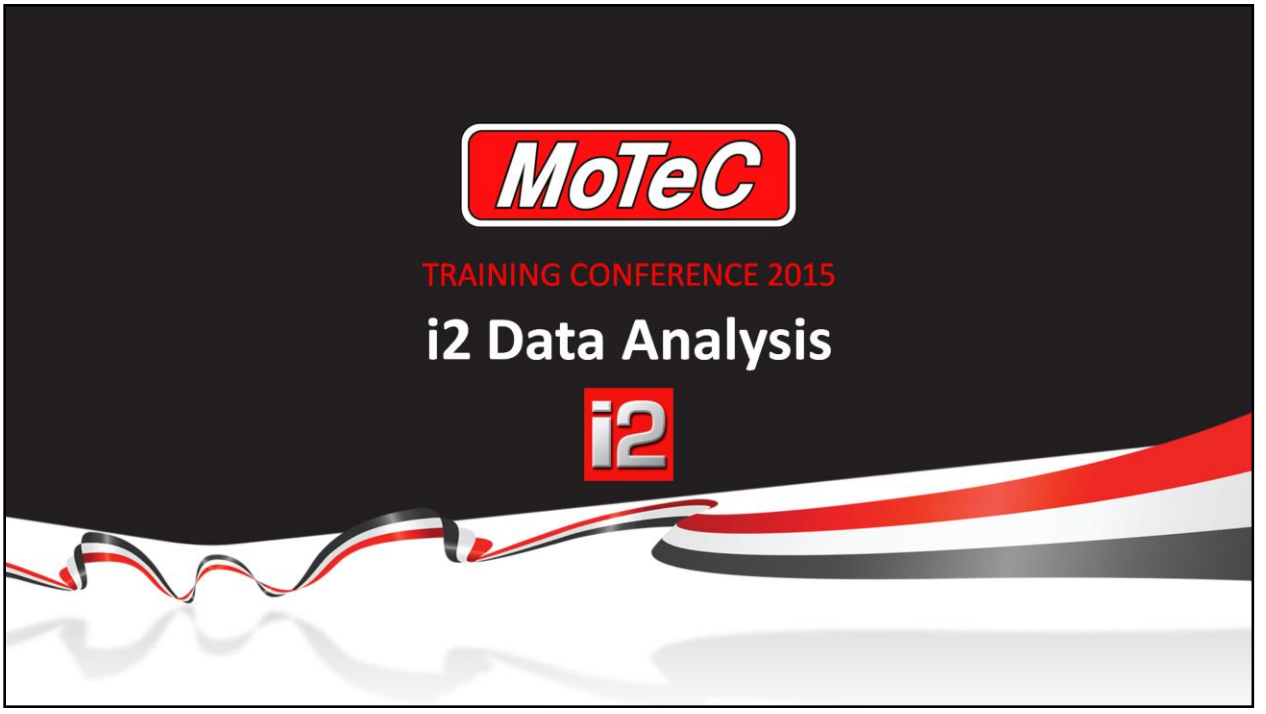
DISPLAY & DATA TRAINING – JULY 2015

Topics

- Reset Window Layout
- Adjusting templates to introduce sponsors
  - Using 'Global' Conditions
  - Using Timers
  - Incorporating Animation
  - Transitioning
- Simulation






MoTeC
TRAINING CONFERENCE 2015
i2 Data Analysis
i2

The above program is an outline of the topics covered in today's seminar. If you have a question at any stage, feel free to ask.

Reasons for Data Logging

Why do we use it?

- Monitor vehicle reliability
- Tool for vehicle and driver analysis
- Analyse performance
- Periodically sample selected inputs
  - Typically once/sec to 5000 times/sec
- Greater value from test laps
- Store data for retrieval/archiving
- Driving technique
- Comparison against reference lap

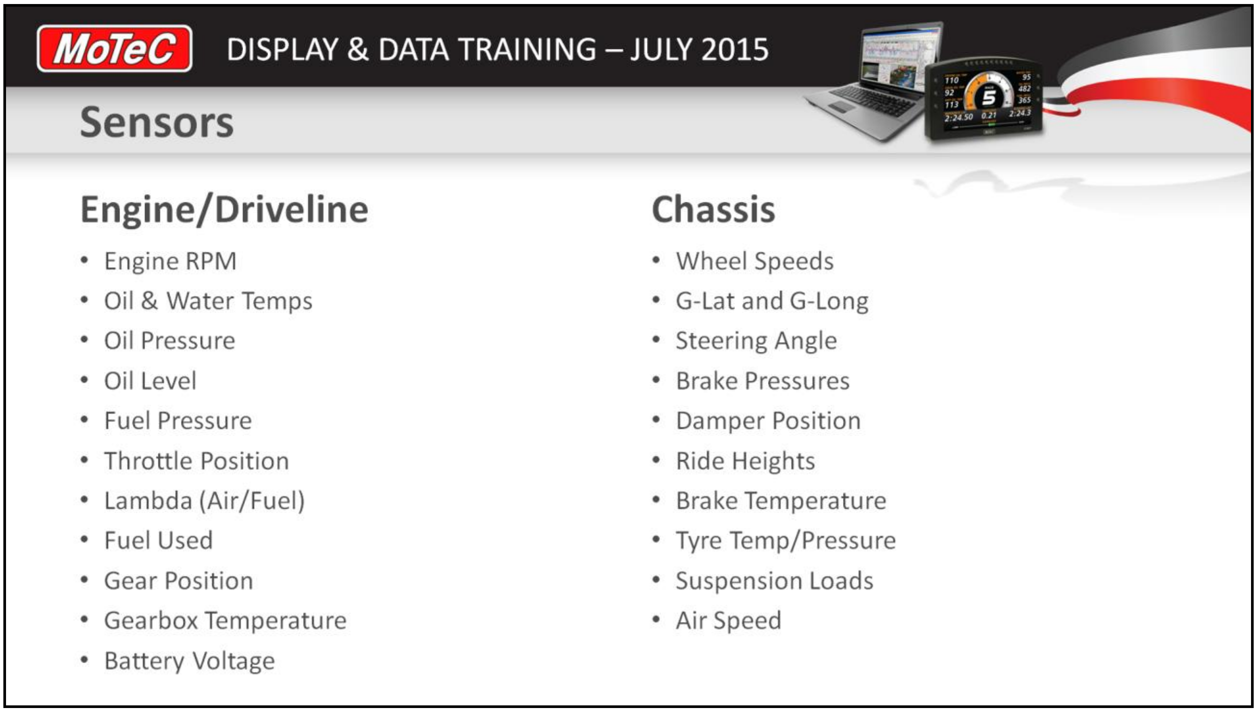
One of the main features of the Dash is its data logging functionality, which gives us the ability to record all sensor values.

This allows decisions to be be made on engine, driving and chassis setup. Data Logging is used to record quantitative data (facts) about performance of these areas.

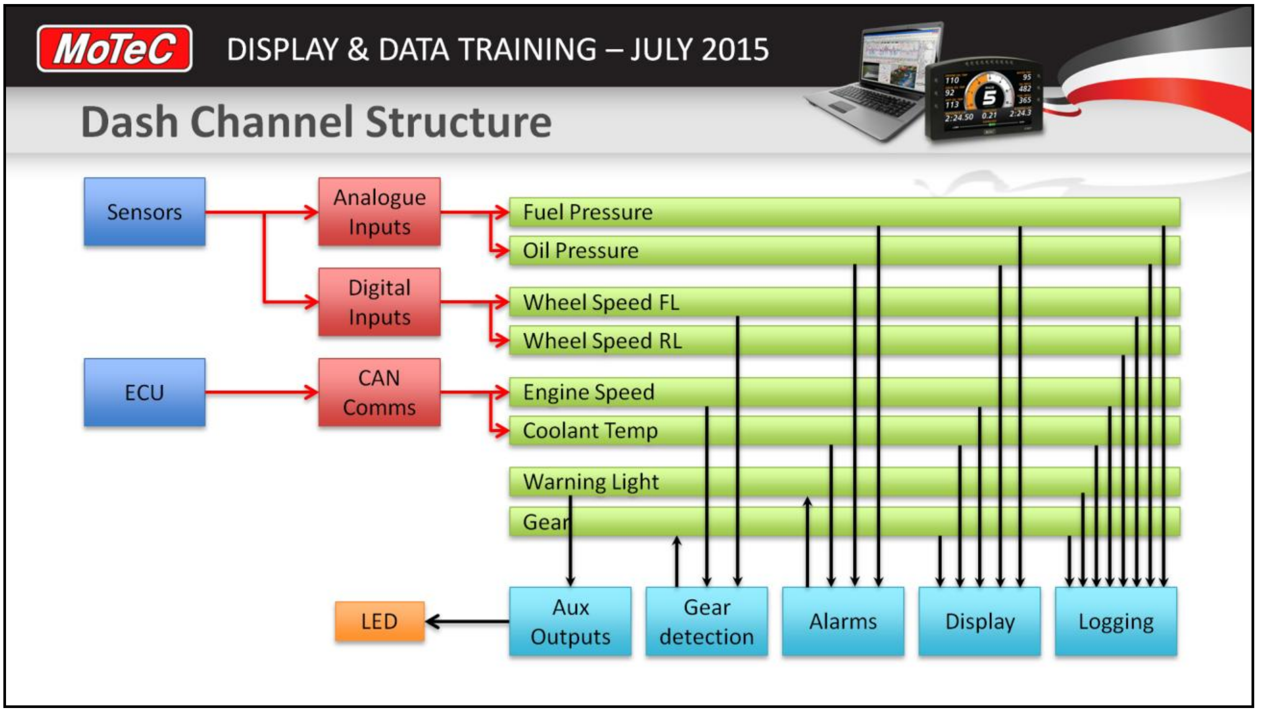
- Monitor the drive train in all parts of a lap to look for unusual changes.
- Confirm driver feedback about what is happening in the vehicle, and its handling.
- Sampling rate is determined by the sensor being logged - must log fast enough to record important data variations.
- Maximise information available in a test session. Data logging will record everything that happens if it is correctly setup, defined and calibrated.
- Data can be used for planning future setups, driver coaching, comparison run to run or with other drivers.
- Help diagnose faults and optimise performance, e.g. check fuel and oil pressure are stable during the session (no surges), brakes/tyres up to temp.
- Overlay data before and after a chassis change to analyse its effect on the chassis.
- Measure oversteer/understeer at individual corners for planning chassis adjustments.
- Measure braking ability of vehicle (and driver).
- Compare all elements of a lap against a Reference Lap to understand chassis changes, driver technique, tyre performance etc.

Logging

- Accepts signals from Analogue or Digital sensors
- Record channels from Sensor Inputs or derived maths calculations
- Data logging stored in Flash Memory
- PC Communications via Ethernet



A list of sensors available for comprehensive measurement of vehicle and driver performance.

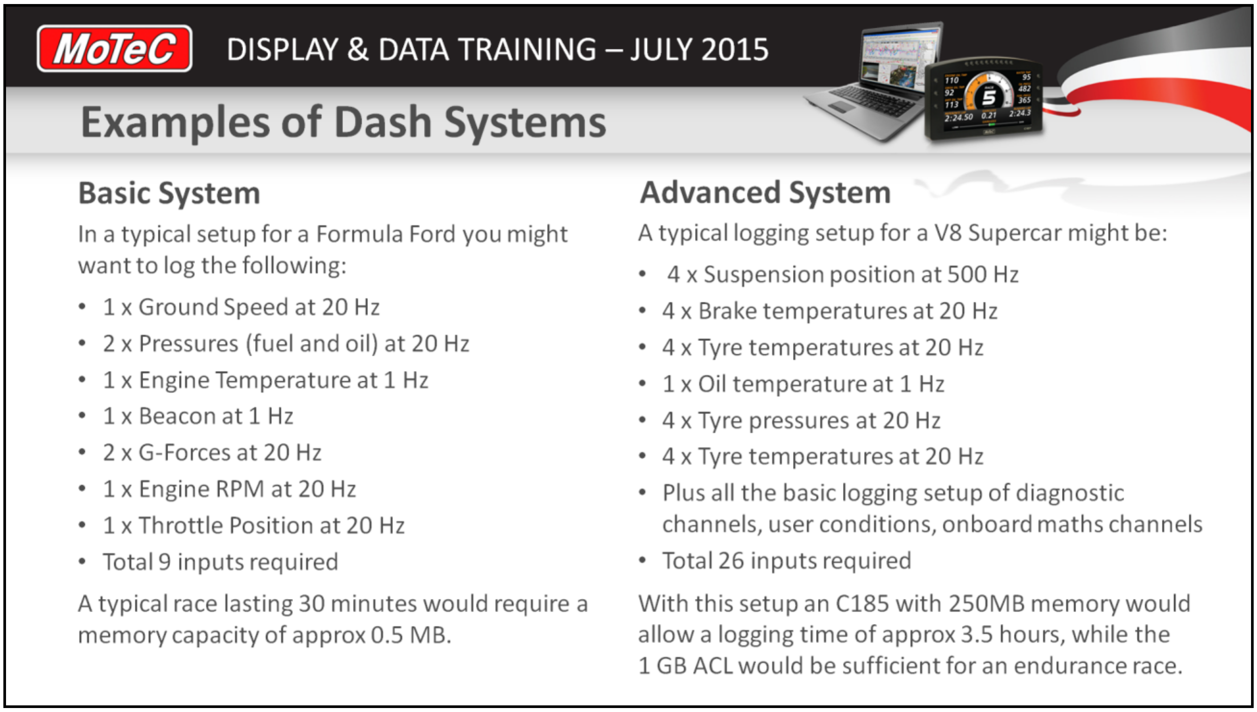


Channel Overview

Channels are used to convey information between the various systems of the Dash. For example, an input sensor may feed a channel called 'Engine Temperature'. This channel may then be used by any other system, such as the Display or Data Logging systems.

Channel Usage

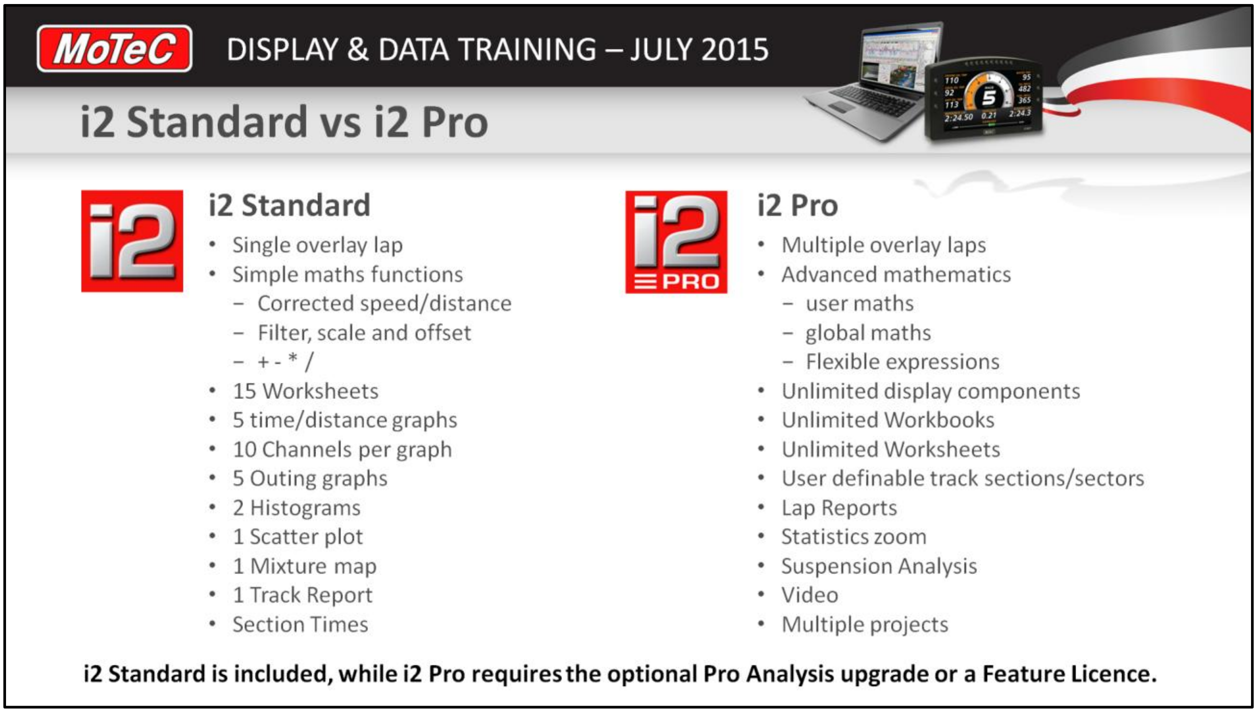
The Dash channel scheme allows complete flexibility in channel usage, as any available channel can be used by any other function, i.e. any channel can be logged, displayed, used in conditions and/or used in alarms.



The onboard data recorded into the logging device is downloaded to a PC, either each time the vehicle comes into the pits or at the end of a race, rally, drag run or test session.

The available memory varies greatly from system to system and more recent logging devices use Ethernet communication for fast download.


MoTeC
TRAINING CONFERENCE 2015
i2 Introduction
i2



There are two levels of analysis functionality: **i2 Standard** and **i2 Pro**. This list shows some of the major differences between the two software versions.

i2 Standard is available to all customers with logging from a MoTeC Data Logger or ECU. It has been designed with the intention of being suitable for teams up to around mid-level motorsport.

i2 Pro provides all the features of Standard but on top of that are extra features that have been requested by professional race teams worldwide, like advanced mathematics, multiple overlay laps, and unlimited components, Workbooks and Worksheets, and viewing Live Telemetry data via T2. It is expected to be used by those in middle to upper levels of motorsport.

There are two ways to make log files compatible with **i2 Pro:**

1. The first option is a Pro Analysis upgrade on your ECU or logging system. This is a password enabled upgrade, which saves all log files from the device as '**Pro**' files.
   The Pro Analysis upgrade can be purchased at any time, allowing you to use the more powerful software when the need arises. This can even be done at the race track, you need only contact your dealer and they can supply the password to upgrade your specific device.
2. The second method is via the Feature Licences, which allow data in different formats to be used with **i2 Pro**.

While a software and resource USB is included with MoTeC products, the software is regularly updated so it will become necessary to download the latest versions from the MoTeC website.

Installing Software

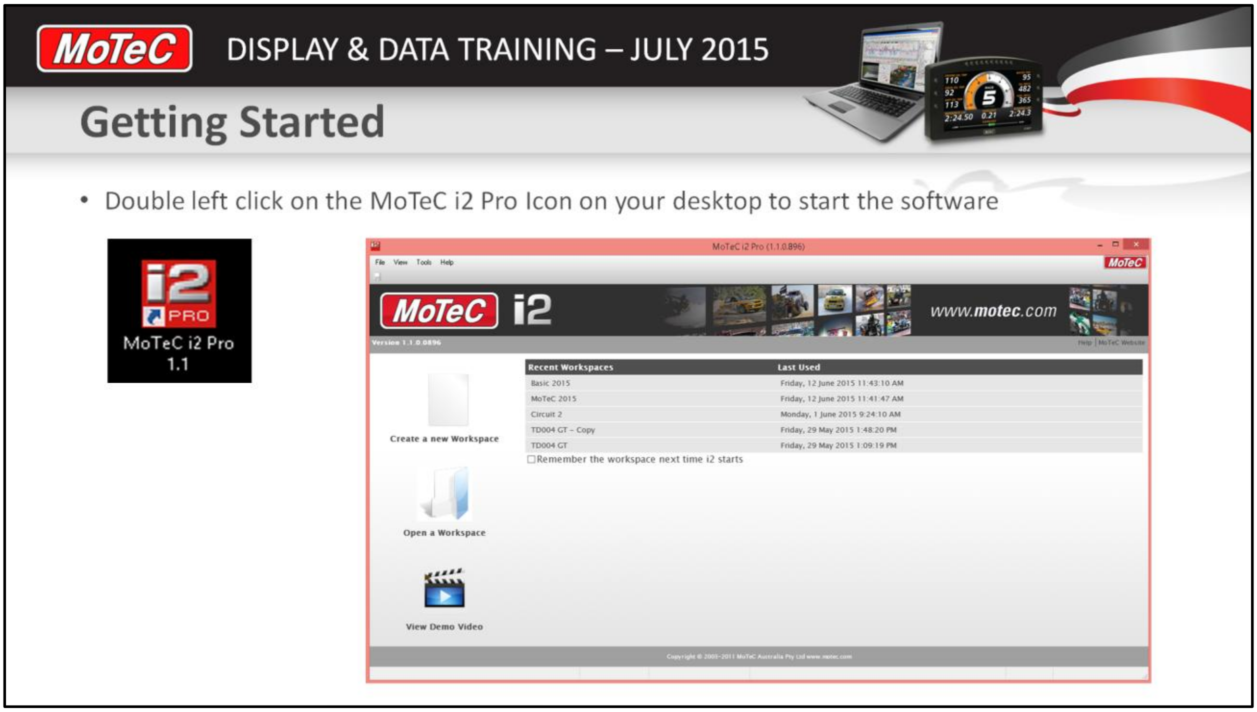
1. Go to the MoTeC website at http://www.motec.com.au/software/latestreleases
   OR
   Locate the Dash Manager software on the MoTeC Resource USB

2. Save the selected file in your preferred location (for example Desktop)

3. When downloading is finished, double click on the file and select run.
   Note: the time taken to download the file can vary widely and will depend on the speed of the connection to the internet.

4. Follow the instructions on the Install Shield Wizard

To be informed of the latest software releases you can join the MoTeC software announce mailing list by sending an email to mailto:announce-subscribe@motec.com.au



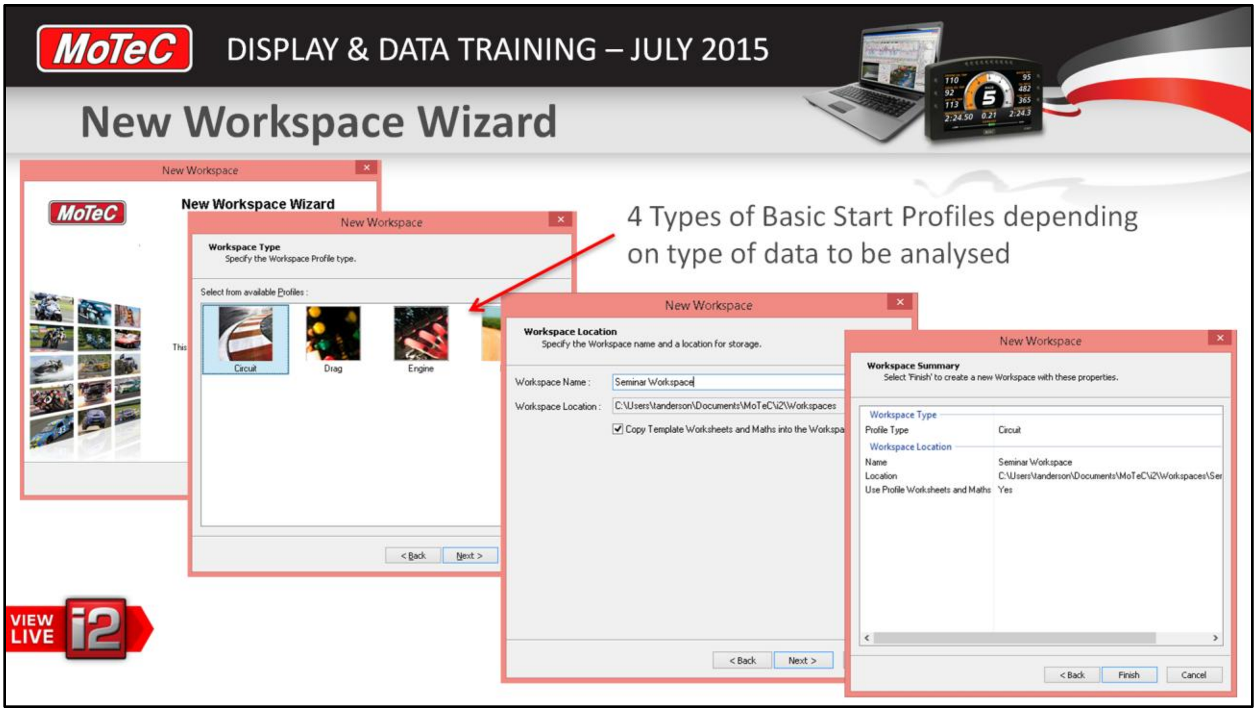
To start the program after installation, click the icon on the desktop or click **Start > All Programs > MoTeC > i2 Pro**

A Workspace stores the **i2** program settings, screen layouts, math calculations etc. used for analysis. Workspaces can be defined per vehicle, by type of racing etc. A user can create as many Workspaces as they wish, each with different settings. New Workspaces can be created or existing older projects opened from the File | Workspaces menu or from the **i2** start up page. Any log file can be opened from within a Workspace, so a Workspace doesn't restrict what information can be analysed.

The first time that **i2** is run, the user is prompted to create a New Workspace. Follow the prompts of the wizard to create the first Workspace.

If upgrading **i2 Pro** to version 1.1, the name changes from Project to Workspace. The older projects can be imported from the File | Workspaces | Open Workspace menu. Click Import, at the bottom of the import window, you will need to change the 'Files of type' to be i2 1.0.Project.

When opening **i2 Standard** for the first time you will be presented with the choice of 4 projects: Circuit, Drag, Rally and Engine. If you click on the box 'load previous project', on subsequent program starts it will take you straight into your graph screens, ready for you to open your data.



Creating a New Workspace:

Workspace Type: There are 4 types of project available: Circuit, Drag, Rally and Engine. The project type determines the default math settings and initial Workbook and Worksheet setups and optimised for that particular data analysis .

Workspace Location: Enter a descriptive project name. This will be used as the folder name under which the project is stored. By default, projects are created in the current user's 'My Documents' folder under 'My Documents\MoTeC \i2\Workspaces\Workspace_Name\' This can be changed by clicking on the button next to the Workspace Location and browsing to the destination folder. Renaming the folder will rename the Workspace.

Profile Worksheets and Maths are included if the box is checked, otherwise the project is blank with no predefined maths or screen layouts.

Workspace Summary: After checking the project summary, click on Finish to close the wizard and begin using ***i2***.

The entire project folder can be copied from one PC to another and some of the components can also be copied. The project folder and its directory structure contains individual files for channel maths, setup sheets, track maps etc.

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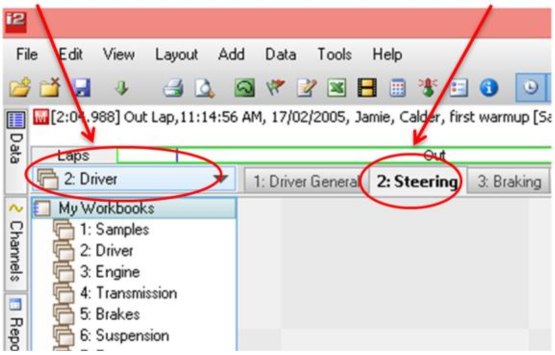
Workbook/Worksheet Setup

- Worksheets should be grouped into Workbooks by their type, such as Engine, Driver, Chassis, Suspension, Power or they can be grouped for different people such as Engineer, Driver A, Driver B.

Workbook Worksheet



Circuit Racing Project:
The 'Samples' Workbook contains 10 sample Worksheets

Drag Racing Project:
The 'Samples' Workbook contains 8 sample Worksheets

Workbooks and Worksheets

Worksheets are used to contain the screen layouts, i.e. where the data is actually displayed. Each Worksheet is completely configurable and may contain a number of different components such as Graphs, Histograms, Gauges etc. These can all be mixed together in any one Worksheet.

Workbooks are used to group a number of Worksheets. This allows a large number of Worksheets to be defined and organised into categories to suit the user's requirements. A Workspace can contain any number of Workbooks which in turn can contain any number of Worksheets.

Selecting a Worksheet

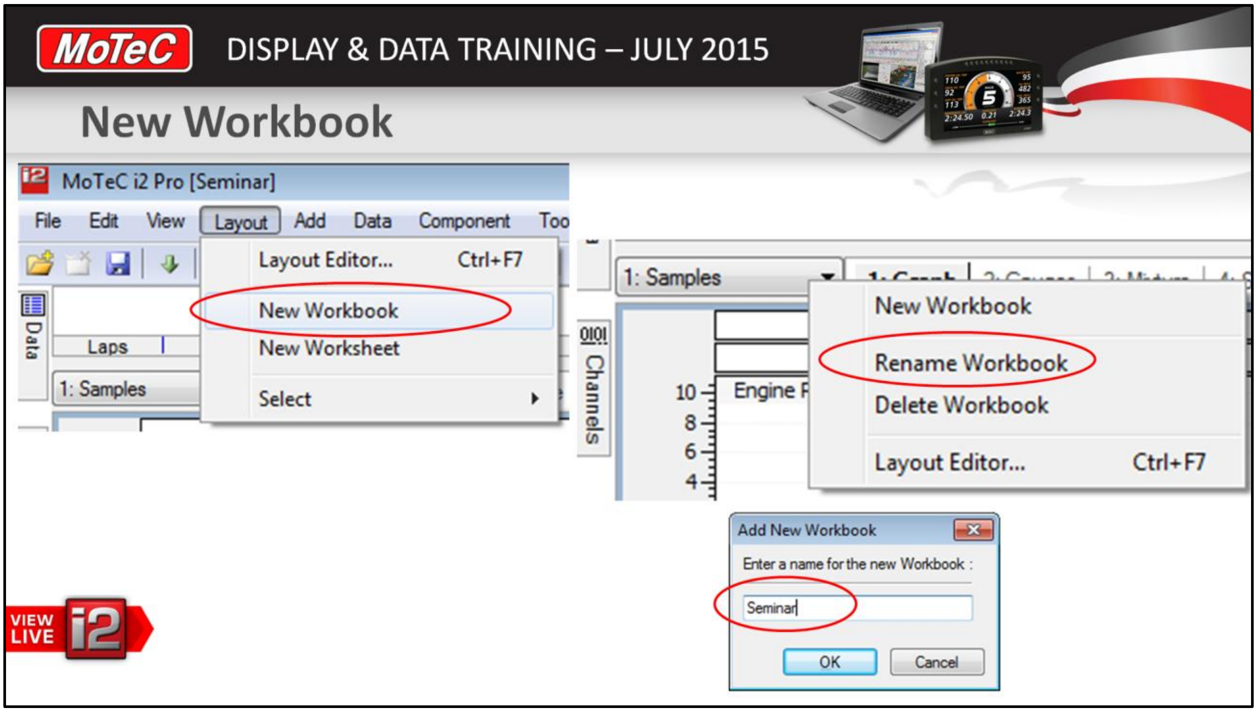
To select a Worksheet use the mouse or press F7 to activate the Select Worksheet dialog or press the corresponding number key that is shown on the Worksheet tab.

Keyboard shortcuts

Worksheets may be selected by pressing the corresponding number key (0…9)

Workbooks may be selected by pressing the Ctrl key plus the corresponding number key (Ctrl+0…9)

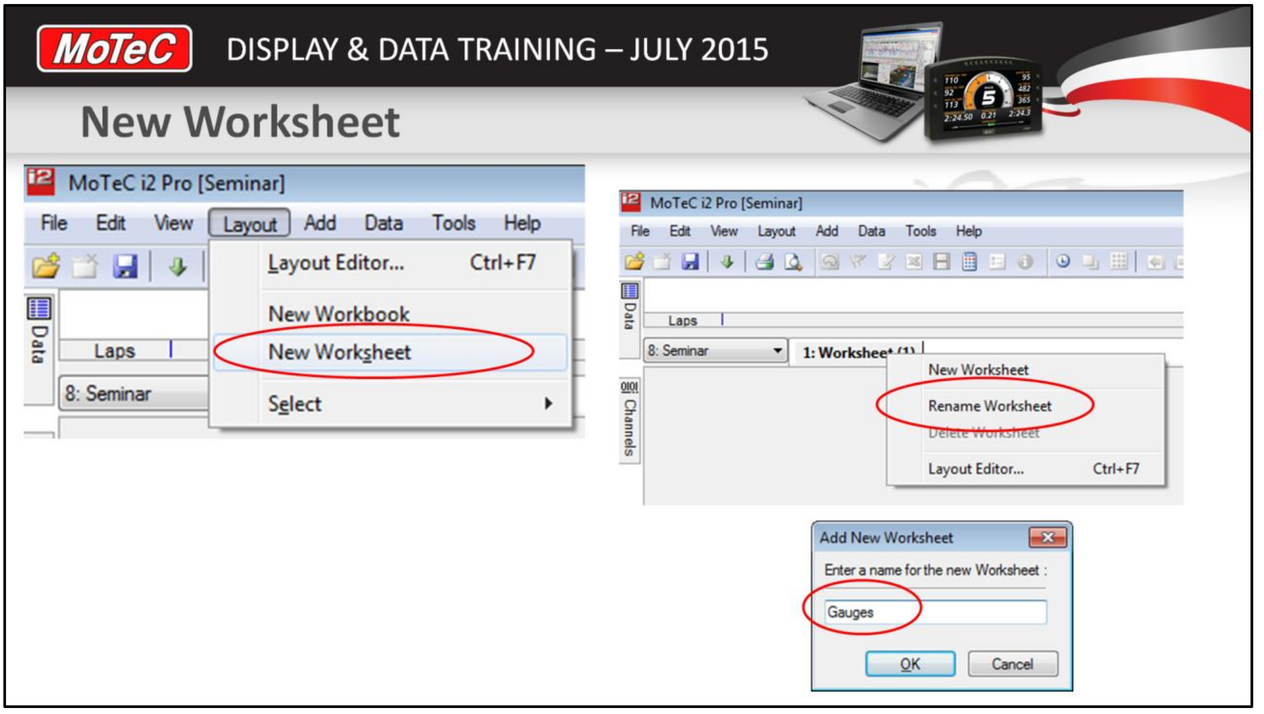
A Circuit Racing project comes with 8 pre-defined Workbooks, each with a number of pre-defined Worksheets, i.e. there are 10 pre-defined Worksheets in the 'Sample' Workbook, several others such as 'Driver', 'Engine, 'suspension, etc. and one blank Worksheet in the 'User' Workbook. A Drag Racing project currently comes with 8 pre-defined Worksheets in the 'Sample' Workbook and one blank Worksheet in the 'User' Workbook.



Creating a new Workbook

To add a new Workbook, go to the ‘Layout’ menu and select ‘New Workbook’. Or this can be done from the Layout Editor (menu ‘Layout – Layout Editor’, shortcut key ‘Ctrl+F7’ then ‘Add Workbook’) or right-click on the Workbook list and select ‘New Workbook’.

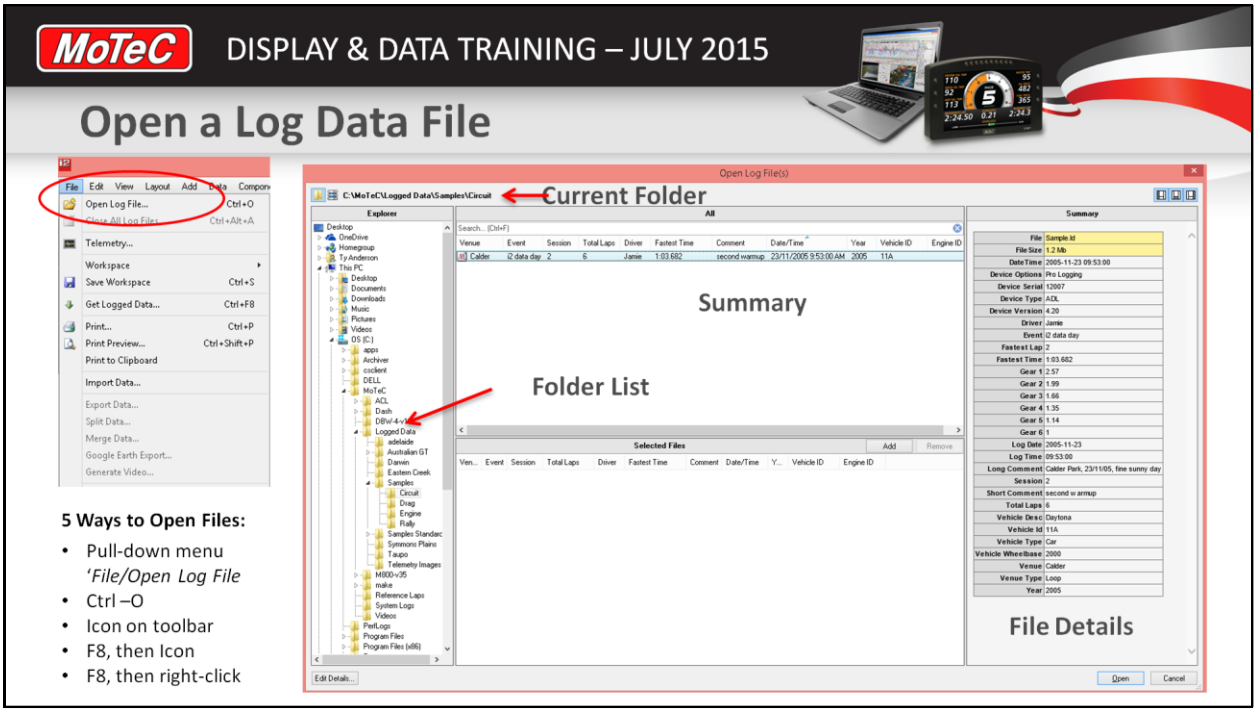
You will be prompted to enter a name. To rename a Workbook, right click on the drop down list and choose ‘Rename’ or use the Layout Manager.



Creating a new Worksheet

To add a new Worksheet, go to the ‘Layout’ menu and select ‘New Worksheet’. Or this can be done from the Layout Editor (menu ‘Layout – Layout Editor’, shortcut key ‘Ctrl+F7’ then ‘Add Worksheet’) or right-click anywhere on the Worksheet tabs area and select ‘New Worksheet’.

You will be prompted to enter a name. To rename a Worksheet, right click on the tab and choose ‘Rename’ or use the Layout Manager.



Open Log File dialogue

A log file can be opened by going to the 'File' menu and selecting 'Open Log File', by using the keyboard shortcut 'Ctrl+O' or by clicking on the Open Log File icon on the toolbar.

On the left is a folder view with the currently open folder highlighted in grey, the folder name is also shown at the top of the window. Full details of the currently selected file are shown in the pane on the right.

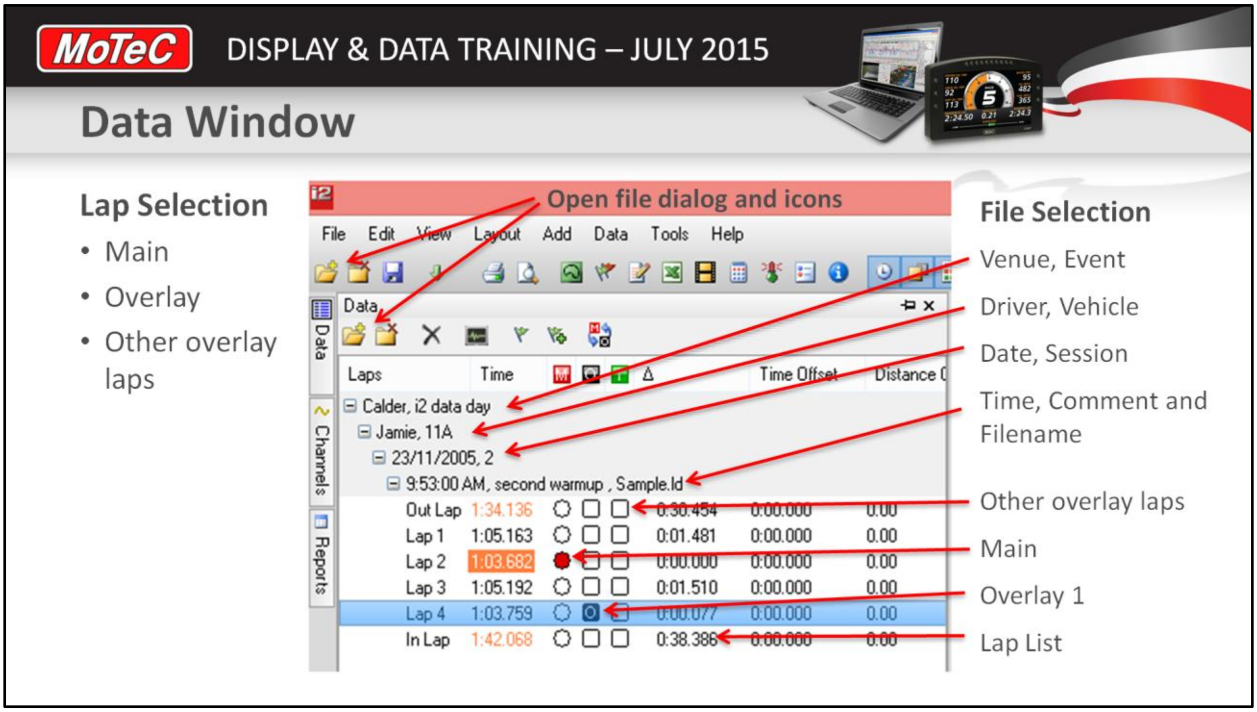
Files shown can be filtered by the Venue, Driver name or Vehicle details by selecting one or more of these from the drop down lists.

Files can be sorted by the columns shown at the top of the centre pane by clicking the heading once – and again to reverse the order.

Columns shown and their order can be selected from a list by clicking on the 'Options' button or by right-clicking on the row of headings to a list of selectable headings.

Select the required file and click on 'Open'.

Multiple files can be opened at once allowing data to be selected from a number of sources - when a file is opened, previously opened files remain 'open'. Files can be closed individually or as a group.



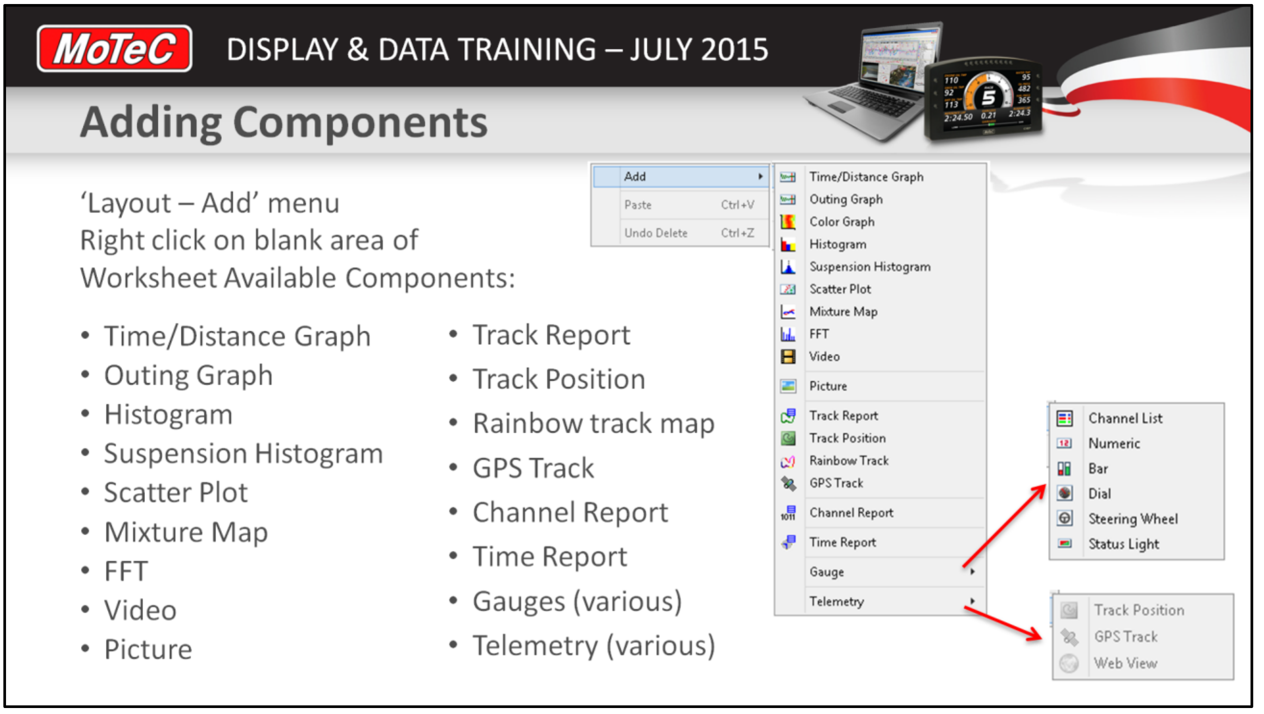
Data Window

Press F8 to go into the data window.

This window lists files that are currently 'open' that you may choose to view. You can open as many files as you like from any folder on your computer. Once one or more files have been opened they will appear listed down vertically along with some file details as shown above.

Use 'R' to select the first overlay lap, and 'O' for an additional overlay. Otherwise press 'M' or 'enter' to select the Main lap. The fastest lap in a session is highlighted in orange. The F4 key toggles the overlay lap on and off. F3 toggles variance.

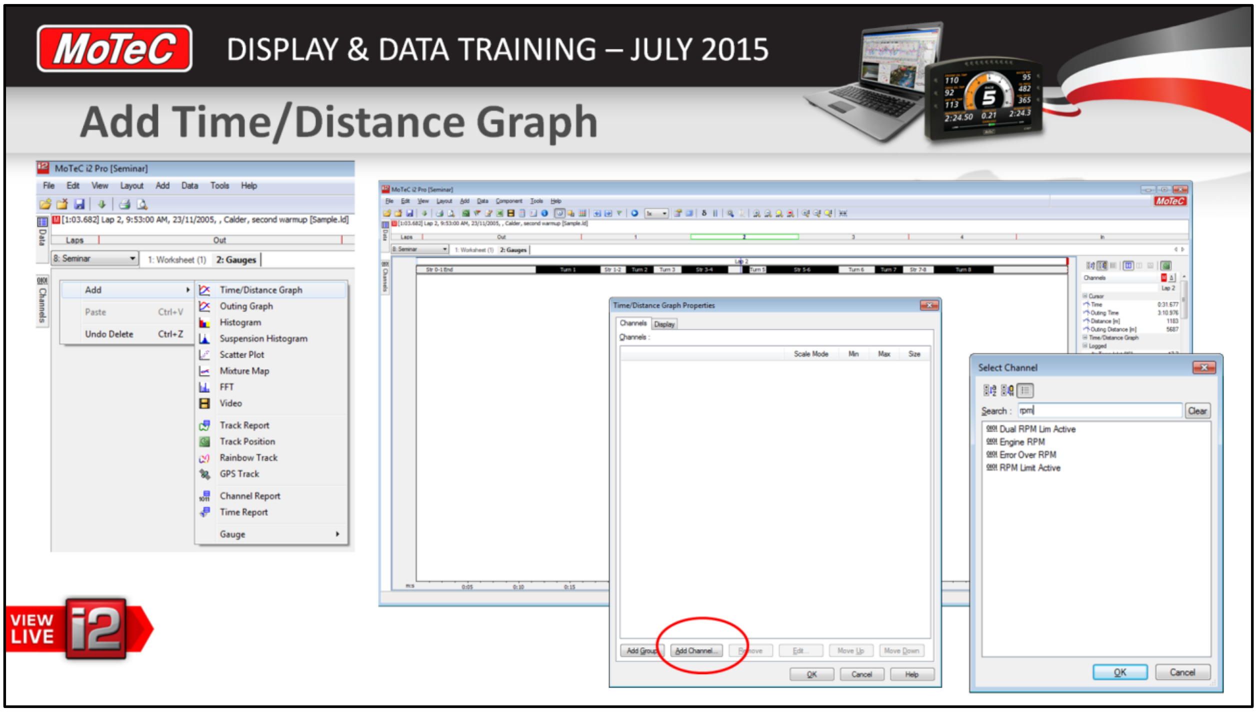
One lap is chosen as the '**Main**' lap, this is indicated by a red dot in the circle next to the lap time. The next column across is for the '**Overlay 0**' lap. This is actually the first overlay lap (displayed on those components that only support a single overlay) and is also used for the variance calculation. The third column is for additional '**Overlay**' laps that are displayed on graphs and in channel reports. The Main, Overlay 0 and Overlay laps can all be from different files or sessions. The trace colour of an overlay lap can be changed by clicking on its label in the title bar above the main display.



Adding Components

With a new Worksheet now open you are still unable to view any data until a component has been added. Right click anywhere within the blank new Worksheet and a list of available components will appear. Or use the 'Layout' menu to select a new display component.

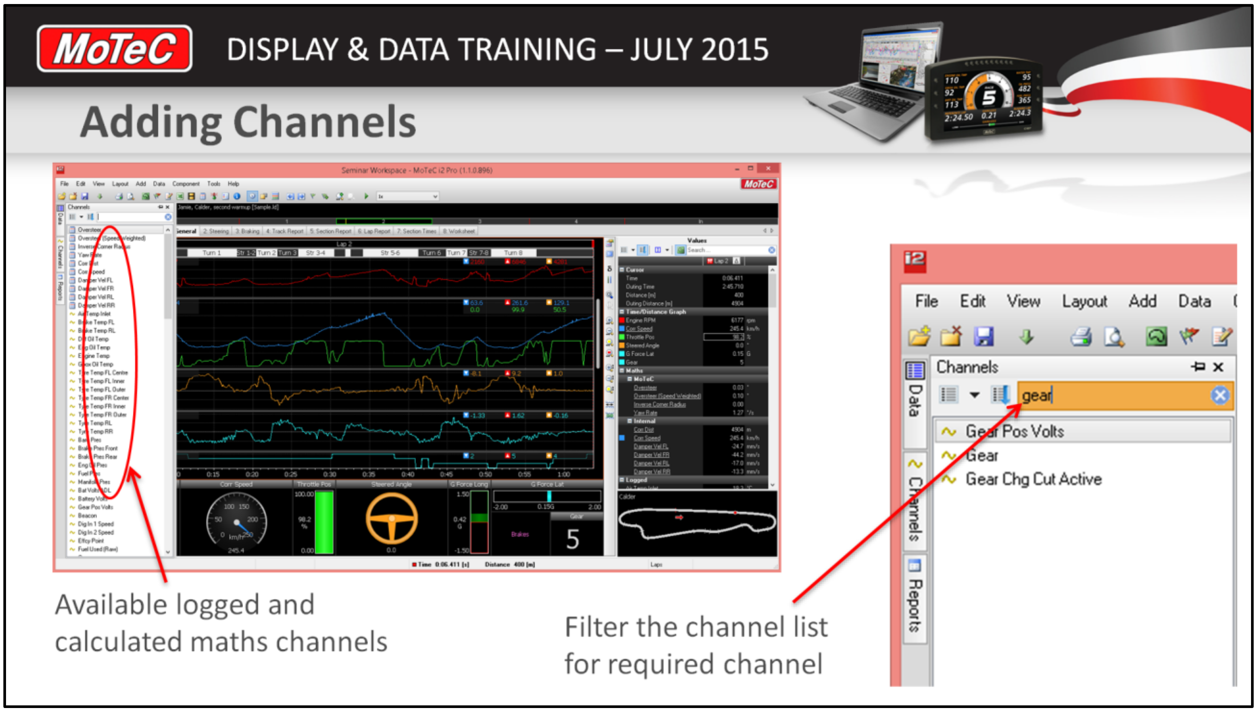
To add a Telemetry Component you will need to add a telemetry stream to the Workspace.



Time / Distance Graph

Select 'Add – Time Distance Graph' from the menu bar.

When adding any new component, initially the software presents the relevant component's Properties dialog box. This allows the user to organise the component with the desired channels to view and the format they are to appear. The user can access the Properties menu for the currently active component at any time by pressing the 'F5' key.



Press ‘C’ to open the Channel list fly out. Double click on a channel to add it to the display component that currently has focus.

Or, press ‘Tab’ to go into the channel list, arrow up and down then press ‘Enter’ to add a channel. The list of channels displayed can be narrowed down by typing the first few letters of one or more words of the channel name into the search box to make finding the required channel easier.

You will find that some channels are grouped together, while others remain on their own. The time/distance graph that we have added is being divided into ‘Groups’. Each Group can have one or more channels on it. If we add channels that have the same units they will be placed on the same group, channels with different units are given a new group.

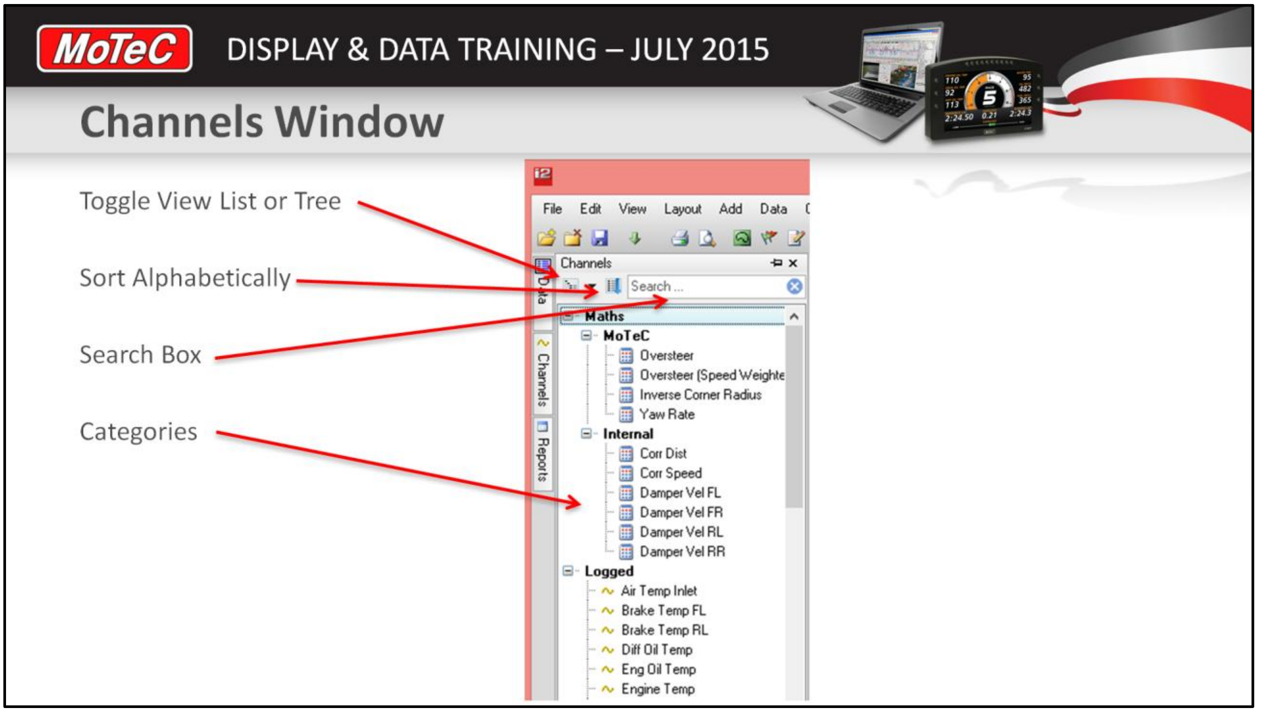
It is possible to change the default behaviour and arranged channels according to how you want them in each case. This is done by accessing the Properties for the time/distance graph. Or hold down the ‘Ctrl’ key when clicking on a channel in the list to force the channel into a new Group (i.e. a separate graph).

Click on the group containing corrected speed to set the focus to that panel

Press the C button to bring up the channel fly out

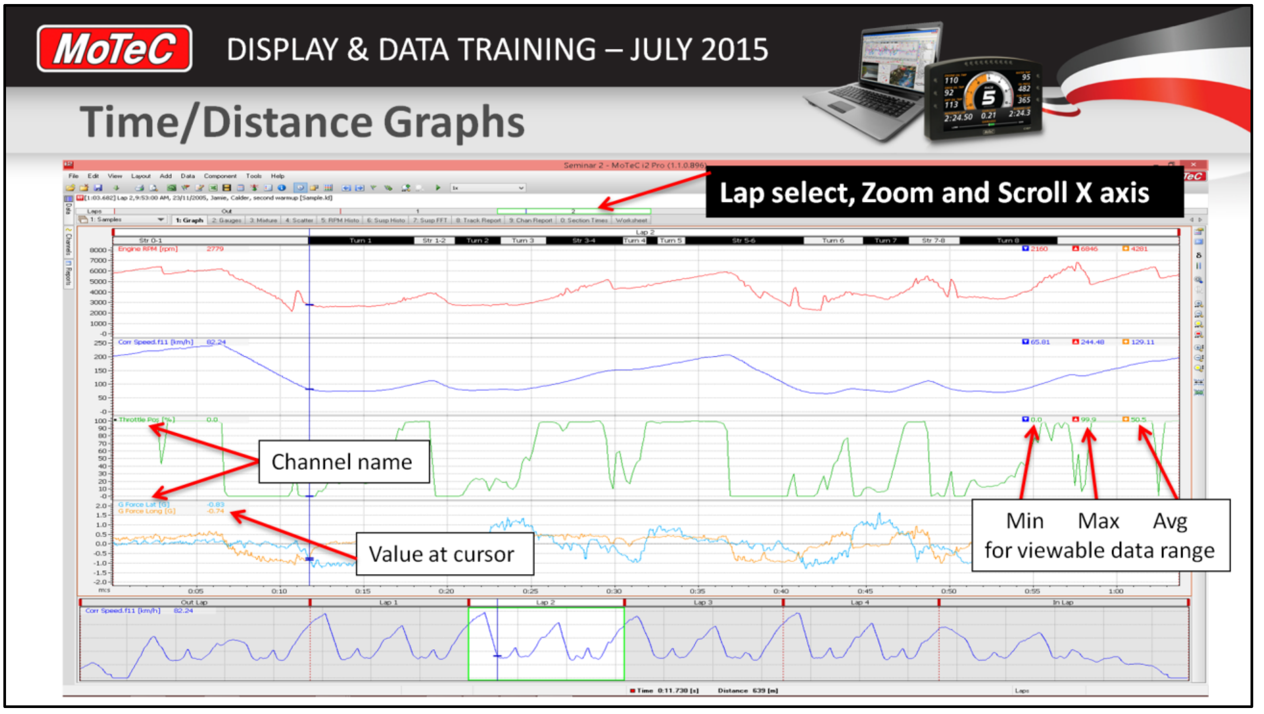
Type ‘Gear’ into the search bar

Double click on Gear



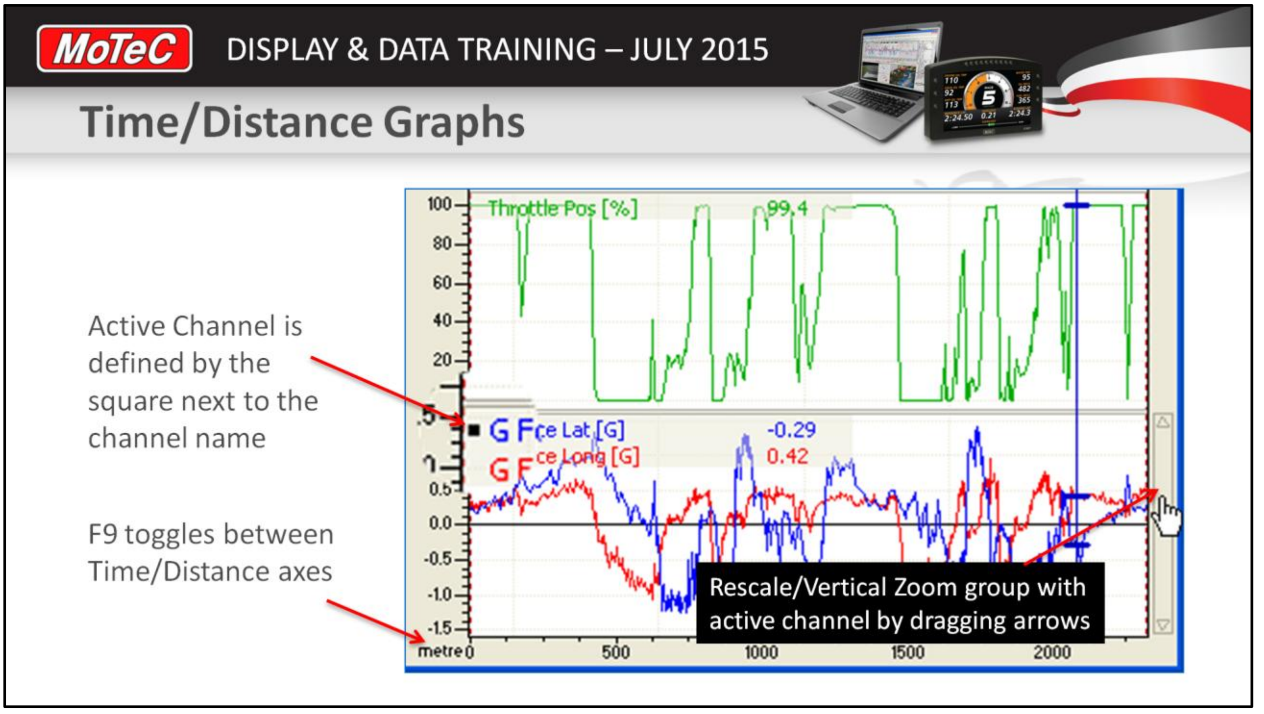
The Channels window is used to add channels to the display component for the currently selected 'Main' logged data, and the selected component display on the Worksheet. This component is the one with the highlight box around it.

The list can be displayed in categories: logged channels, status channels and various maths. Or they can be displayed as a combined (alphabetic) list.



The first sample Worksheet includes two graphs. The top graph displays a single lap of data of 5 channels in four groups. The lower graph shows the Corrected Speed channel over the entire session. The cursors on the 2 graphs are linked, and the currently selected lap is highlighted in a green rectangle on the second outing graph.

Lap selection bar: grab to scroll through laps, double click to select a lap, grab edges to zoom in/out.



Time / Distance Axis

The graph may operate in time or distance mode – the F9 key toggles the horizontal axis between time and distance. The mode is remembered for each Worksheet and all components on the Worksheet use the same mode.

The graph uses the corrected distance (Corr Dist) channel to determine the distance for the axis when in distance mode. If the Corrected Distance channel cannot be calculated then the graph will not display data in distance mode. Note that the Corrected Distance calculation normally requires that the Corrected Speed calculation is working.

Active Channel

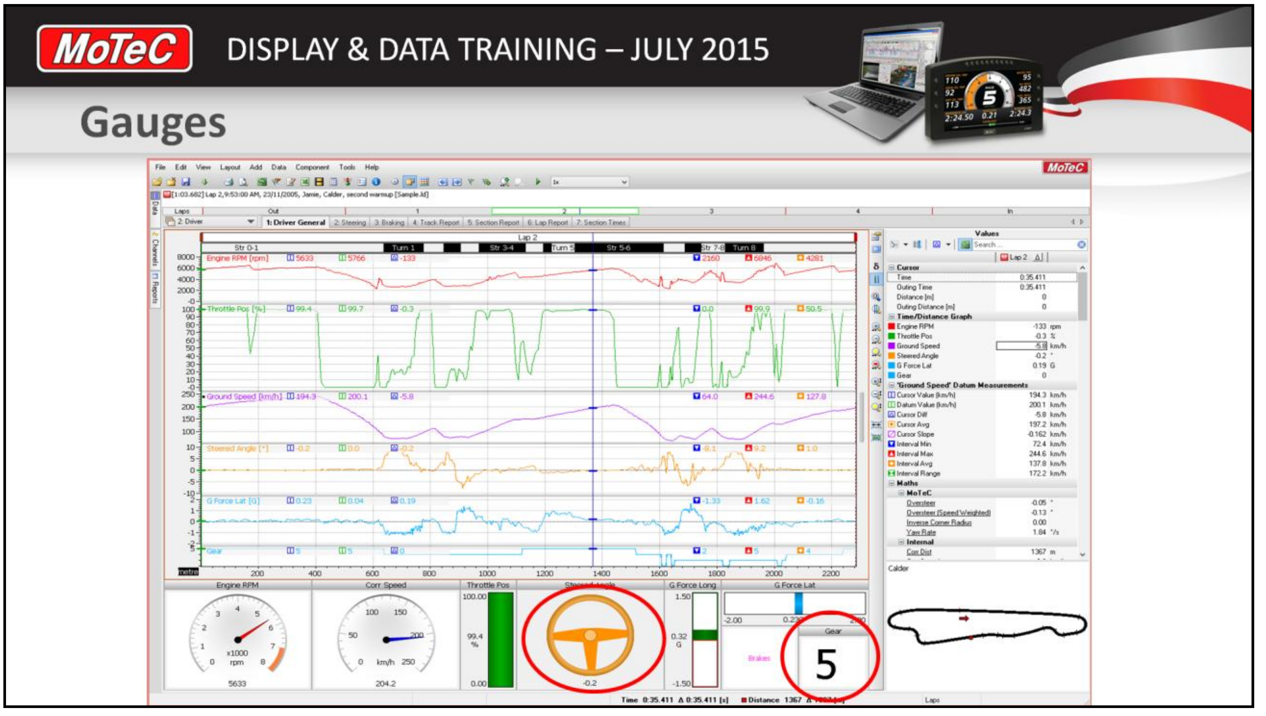
Each graph has an active channel. A square next to the channel name indicates which is the active channel. The active channel can be selected by clicking on the channel label or by using the PgUp & PgDn keys.

This is required for operations that are initiated via keyboard shortcuts. For example the shortcuts from the active channel menu will operate on the active channel. (e.g. Ctrl+Shift+F to filter the channel).

Also when vertical zoom or vertical pan are used via the keyboard they apply to the panel containing the active channel.

The active channel is also used when showing information on a particular channel – for example the datum cursor measurements that are shown in the values window are for the active channel.

- Press Page Up and Down to change channel selection.
- Use the rescale/vertical zoom to horizontally zoom the data.
- Press F9 to change from time mode to distance mode and back again.



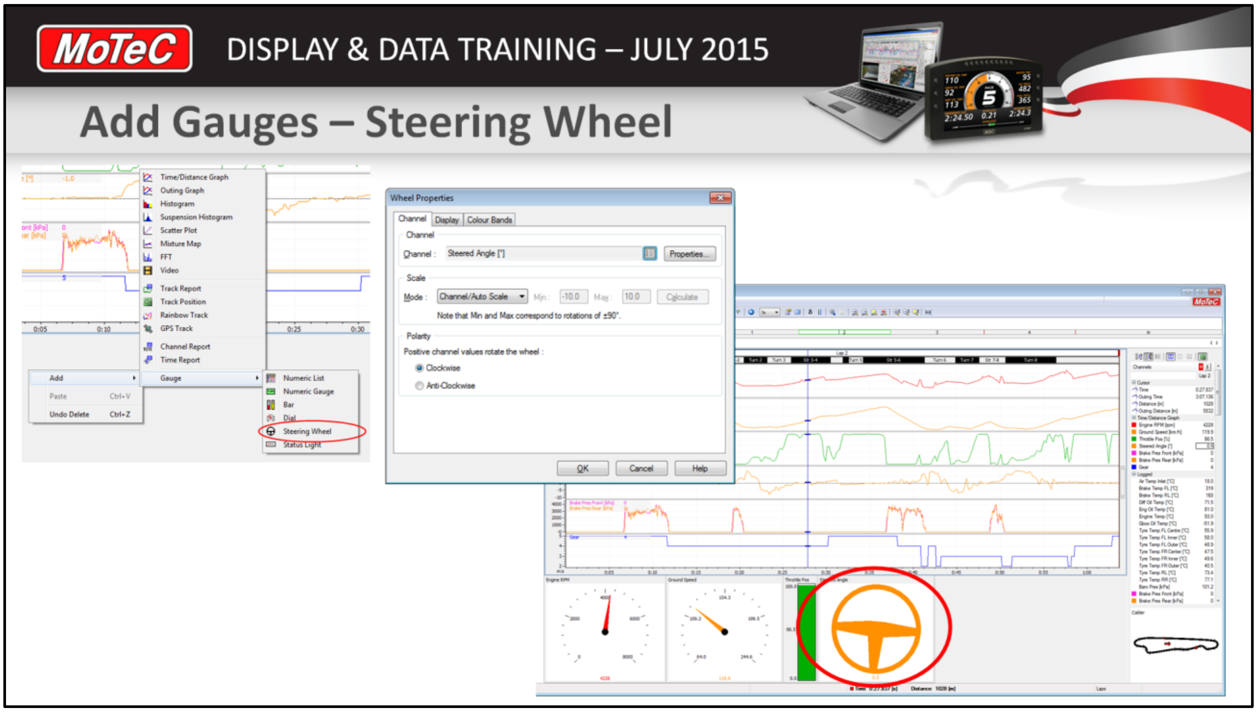
This Worksheet includes a graph as well as a selection of gauges. Gauges are most commonly used when playing back log data.

The shortcut key ‘A’ is used to toggle the animation on/off. The playback rate can be selected from the drop down list in the middle of the toolbar.

The gauges are linked to show the channel value at the current cursor position. This can be moved using the shortcut keys, or by clicking and dragging the cursor along the graph. In its function as a gauge the graph acts as a ‘chart recorder’ with the cursor moving rather than the graph scrolling across the page.

To reorganise the layout in **i2 Standard**, the ‘unlock layout’ box must be unchecked under the Layout Menu.

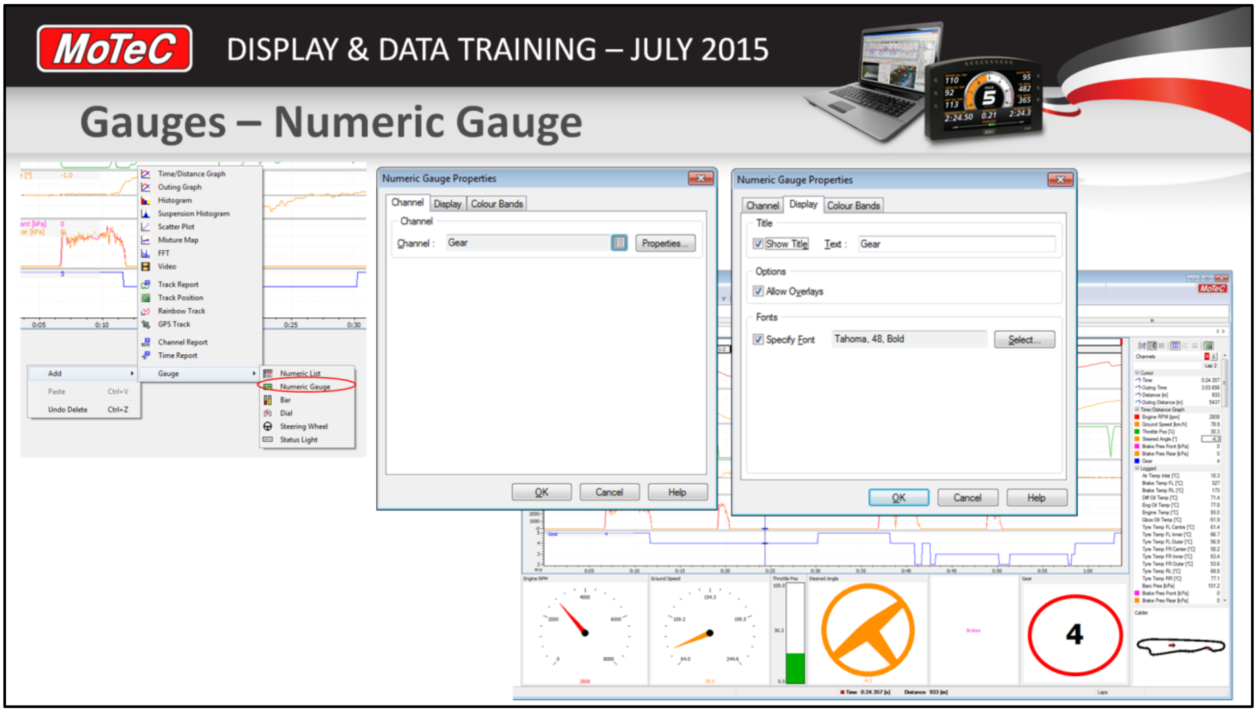
It is also possible to copy and paste components when you are setting up screen layouts.



Right click in the spare space and choose ‘Add’, ‘Gauge’ and ‘Steering Wheel’.

Select the channel to display by selecting the button to the right off the channel box

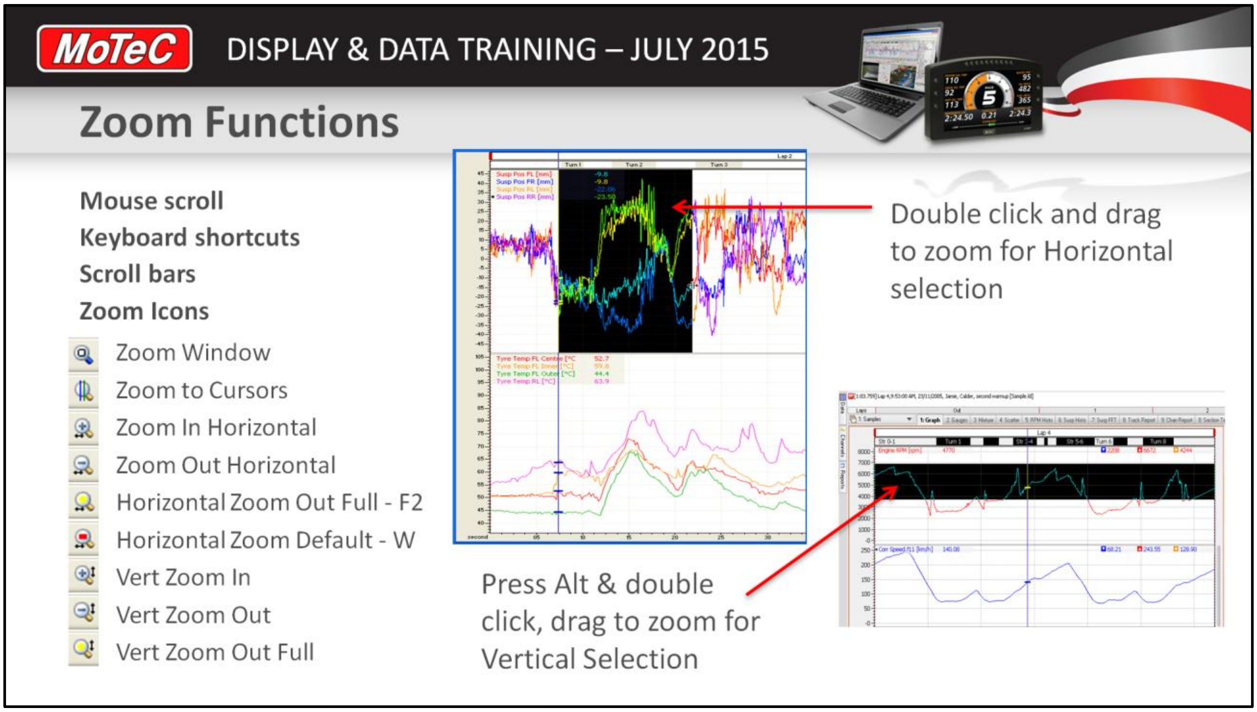
Type in ‘steer’ and double click on “Steered Angle’ then select OK.



Right click in the spare space and choose ‘Add’, ‘Gauge’ and ‘Numeric Gauge’.

Select the channel to display by selecting the button to the right off the channel box

Type in ‘Gear’ and double click on ‘Gear’ then select OK.



Horizontal Zoom

Zoom In and Out is normally performed using the Up and Down arrow keys to zoom around the cursor, or by dragging the ends of the horizontal scroll bar. The wheel on a mouse will also scroll in/out around the cursor. Place the pointer, double click and drag, then click again to zoom to the selected level.

The W key is used to return to the default zoom level, which in the case of lap mode is a single lap. Note that if the cursor is placed on a lap other than the current main lap then the main lap will be changed to the lap that the cursor is in when W is pressed.

The F2 key is used to zoom Full Out’ and show the entire file.

Horizontal Pan

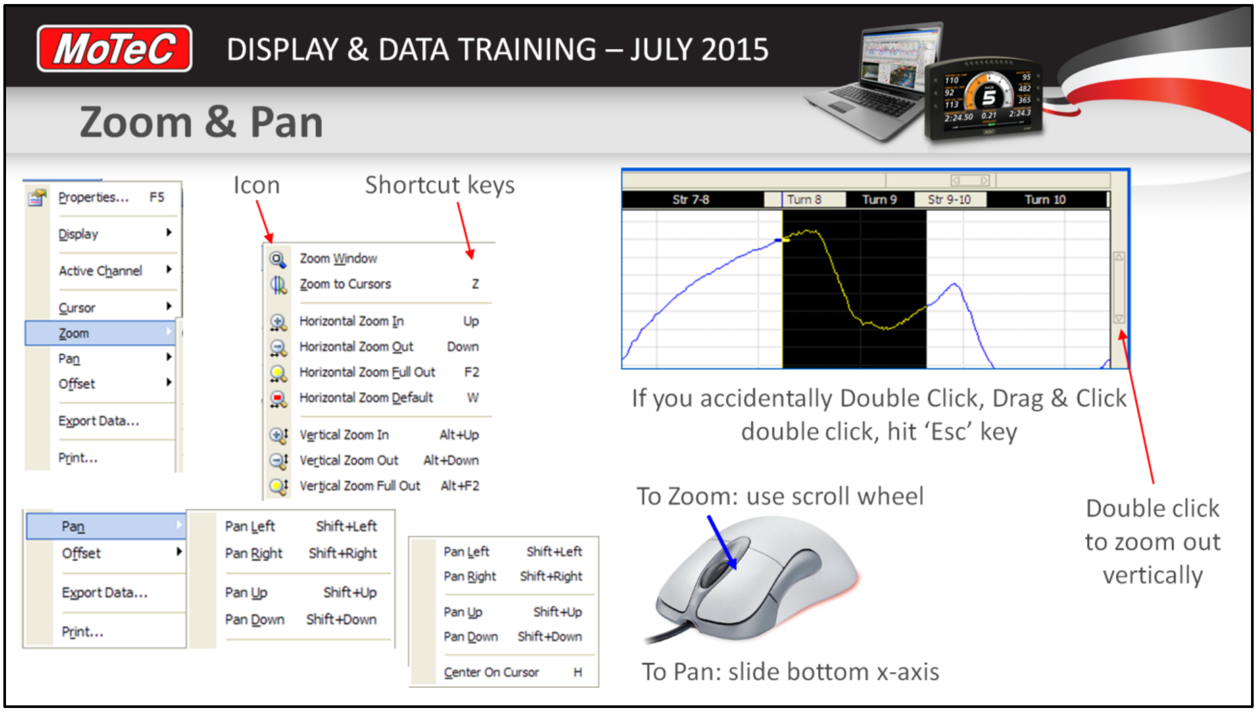
Horizontal pan is performed by dragging the horizontal axis or by dragging the horizontal scroll bar or using the Shift+Left or Shift+Right Arrow keys or the F and B keys (Forward & Back)

Vertical Zoom

Vertical zoom is performed on the panel for the active channel and can be performed using the Alt+Up or Alt+Down Arrow keys, or by dragging the ends of the vertical scroll bar.

Vertical Pan

Vertical pan is performed using the Shift+Up or Shift +Down Arrow keys, or by dragging the vertical scroll bar.


MoTeC
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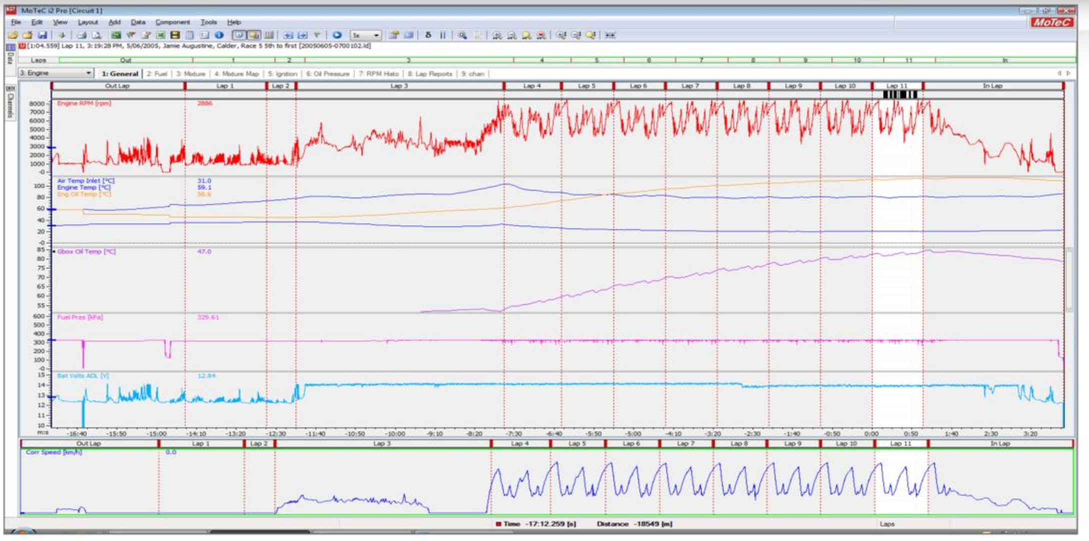
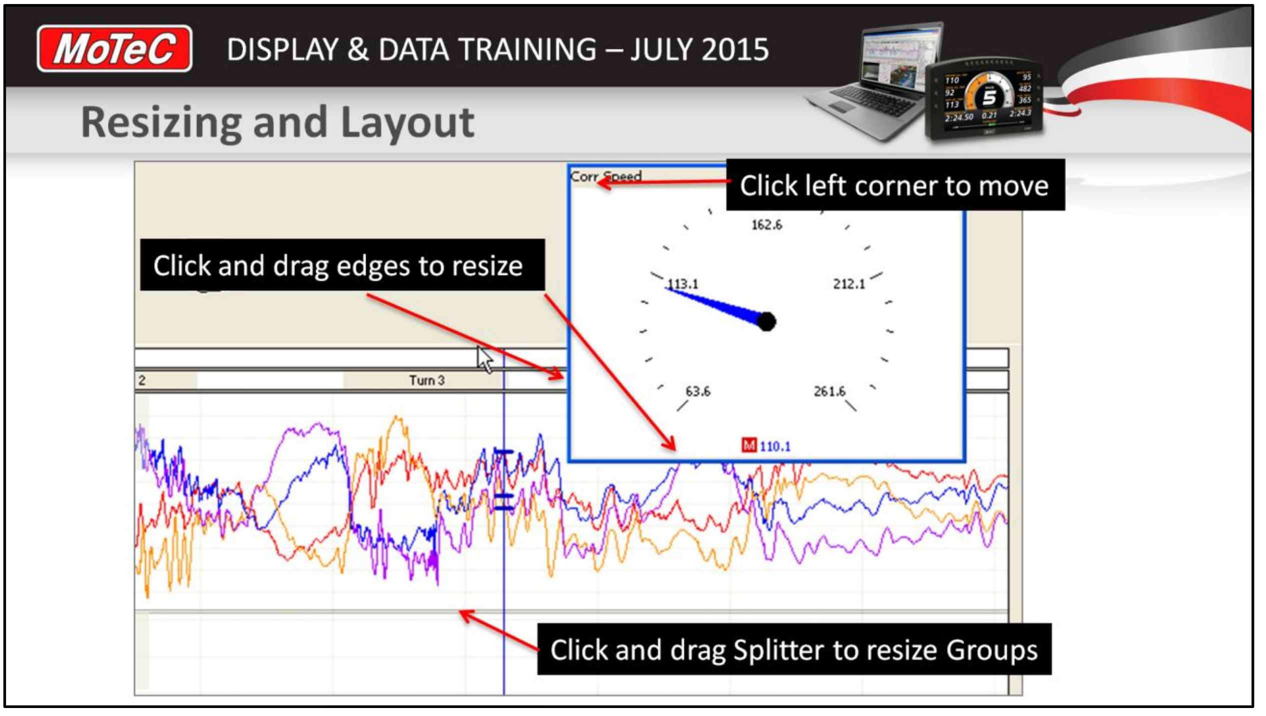
Zoom & Pan
Icon
Shortcut keys
Properties... F5
Display
Active Channel
Cursor
Zoom
Pan
Offset
Export Data...
Print...
Zoom Window
Zoom to Cursors Z
Horizontal Zoom In Up
Horizontal Zoom Out Down
Horizontal Zoom Full Out F2
Horizontal Zoom Default W
Vertical Zoom In Alt+Up
Vertical Zoom Out Alt+Down
Vertical Zoom Full Out Alt+F2
Pan Left Shift+Left
Pan Right Shift+Right
Pan Up Shift+Up
Pan Down Shift+Down
Center On Cursor H
Str 7-8
Turn 8
Turn 9
Str 9-10
Turn 10
If you accidentally Double Click, Drag & Click double click, hit 'Esc' key
To Zoom: use scroll wheel
Double click to zoom out vertically
To Pan: slide bottom x-axis

Zoom Out to Entire Run



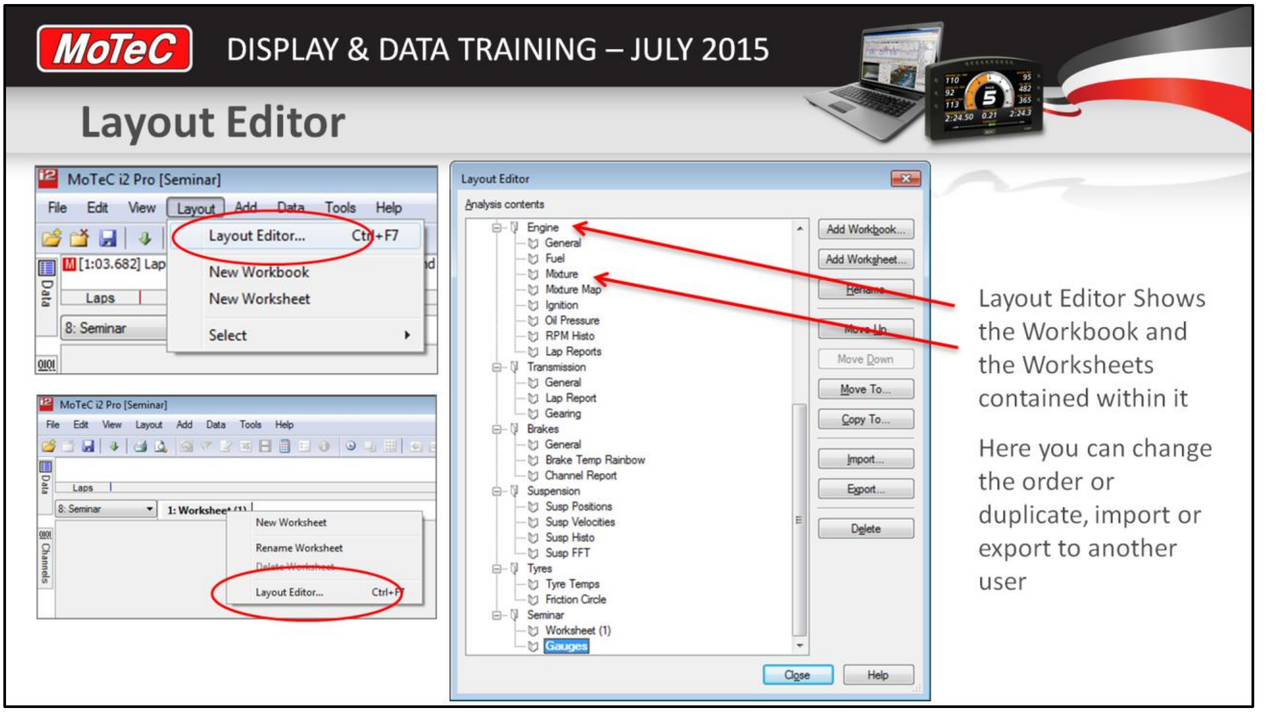
By pressing ‘F2’ you will be able to zoom out to the entire run of your chosen log file. It is useful sometimes to zoom out to see any trends in temperatures or pressures over a complete outing. In the example above Gearbox Oil temperature is increasing throughout the session and may not have reached its peak before the race was ended.



When modifying your layout, you can examine active component properties.

Resize components by dragging edges.

To move component, hover mouse over the top left corner – the mouse cursor will change to a symbol of 4 arrows.

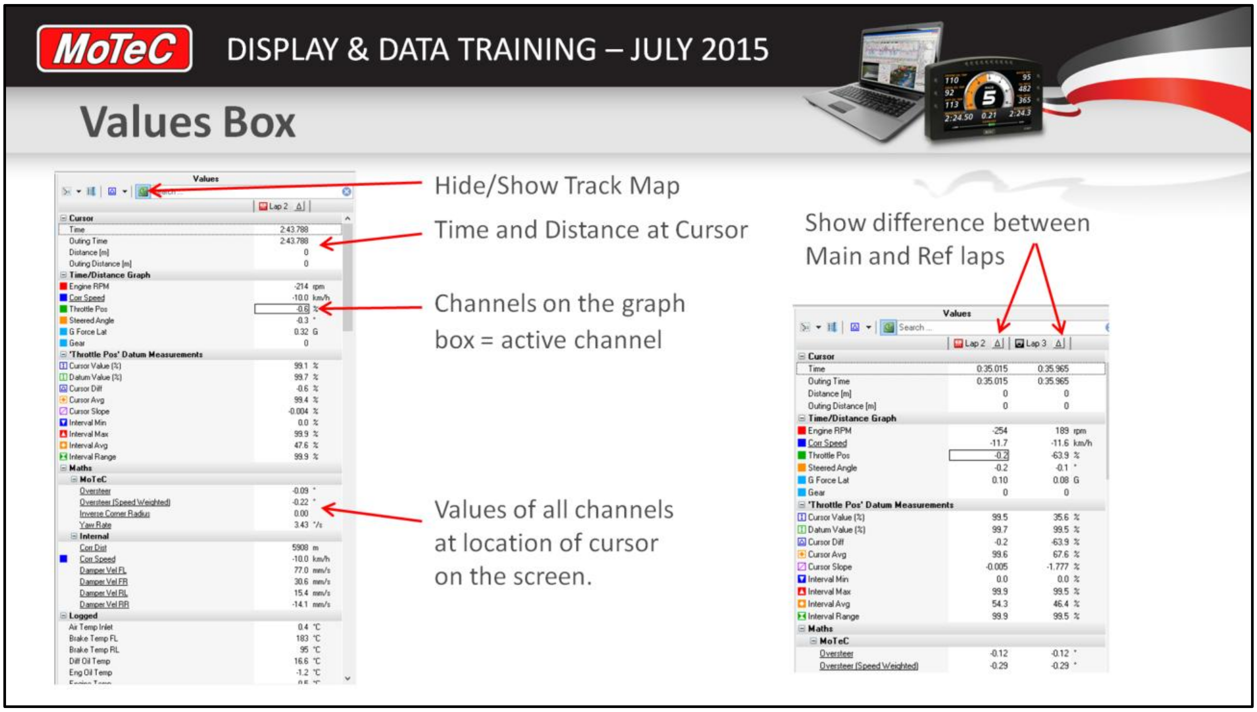


Layout Editor

Press Ctrl+F7 to activate the 'Layout Editor'. The Layout Editor can also be used to rearrange the order of Worksheets and Workbooks as well as rename, delete etc. To rearrange the order of Worksheets, highlight one and click on 'Move Up' and 'Move Down' to change its position.

Workbooks and Worksheets can be 'Exported', to be saved as individual files, so they can be imported into other Workspaces or copied to another PC.

The 'Copy To' function is used to make a copy of a Worksheet in another Workbook.

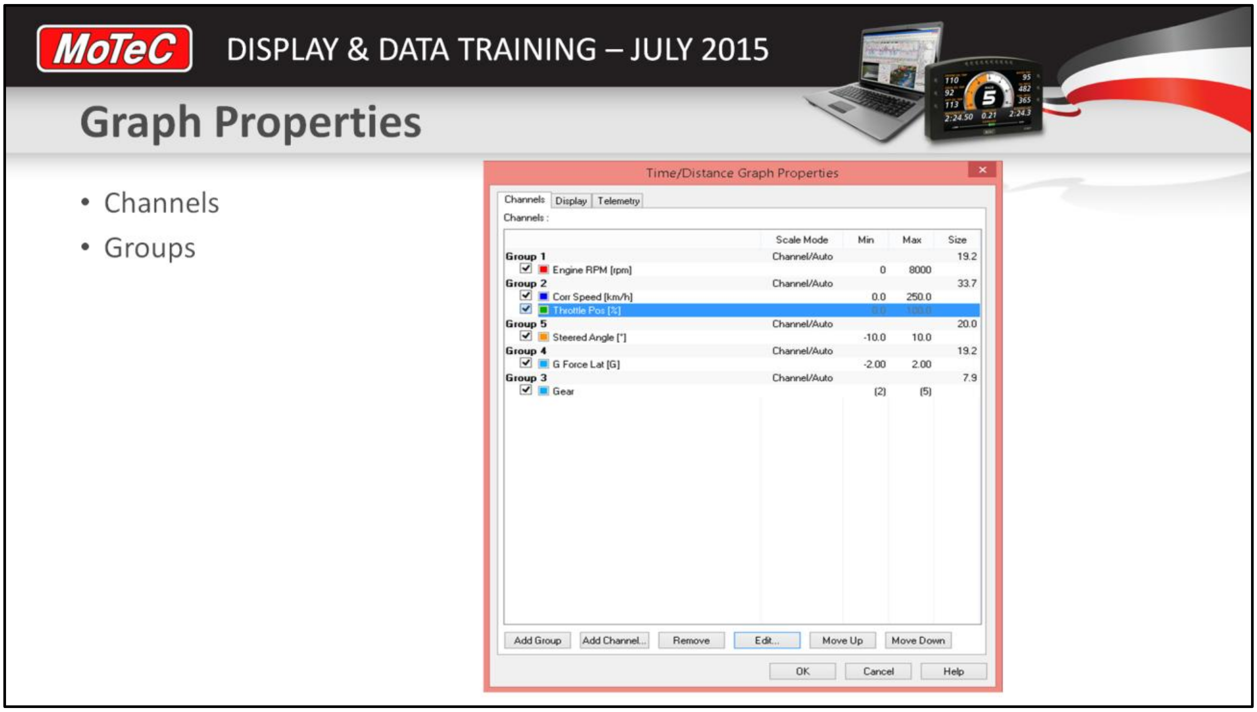


The Values box shows channel values at the cursor for all channels, with those on the focused graph listed at the top. When Reference and Overlay laps are shown, their values are shown in additional columns.

The Values box can be toggled On/Off using the 'V' key.

It is also possible to show the difference between the Main and Reference laps by clicking on the 'delta' symbol at the top of the column. Whichever column is selected is used as a base, with the other columns showing the difference.

In the above example the Main Lap column shows channel values, while the Ref Lap column shows the difference to the Ref Lap.



Channels are divided into 'Groups' according to channel units. Use the Graph Properties page to add groups – which can contain one or more channels, and then add channels to those groups. The 'move up' and 'move down' functions apply to groups and channels.

The Remove function will remove either a single channel or a group, depending on which is selected.

Channel properties such as scaling and colour can be accessed from this screen by double clicking on a channel, or by selecting a channel then hitting 'Edit'. Note that these are global properties and will be applied wherever this channel appears.

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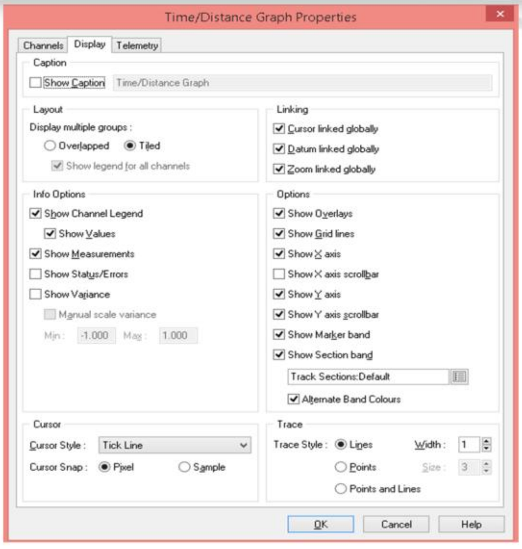
Graph Properties

Display

- Title
- Layout
- Info Options
- Options
- Cursor
- Trace



Display

Sets various options for the appearance of the graph. By default the X axis scrollbar is turned off. Check the box to turn this back on. This adds a scrollbar at the top of the graph window that can be used to move the graph through the data at the current zoom level. Measurements, Variance and Status/Errors can be toggled with the 'M', 'F3' and 'E' keys respectively. The graph properties can be used for default settings.

Overlapped

Shortcut key 'G' toggles between Overlapped and Tiled mode. When overlapped, all groups are displayed together as though on one graph. Each group still has separate Y axis scaling that can be set by making a channel in that group active then using the scroll bar.

Cursor & Trace

Select the cursor type, this is selectable for each graph. The traces can be lines or individual data points, line width can also be specified. Showing individual samples allows you to quickly determine if a channel such as damper position is being oversampled.

Linking

By default the cursor is linked across all Worksheets and books. This means that a cursor position set on one Worksheet will be in the same position on another Worksheet. To change this, go to the particular display element properties (F5) and under 'Mode - Link Options' uncheck the box 'Cursor Linked'. The cursor will now be 'local'.

Similarly for the Datum cursor – it can be Datum linked to be in the same position on multiple graphs. More on the Datum cursor later.

By default all components are also 'Zoom Linked', when the zoom level changes on a graph, linked components will display data based on the selected zoom level. It is possible to uncheck this option so that a graph can be zoomed independently from other display components.

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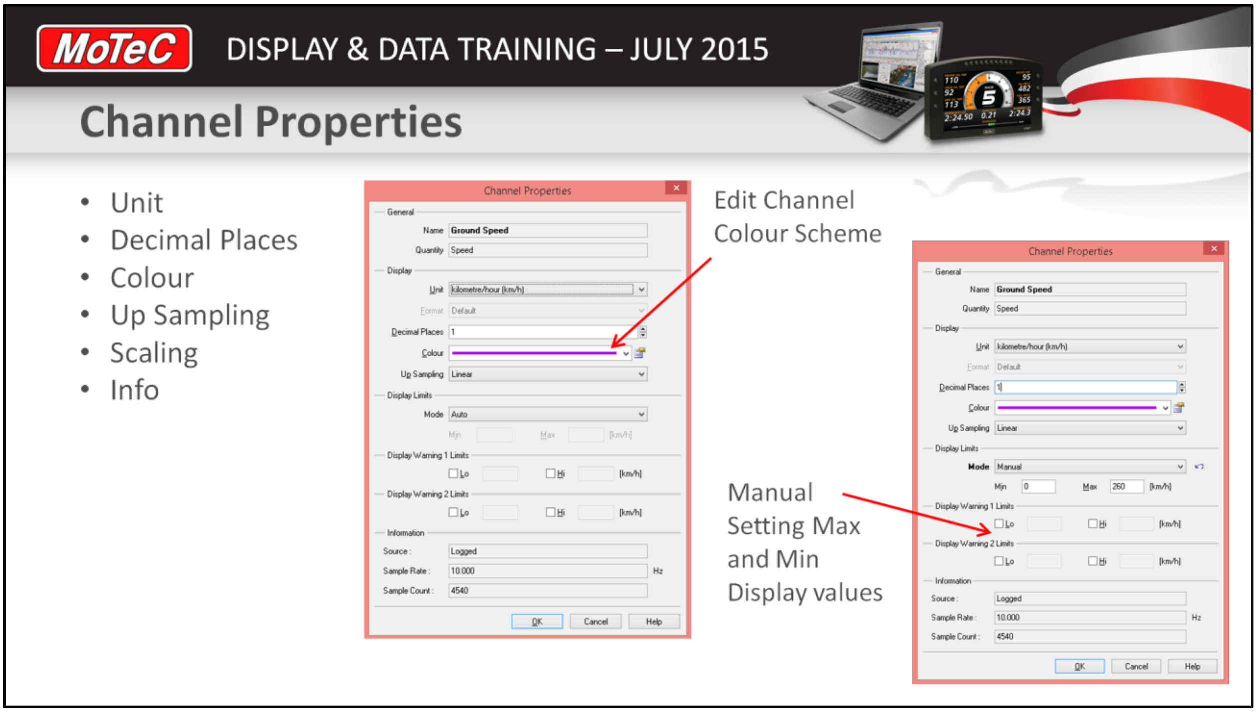
Graph Properties

- Telemetry
  - Zoom Settings

Global Zoom settings are defined under Tools/Options.

All graphs use these settings unless local settings are defined, then these only apply to this graph.



Channel properties such as scaling and colour can be accessed from this screen by double clicking on a channel, or by selecting a channel then hitting ‘Edit’. Note that these are global properties and will be applied wherever this channel appears.

Channel Name and Quantity (unit type) are shown at the top, these cannot be edited.

Unit: Display units on all components

Decimal Places : Displayed on all components

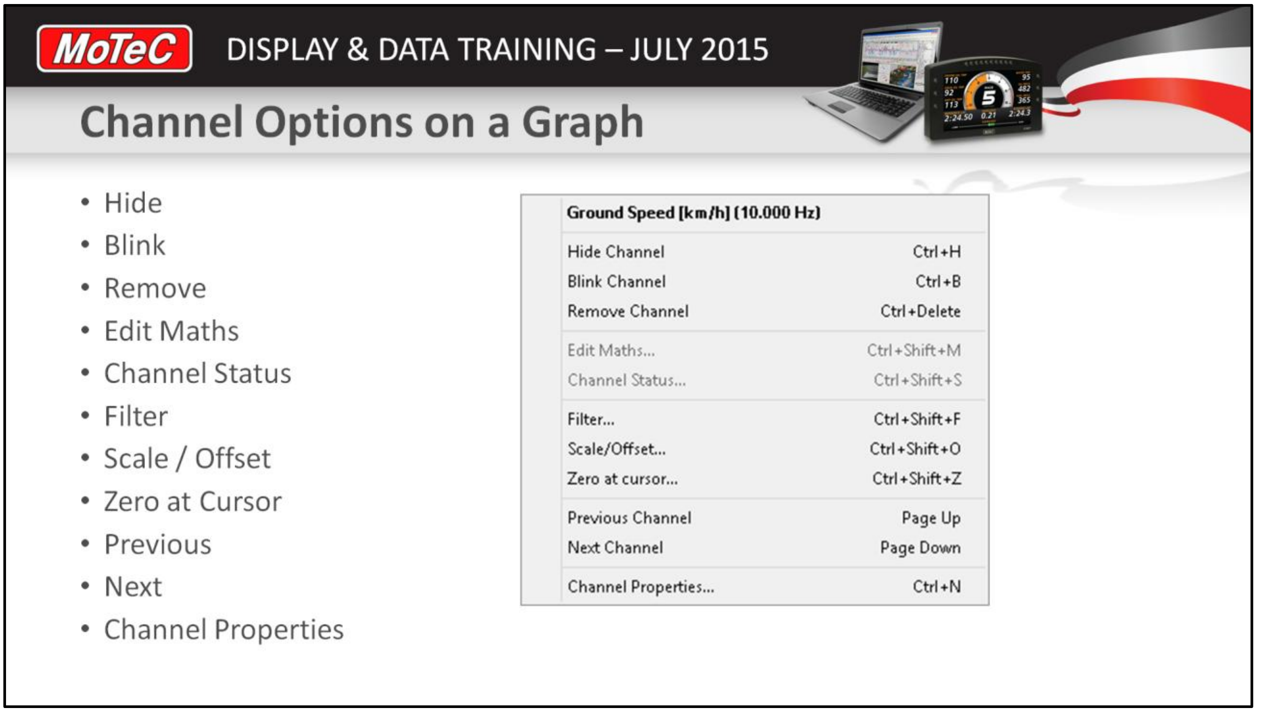
Colour: The channel will be the same colour in all graphs and gauges. 8 colours are available in a colour scheme, these can be changed by clicking on the icon next to the channel colour selection. There are also complete colour schemes that can be loaded, e.g. black backgrounds. See ‘Tools – Options – Colours’ and then ‘Select Scheme’. You can also add colours to your channel colour selection in the same place.

Up Sampling: How lines are drawn on a graph between sample points. By default this is linear, meaning that a straight line is drawn to join data points. This is generally what you would use, except for on/off channels such as Brake Status.

Scaling: Manual: A min and max value may be set for each channel. This allows the components to use common scaling avoiding the need to set the min and max for every component. Auto: the various components will auto scale the min and max scale unless they are specifically set to manual scale. Auto scaling can be bad for noisy data as it often expands the trace out beyond the area that you would like to see anyway.

Information: General information about the channel - Source Type, the sample (log) rate and number of samples in the file.

A complete list of channels can be found under ‘Tools – Channel Editor’, the properties for any channel can then be edited from this screen.



Right click on a channel name to see the above menu. At the top is shown the channel name along with the logging rate.

Hide channel: removes the trace from the graph, but leaves the label and channel value.

Remove channel: removes the channel from the graph. If there are no other channels in the group, the group will be removed and others automatically expanded to fill the available space.

Edit Maths: is greyed out unless there is a filter or Scale/Offset applied to the channel

Filter: a channel can be filtered by time or number of samples. This filter is temporary while i2 is open and will be lost the next time i2 is loaded.

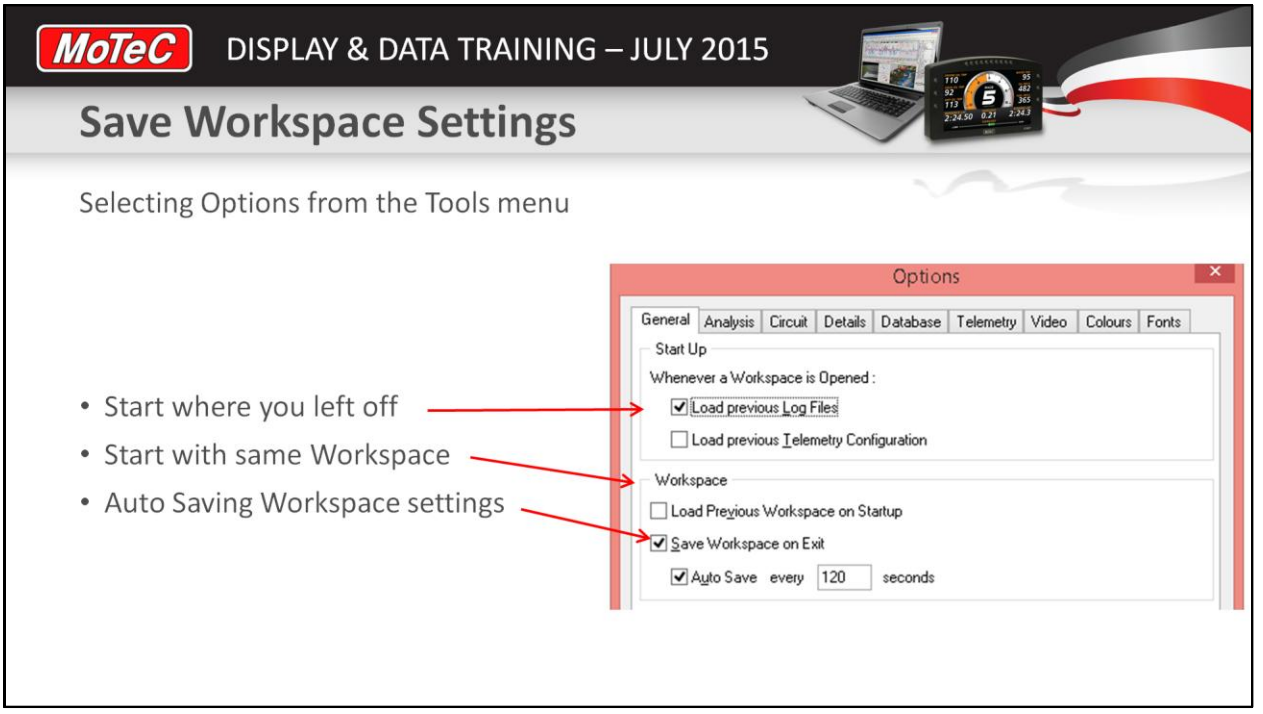
Scale and Offset : Correct or adjust data. Changes are stored as local file maths.

Zero at Cursor: Correct sensors that have not been zeroed. Changes are stored as local file maths.

Previous Channel: Make previous channel on graph the active channel

Next Channel : Make the next channel on the graph the active channel

Channel Properties : display the channel properties window



At any time go to ‘File – Save All Settings’.

Under ‘Tools – Options’, there is an option to enable ‘auto-save’ of settings at a specified time interval. Additionally, all changes are saved automatically when exiting the program

General Tab Save Options

The project settings can be Saved on Exit of i2 and at regular intervals. If the Save on Exit feature is tuned off, i2 will ask if the changes should be saved or not.

Analysis

Load data after device unload – data can be downloaded directly from i2 by going to ‘File – Get Logged Data’. When this option is checked, that data will be loaded into i2 automatically.

Autoscale options

In general for circuit racing untrusted data is from in/out laps. This data is not used in auto scale as it often contains values outside that seen during a race.

Telemetry Tab

Video Tab

Codec Preference

When you play a video in **i2 Pro** the codec used will determine the visual quality and playback performance.

There are many codecs available and their performance varies widely. To achieve consistency in playback quality within **i2 Pro**, MoTeC recommends the MainConcept codec.

The Download Codec link will connect you to the MoTeC website where you can download the MainConcept codec. (Internet connection required).

Colour Tab

Change individual colours or select an overall colour scheme.

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Histograms

Used to interpret data in other formats

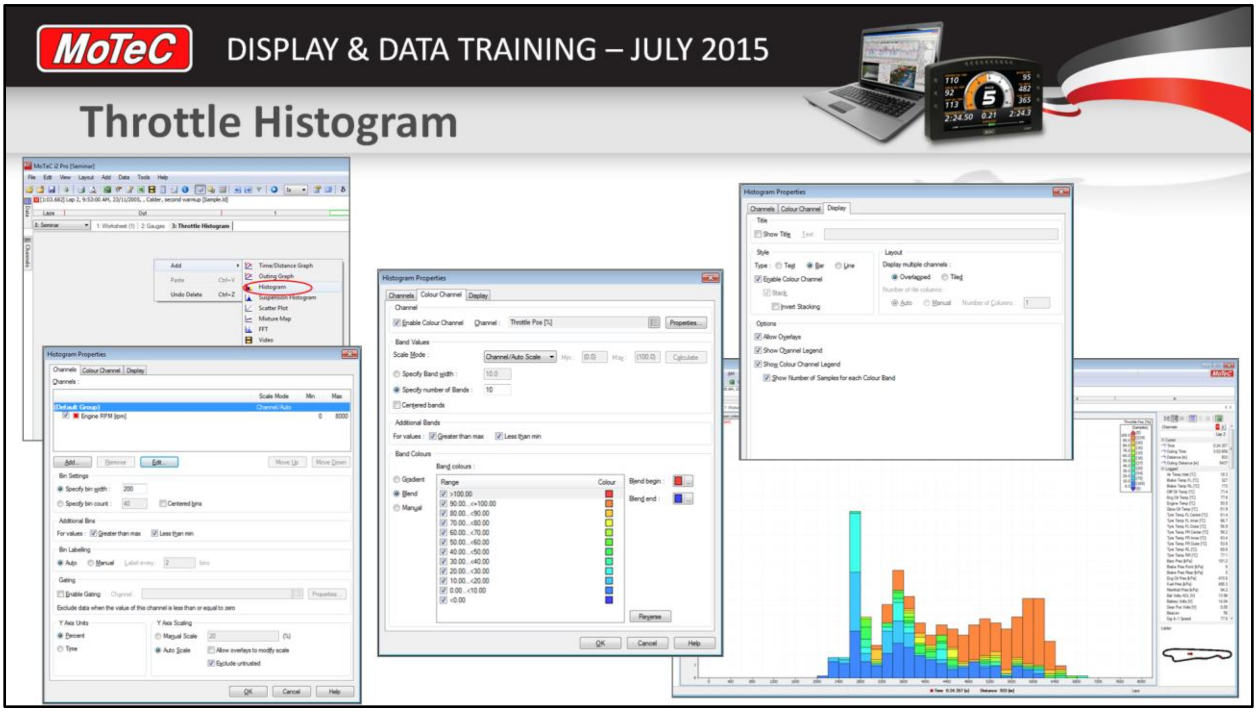
This function provides a Histogram of any channel(s) from the current file.

For example: If RPM is selected, it can be useful in determining where the engine is spending most of its time and therefore identifying where the development effort should be targeted, as well as identifying maximum revs and the duration of time spent there.

The Histogram can be viewed as a chart, individual bar graph and a stacked bar graph. The values shown can be a percentage of the time shown or actual time in seconds. This can be selected in the Properties section (press F5).

The duration of the Histogram can be for a single lap or the entire logged session. Use zoom functions on a graph to select the time period you wish to view, i.e. the outing graph above is used to control which part of the outing the histogram is being calculated from. This can be changed using the normal zoom keys, up/down or the mouse thumbwheel.

For example: A histogram of the gear channel to show how much use each gear is getting – determine when to replace parts.

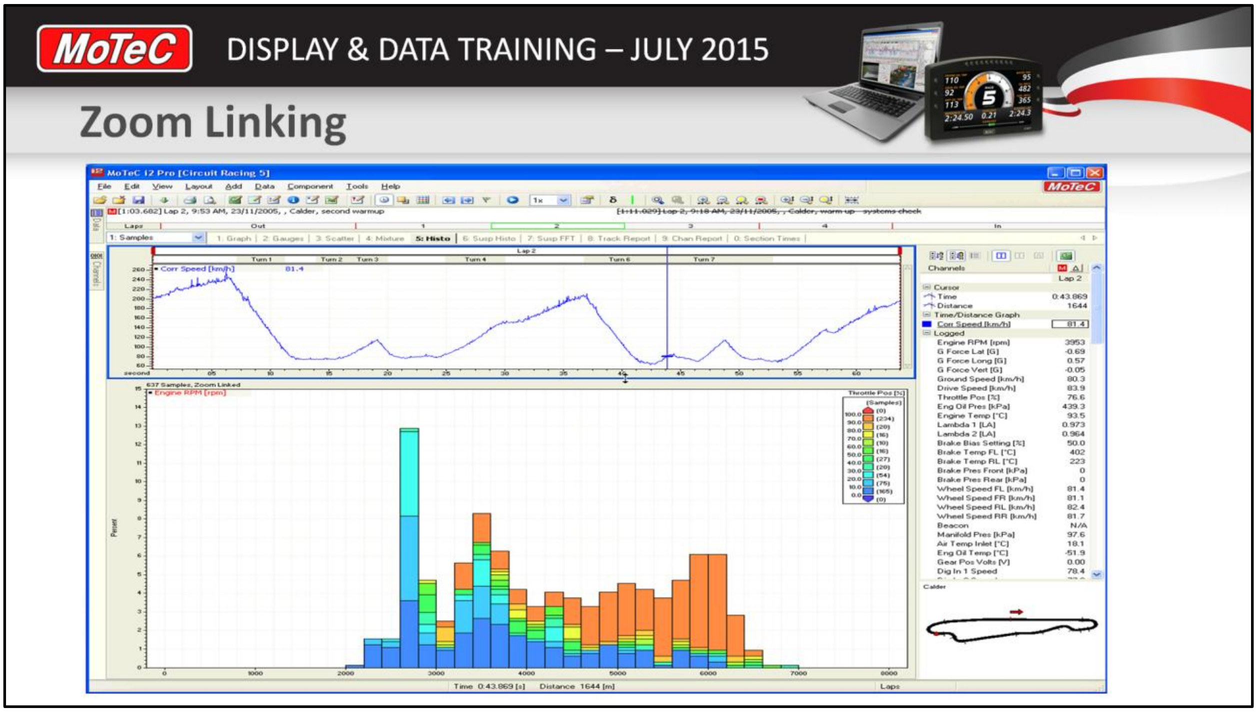


The Histogram consists of a user definable number of bins that the logged data is placed into which shows how often a certain channel values have occurred.

The histogram may be displayed in various styles: bar, line and text and may be optionally colour coded against another channel. For example: If RPM is selected, it can be useful in determining where the engine is spending most of its time and therefore identifying where the development effort should be targeted, as well as identifying maximum revs and the duration of time spent there.

Colour Channel

The histogram may be colour coded against another channel. The bar chart ‘stacks’ are divided according to the value of another channel, e.g. throttle position on top of engine RPM as above. In the Histogram Properties, select the ‘Colour’ tab, then select the secondary channel. The rest of the page gives options for the colour channel range and the number of colour bands.



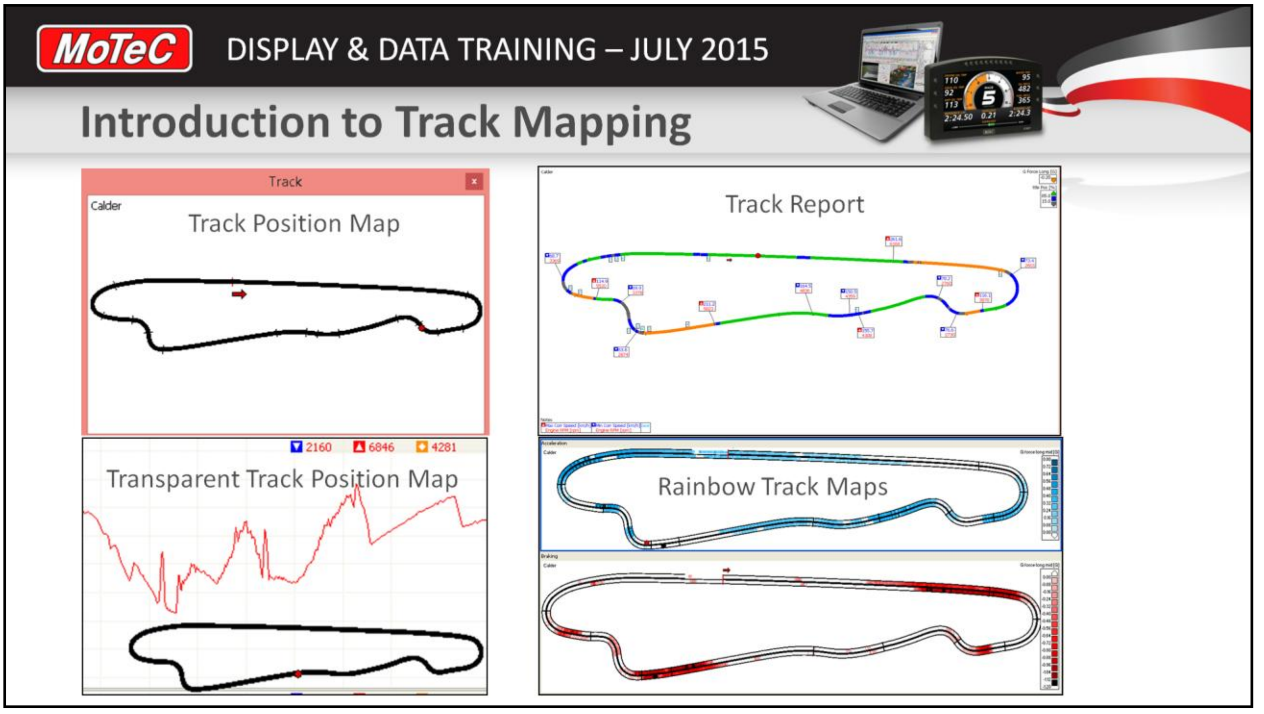
Zoom Linking

The data that is displayed is normally for the currently selected range (normally a run or a lap). All graphs, histograms, track reports, FFTs, Scatter Plots and Mixture Maps are ‘Zoom Linked’. This means that changing the zoom level on one graph will change the zoom level on all graphs. This changes the amount of data shown on the other linked display elements. This allows you to zoom in on one corner, for example, and view the suspension data just for that area.

Display elements are also ‘zoom linked’ across Workbooks/sheets. This way you can change the zoom level on one sheet and then see the same data section on another sheet.

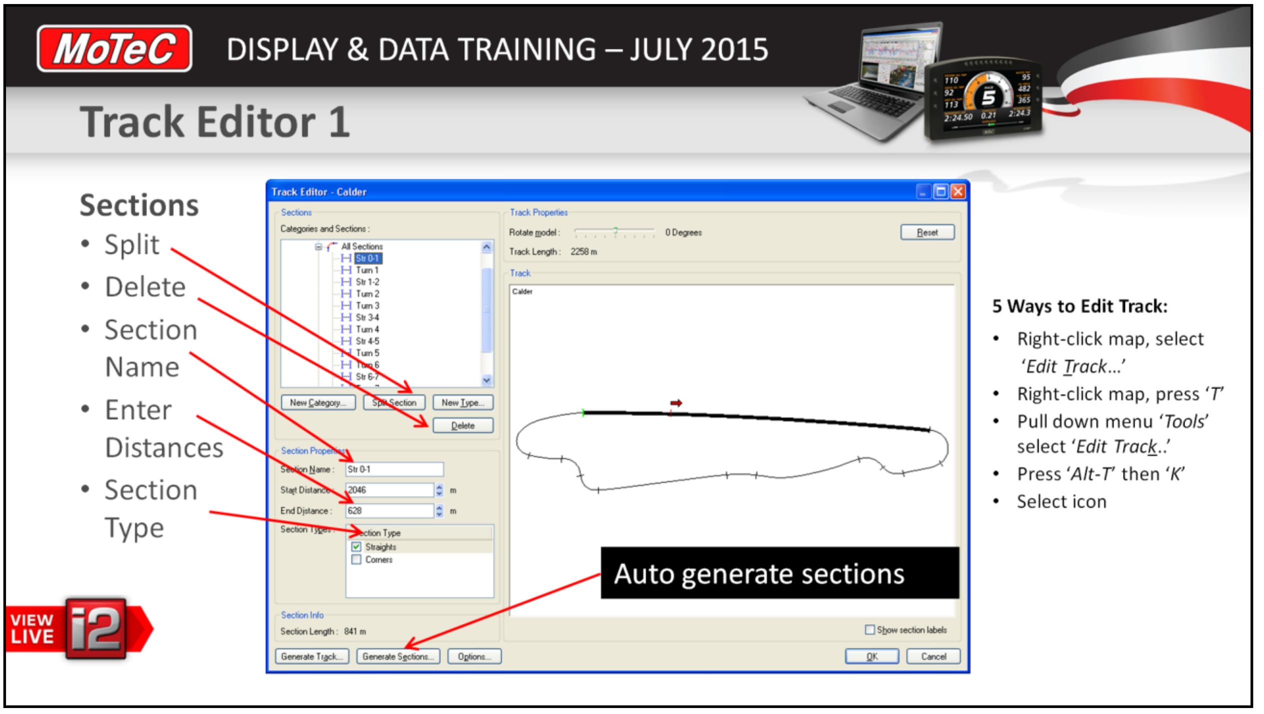
For display components such as Scatter Plots and Histograms, the shortcut keys ‘F2’ and ‘W’ still apply. To zoom within a lap or across multiple laps use a graph to select the zoom level.

It is possible to disable zoom linking for a specific component by going into the Properties page and un ticking the box for ‘Zoom Linking’.



A track map provides a graphical representation of the venue at which the logged data was acquired. For this function to be available it is necessary for the following inputs to be logged: lateral G force, vehicle speed and a lap beacon. Or GPS data and a beacon. The software will then derive a map based upon the driving line of the fastest lap in the log file. The map allows the user to relate the data to the specific track position where an event has occurred.

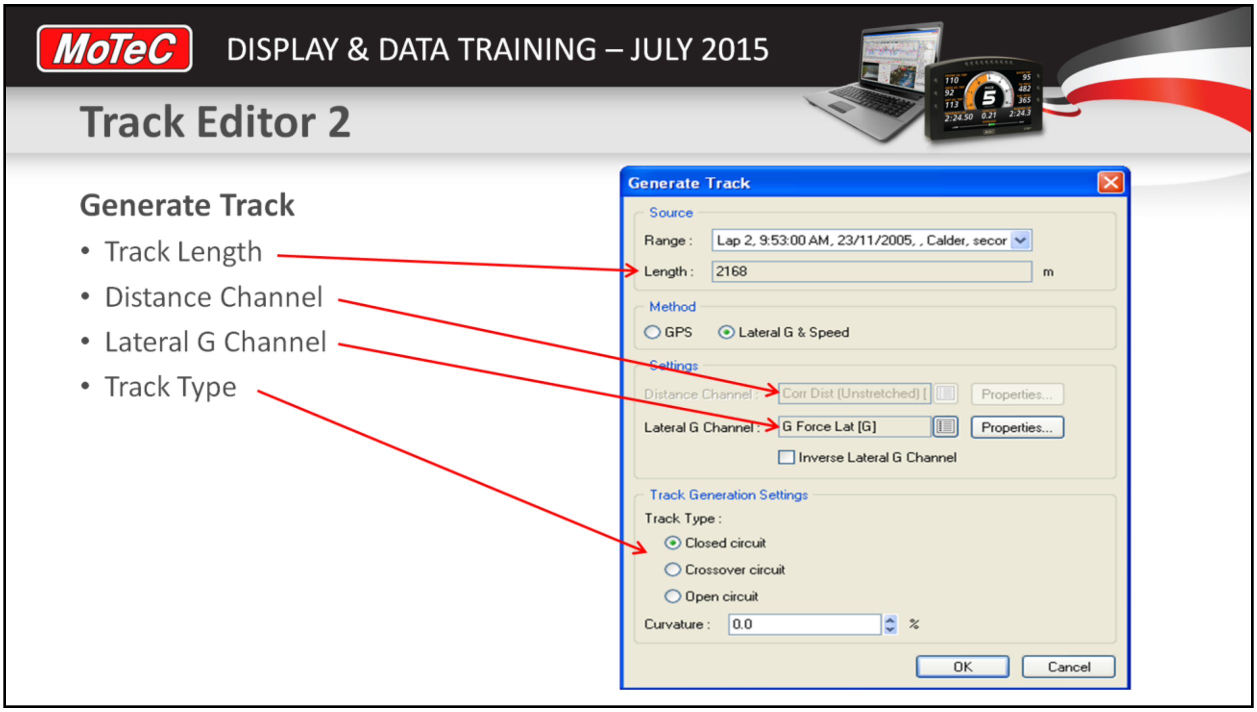
In i2, track maps can be used to show a graphical representation of data logged in the log file. It can of course show the channels Throttle position, Brake Active and Gear, but can also be used to show oil pressure across a lap, or braking pressures for instance, as shown in the rainbow track map examples above.



The Track Editor is used to generate/regenerate a track map, create/modify sections and add new section categories. These can then be used to generate a time report or channel report, e.g. divide the track into 3 sectors for a time report.

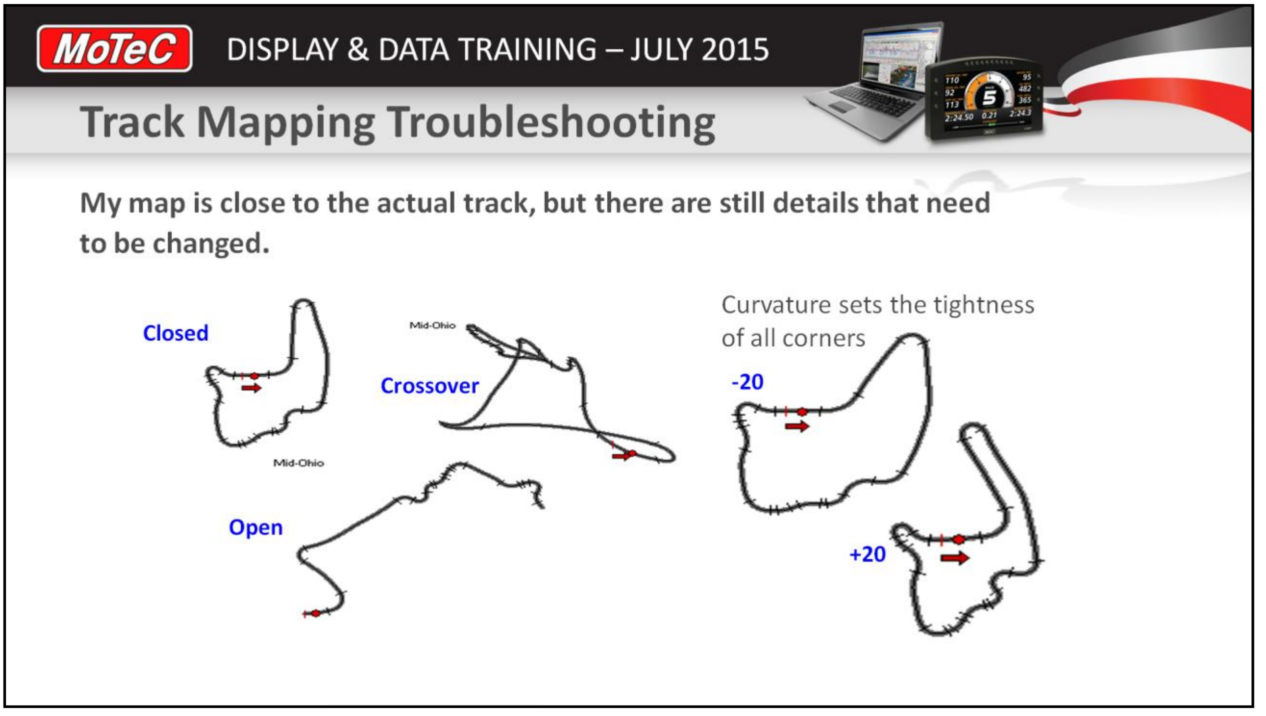
The Track Editor can be accessed from the menu 'Tools – Track Editor', by right-clicking on a track report and selecting 'track editor', or by right-clicking on any track map and selecting 'track editor'.

A track map will automatically be generated from data from the fastest lap that is selected on a venue for which no track map currently exists.



Distance Channel is 'Corr Dist' by default and lateral G is 'G Force Lat'; other channels can be selected using the button next to the channel name. There is an option to use an invert of the lateral G channel if the sensor calibration had been reversed. The track length can be entered manually or use the calculated length of the current lap. If the length is changed, the shape will remain the same, but the map is rescaled to the new distance.

Note that after regenerating a track map, the sections may need to be recalculated. This is done from the main Track Editor page. Again the distance and lateral G channels can be selected, along with a 'lateral G threshold'. This determines the changeover value between straights and corners.



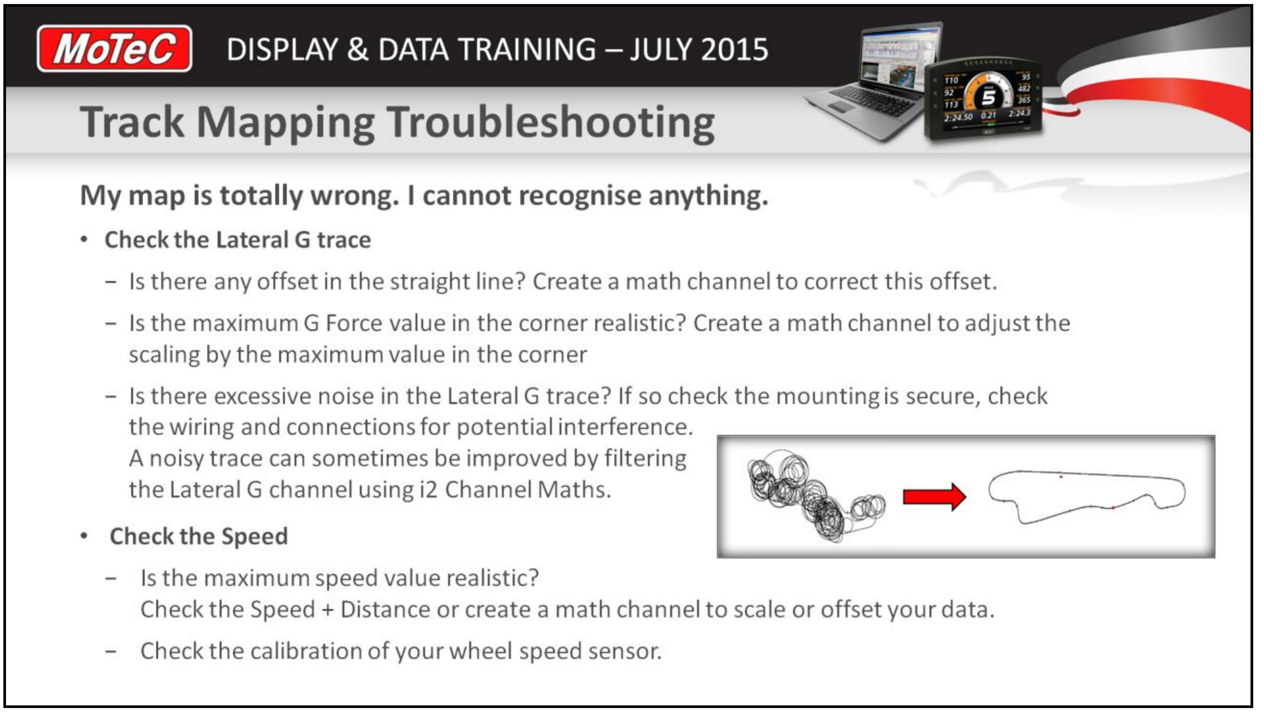
It is not the right type of track: When the track map is displayed, right click on the track. Select ‘Track Editor’ and then click ‘Generate Track’ button, choose between Closed, Crossover Circuit or Open Circuit.

The orientation of the track is wrong: When the track map is displayed, right click on the track. Select ‘Track Editor’. Use ‘Rotate Model’ slider.

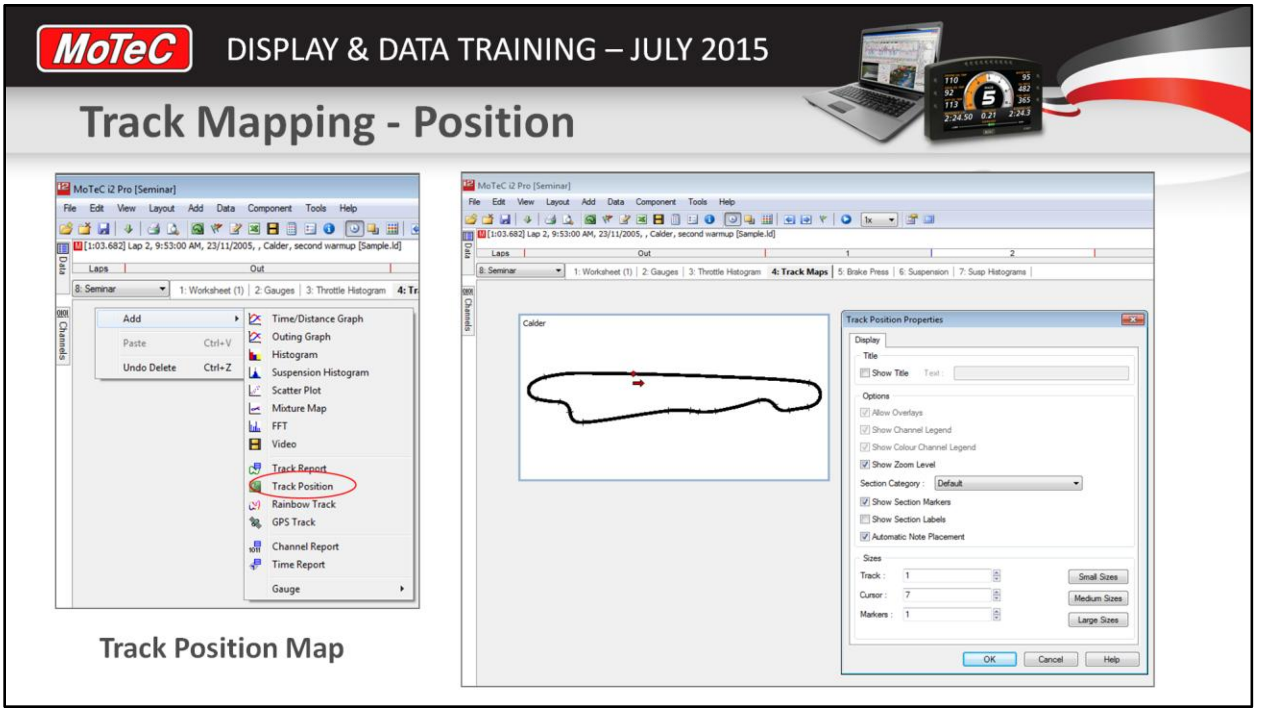
The ‘Curvature’ parameter will alter how ‘sharp’ the corners are, a positive number will make the turns tighter, a negative number will do the opposite. This number can be set between –100 and +100.

This is sometimes required due to low sampling rates that distort the shape of the circuit slightly and hence this feature enables us to either ‘fatten’ or ‘thin’ the circuit down as required

The radiuses of the turns are either too small or too large: When the track map is displayed, right click on the track. Select ‘Track Editor’ and then click ‘Generate Track’ button, the curvature can be adjusted.



Open the logging and display the Lateral G, Longitudinal G (if fitted) and Wheel Speed. If either of these will not display then they are probably not being logged and the map will not be drawn, check your Dash Manager setup and your sensor wiring.



Select the Workbook 'Samples, then add a new Worksheet by right clicking on the Worksheet name area.

Call this sheet 'Track Maps', then right click on the page, then select 'Add', 'Track Position'.

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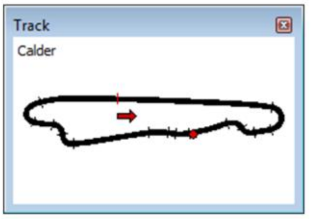
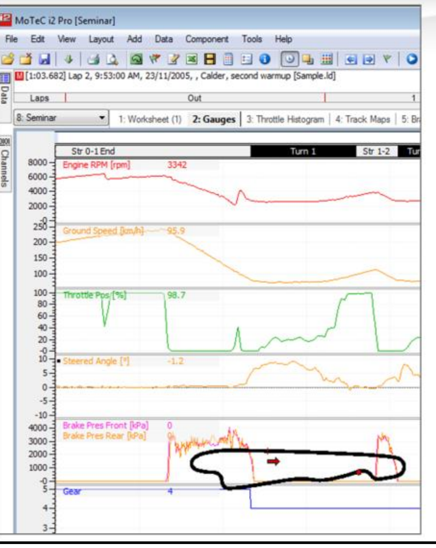
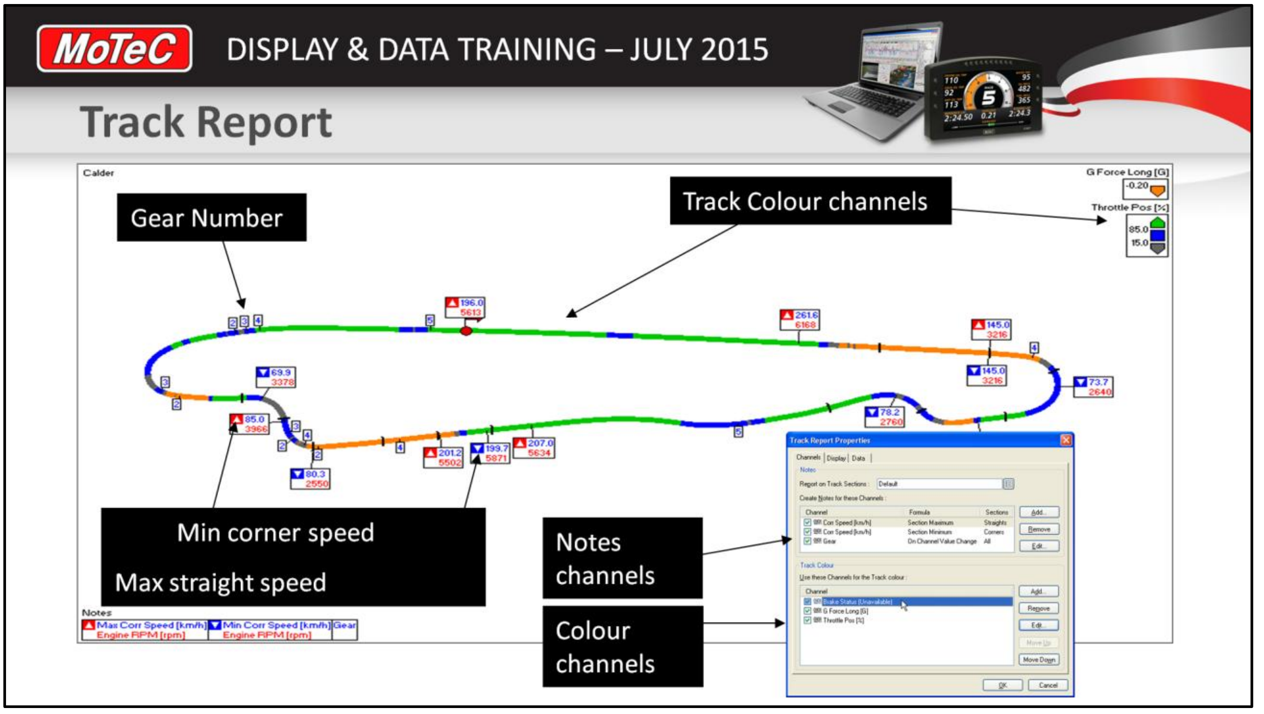
Track Mapping - Transparent

- Pressing ‘T’ will bring up the Track Display Box
- Dragging the box you can move it on the screen to a position that suits your data layout.
- Now Press ‘Ctrl + Shift + T’ to make the map transparent







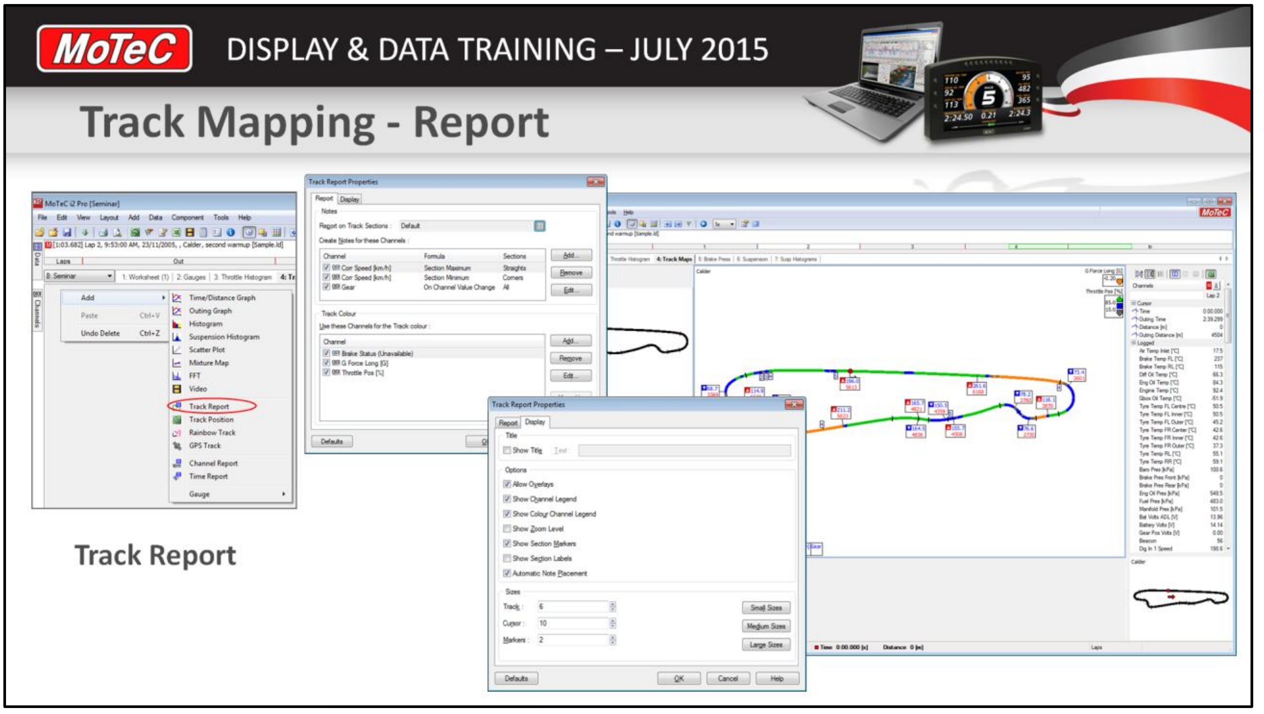
The Track Report shows channel statistics on a Track Map based on track sections. The channels shown are fully configurable with a statistical calculation performed over the section in question.

Press ‘F5’ to see report properties and select the channels shown. They can also be displayed for a particular section type only, e.g. Max Speed on the straights, Min Speed on the corners.

The report may use the default sections or user defined sections. The notes point to the position on the track at which the event occurred. This means that engine RPM is shown at the point of maximum speed, for example.

The notes may be moved by dragging them if their positioning is not suitable. It is worth remembering that once a note is dragged, all others will maintain their positions until ‘Automatic Note Placement’ is reselected under Properties - Display.

Additional channels can be used to ‘colour’ the track. These are added in layers with a channel lower in the list only being visible if the channels above it are not being displayed at that point.



Right click on the page, then select 'Add', 'Track Report'.

The Notes: The Notes (value boxes) can be shown for each section of the track or at the point that the channel changes. The section notes may show various channel statistics for each section such as min max or average. The Note may also show the value of other channels at the same point in time where the statistic occurred, for example a Note may be configured to show maximum speed for the section, in this case it may be useful to show the Engine RPM at the same point in time.

Report On Track Sections: The sections used for the report may be selected to base the report on the default sections or on user defined sections.

Report Formulas: The following formulas are available:

- Section Average
- Average channel value for the 'Report on' range
- Minimum
- Minimum channel value for the 'Report on' range
- Maximum
- Maximum channel value for the 'Report on' range
- Absolute Maximum

Maximum 'absolute' (maximum positive or negative) channel value for the 'Report on' range

Value at Start: Channel Value at the start of the 'Report on' range

Value at End: Channel Value at the end of the 'Report on' range

Value Change: The change in value between the start and end of the 'Report on' range.

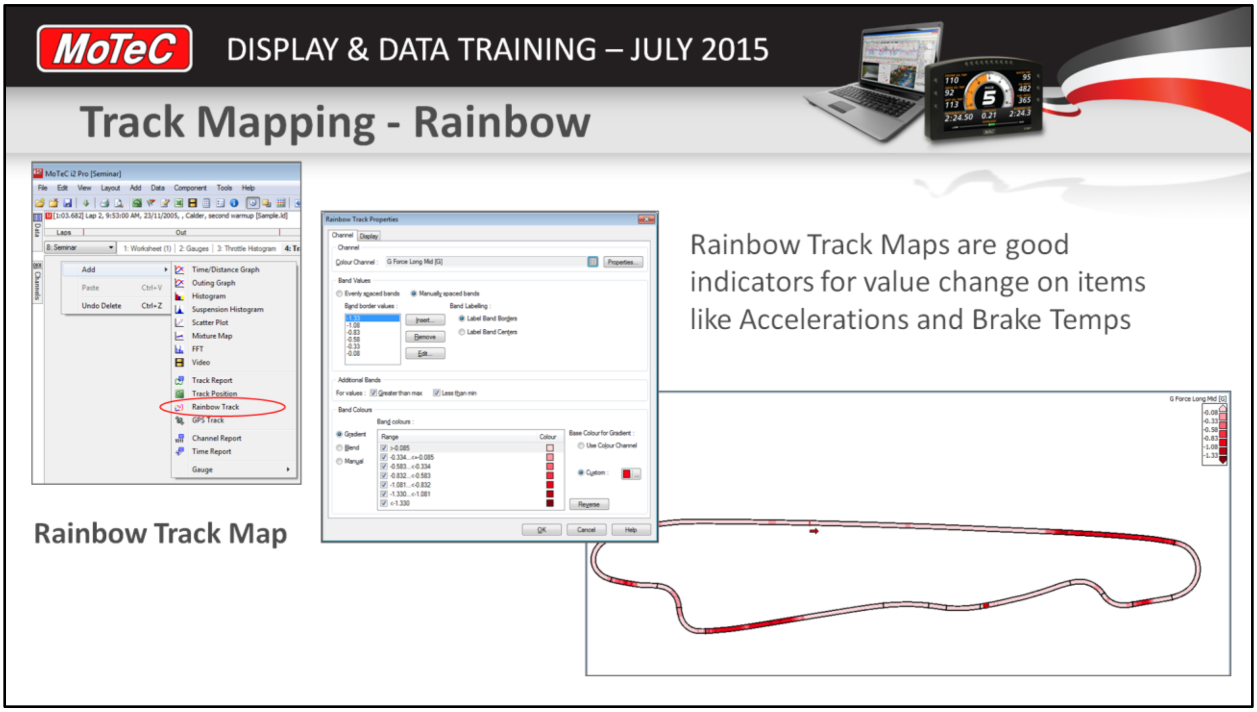
Standard Deviation: The standard deviation of the channel value for the 'Report on' range.

On Channel Value Change: Shows a note every time the value changes. This is useful for channels that change infrequently such as gear. This formula ignores the report on range.

Filter by Section Type: Each note can be filtered by section type. For example if the Report On range is set the default sections then the notes can be filtered by Corner or Straight, this means that notes will only be placed for the section types specified in the filter.

Moving the Notes: The notes may be moved by dragging if their positioning is not suitable. Once a note is dragged, all notes will maintain their positions until **Automatic Note** placement is re-selected from the component menu.

Track Colour Channels: The track can be rendered in a colour gradient according to one or more channels. When using more than one channel, the colours are layered. In this case the channel on top must include gaps so that the channel below can be seen. For example the brake status can be setup such that it only shows colour when the brake is applied allowing the channel beneath to be seen during the non-braking periods. The default configuration for the track report shows how to do this. The channel that is first in the list is the channel that is rendered on top.



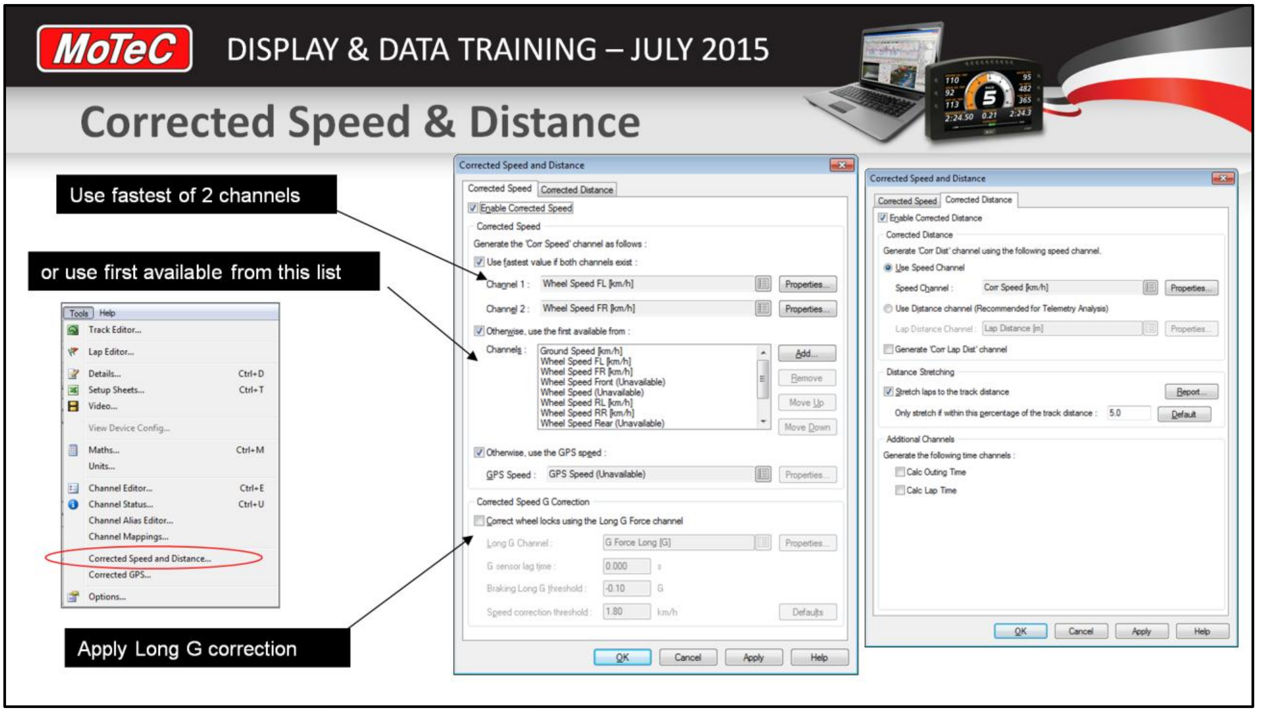
Select the Workbook ‘User’, then add a new Worksheet by right clicking on the Worksheet name area

Call this sheet ‘Rainbow Track Map’, then right click on the page, then select ‘Add’, ‘Rainbow Track Map’.

Click on the button to the right of the ‘Colour Channel’ box, and choose ‘G Force Long’

Click on the number of bands, and change it to 5, click the ‘Reverse’ button, then finish with ‘OK.

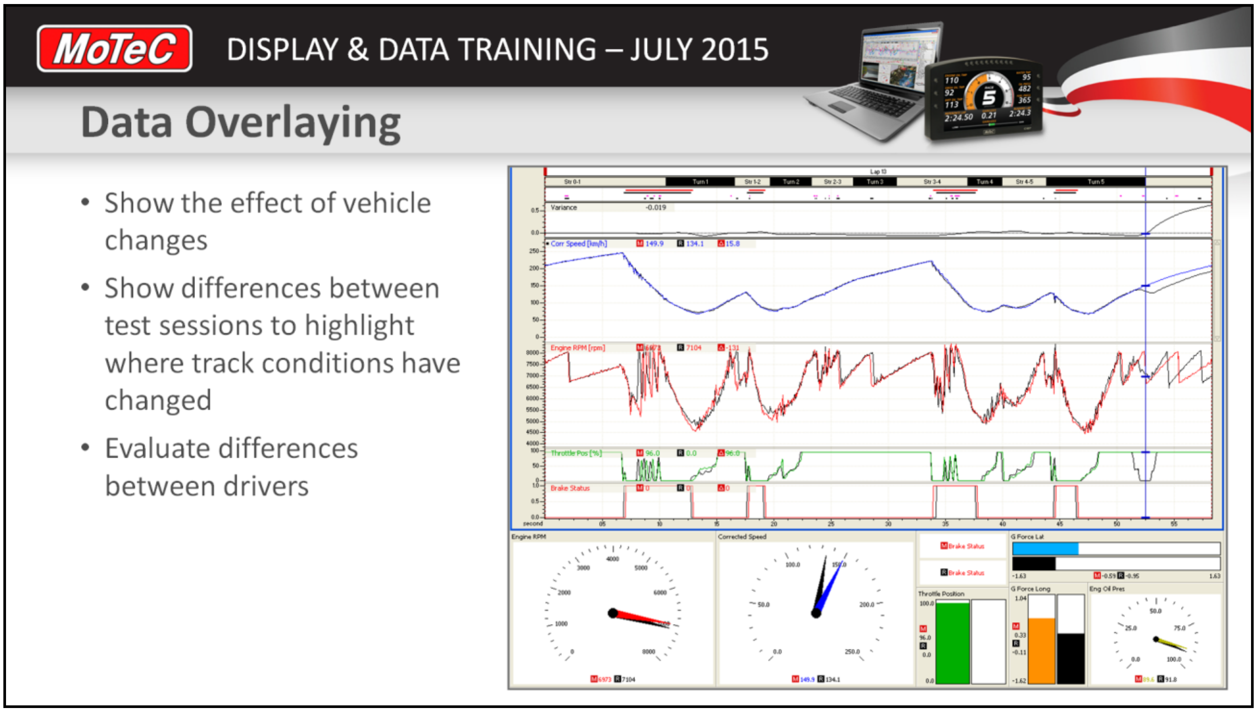
Right click on the page, then select ‘Add’, ‘Rainbow Track’.



Although distance is generally calculated in the Dash Logger, i2 also performs a distance calculation to give what is known as 'Corrected Distance'. Corrected Distance must be calculated so that the graphs can be plotted against distance rather than time. This allows laps to be compared at the same distance point on the track – the only way to make a meaningful comparison. To ensure that the distance is as accurate as possible, there is an option to calculate a 'Corrected Speed' channel from one or 2 input channels, along with Longitudinal G correction to account for wheel lifts or lock ups.

Setup for Corrected Speed is under the 'Tools' menu. By default Corrected Distance is calculated from Corrected Speed, however another speed channel can be selected as the input to this calculation. To account for variations in the measured speed and resulting distance from one lap to another, lap lengths are stretched to match the track length. This allows for consistent comparisons across different laps and sessions.

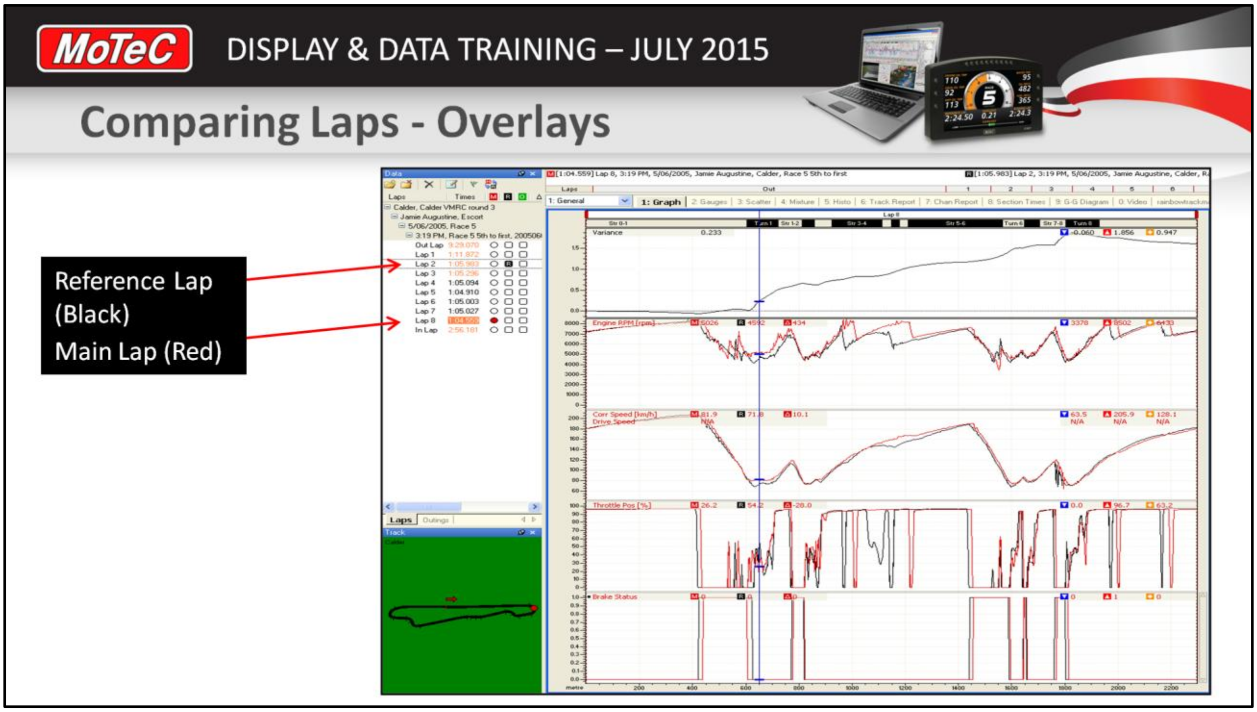
On the 'Corrected Distance' tab there is a button labeled "Report". Click this button to show the distance report of all laps. This report shows lap stretch or shrink to allow for slight lap length variations. You can turn this on or off in the previous screen, as well as set the maximum stretch/shrink percentage.



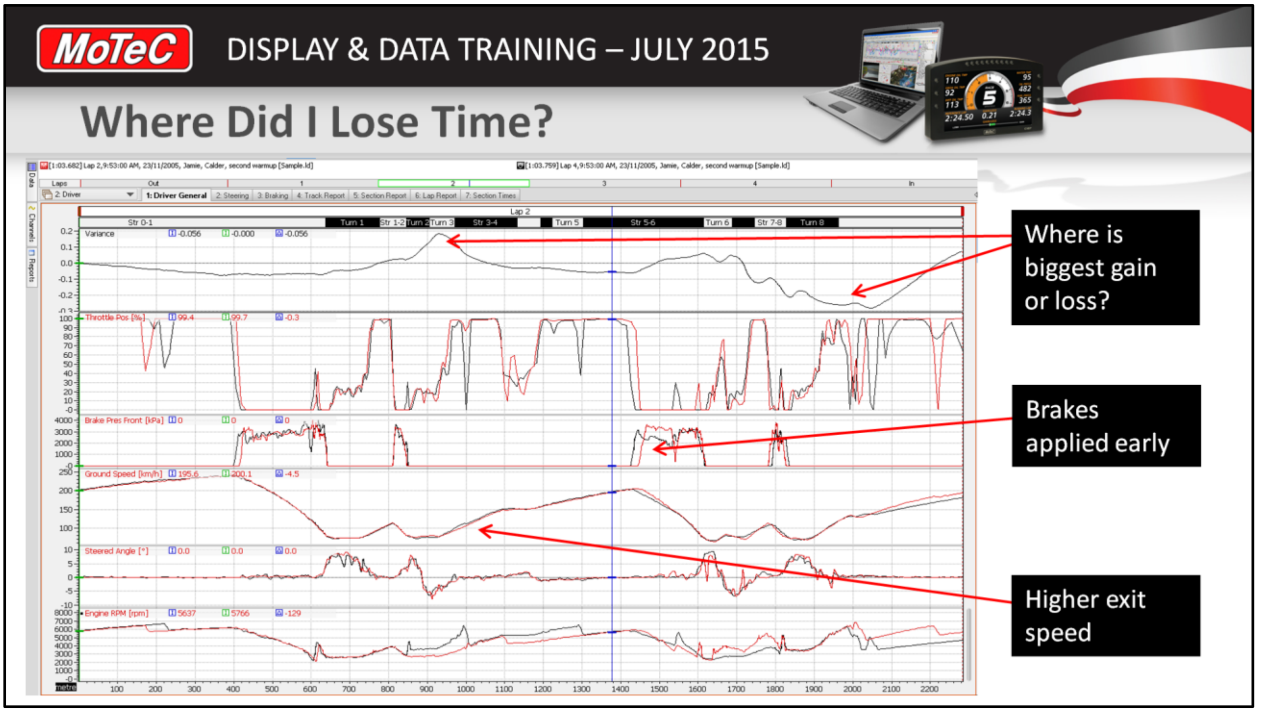
Overlaying allows the differences between two laps to be accurately determined. i2 can display the variance - the cumulative time difference or delta time - between two laps. This shows where time was gained or lost between the two laps being compared to indicate which sections of the lap need further investigation.

Analysis of vehicle speed, throttle position, and lateral G force allows differences in braking points, use of throttle and the line through the corner to be evaluated to provide direct information on how the vehicle and driver have changed between the laps being compared.

Comparing two laps is one of the best ways to find places where your car or driver can improve. Using two laps of data, select one as the Main lap, and the other as the reference lap. When you do this, it puts the overlayed data in black (colour can be changed) alongside the Main data. One thing to remember when overlaying laps is to always do it in distance mode, not time. The reason for this is that if you are comparing two laps, the track distance will be the same lap to lap, so your speed, throttle, pressure and other readings are compared at the same points on the track. If you try to compare the data using time, as you lose time over the lap, the traces become no longer aligned, offset by the amount that one lap is slower than the other.

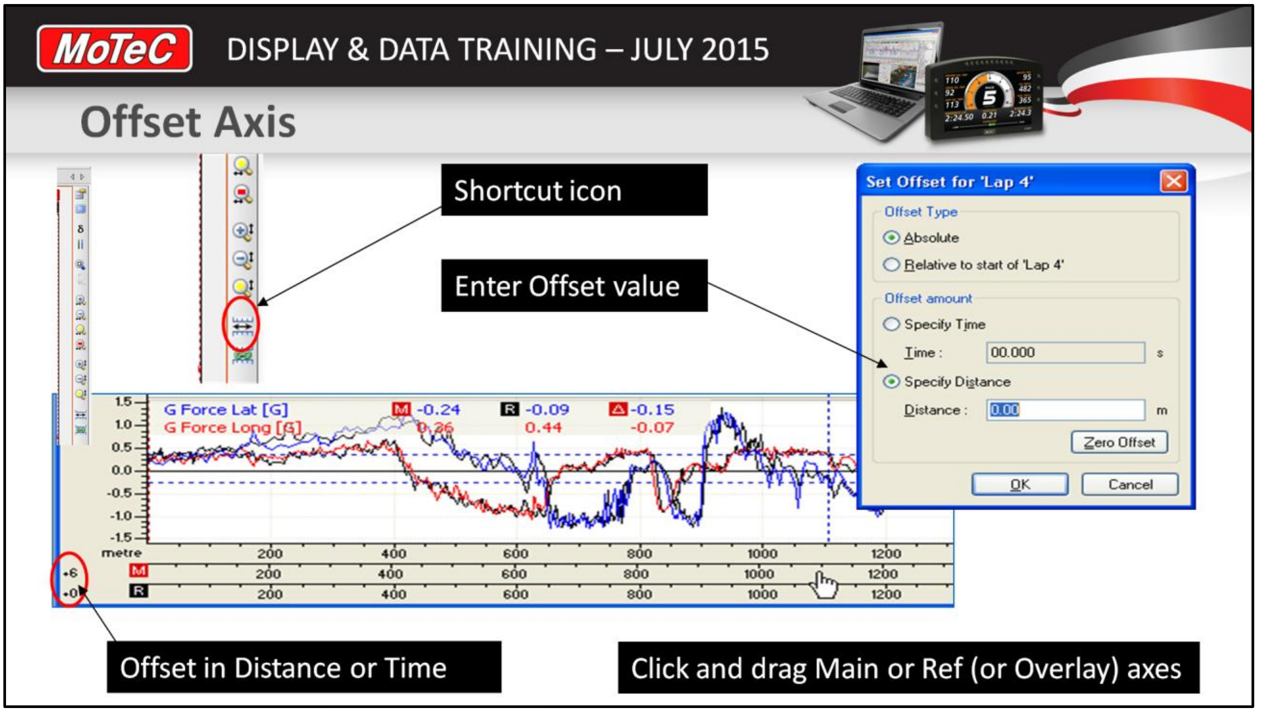


By pressing F3, you can insert a variance trace at the top of the Worksheet as shown above. As you can see, the variance line shows where one lap has gained or lost time over the other lap. This is a useful trace to find the points on the track where the most time has been gained or lost, showing the driver what part of the track to focus on to make gains in time. As a starting point look for the steepest slope or biggest jump in the variance line, then zoom in on that area of data.



Overlaying data from different drivers allows for quick identification for where one driver may be quicker than the other, by means of different line being driver, braking/turning/ on throttle at different times.

Overlaying the same car but run to run can help in identify where a chassis change has had effect on the car balance and handling.



In some instances you may be comparing data from different sessions where the beacon has been moved. In this case it becomes necessary to offset one lap relative to another. This can be achieved using the 'Offset Axis' feature of i2.

To allow precise alignment of main and reference, each may be offset in time or distance. This is done by turning on the offset axis by selecting Show Offset Axis from the graph component menu or by pressing the 'O' key.

This shows an axis for the main and reference below the nominal axis, which allows either one to be dragged relative to the nominal axis. Dragging can be performed using the mouse or by using the keyboard shortcuts: Ctrl+Shift+Arrows to move the main lap or Alt+Shift+Arrows to move the Reference Lap.

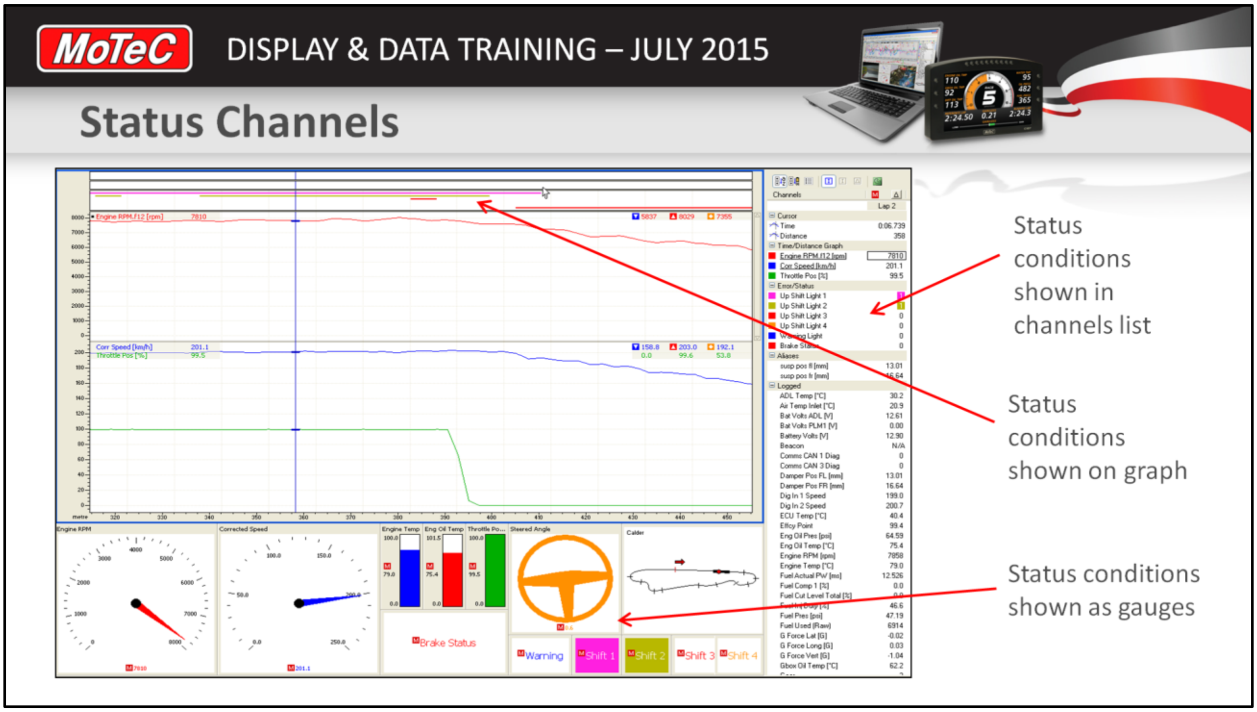
Offsetting may be turned off by pressing the O key again, this will also zero the offsets for the main and reference laps. Normally offsetting is used to make small corrections to allow for slight difference in the distance calculation from lap to lap. The best way to align laps is to look at bumps in the track surface using either the vertical G channel or a suspension position channel.

An offset can also be entered in seconds or meters by right clicking on an offset axis and selecting 'Set Offset'.

Press 'O' to show the offset axis

Click and hold on either the 'M' or 'R' axis, and drag it around to line up the data.

Remember to be in distance mode for overlays (F9)



Status channels are used within data logging to indicate when an on/off condition has occurred. Examples of this include a brake switch, shift lights, alarm/warning light, alarm acknowledge button, full throttle switch, clutch switch, nitrous activate and more. It is useful to see this information in the context of the rest of the data, knowing just where on the straight the nitrous is being activated, and what that is doing to your ignition timing, air fuel ratio and ground speed.

By pressing ‘E’ you can turn the status conditions on and off viewing them only as required.

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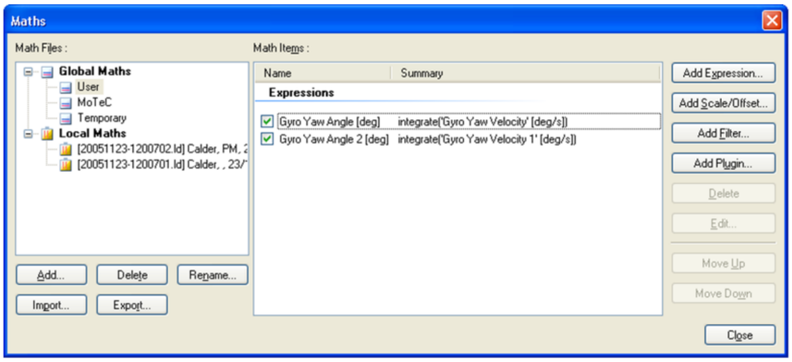
Maths

Simple Maths Functions (Filter, Scale & Offset)

- A number of simplified maths functions are provided to avoid the use of Expression Editor for simple operations like Filtering and Scale & Offset.
- All other functions must be performed using the Expression Editor.
  Note that these functions modify the original channel – they do not create a new channel.
  To create a new channel use the corresponding functions in the Expression Editor.



Global Maths

Global maths is calculated for all log files that are loaded. Global maths is stored in maths files within the project. Multiple maths files can be used, which allows the maths to be separated into functional areas such as Engine, Chassis, Aero etc. The global maths files may be copied to other projects by clicking on the Import and Export buttons in the Maths Editor. An example of maths that may be useful as global is a Lateral G filter that you always apply to your car to give your data a comparable trace.

Local Maths (Maths per log file)

Maths may also be created per log file. The local maths is stored alongside the log file in the companion (.ldx) file, the original file is never modified. This would normally be used for things such as setting the steering trace to 0 if you had forgotten to do so before the session.

Order of Calculation

The order of the maths equations in the list does not matter. Any dependencies are determined at calculation time so that if a maths equation requires other maths channels then the required maths channels will be calculated first.

On Demand Processing

The maths equations are processed on demand, i.e. as different Worksheets are displayed the required maths channels will be calculated as the Worksheet is displayed (unless they have already been calculated).

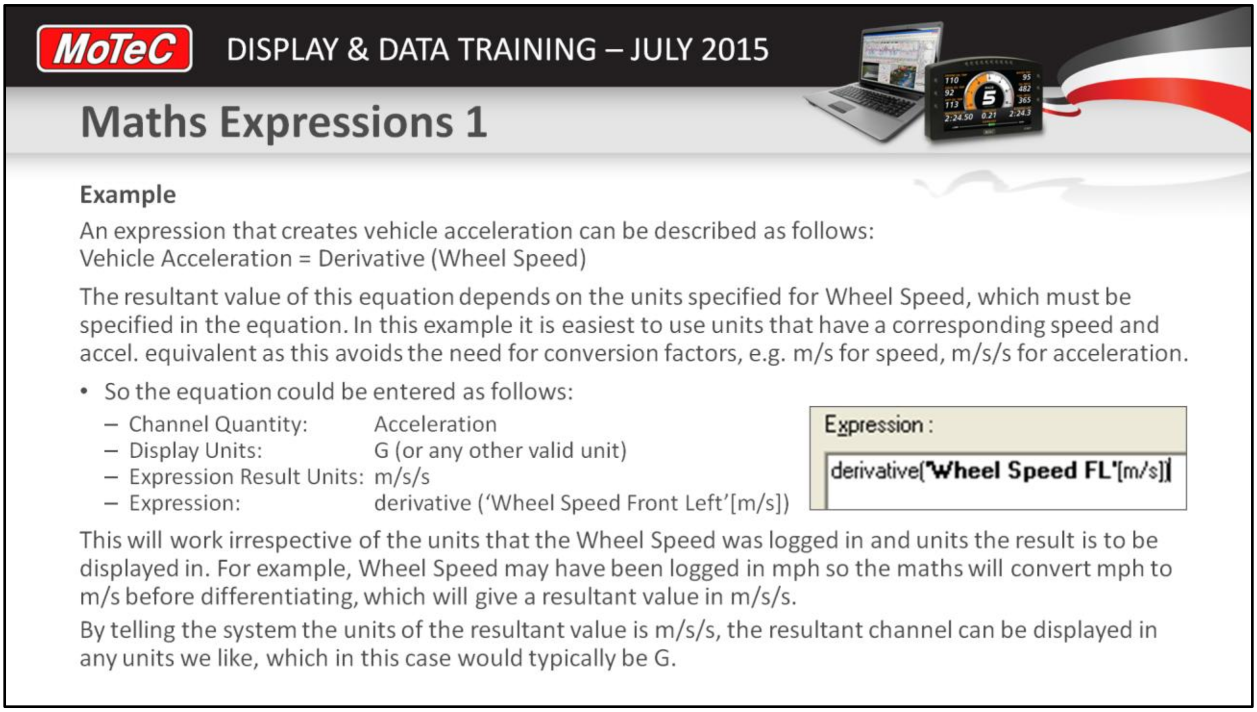
Maths Status

The status of the maths calculations is available in the Tools | Channel Status dialog. Note that any maths channels that have not been displayed or otherwise required will be tagged as Pending due to the "on demand" processing scheme.

Constants

Constants are used to represent common factors such as Pi. Maths Constants are stored in the maths files and can only be accessed by maths within that file.

Maths File constants are specified in the Maths Expression Editor.



Maths Expressions are powerful maths formulas that are entered in plain text format.

Channel Names Used in Expressions

When entering channel names into an expression, all channel names must be enclosed in single quotes, for example: ‘Engine RPM’. The quotes are added automatically if selecting a channel from the embedded channel list. Channel names are not case sensitive so ‘Engine RPM’ could also be entered as ‘engine RPM’

Units of Channels Used in Expressions

When entering an expression, every channel should be followed by units in square brackets. For example: ‘Wheel Speed Front Left’ [km/h]

The units specified are the units that the channel value is converted to before the calculation is performed and thus affects the resultant number and the appropriate result units (see below).

Note that when a channel is selected from the channel list, the default units will be automatically appended to the channel name. If the units are not the desired units then they may be edited as necessary. When typing the units a help window will show the valid units for the particular channel.

Maths Functions

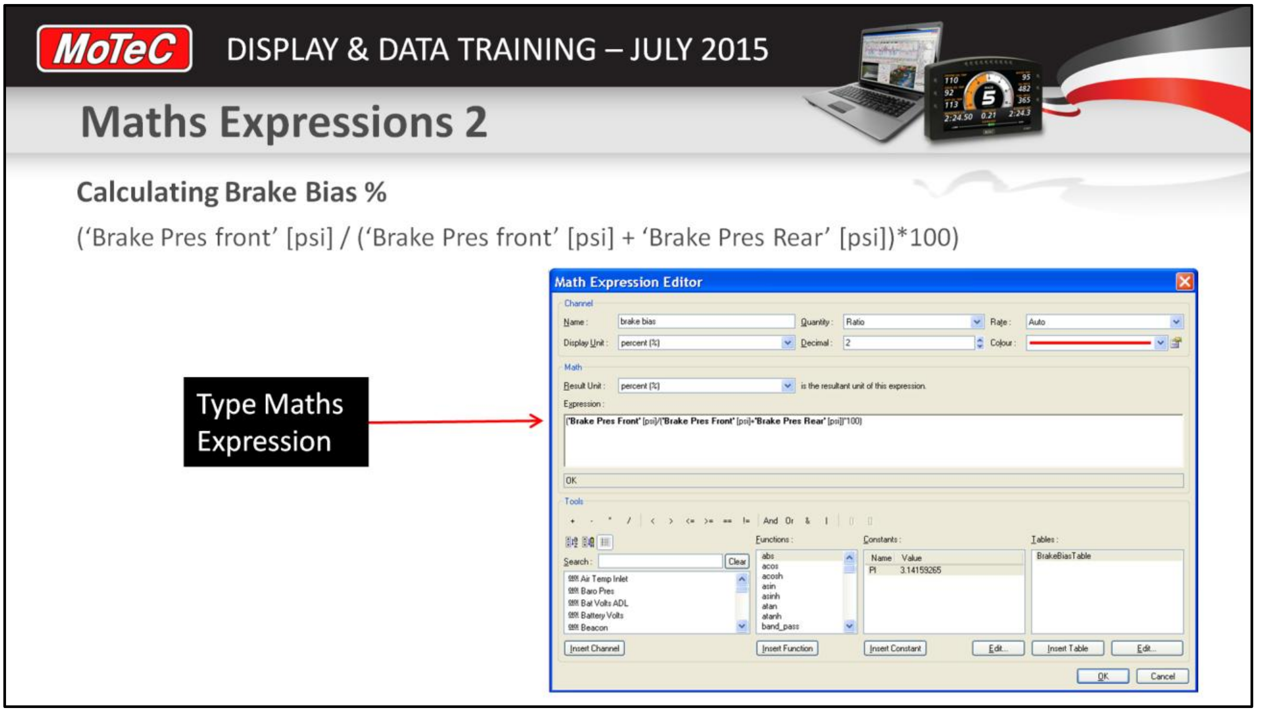
An extensive set of maths functions is provided for use in the expressions.

For details on the available maths functions and associated parameters see: Maths Functions

Result Units

The result units of the expression must match the numeric result of the expression.

Note that the result units need not be the same as the display units. It is very important to understand this difference.



Maths Channel Name

The name of the resulting maths channel is specified in the expression editor.

The maths channel name may contain any character except single quote (').

Sample Rate

The sample rate specifies the sample rate of the resultant maths channel.

If the channels used in the expression do not have the same sample rate then they will be re-sampled to the result sample rate before the maths expression is run. The re-sampling function uses linear interpolation to determine the values at the new sample rate. It is normally best to use a sample rate that is equal to the highest sample rate of the maths input channel(s).

Auto Sample Rate: The Auto sample rate selects the highest sample rate of the input channels and is therefore suitable for most maths processing.

Quantity : The quantity must be set so that valid display and result units can be set.

Display Units, Decimal Places, Colour: Sets the default values for these channel properties.

Enter this expression for Brake Bias Calculated:
('Brake Pres front' [psi] / ('Brake Pres front' [psi] + 'Brake Pres Rear' [psi])*100)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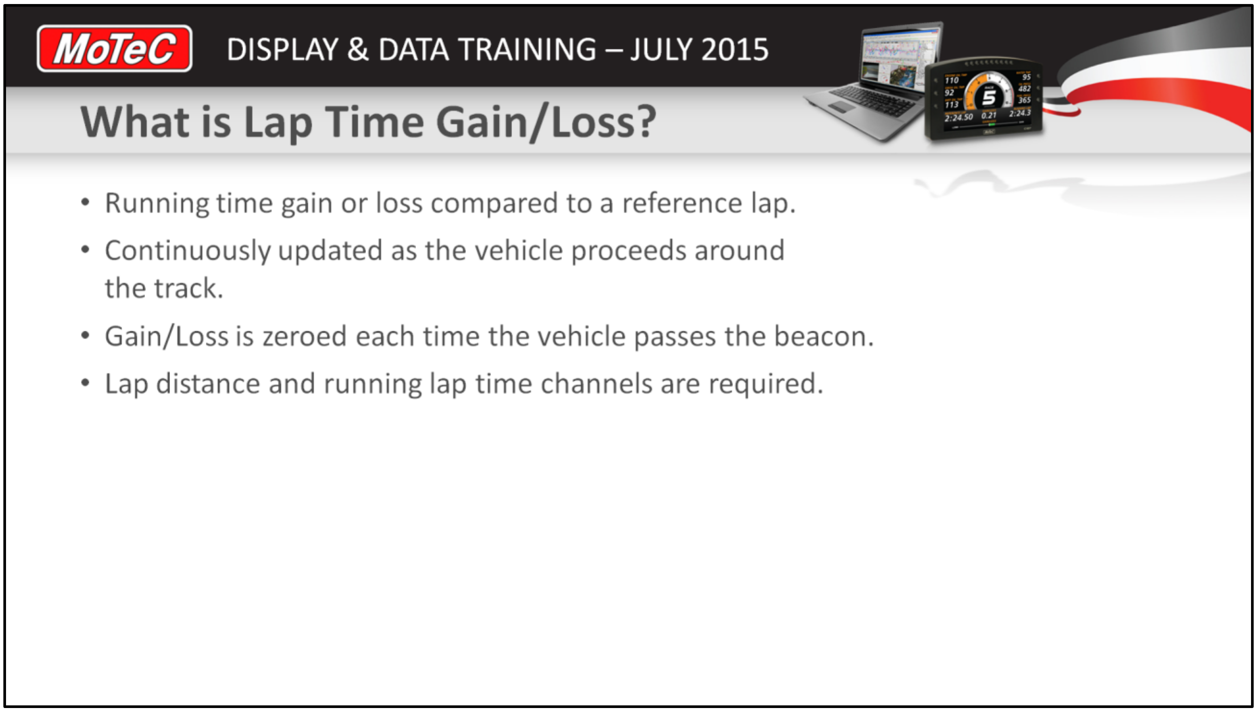
Lap Gain/Loss
i2



When driving in the car with Lap Gain/Loss displayed, the driver can get instantaneous feedback on the car, the driving and the current lap. A driver can determine the following easily with Gain/Loss:

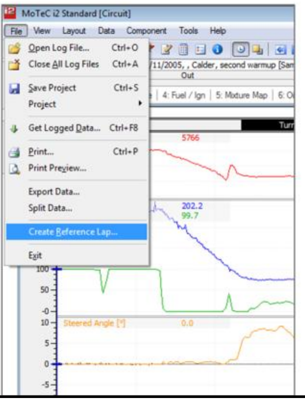
- Which specific corner or straight is most of the lap time being gained or lost on?
- Which part of the corner is the time gained/lost?
- Is this lap going to be a fast one?
- Should I pit this lap for a change, or complete the lap?

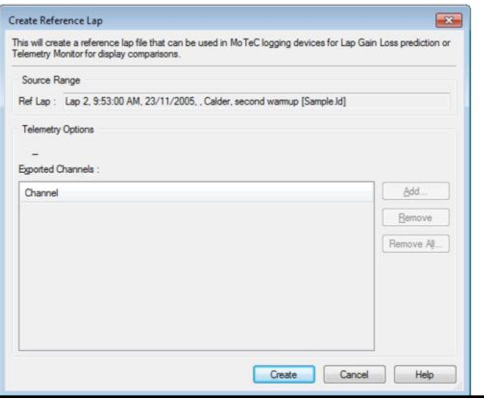
What is a Reference Lap?

- A Reference Lap contains time and distance pairs, indicating what time to expect at a certain distance around the track from a known logged data lap
- The Reference Lap file must be created with i2, then loaded into the Dash using the Dash Manager configuration software

Generating a Reference Lap in i2

- Click on File on the Main menu then click Create Reference Lap make sure that Lap Distance Channel is logged in the data
- i2 will create a reference lap file for the current main lap

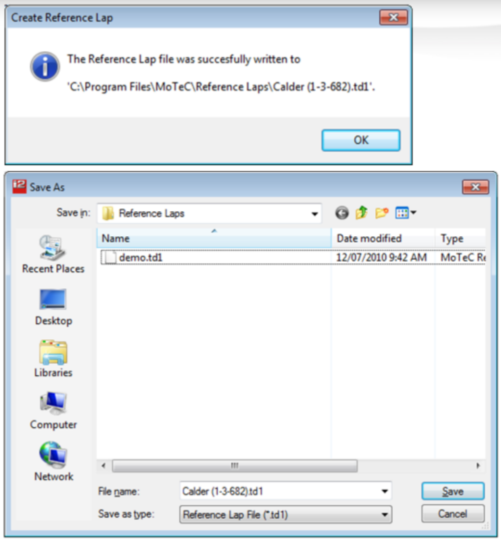


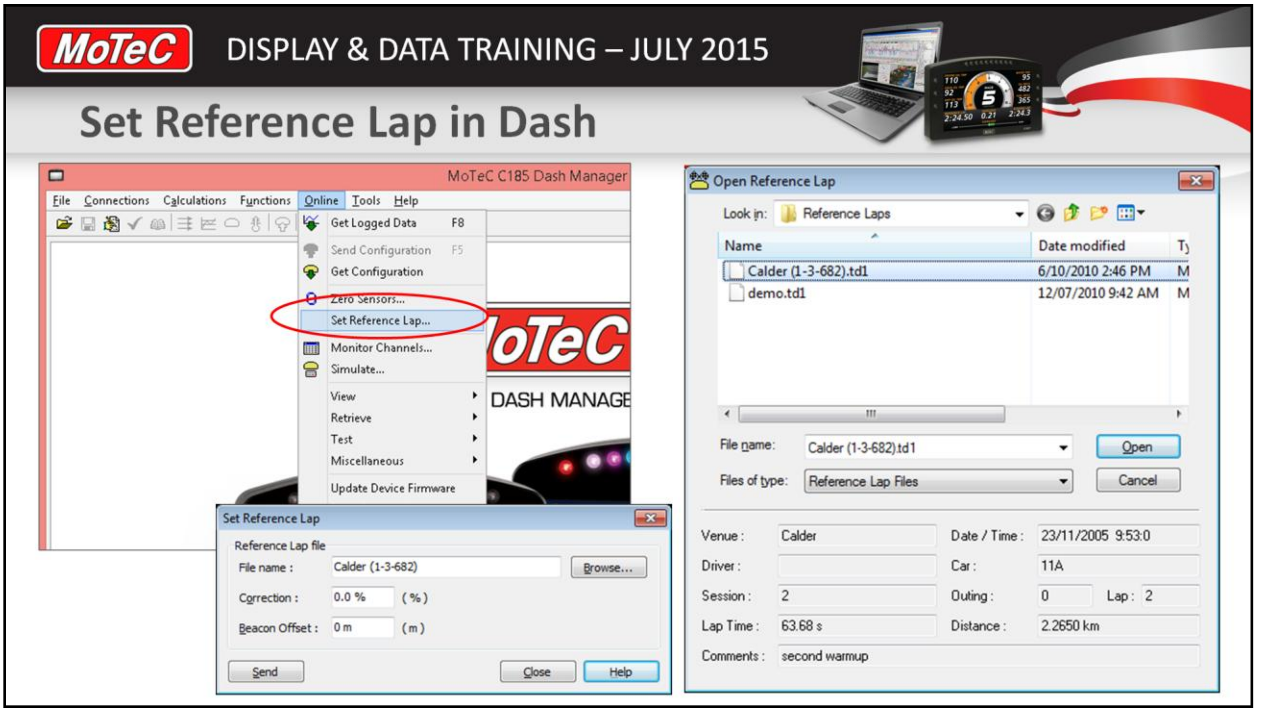


Generating a Reference Lap in i2

Click Save button to create Reference Lap

- The default file name is created as follows:
- Venue (Lap-time)
- For example: Calder (1-3-682)
- In this case the venue was Calder and the Lap-time was 1:03:682



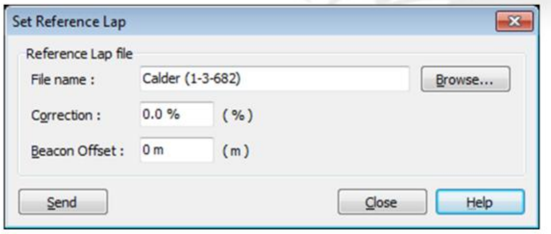


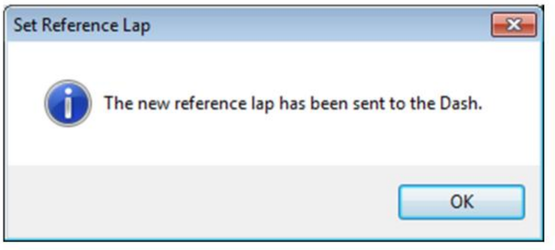
When connected to the Dash, go to the Online Menu and find ‘Set Reference Lap’ to send your lap.

Click on Browse button and select Reference Lap then click Open.

Set Reference Lap in Dash

- Click on the Send button to load a Reference Lap into C185
- If you want to make a correction to the Lap Distance or Lap Beacon Position you can change it here
- Click OK and your Reference Lap is set





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Gain Loss Displayed in the car

- Lap time Gain/Loss can be displayed in any position on the driver’s display.
- In this example, it is shown on the bottom row as a Gain/Loss bar.
- When the driver is slower than the loaded Reference Lap it colours the bar red
- If the driver is faster than the Reference Lap it colours green in the direction of Gain
- The Predicted Lap Time is also being displayed to the driver (right hand side middle value)


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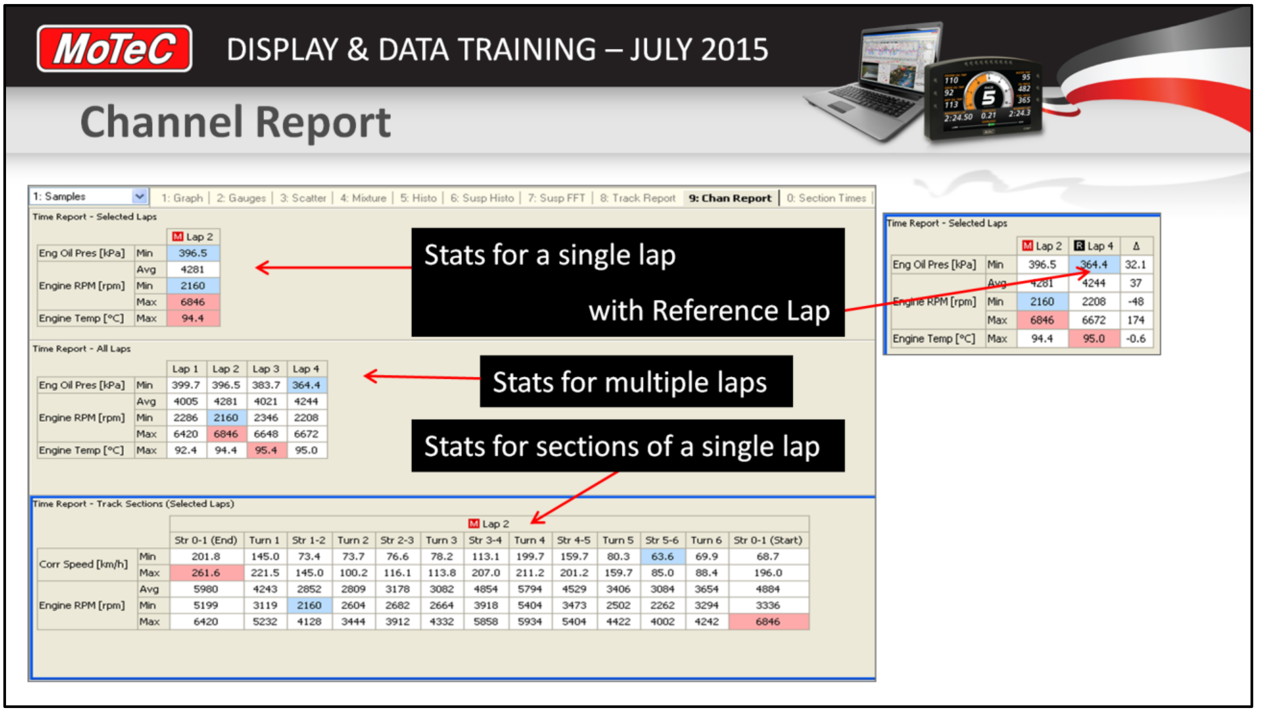
Reliability and Safety
i2



The Channel Report shows channel statistics in a tabular form.

The report may be configured to report on various ranges including:

Report on Laps for All Laps

Report on Laps for the Selected Laps

Report On Sections for Selected laps (either the default sections or user defined sections may be used)

The statistics available are:
Average, Minimum, Maximum, Absolute Maximum, Start Value, End Value, Value Change & Standard Deviation.

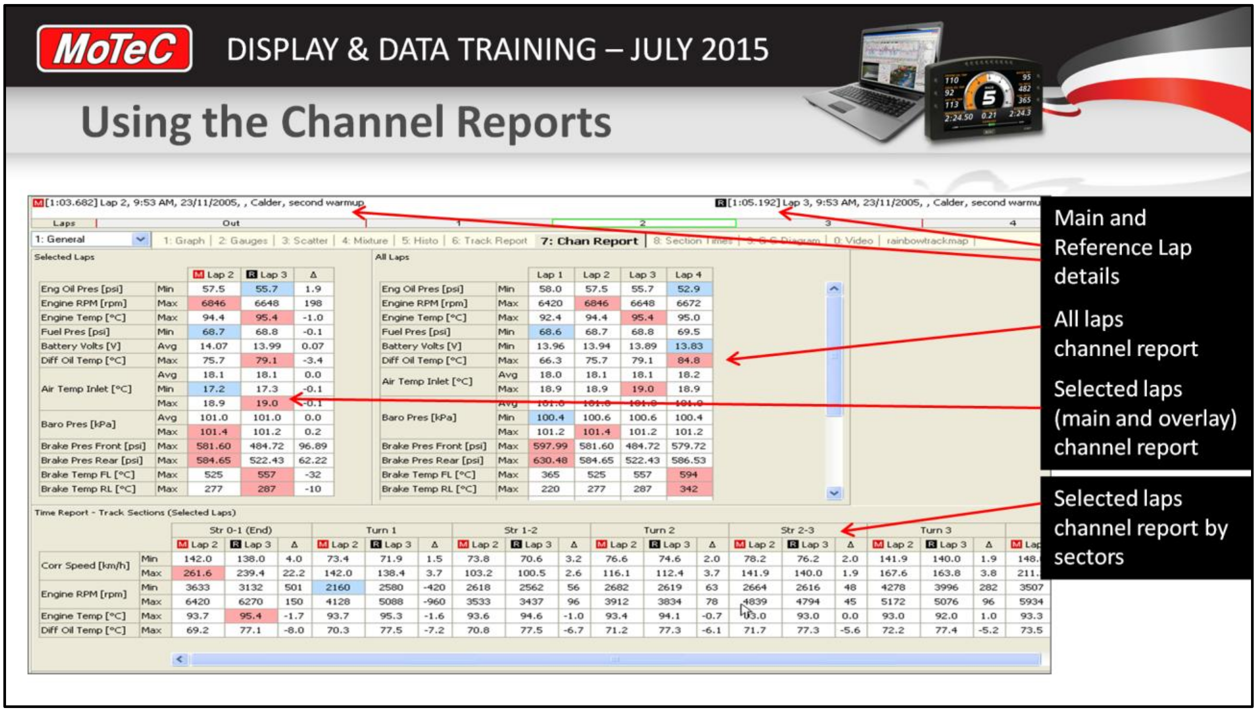
Reports for selected laps (not all laps) can also display data from the Reference and Overlay laps when these are selected. Also shown is the difference between the Main and Reference laps.

Press '9' or select 'Chan Report' from the 'Samples' Workbook

Click on the top channel report to give it focus and press 'F5'

Select 'Add' then search for fuel pressure and double click on it.

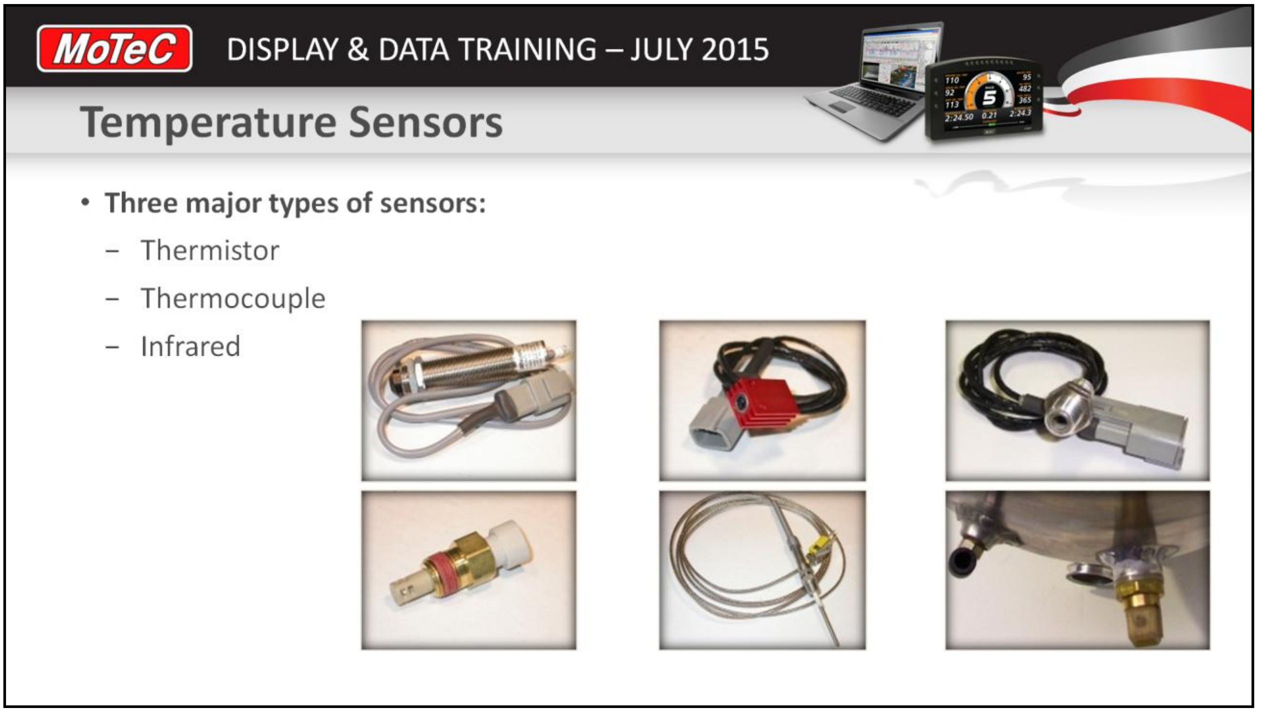
Turn on the tick box for minimum and click 'OK'.



The **i2** Channel report is the best way to get summary data about your outing. This data is often under utilised but can be a very powerful tool for trying to maintain the reliability of your vehicle. By checking this information at the end of each session you may notice trends in the temps, pressures, speeds or voltages of your vehicle.

This screen can show you the data in a lap by lap arrangement, useful to make sure that the data is from a lap where the car is at racing speeds. This is important to consider as there is no use looking at the minimum oil pressure on a lap when the engine was not running, or taking engine temp from a lap where the vehicle is stationary and heat soak is affecting temperature readings.

The data can also be shown in an outings mode where it just shows the min/max readings for an outing. You can even choose to exclude 'untrusted laps' which means that it doesn't include data from your in or out laps in the calculations of your statistics, a problem that often skews statistics of an outing.



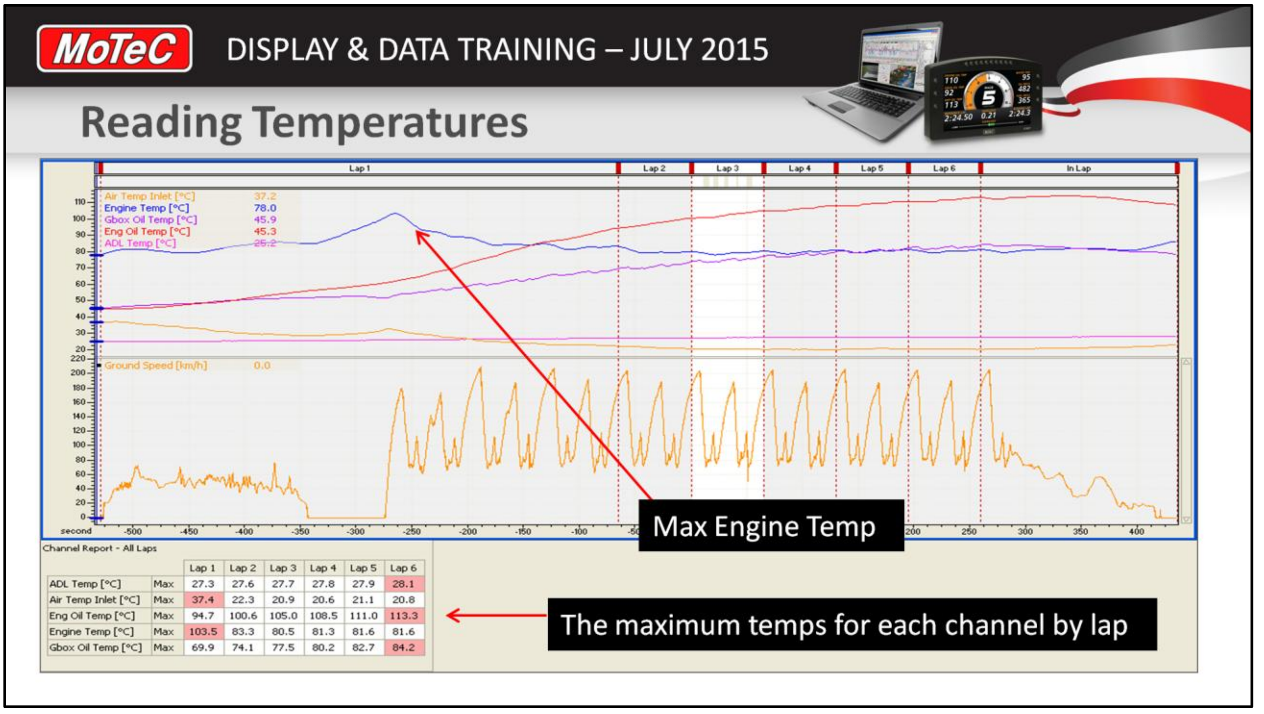
Exhaust Gas Temps come in either ‘open tip’ or ‘closed tip’ versions.

The closed tip type are more robust and will last longer, but they have a slower response than the open tip sensors.

Sensors

Top Row: Infrared tyre temp, infrared brake temp, infrared tyre temp

Bottom Row: Delco Air temp, EGT, installed Bosch water temp



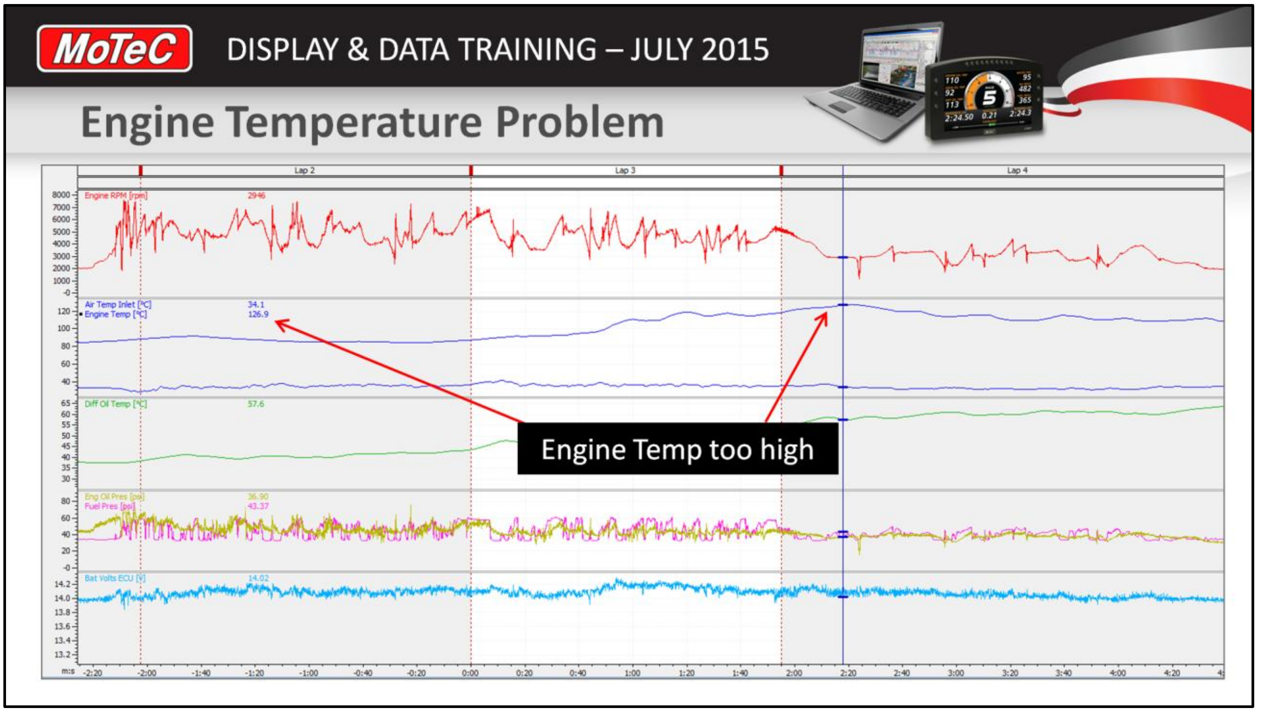
		Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6
ADL Temp [°C]	Max	27.3	27.6	27.7	27.8	27.9	28.1
Air Temp Inlet [°C]	Max	37.4	22.3	20.9	20.6	21.1	20.8
Eng Oil Temp [°C]	Max	94.7	100.6	105.0	108.5	111.0	113.3
Engine Temp [°C]	Max	103.5	83.3	80.5	81.3	81.6	81.6
Gbox Oil Temp [°C]	Max	69.9	74.1	77.5	80.2	82.7	84.2

If we look at the engine temperature trace, we can see that it started at around 80 degrees, and fluctuated up and down for a while. At around –250 seconds (from the start of the selected lap) we can see that the temperature peaks at over 100 degrees.

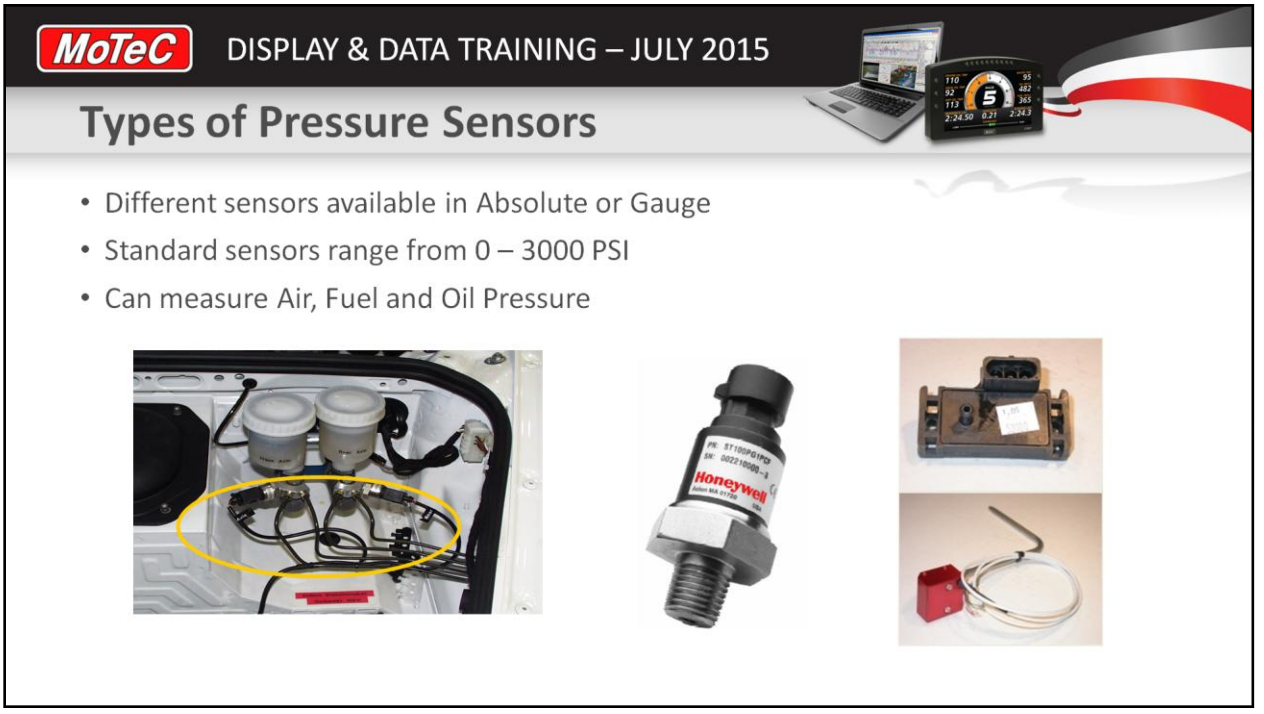
It is important to consider for what reason are you looking at the temperature. Are you looking for peak temperature to decide if a thermo fan is required for times on the grid or as the car cools down at the end? Perhaps you are looking at racing laps only, so that you can see if there is sufficient cooling during a race situation. The answer to this determines where and how you should be looking at the data.

If you are keeping a log of maximum temperatures that an engine has reached, it is usually best to look at peak racing temperature rather than a stationary temperature.

Press F2 to look at the temperatures across the whole session.



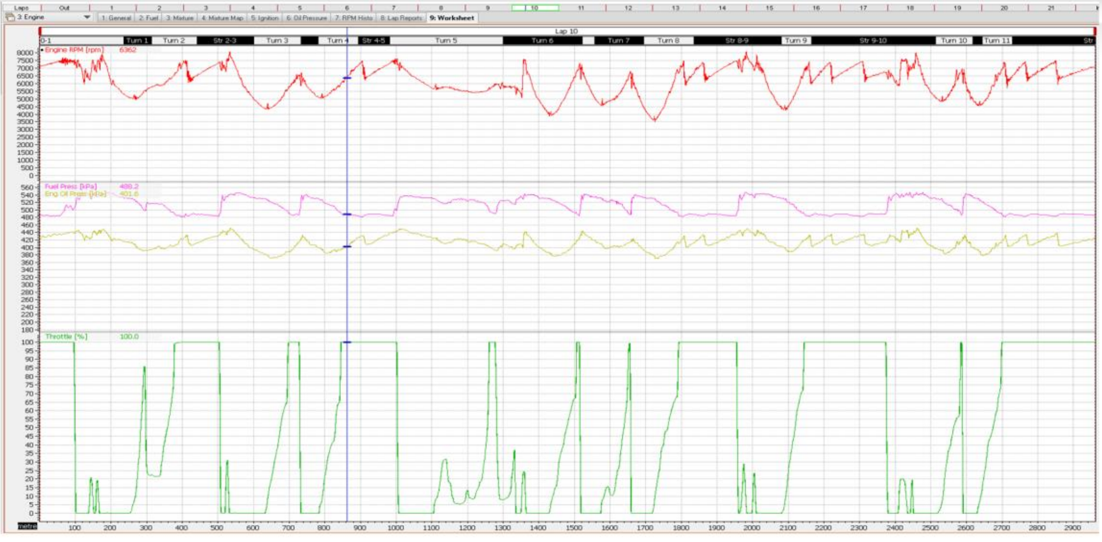
You can see that at speed the temperature is still climbing. There is a cooling problem and it would be a good idea to stop driving and investigate the situation.



Typical pressure sensors used in motorsport applications. Some sensors shown here can be used to measure brake, crankcase, fuel, oil and water pressure. MoTeC sells a wide range of sensors with varying measurement ranges. The most accurate measurements are made with sensors that are correctly sized for the application.

Response and accuracy vary between different types of sensors.

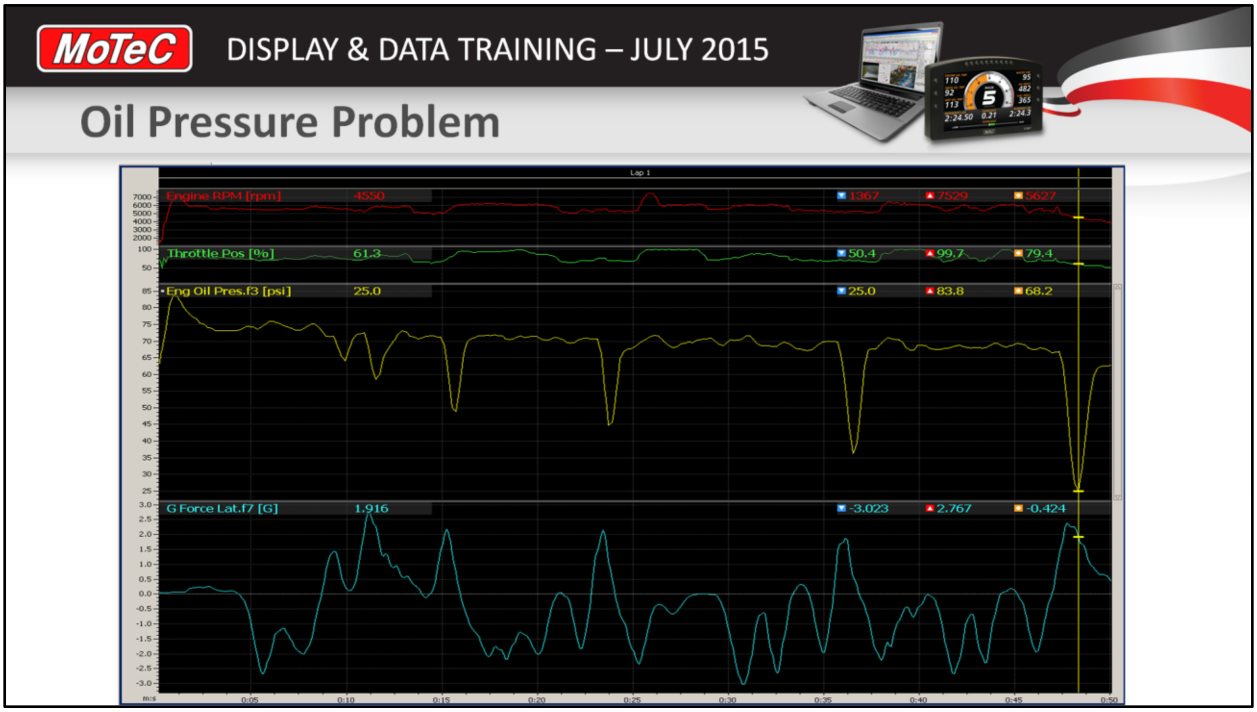
Reading Pressures



Pressure traces are often vital in examining the health of your vehicle. Whether it be fuel, oil, brake, manifold or other pressure, checking these values after each outing is an important part of ensuring that the engine is running safely.

It is common to see very noisy fuel pressure readings, although sometimes it is believed that the noise is the logger or the sensor.

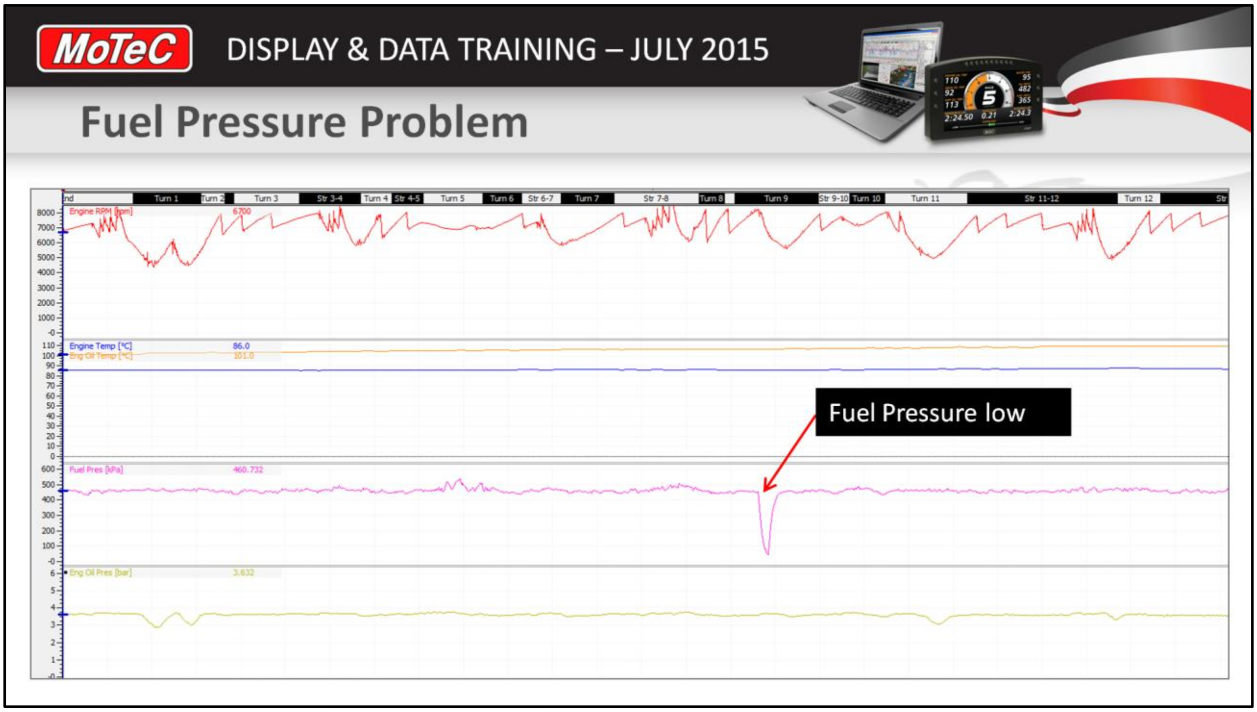
Looking at fuel pressure data from even highly developed race engines, it is common to see fluctuations of 10-15psi when a good sensor is used. Don't assume that the noise isn't a genuine indication of the pressure that is happening in the fuel rail, it is more likely to be the actual fuel pressure pulse waves than sensor noise. These pressure waves are often dependant on injector duty cycle.



To read the traces, again from the left, you can note that the oil pressure trace has some alarming dips.

The first thing to look at is the RPM going up and down to match this, a quick glance we can see that's not the case.

In this example, a check of the lateral G trace clearly shows the engine losing oil pressure each time the vehicle travels around a left hand corner.

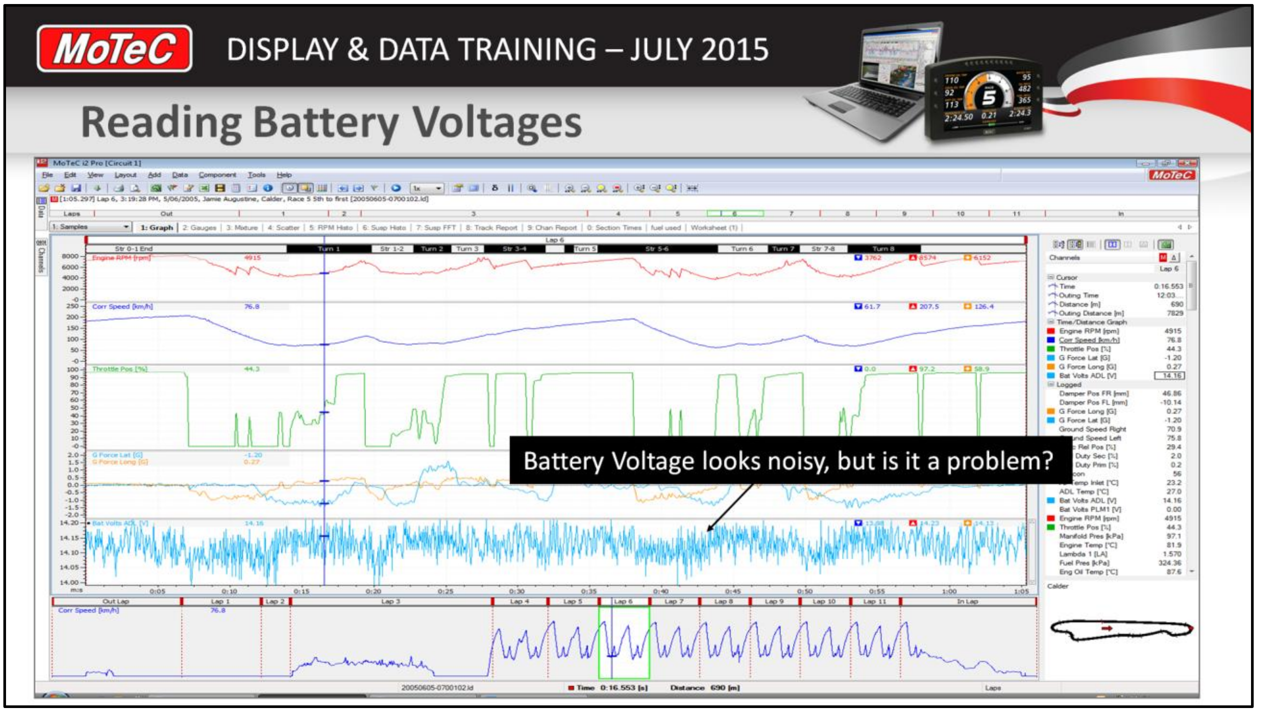


Here you can see a fuel pressure drop. This could be caused by a number of reasons.

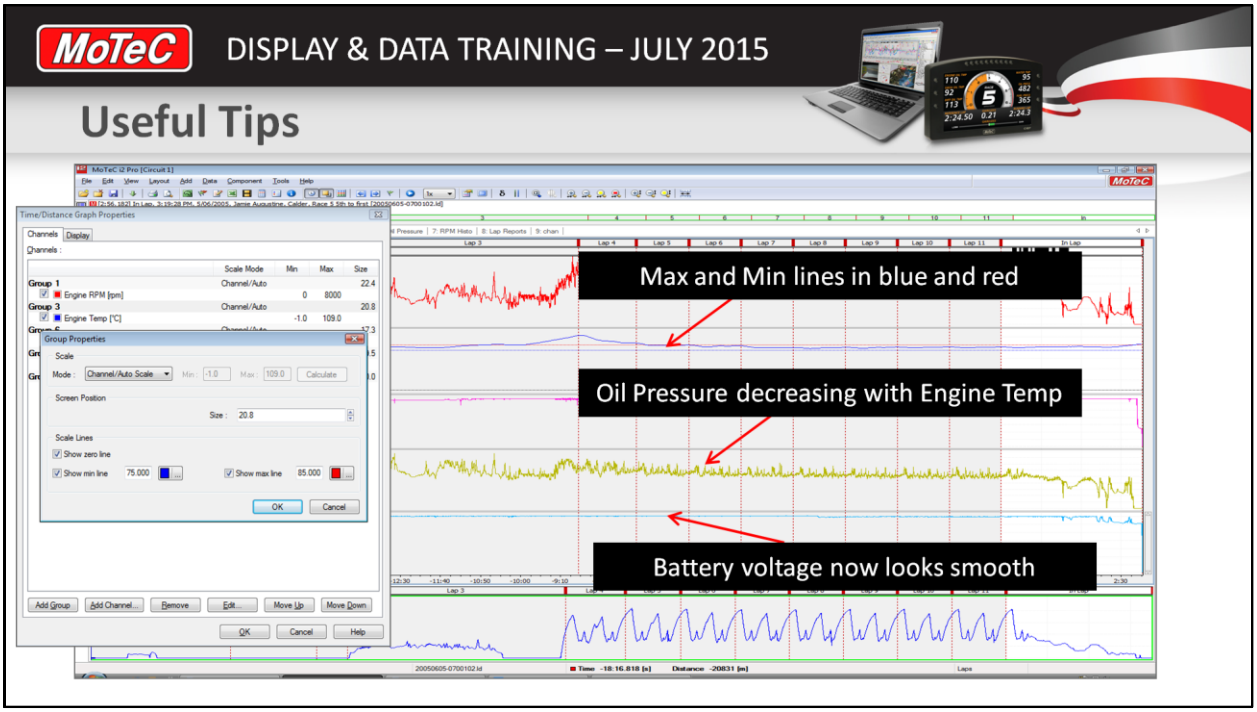
Items to check :

Are the Fuel pumps are staying on?

Possible blockage in the fuel system?



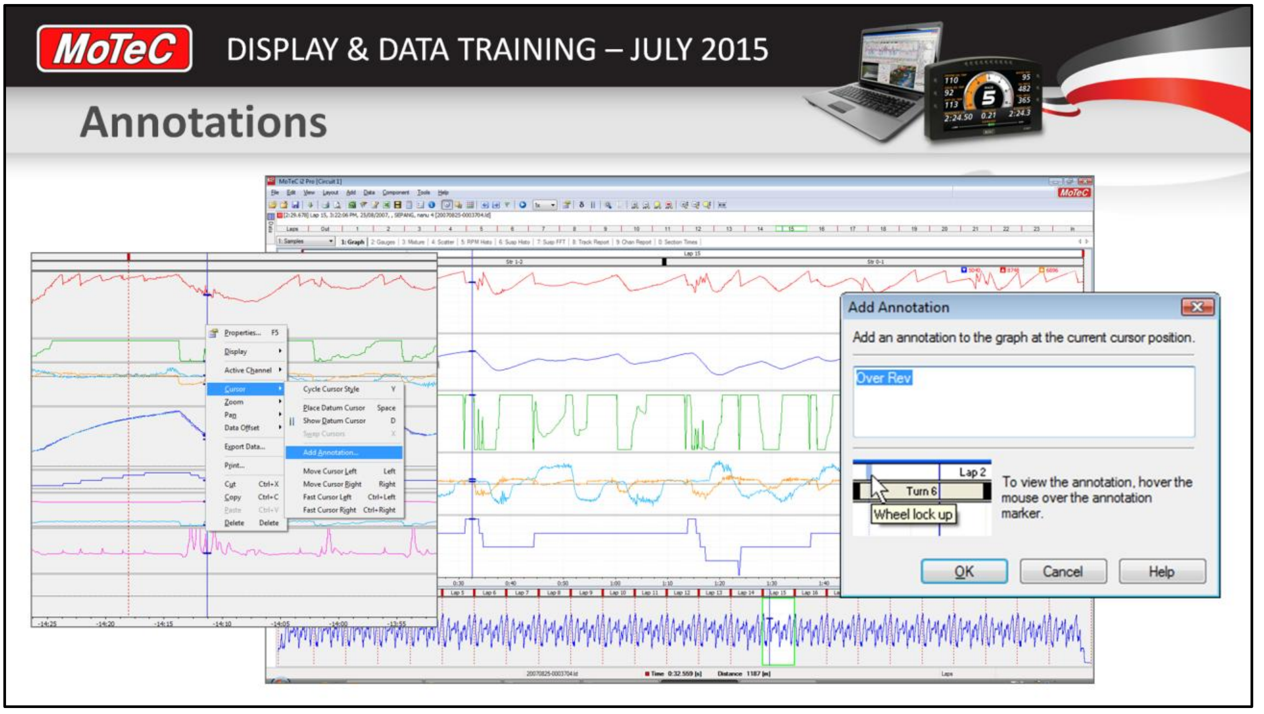
Voltage should be logged at 10 Hz as a minimum. They can appear noisy in their trace; this could be interference from the alternator/regulator on the vehicle, or possibly the display scale is to close.



By right clicking on the graph properties, you can rescale channels to a range they work in.

Above we have scaled the battery voltage. This has smoothed out the trace compared to the previous slide .

You can also add a line to the graph at a Max value and a Min value.



An annotation or note can be placed at any point in the data. A line will be placed in the data which you can see in all the Worksheets. So, for example, if you have a 'Wheel Lockup' event, you could also look at the oil pressure on a different Worksheet.

How to add an annotation:

- Place the cursor at the required position in a graph
- On the Component menu, click Cursor
- Click Add Annotation.

How to display an annotation:

- The annotation is indicated by a dotted line on the graph. Place the mouse over the dotted line on the graph as shown below

How to edit or remove the annotation:

- Place the mouse over the dotted line
- Right-click and select the appropriate item from the menu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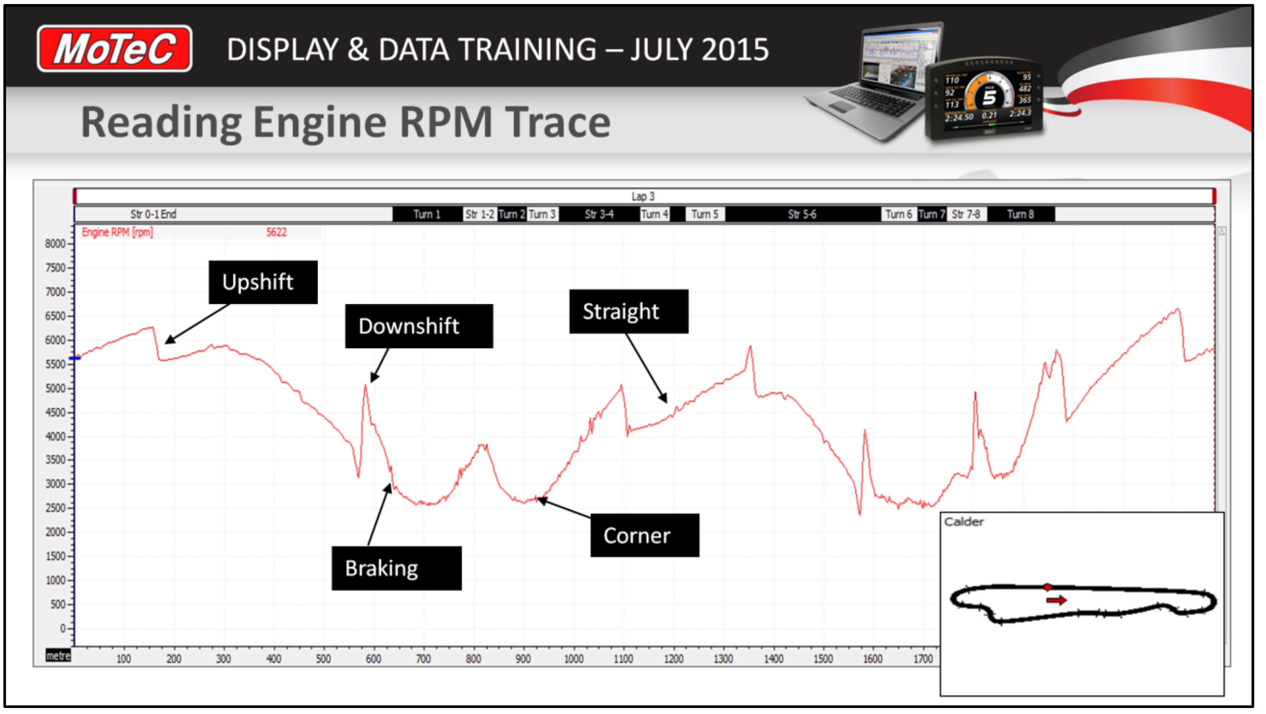

MoTeC
DISPLAY & DATA TRAINING – JULY 2015
Reading Engine RPM Trace
Lap 3
Str 0-1 End
Turn 1
Str 1-2
Turn 2
Turn 3
Str 3-4
Turn 4
Turn 5
Str 5-6
Turn 6
Turn 7
Str 7-8
Turn 8
Engine RPM [rpm]
5622
Upshift
Downshift
Straight
Braking
Corner
Calder
metre

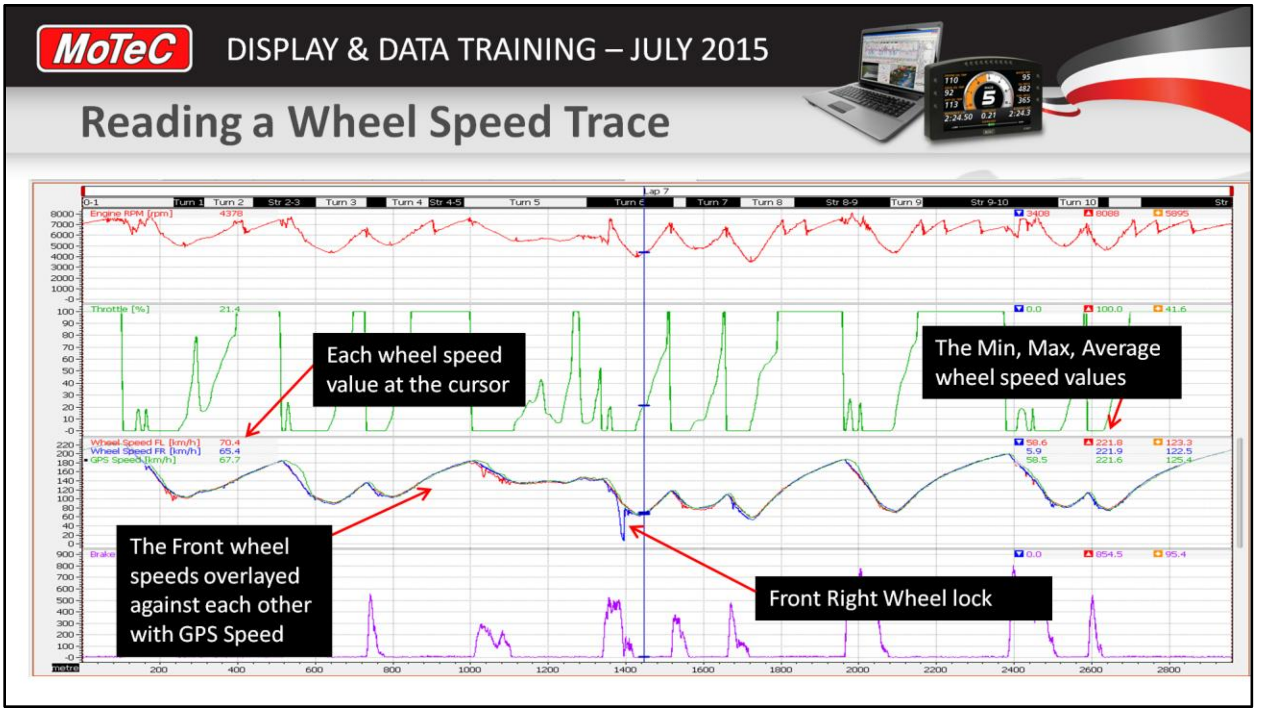
Wheel Speed Sensors

- Toothed wheel and sensor arrangement
- Accurate calibration in Dash/ECU software is required

Measurement	Sensors Required	Outcome
Vehicle speed	Wheel speed	Top speed, min corner speeds, corrected ground speed, corner
Lap by lap speed comparisons	Wheel speed, lap beacon	Compare each lap for speed, overlay to find driver mistakes or faster race lines
Wheel lockups under braking	Wheel speeds, front and rear	Brake locking into corners, help determine incorrect setup
Driven wheels slip	Wheel speeds, front and rear	Diagnose traction problems, evaluate driver performance, find the slip ratio of the driving wheels
Gear selection trace	Wheel speed, RPM, throttle position	Create accurate gearing charts to see whether gear selection is correct, driver analysis
Track Mapping	Wheel speed, Accelerometer, Beacon	Create visual representations of the track for reference when examining data, virtual segment time.
Driver analysis	Wheel speed, G sensor	Extensive driver analysis through lap overlays, minimum and maximum speed comparisons, and accelerating/braking efficiency.

The wheel speed sensor is one of the sensors that you get with a data acquisition system. Beside speed and distance computation, this sensor will allow you to:

- Compare the speed of drivers or of cars, lap after lap.
- Detect the wheel locking under braking.
- Detect wheel spin.
- Draw a track map on your screen.
- To detect the gear you are using without having a defined gearbox sensor.



Above you can see all wheel speeds directly determined by sensors on the front wheels, overlayed against each other. The green trace shows a GPS speed trace sampled at 10hz.

Logging Rate and Accuracy 1

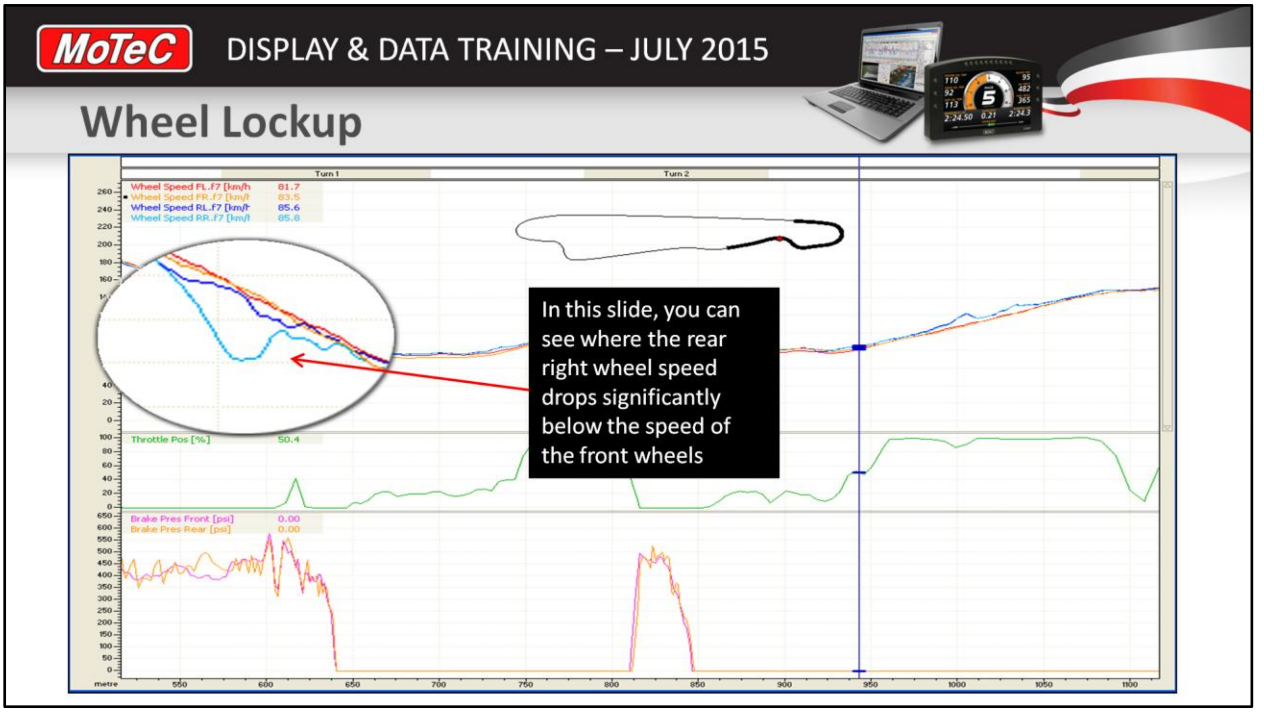
Precision of measurement in metres, as result of logging rates at different speeds								
	Logging Rate in Hz							
Speed Km/h	1	2	5	10	20	50	100	200
20	5.56	2.78	1.11	0.56	0.28	0.11	0.06	0.03
60	16.67	8.33	3.33	1.67	0.83	0.33	0.17	0.08
100	27.78	13.89	5.56	2.78	1.39	0.56	0.28	0.14
140	38.89	19.44	7.78	3.89	1.94	0.78	0.39	0.19
180	50.00	25.00	10.00	5.00	2.50	1.00	0.50	0.25
220	61.11	30.56	12.22	6.11	3.06	1.22	0.61	0.31
260	72.22	72.22	36.11	14.44	7.22	3.61	1.44	0.72
300	83.33	41.67	16.67	8.33	4.17	1.67	0.83	0.42

During the study of the various curves, there are two points that are important to remember. Firstly, it is important to understand the influence of the logging rate on the measurement precision. Then, it is useful to have an idea of the consequences of the driver's mistakes at high speed.

This table shows the distance in meters between two measurements for different combinations of logging rates and vehicle speed. As an example, let's consider a car travelling at 220km/h with a Lateral accelerometer logged at 20Hz:

Distance travelled per sample at 220km/h is:
220x1000/3600x20 = 3.06m

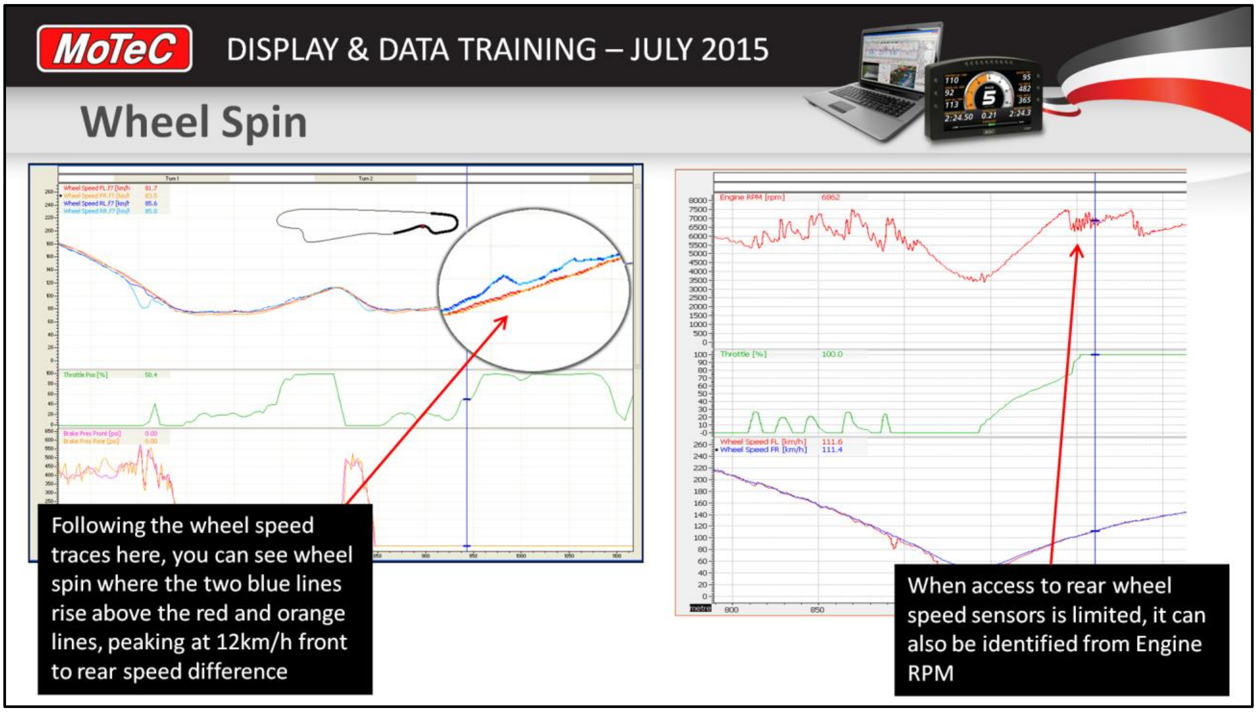
In an average data logging configuration gear changes are recorded at 10 Hz. At 220 km/h, if two drivers are changing gear at exactly the same time, on the data acquisition system it can appear with a difference of up to 6.11 m.



Another very useful tool of the wheel speed comparison graph is to determine wheel lockup. To make this comparison, at least two front (or rear) wheel speed sensors are needed. The screenshot above shows all four wheel speeds together. It can be seen that the rear right wheel speed (light blue trace) has a notable deviation from the other wheels.

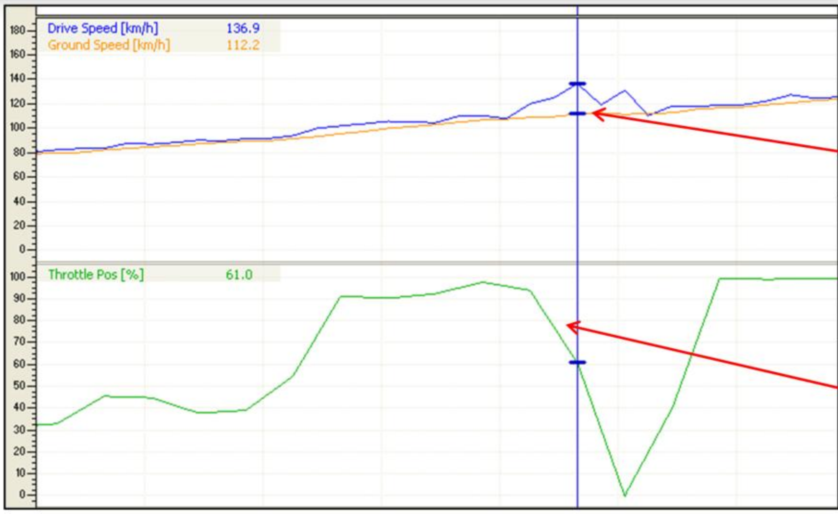
If a trace like this is encountered, it means that there is an imbalance in the car setup – whether it is caused by the driver, car setup or track conditions. It is worth looking at setup parameters other than just brake bias. Uneven corner weights, damper problems, brake pad compounds and temperatures and even oil on the track can cause such a lockup.

As you would do every time you analyse data, be sure that what you think you have detected is really happening on the car. Use other sensors such at tyre temps, G sensors, brake pressure sensors and brake temp sensors to confirm your hypothesis. Especially here with an imbalance under brakes, you may be able to determine the cause of the issue, whether it be bias of line pressure or lack of braking friction to the front by looking at the braking pressures versus G force and brake temperatures. You may have the same brake pressures front to rear, but have less retardation at one end to the other depending on calliper piston sizes, pad compounds, rotor types and brake temperatures.



Wheel spin is an important thing to be able to monitor in data logging. At the end of a session, the driver will reflect upon the performance of the vehicle, and determine what it is that is stopping the car from going any faster. Understeer and oversteer are common problems that a vehicle encounters at the limit and you want to determine what is causing the vehicle to behave in this way. With oversteer, sometimes it is due to the suspension settings in the vehicle, whilst other times driving style is more to blame. Determining this is an important part of deciding how to go about tackling the problem.

Wheel Spin Analysis



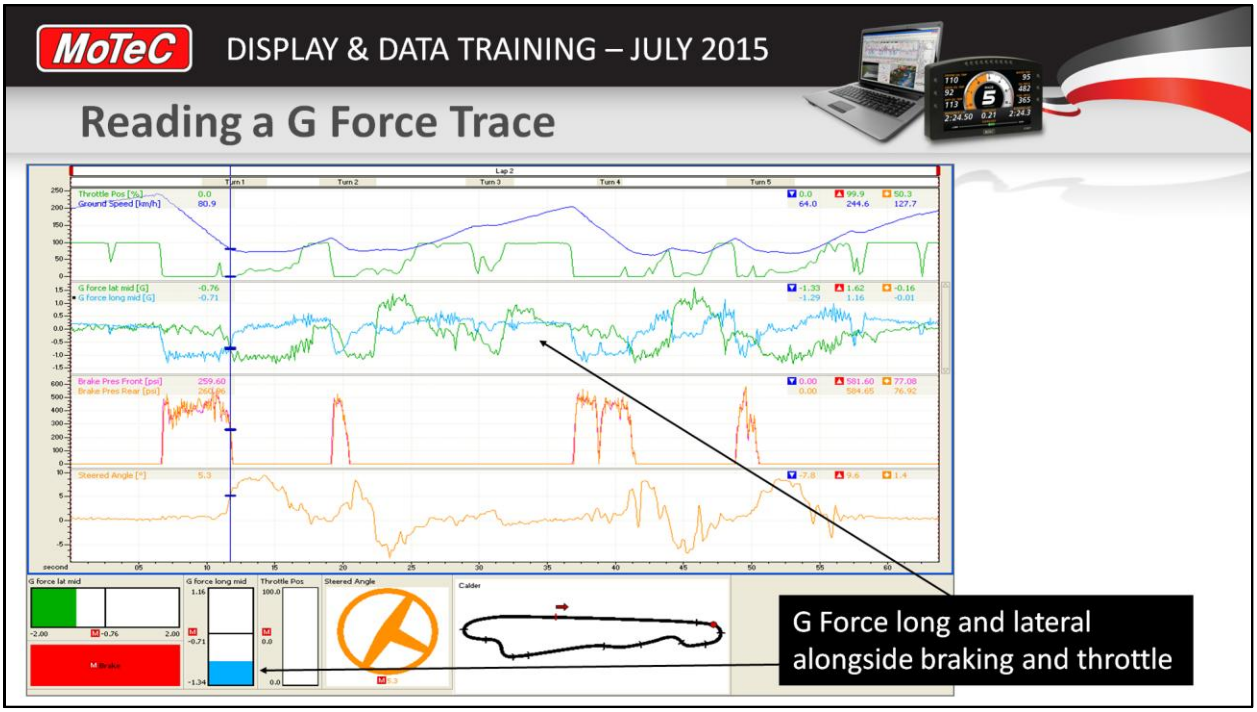
This is where the rear wheels have lost traction

Here you can see the driver lifting the throttle to stop the wheel spin

What is an accelerometer?

An accelerometer or G force sensor measures the forces being applied to the car. These forces include acceleration, braking, cornering in both directions, up and down. To understand what they are measuring, imagine a bob weight being hung from the roof of a race car, as you accelerate it swings backwards, as you brake it swings forward. The distance of the bob swing represents how much force there is in that direction. A G sensor measures this force, and the data logger gives a value proportional to the force of gravity, hence 'G' sensor.

- Can be used to measure Acceleration, Deceleration, Cornering, Yaw, Forces etc.
- Strain Gauges can be used in many ways, damper/suspension forces, steering force, pedal forces .



What can I get from a 3 axis accelerometer?

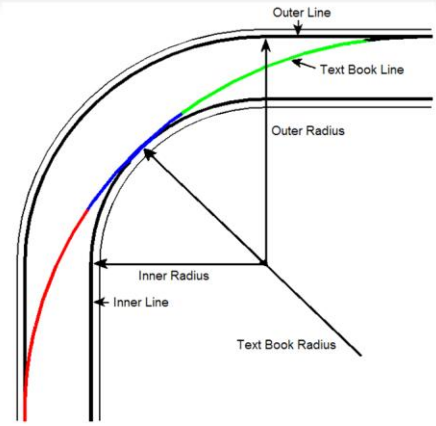
3 axis accelerometers allow the user to measure and record the acceleration of a vehicle in three dimensions. By combining the information from all three accelerometer axes it is possible to calculate the resultant overall acceleration in three dimensions.

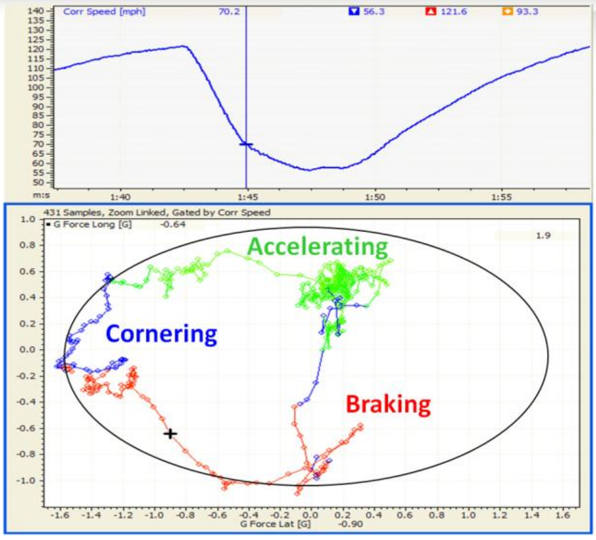
Accelerometers allow the user to perform fundamental operations, for example obtaining a track map or studying the balance of the car in terms of understeer and oversteer. They also permit more complex calculations, for example computation of the weight transfer the car experiences during braking, acceleration or turning phases.

It is extremely useful to use the G sensor to compare braking forces and technique in overlay mode. You can see how hard the initial deceleration is, and verify that the braking is hard, right into the corner, not tapering off at the end. You can also see how consistent the pads are, you could compare a brake fluid line pressure to a deceleration force to look for fade in the braking system.

They can also be used to compare how much lateral traction a given tyre/track/suspension setting is able to obtain, then compare to another lap to see how your changes have affected vehicle cornering grip.

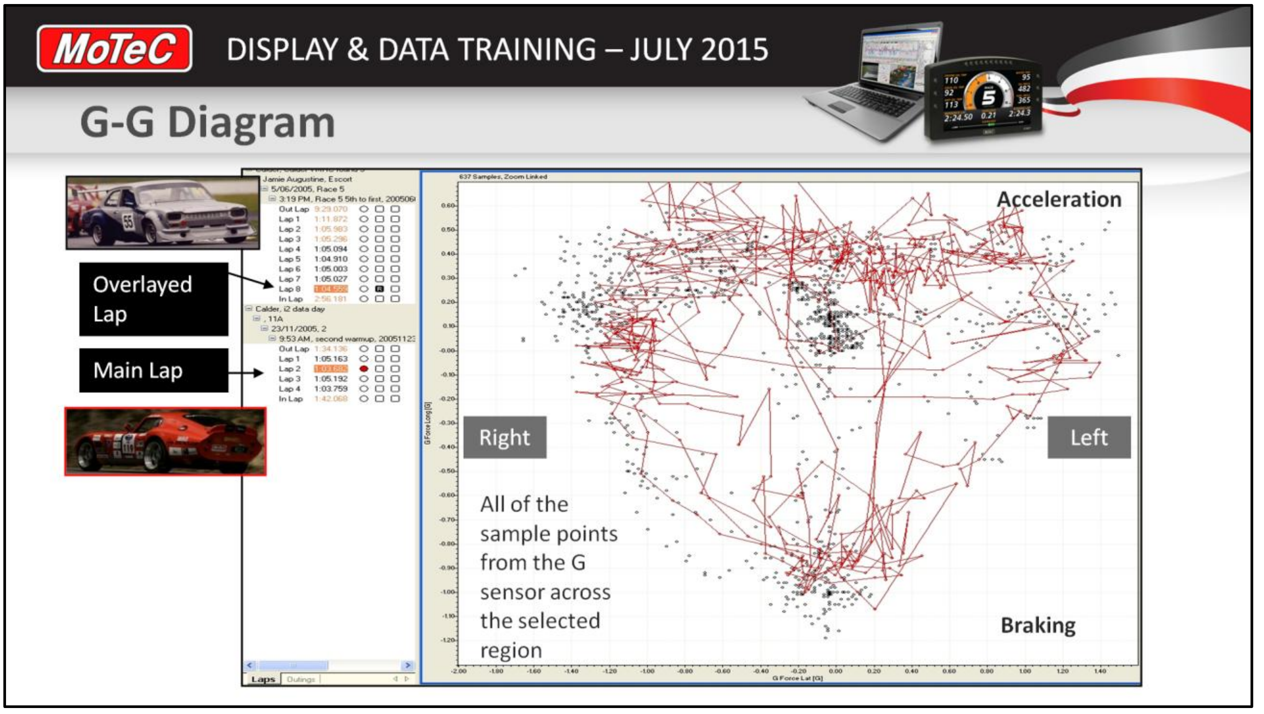
Driving Line Analysis





This method maintains the highest 'minimum corner speed' possible through a corner. Driving the *Traction Circle* is the fastest way through this corner.

Above we can see racing line through a corner. There is also a G-G diagram which is a scatter plot of longitudinal and lateral G zoomed on a specific corner.



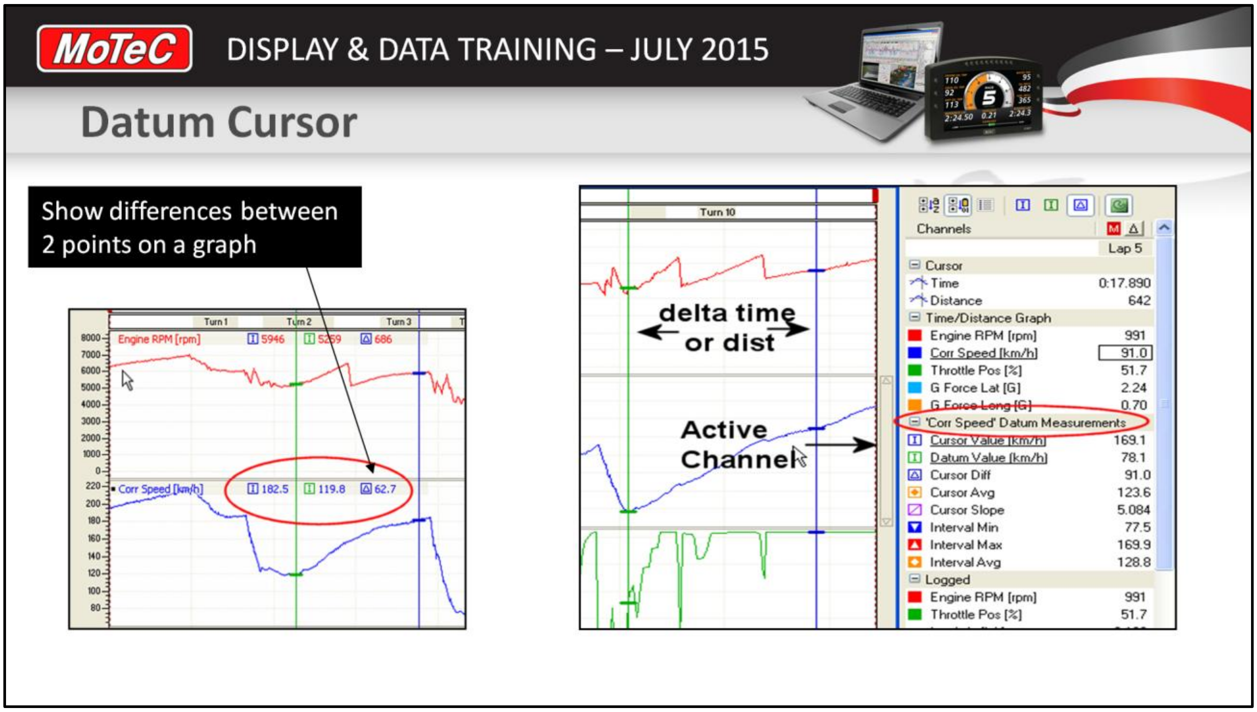
The G-G diagram is a conceptual way of showing the performance of a driver, vehicle and circuit together. This method of measuring performance has been around since the late ’50s with the first methods of creating these diagrams using a two axis pen recorder.

In theory, the driver should try to operate as close to the boundary of the G-G circle as possible at all times. In reality, physical limitations prevent a vehicle reaching the theoretical boundary (e.g. changes in suspension geometry, brake balance, tyre grip, etc). The more the driver can push out the envelope of the plot to the ideal circle, the better use he/she is making of the available grip of the tyres and the available grip of the track.

But what is the limit of the vehicle, or the limit with a perfect driver? A G-G diagram is useful as a comparison tool.

Take the example above, the red data is fastest lap from the Daytona sample file, the overlayed lap is the fastest lap of the Escort sample file. From this example we can see that although the lap times are less than 1 second different, the plots show very different characteristics of the two cars. The black data is out further to the left and the right, showing more cornering forces from the Escort compared to the Daytona. The Escort also shows more samples in the braking area, up to 1.2G deceleration, with the Daytona reaching only just over 1g from a far heavier vehicle. The obvious place where the Daytona is better is up the top of the G-G diagram, showing consistently greater acceleration. Now this example is comparing two different types of car, but it shows how you can overlay different drivers, in the same car and learn how, and why one driver is different than another in the way they extract speed from a car.

The best way to obtain high quality data is to use a 3-axis accelerometer mounted at or below the centre of gravity. We recommend mounting the sensor on Velcro or alike to isolate the vibration in the car from the forces applied to the vehicle itself that we really want to measure.



The datum cursor is a second cursor that allows measurements to be made between two points. To place the datum cursor, position the main cursor to the point of interest then press the 'Space Bar' key, then move the main cursor as normal. The graph labels now show the values of each channel at the datum cursor, main cursor and the difference between the 2 values.

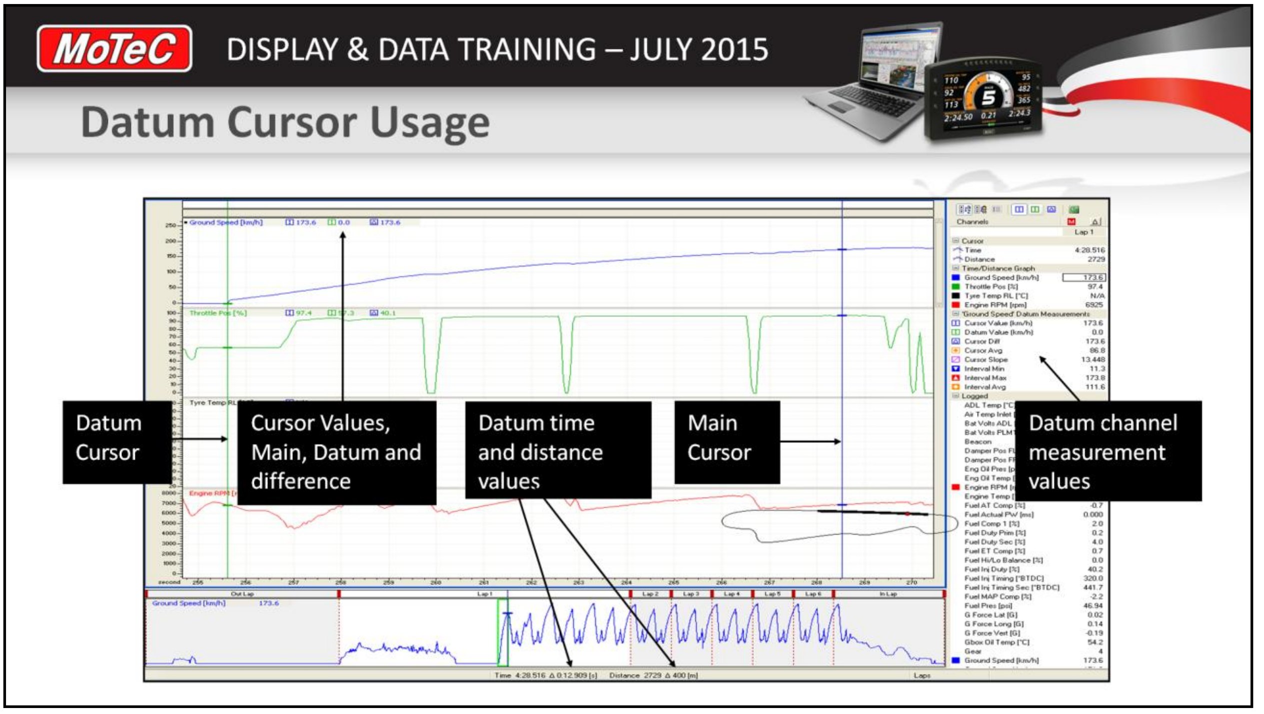
In addition to this, there are Datum Measurements in the cursor window for the currently active channel. The active channel is denoted by the vertical scroll bar next to that trace, by the channel value having a box around it, and the channel name is given in the 'Datum Measurements' area.

Measurements:

∆Time	Time difference between the cursors
∆Distance	Distance difference between the cursors
Cursor Value	Channel value at main cursor
Datum Value	Channel value at datum cursor
Cursor Diff	Channel difference between 2 cursors
Cursor Avg	Average of the 2 cursor positions
Cursor Slope	Rate of change between the 2 cursor positions (gradient)
Interval Min	Min channel value b/w cursors
Interval Max	Max channel value b/w cursors
Interval Avg	Average of all points between the cursors

Keyboard shortcuts:

'D'	Toggle datum mode (& cursor) on/off
'X'	Swap positions of main and datum cursors



Datum Cursors are an efficient way to measure the change in a channel across a period of either time or distance. Common uses of this include measuring the starting performance of a car (0-100km/h), measuring temperature change across a period, RPM rate of change in each gear and much more.

Straight Line Acceleration

- Race Starts, 0-100 kmh times use Datum Cursor

The above example shows the car leaving the line where the green Datum cursor has been placed. The Main cursor has been placed when the car has reached 100km/h.

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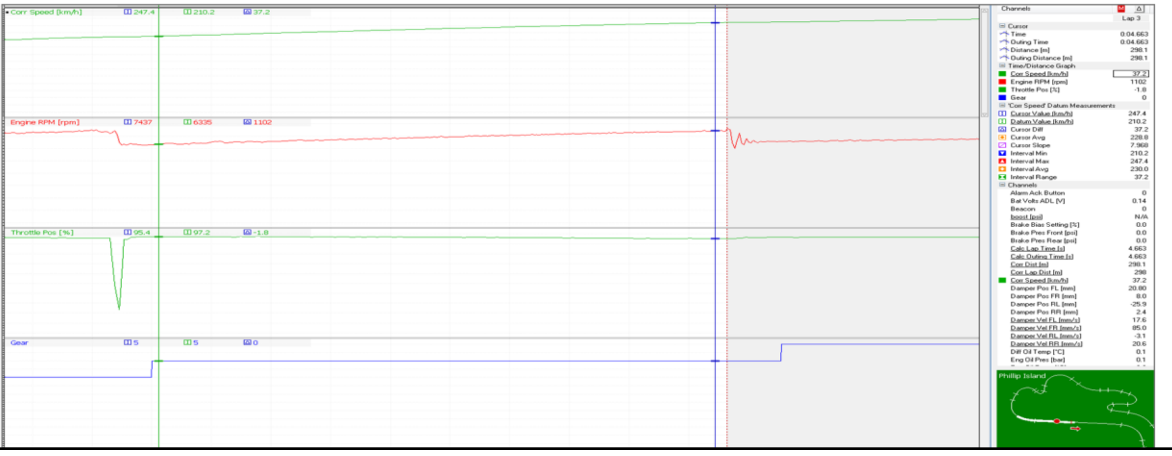
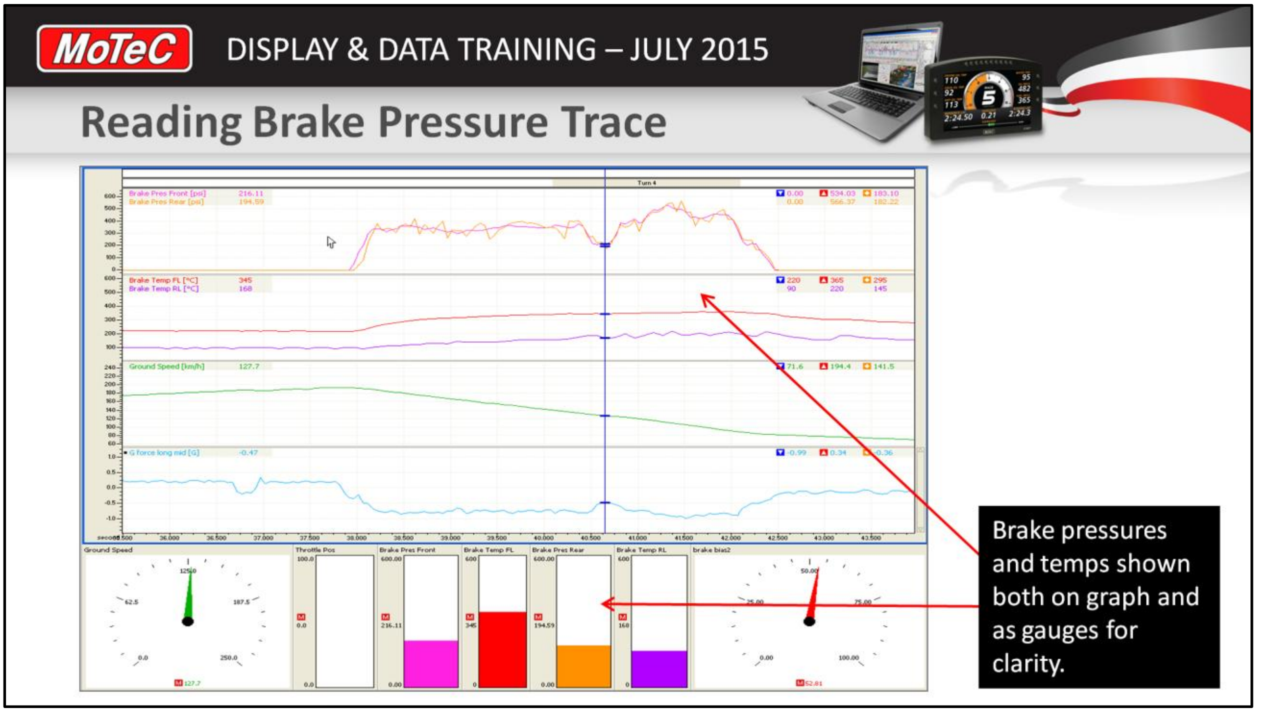
Rate of Change Measurement

- Easily measure rate of change using Datum Cursor. See acceleration (km/h/Sec) of a V8 Supercar at Phillip Island in 5th gear. Keep this number in mind when dyno tuning your car next time.

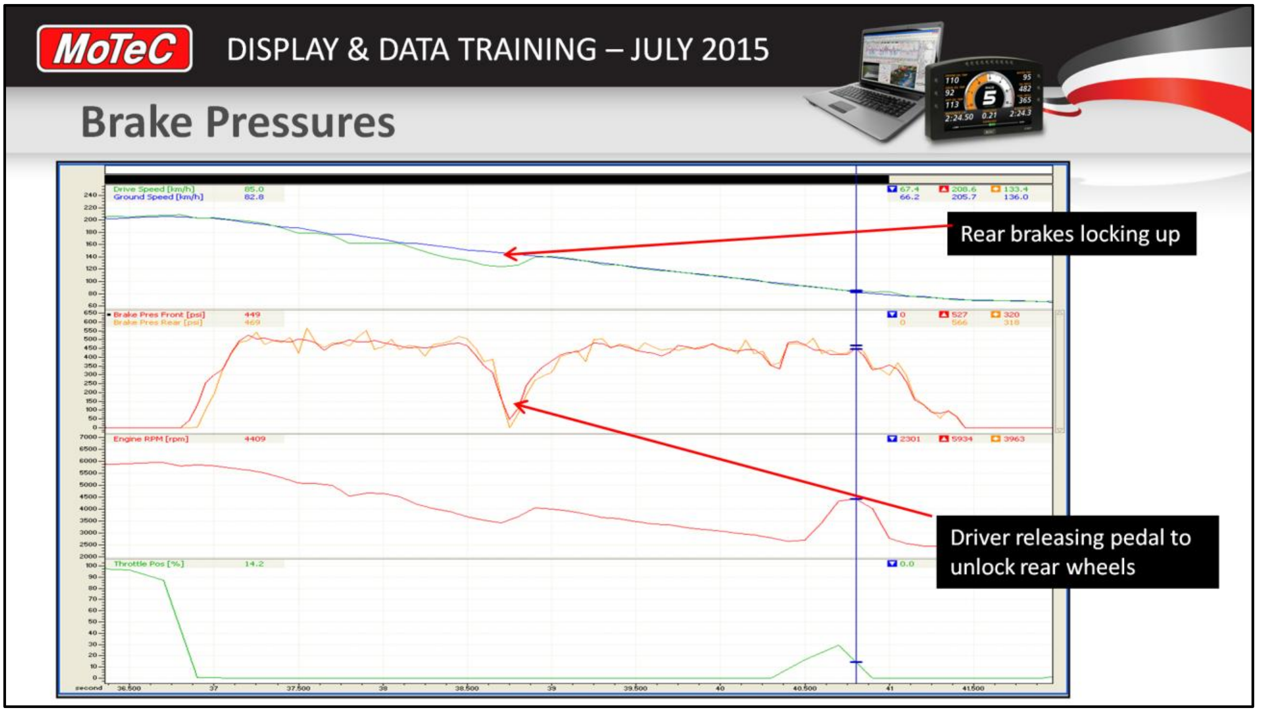


Rate of change measurement is very useful in looking at real world accelerations. You can look at gear accelerations to compare to other cars. Just place your datum cursor at the start of the measured area, then put your cursor at the end of the area, and select the channel you wish to measure. Cursor Slope from the values box will tell you your rate of change.



When it comes to fine-tuning a racecar to improve its performance around the track, many people focus on the horsepower delivered by the engine and the handling characteristics in corners. In fact, the brakes are going to have a significant effect on lap time, as well as lap-to-lap consistency and driving ease. Fine tuning the brakes allows us to exploit more efficiently the grip available under each wheel to minimize the braking distance and facilitate overtaking maneuvers during the race. The right brake bias setting will also reduce the risk of flat spotting the tyres, and make the car easier to drive. One of the most effective tools to monitor the brakes is two brake hydraulic pressure sensors – front and rear. This type of measurement will allow you to understand how your brake system is being used and help the driver to evaluate its performance after a session.

Often, a better braking system can make the little difference at the end of the straight that allows overtaking another car. As in any other hydraulic system, knowing the pressure of the fluid circulating is going to help you to monitor the different forces applied in each of the devices connected. Moreover, the driver can make progress in his driving style: comparing his braking point lap after lap, the intensity of his braking and his speed on the pedal.



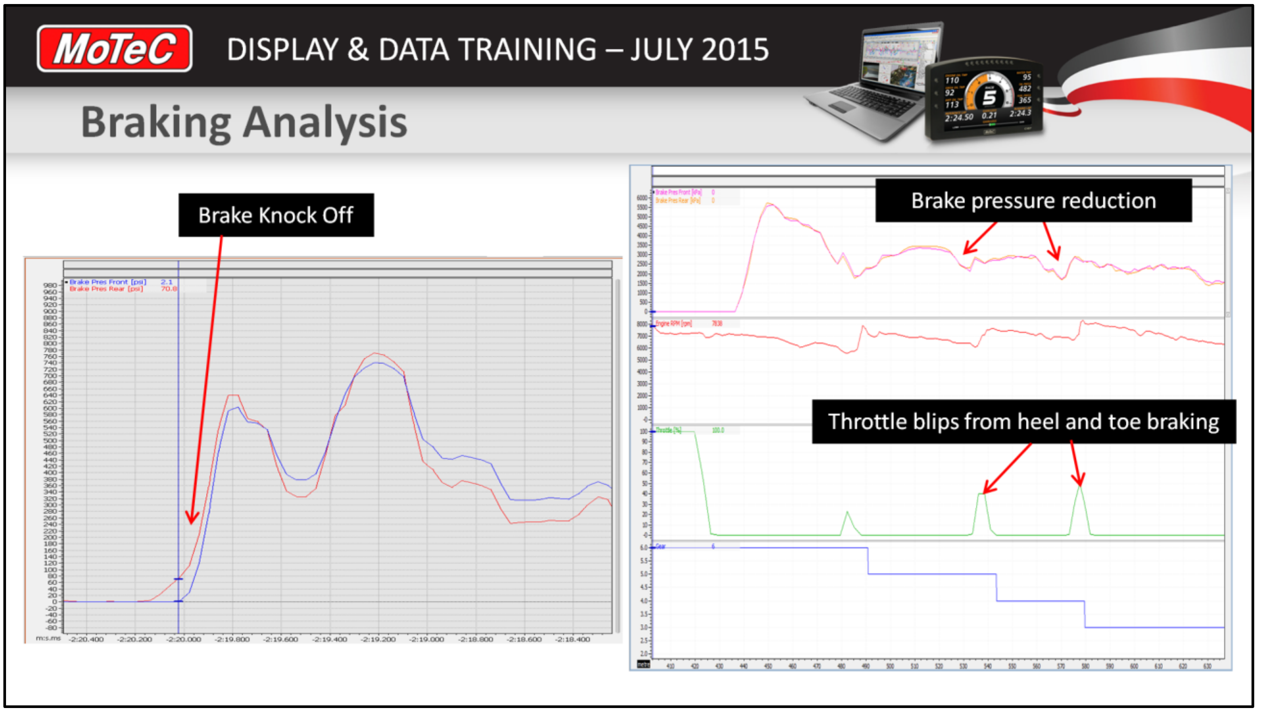
It may seem obvious, but looking at the brake pressure traces gives you the time at which the driver started to brake. This information is very important, as a few meters difference in braking are very important for the speed you carry through the corner, and the time you gain or lose. Once again, looking at these traces with an overlay between two laps will permit you to perform a quick and efficient analysis of driver style and consistency.

Be careful with the logging rate used for those channels. If it's 10Hz for example, the system will record one value each tenth of a second. And at the end of the straight, at 250 km/h, the car is traveling 7 meters in one tenth of a second. So before concluding that driver A brakes 21 meters later than driver B at the end of the straight, check if your logging rate needs to be increased.

Directly measuring the pressures in the Front and Rear brake systems allows you to know how the driver is braking. In effect, both the shape and the amplitude of the brake pressure traces are very important for optimum braking. Most of the time, you want the maximum deceleration (indicative of late braking) to reach the maximum speed in the corner without losing speed in corner entry and being able to carry the maximum speed in corner exit.

The shape of the optimum trace can be explained by:

- Having the maximum deceleration in corner entry
- Losing the minimum time and speed in corner entry
- Releasing the pedal progressively and gently while turning
- Braking hard at the beginning (by literally jumping on the pedal) will be shown as bigger pitch acceleration.

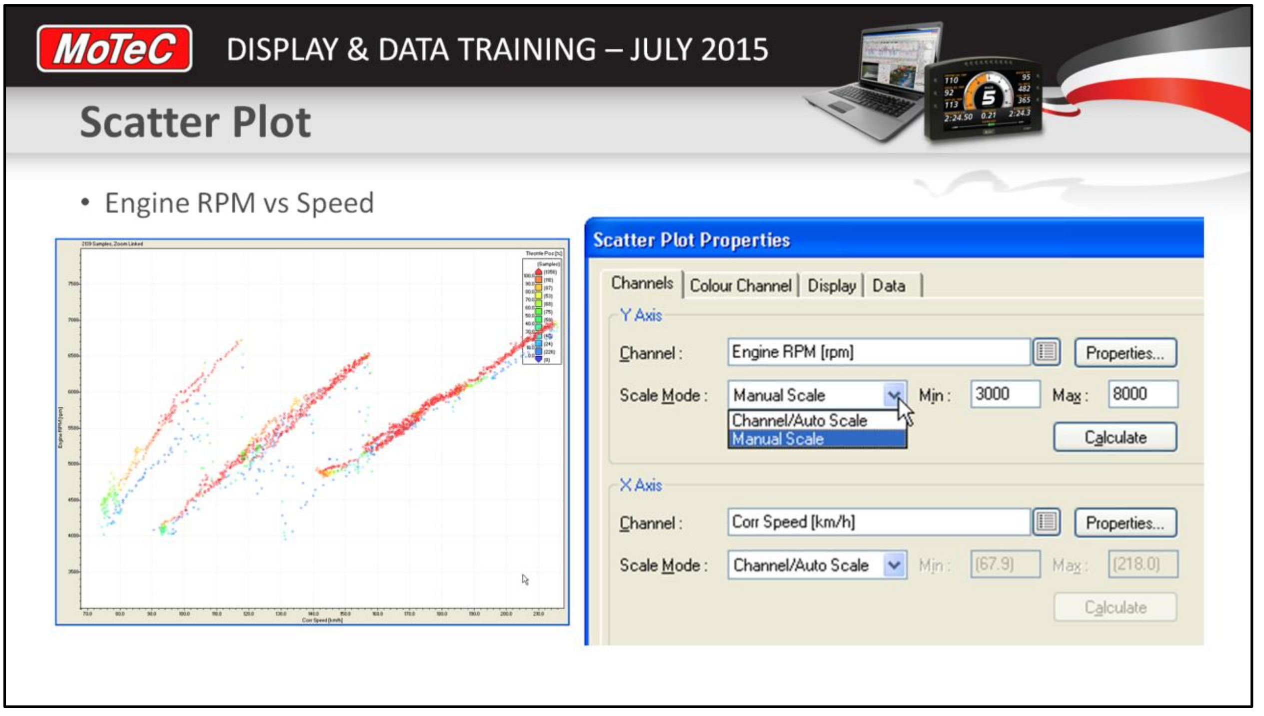


How much does he lose in heel-toe braking?

In a braking zone where the driver downshifts gears, it is always interesting to look at what happens to the brake pressure during that time.

We can clearly see that each time the driver downshifts, he is adding a small amount of throttle, and because he is doing that the brake pressure diminishes slightly. As this ends up being time lost under brakes, the goal here is to lose the minimum of braking pressure while downshifting. It is possible to monitor the driver's progress on this issue using brake pressure sensors.

Brake knock off can be identified when the pressure in the rear builds before the front measures. This is due to the front pads needing to be pushed out further before making connect with the brake rotor.



The scatter plot shows points for two channels where one channel is on the x axis and the other on the y axis, allowing for relationships and dependencies between them to be identified.

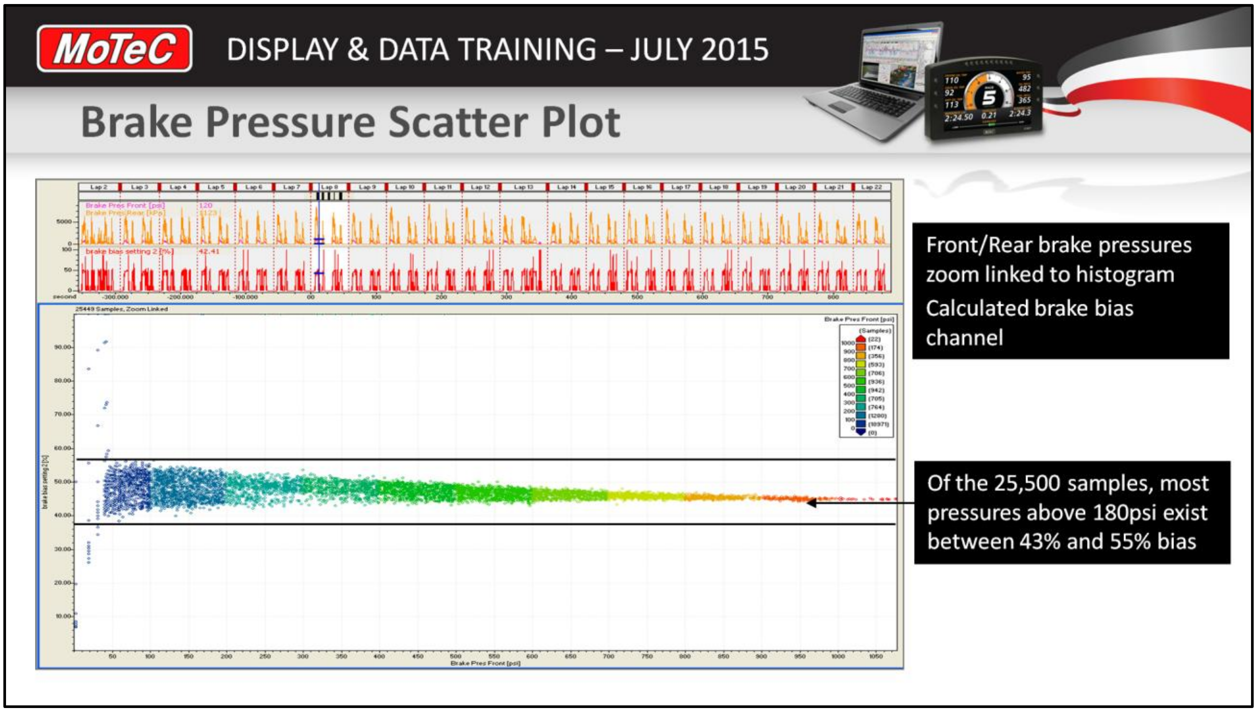
By default the Scatter Plot will scale according to the minimum and maximum channel values of the X and Y axis channels. This can be changed by selecting 'Manual Scale' for either channel and entering min and max values. It is zoom linked to other Worksheets and will display data based on the current zoom level. To see an entire session worth of data press F2. Select a different lap using the Data window or the lap select bar above the Worksheets.

Colour Channel

The scatter plot allows a 3rd channel to be used to colour each of the data points, the above example uses throttle position as the colour channel. The channel selected is divided in the number of bands specified and colours assigned accordingly. Data can be removed from the plot by unchecking the box next to the range values.

It is also useful to know that the number of samples logged in the particular band areas is shown on the right of the colour.

Press the up and down arrow to increase and decrease the selected data used to create the scatter plot.



An XY graph, or Scatter Plot is a graph that shows the relationship between 2 channels. They can be used to represent many things, such as gearing, G-G diagrams, Brake bias, oil temp vs Pressure and much more. In this instance, we are looking at a Brake Bias Scatter Plot. The graph shows brake bias on the Y axis and Front brake pressure on the X axis. What you are being shown above is one dot on the graph per sample of combined brake pressure and brake bias across the selected session. In the example above, there are 25,449 samples across the 24 laps around Calder Park Raceway.

In a good brake setup, each time that you press the brake pedal to a given pressure, you should get a consistent amount of pressure going to the front brake lines, and a consistent pressure going to the rear brake lines. The last thing that a driver wants is to press the brakes one time and get mostly front brakes, then do the same thing again and get mostly rear brakes.The integrity of the brake system is the critical element you must minimize. In practice, there is nothing worse than an inconsistent brake system. You can always change your brake pads, rotors or calipers, but if your system does not react the same way each time you use it, you cannot rely on it.

What the brake bias knob on the dashboard tells you is one thing, and what really happens inside the system may be different, sometimes very different, all because of compliance in the pedal box and master cylinder. That’s why it is so interesting to look at changes in the hydraulic brake bias.

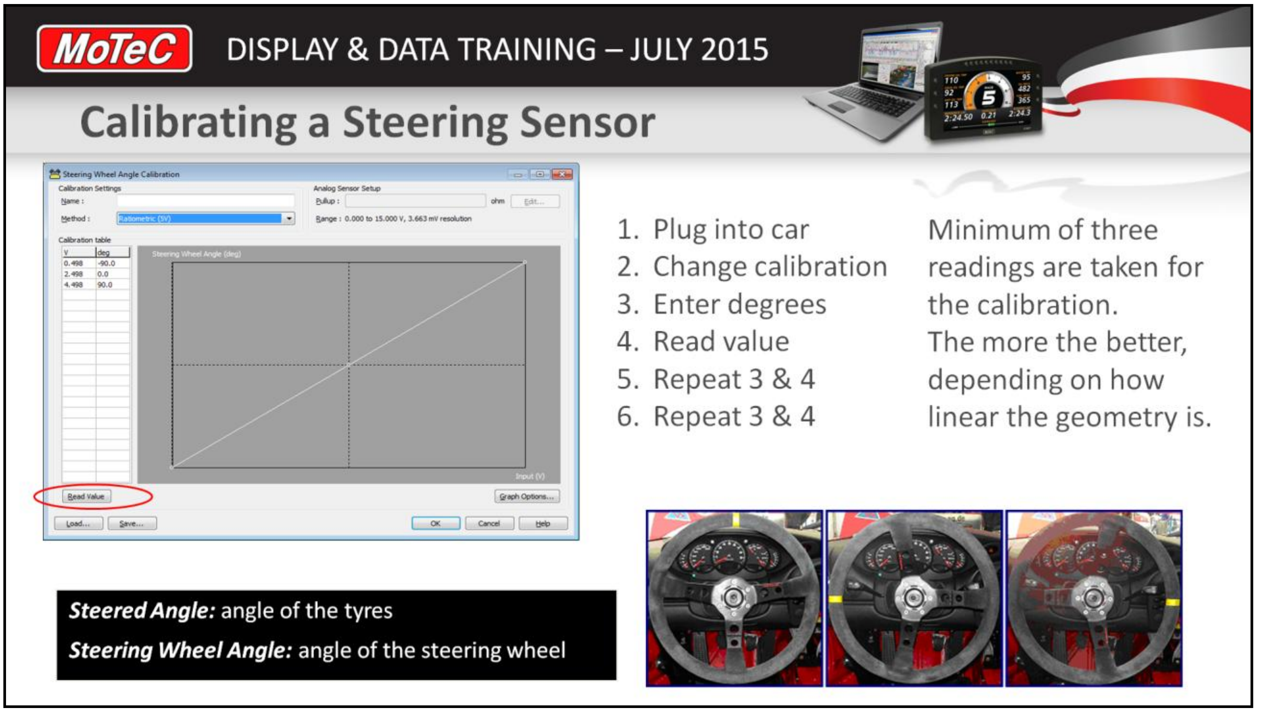
This graph is colored to indicate the front brake pressure. We can see that for small pressures (i.e. for light braking) the brake bias is very inconsistent, but fortunately, it is better when the pressure increases. By plotting this kind of graph, you can either see how consistent your braking system is, or compare two different systems.

- Select Workbook ‘Seminar, Create a New Worksheet, choose ‘ADD’, then ‘Scatter Plot’.
- Ensure that you still have out lap (1:34.136) from the Calder, i2 data day file from 9:53am selected.
- Click Add type in brake and choose ‘Brake Pressure Front’.
- Select the button next to the channel box listed under X axis, and choose ‘Brake Bias Setting’.
- Select scale mode, and change it to manual, setting min value to 0, and max value to 100
- Select the ‘colour channel’ tab, tick the ‘enable colour channel’ box, then select brake pressure front as the colour channel. Click OK.

DISPLAY & DATA TRAINING – JULY 2015

Steering Sensors

- Rotary Sensors
- Interlocking geared teeth
- Can measure steering wheel rotation



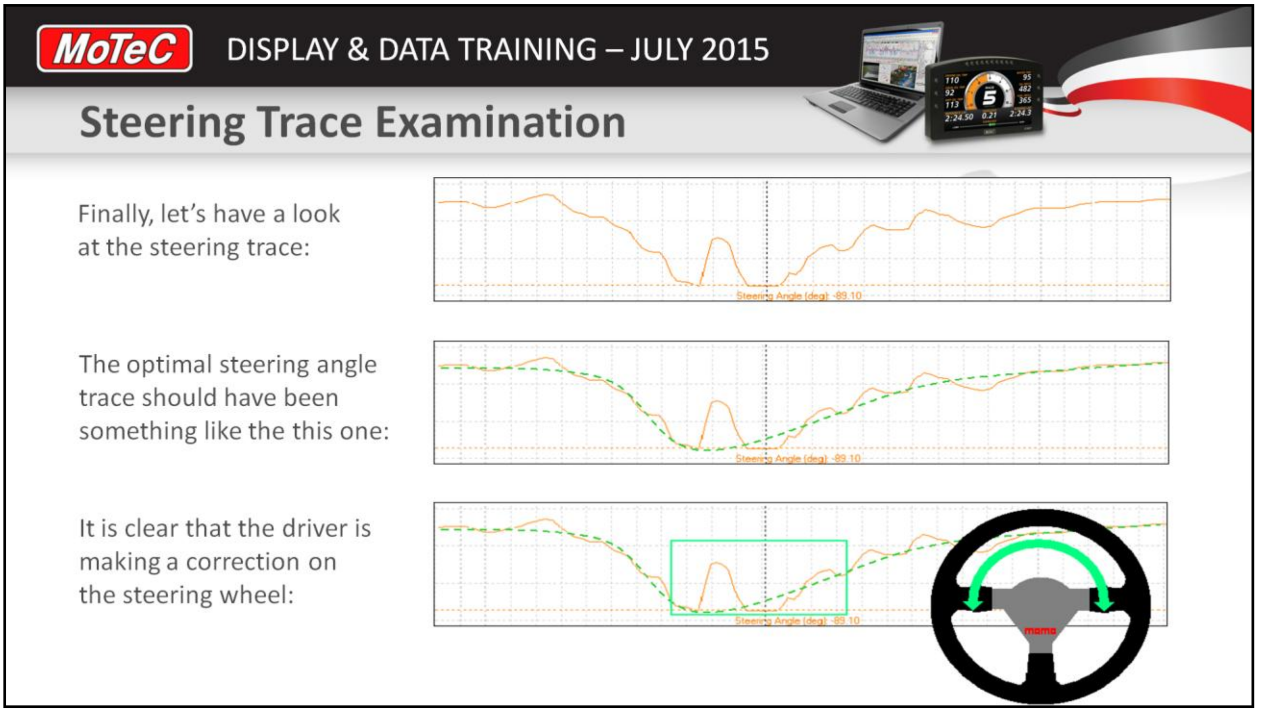
1. Generally for calibration of linear sensors a max/min measurement is taken and the points are interpolated. The above example shows a simple way to calibrate such a sensor for Steering Wheel Angle.

2. We know that at maximum lock the steering wheel angle is 90 degrees. By turning the wheel to full lock we enter the number in the right hand column for degrees.

3. By pressing the READ VALUE button the voltage from the signal wire is read into the Dash and displayed in the left column.

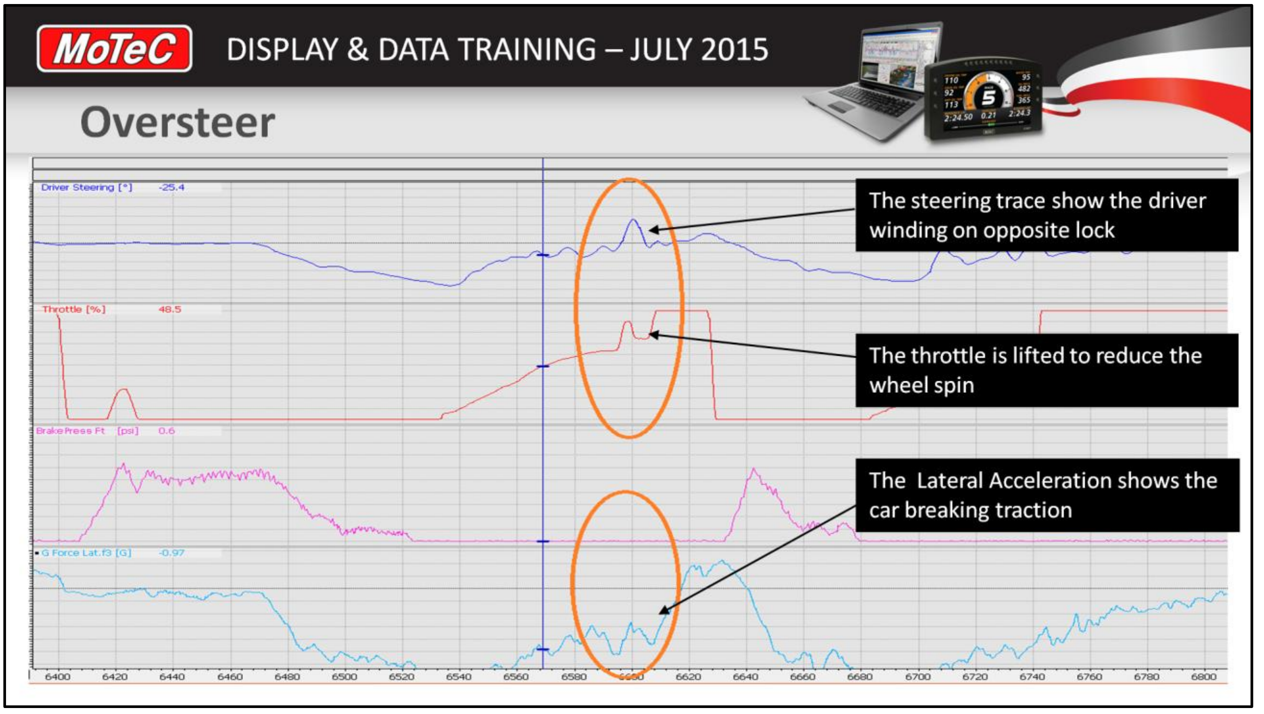
4. This procedure is repeated for straight ahead and the opposite lock.

Reading a Steering Trace



The actual steering trace is shown in orange, an ideal trace is shown as a dashed green line.

Note that a right handed turn has a positive steering wheel angle, while a left turn has a negative angle. Some users will use the reverse. This is ok as long as you are consistent and preferably use the same convention for lateral G force.

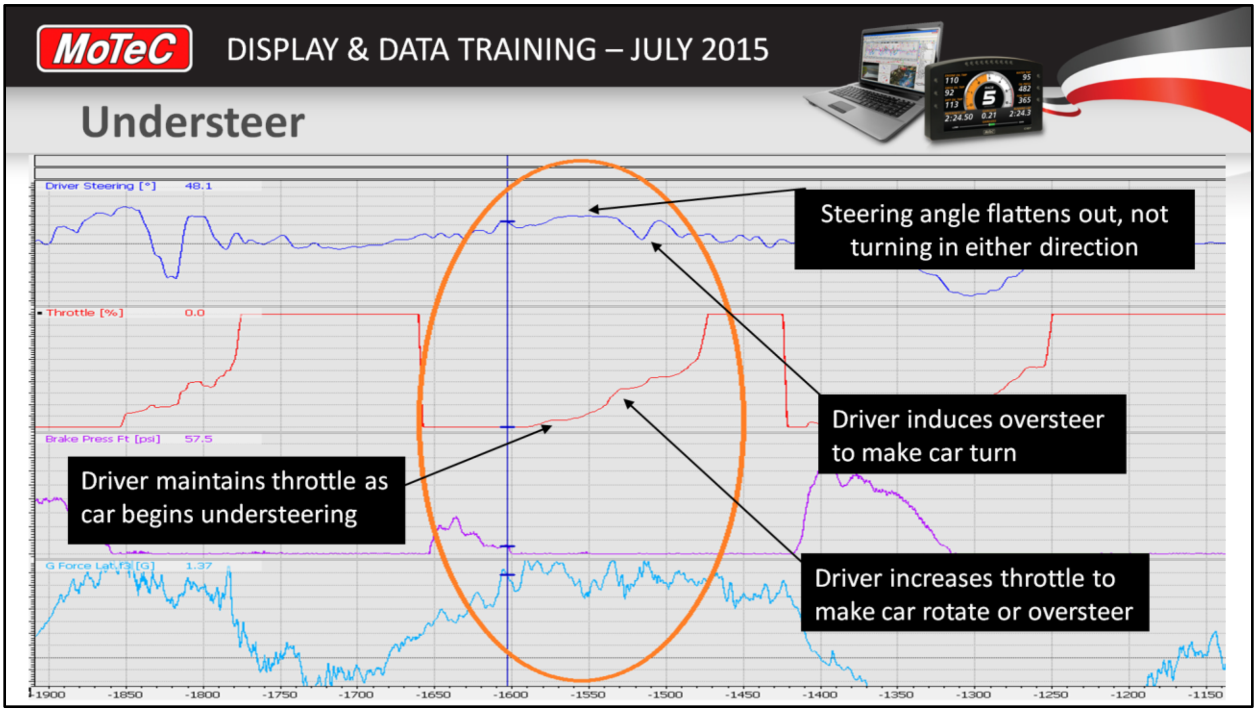


Oversteer

Oversteer can also be recognised by a loss in lateral G force along with a steering correction by the driver and a reduction in throttle. The G force trace is one in which we can see a balance problem with the car. The driver is unable to drive the car hard out of the corner for fear of spinning the car around, hence the decrease in lateral Gs at the exit of the corner.

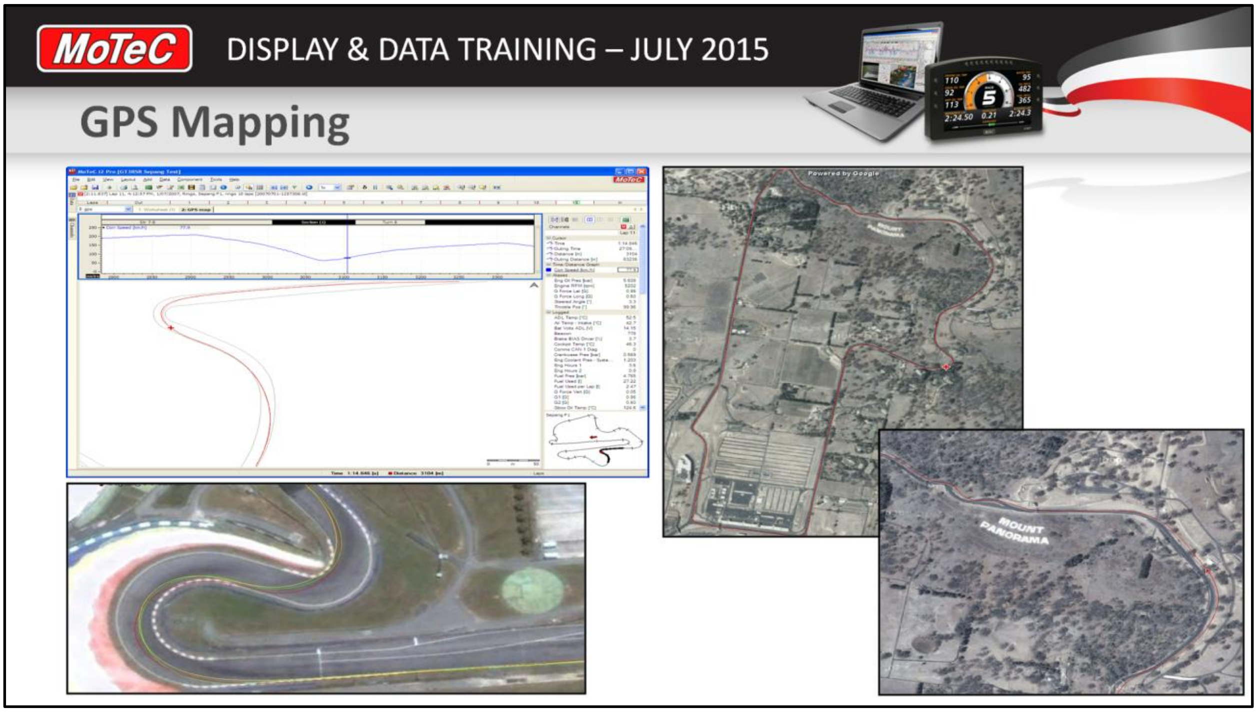
If we examine the steering trace we will be able to see how the driver is reacting as the car exits the corner. It is useful to be able to see this, as you can use it to measure the reaction time of the driver to the oversteer, and perhaps be able to better quantify just how severe the oversteer is. This is an important measurement to make when trying to solve a handling issue; yes the car may still oversteer, but have we made an improvement or not?

After observing the steering trace it is clear that the driver has quickly reacted to correct the situation by opposing the direction of the corner to prevent the car from swapping ends. A throttle lift often accompanies this trace, as it does in this case, but sometimes the driver decides to power through the oversteer to compensate for the loss of cornering grip with pure forward acceleration.

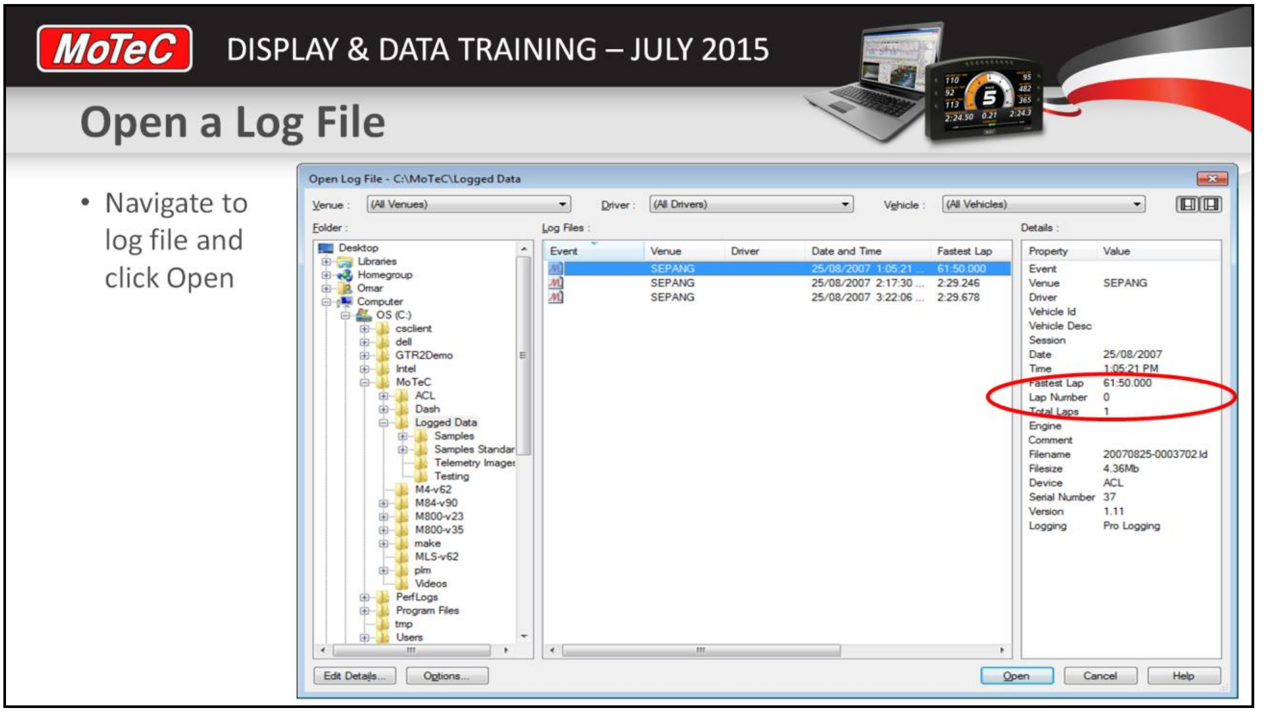


In this example the driver has turned into the corner and stopped moving the steering wheel, this is evident by the flat trace, at this point the driver has began to introduce some throttle, this further adds to his understeer.

The driver of this vehicle has than induced a rapid change in throttle position to help induce some oversteer to make the car rotate as the front wheels are no longer turning the car.

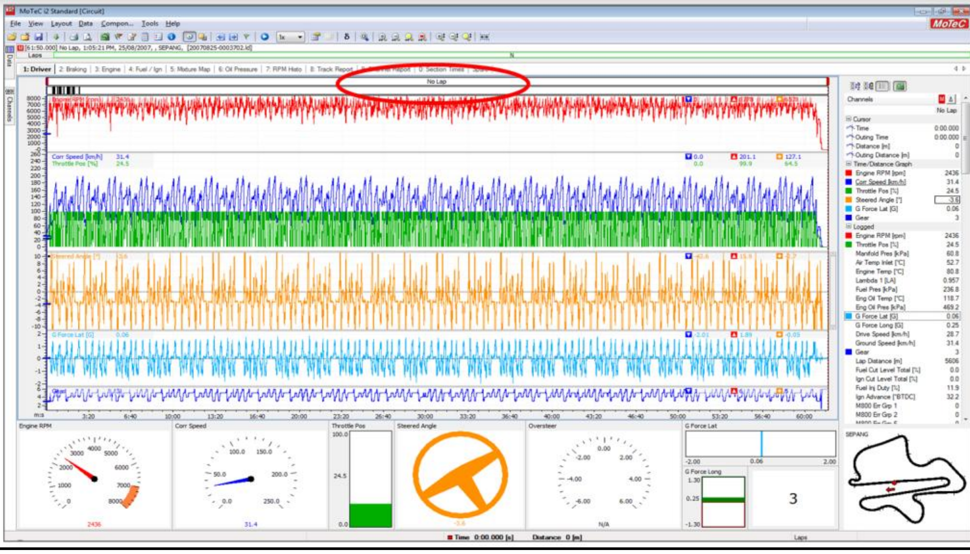


Track maps in **i2** can now be created purely from the GPS data with no other sensors needed. See example above. i2 will allow also you to use an export function to place your driver's line into Google Earth. The function is under the 'File' menu and creates a kml file that is compatible with Google Earth from the position data that is currently visible on the graph. Note the red trace in the image above right.

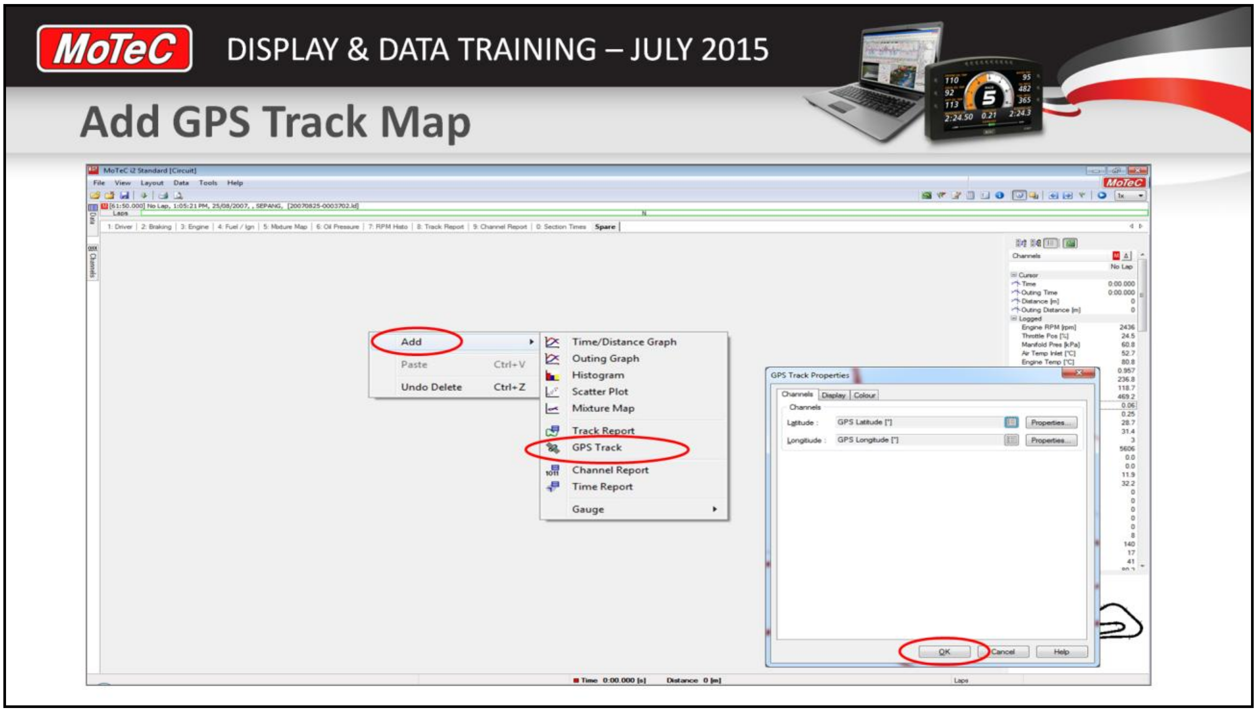


Open the log file that is missing laps but has GPS Latitude and Longitude logged.

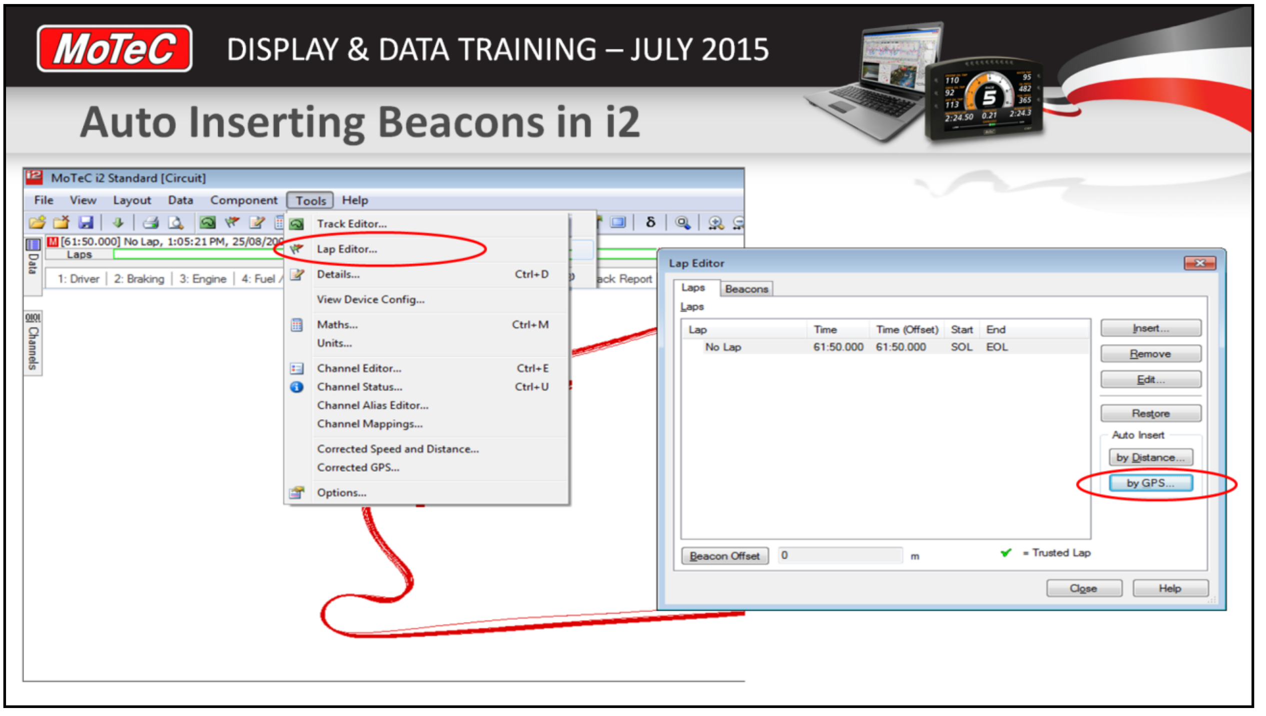
Open a Log File



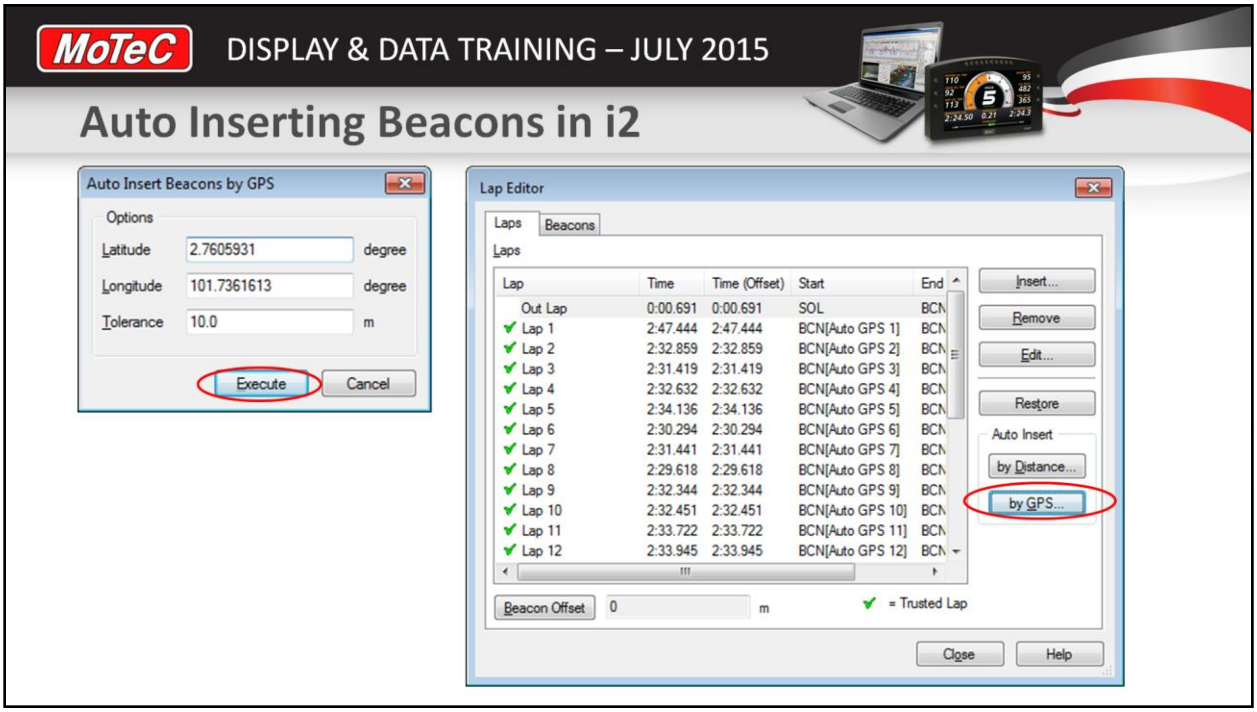
You can see that there are no laps in this data.



Add a 'GPS Track'.



Go into 'Lap Editor' and click 'By GPS'.



Enter the GPS Co-ordinates and click Execute, then click Close.

DISPLAY & DATA TRAINING – JULY 2015

Time Report

Section Times

	Lap 1	Lap 2	Lap 3	Lap 4	Eclectic	Rolling Minimum
Main Str (End)	0:07.275	0:07.151	0:07.462	**0:07.079**	0:07.079	**0:07.079**
Turn 1	0:04.158	0:04.141	0:04.467	**0:04.139**	0:04.139	**0:04.139**
Str 2-3	0:02.710	0:02.609	0:02.574	**0:02.638**	0:02.574	**0:02.638**
Turn 2	0:02.787	0:02.649	0:02.688	**0:02.661**	0:02.649	**0:02.661**
Turn 3	0:03.616	0:03.500	0:03.573	**0:03.557**	0:03.500	**0:03.557**
Str 3-4	0:05.155	0:04.900	0:04.965	**0:05.044**	0:04.900	**0:05.044**
Turn 4	0:05.336	0:05.098	0:05.140	**0:04.899**	0:04.899	**0:04.899**
Back Straight	0:07.050	0:06.726	0:06.955	**0:06.701**	0:06.701	**0:06.701**
Turn 5	0:01.829	0:01.681	0:01.897	**0:01.763**	0:01.681	**0:01.763**
Turn 6	0:02.770	0:02.693	0:02.978	**0:02.725**	0:02.693	**0:02.725**
Turn 7	0:11.749	0:11.730	0:12.028	**0:11.491**	0:11.491	**0:11.491**
Main Str (Start)	0:10.723	0:10.800	**0:10.459**	0:11.055	0:10.45[illegible]	**0:10.459**
Totals	1:05.163	1:03.682	1:05.192	1:03.759	1:02.770	1:03.162

Split Times

Time Report - Track Sections (All Laps)

	Lap 1	Lap 2	Lap 3	Lap 4	Eclectic	Rolling Minimum
Split 1	0:18.894	0:18.301	0:19.027	**0:18.331**	0:18.301	**0:18.331**
Split 2	0:32.856	0:31.888	0:32.806	**0:31.666**	0:31.666	**0:31.666**
Split 3	0:13.413	0:13.493	**0:13.359**	0:13.762	0:13.359	**0:13.359**
Totals	1:05.163	1:03.682	1:05.192	1:03.759	1:03.326	1:03.356

The Time Report shows split times in a tabular form. The sections that are used may be the default sections or user defined sections.

Eclectic

The Eclectic column shows the minimum times for each section and totals them to show the best possible time if all sections could be completed in the minimum times. This can be a bit unrealistic as driving line etc. can affect the times from one section to the next so the minimum times can't be joined up in practice.

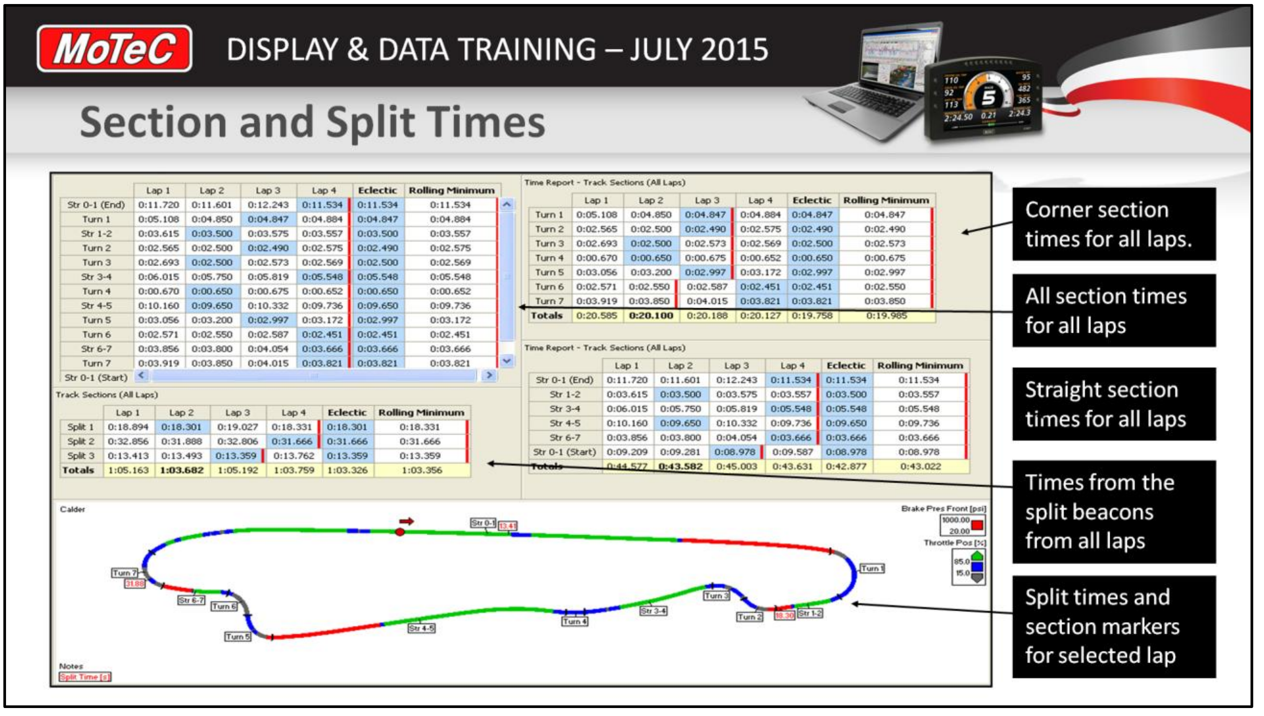
Rolling Minimum

The rolling minimum shows the set of consecutive section times that form the minimum overall time for a complete lap. These times are highlighted in bold to easily determine where this starts, i.e. it will typically be spread across 2 laps.

Sections

To change the sections used, go to the Time Report properties (F5) then 'Data – Ranges – Report on:' and select the section type – Defaults, User Defined or Splits (if available).

Press the '0' key, or choose section times to select the section times report.

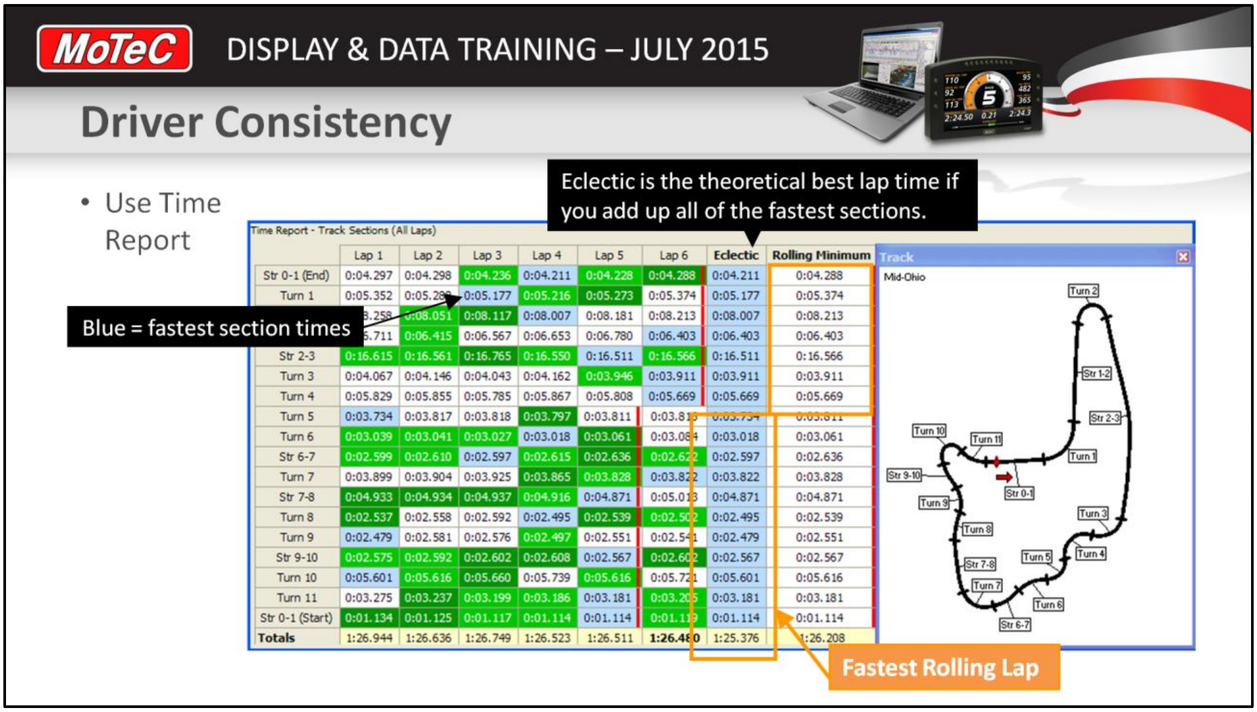


Similar to channel statistics**, i2** can create reports based on time around the track, called a 'Time Report'. These time reports are used to further examine the detail about where you were fast and where you were slow, section by section across the whole lap.

You can report on:

- All sections
- Corner sections only
- Straights sections only
- Custom sections only
- Split beacon sections

You can create a report such as the one in the top right corner which shows times for the 4 lap outing, only when the car was going around corners as shown by the section markers on the track. The red line indicates the rolling minimum lap time. The rolling minimum is the fastest lap that the car did for that outing regardless of where the Start/Finish line is. It may start and finish on the back straight, instead of at the start finish line. It is good indication of a lap that the car is capable of doing, as it was actually driven, but can be affected by an artificially fast section, such as forgetting to brake at all for a corner. Check adjacent section times to see if it is a realistic time.



	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Eclectic	Rolling Minimum
Str 0-1 (End)	0:04.297	0:04.298	0:04.236	0:04.211	0:04.228	0:04.288	0:04.211	0:04.288
Turn 1	0:05.352	[illegible]	0:05.177	0:05.216	0:05.273	0:05.374	0:05.177	0:05.374
[illegible]	[illegible]	0:08.051	0:08.117	0:08.007	0:08.181	0:08.213	0:08.007	0:08.213
[illegible]	[illegible]	0:06.415	0:06.567	0:06.653	0:06.780	0:06.403	0:06.403	0:06.403
Str 2-3	0:16.615	0:16.561	0:16.765	0:16.550	0:16.511	0:16.566	0:16.511	0:16.566
Turn 3	0:04.067	0:04.146	0:04.043	0:04.162	0:03.946	0:03.911	0:03.911	0:03.911
Turn 4	0:05.829	0:05.855	0:05.785	0:05.867	0:05.808	0:05.669	0:05.669	0:05.669
Turn 5	0:03.734	0:03.817	0:03.818	0:03.797	0:03.811	[illegible]	[illegible]	[illegible]
Turn 6	0:03.039	0:03.041	0:03.027	0:03.018	0:03.061	[illegible]	0:03.018	0:03.061
Str 6-7	0:02.599	0:02.610	0:02.597	0:02.615	0:02.636	[illegible]	0:02.597	0:02.636
Turn 7	0:03.899	0:03.904	0:03.925	0:03.865	0:03.828	[illegible]	0:03.822	0:03.828
Str 7-8	0:04.933	0:04.934	0:04.937	0:04.916	0:04.871	[illegible]	0:04.871	0:04.871
Turn 8	0:02.537	0:02.558	0:02.592	0:02.495	0:02.539	[illegible]	0:02.495	0:02.539
Turn 9	0:02.479	0:02.581	0:02.576	0:02.497	0:02.551	[illegible]	0:02.479	0:02.551
Str 9-10	0:02.575	0:02.592	0:02.602	0:02.608	0:02.567	[illegible]	0:02.567	0:02.567
Turn 10	0:05.601	0:05.616	0:05.660	0:05.739	0:05.616	[illegible]	0:05.601	0:05.616
Turn 11	0:03.275	0:03.237	0:03.199	0:03.186	0:03.181	[illegible]	0:03.181	0:03.181
Str 0-1 (Start)	0:01.134	0:01.125	0:01.117	0:01.114	0:01.114	[illegible]	0:01.114	0:01.114
Totals	1:26.944	1:26.636	1:26.749	1:26.523	1:26.511	**[illegible]**	1:25.376	[illegible]

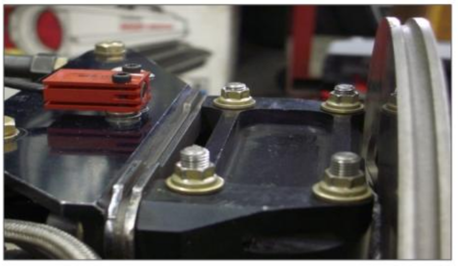
Different shades of colour can be used to indicate how close the driver is to the minimum time in terms of percentage. The lower the percentage, the closer the time is to their minimum and therefore the more consistent the driver is in those track sections.

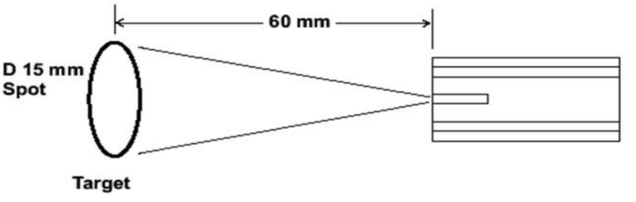

MoTeC
TRAINING CONFERENCE 2015
Evaluating Chassis Performance
i2

MoTeC DISPLAY & DATA TRAINING – JULY 2015

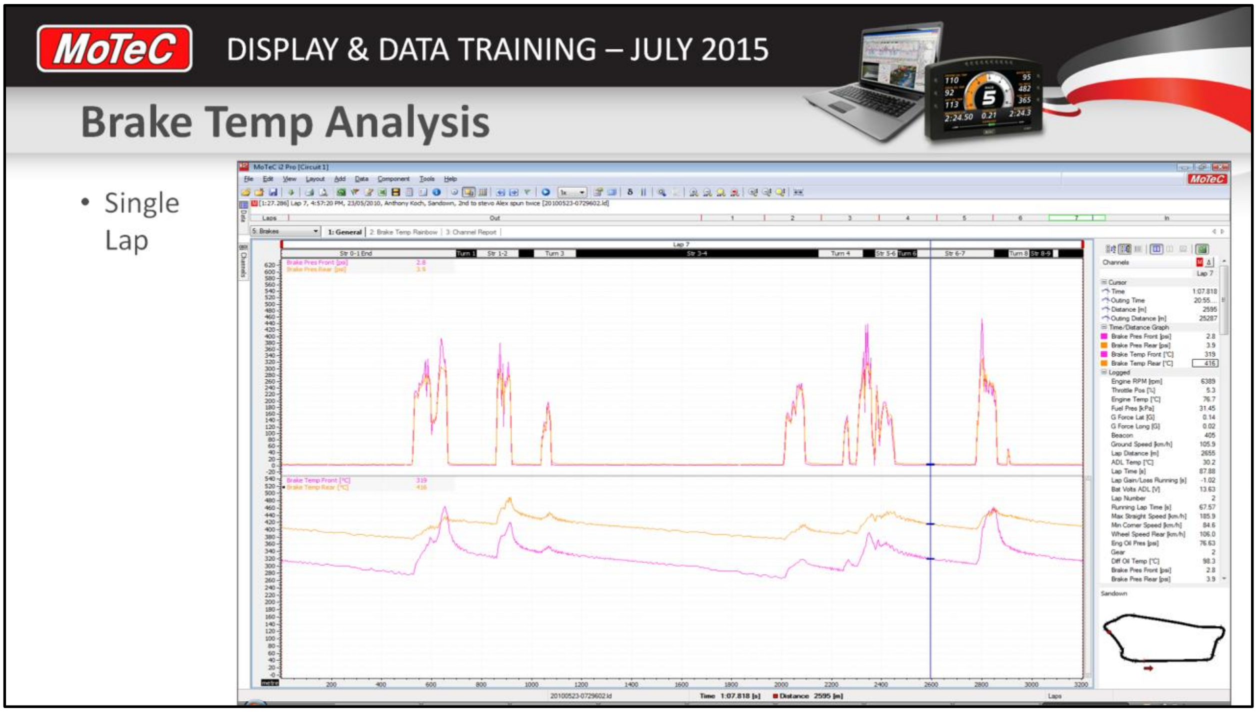
Brake Temp Sensor

- Working temperature of your brake
- Are your ducts cooling efficiently?

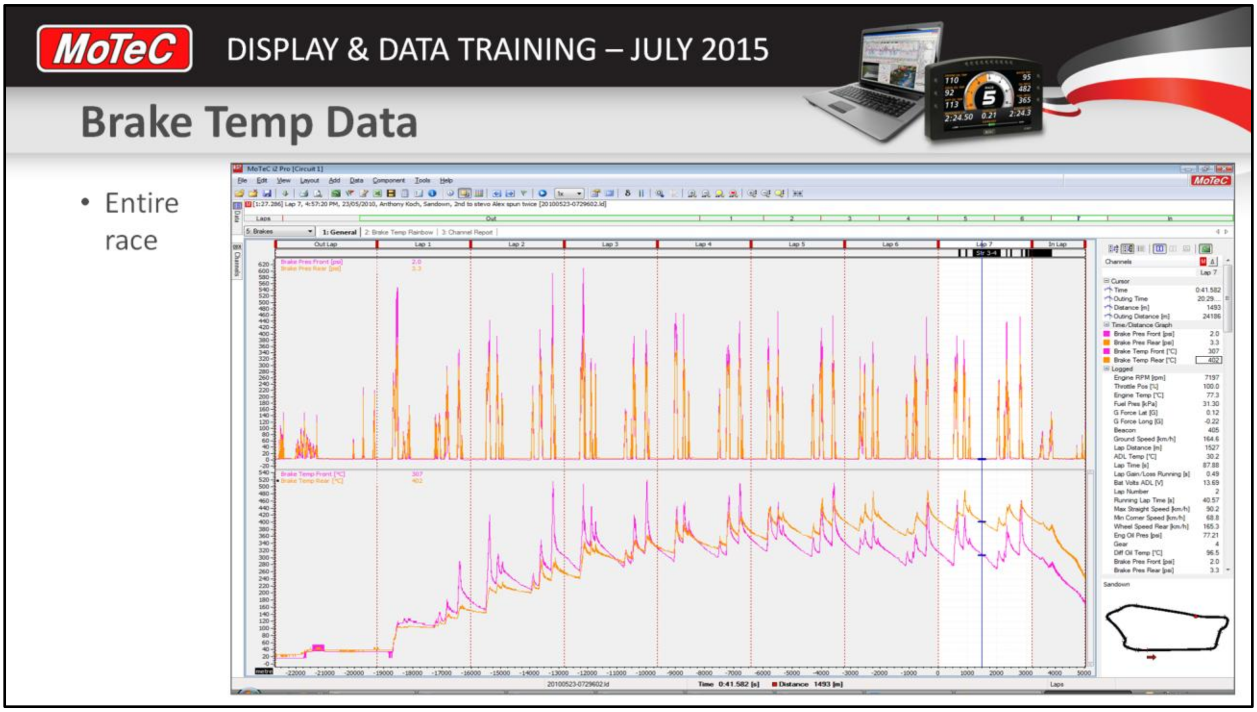




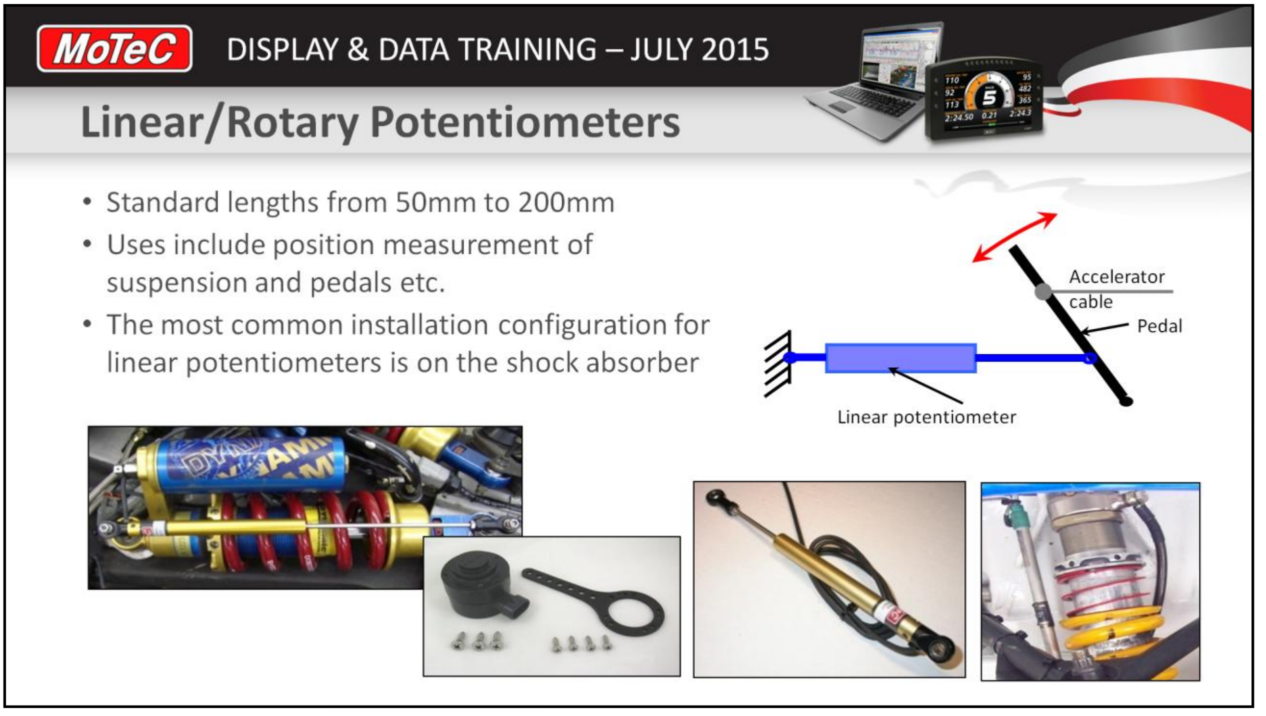
Under braking the kinetic energy is turned into heat and light in the brake rotor. This energy can be detected using an Infrared sensor. These type of sensors are also used to measure tyre temperature.



From the brake pad manufacturer – know the temperature range within the braking system when it is operating at its peak performance. From the data we can see if we are achieving the desired temperatures. Then decide what we need to do with brake ducts.



Notice the increasing brake temperatures over a race distance and the stabilization of temperatures over a number of laps.



Linear potentiometer (resistive sensing element) or a linear pot. There is a slider that moves along a track and the resistance changes. Useful sensors but fragile and need to be maintained.

Suspension Analysis

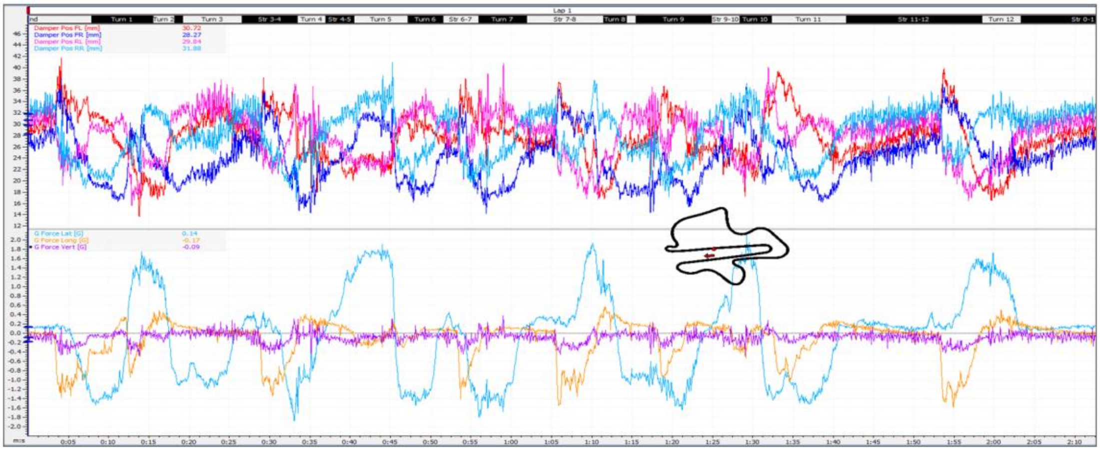
Click on Workbook list, and select ‘Seminar’, select new Worksheet, calling it ‘Suspension’.

Right click on Worksheet space, and select ‘Add’ then ‘Time Distance Graph’.

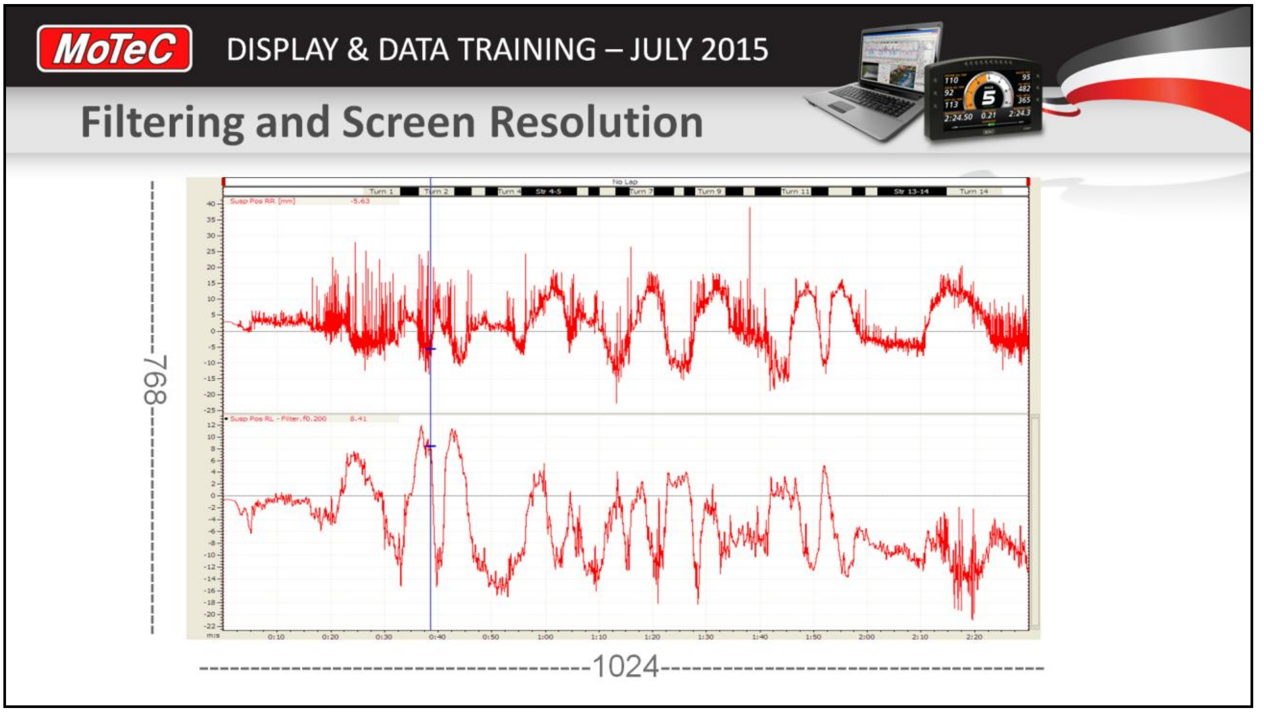
From the next panel, select ‘Add channel’, then add the channels shown above.

Suspension Analysis

- In this example, the front suspension goes negative under braking. Therefore, for suspension position, bump or compression is negative. This is the easiest convention for people to follow.



Observe what is happening on the straights and corners. Convention is to have negative suspension travel as compression.



Firstly, it is important to observe the raw data because this could already highlight some car setup problems, or sensor installation/wiring problems.

Moreover, you may see differences between vibrations in compression and in rebound. Raw data from shocks or strain gauges could be difficult to understand in terms of noticeable car attitude change, especially without zooming in. A filtered signal allows overall trends to be seen without any zoom needed. However, it is important to have a look at them first without applying any filter to be sure that you do not miss a part of the behaviour.

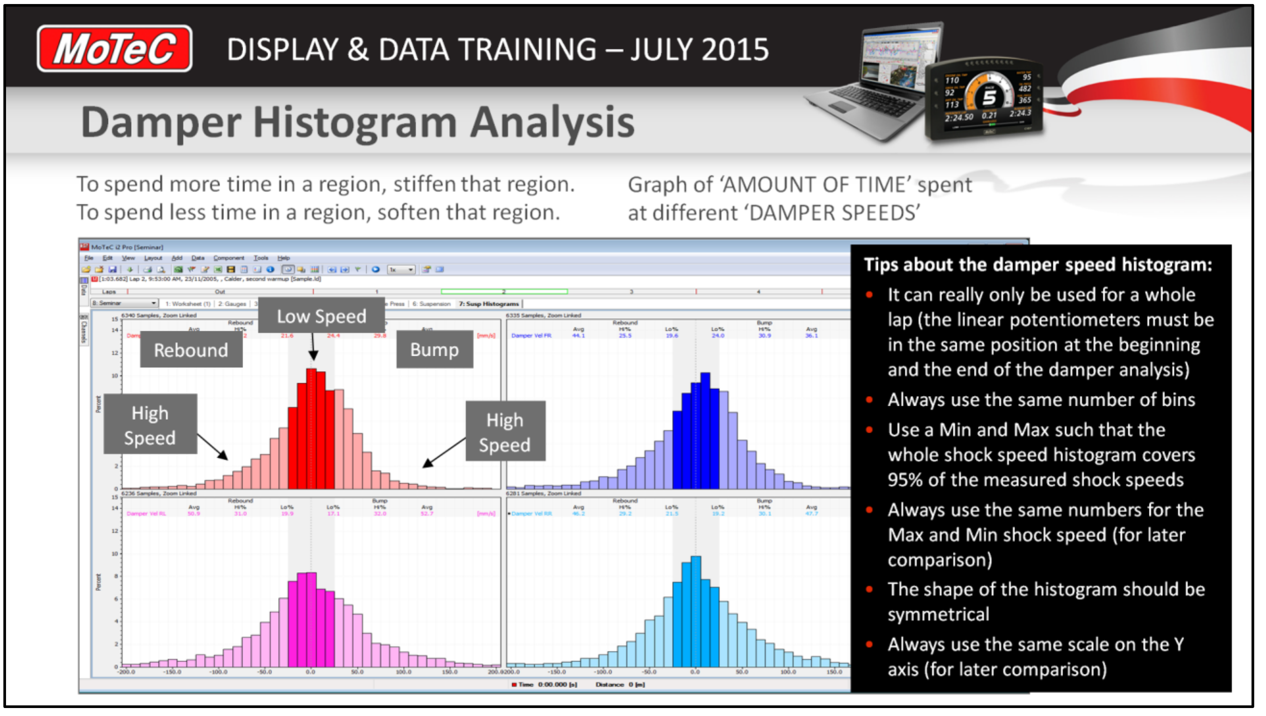
In the same way, it's important to also consider that the size of your screen also acts like a filter.

For example, say that your computer resolution is 1024 x 768 and you are looking at data logged at 20Hz. At the best you will see only 1024 / 20 = 51.2 seconds of the data without any filtering. So if you look at an entire lap that is longer than this you are necessarily 'filtering' – not all of the data points will fit onto the screen. If you want to see the each point, you need to zoom onto a segment equal to or smaller than 51.2 seconds.

Changing the display to show 'Points' rather than lines will quickly tell you if you are seeing all of the data or not.

Talk to the Driver

- The experience of your driver, the comments they give and the way they feel the car will all affect the analysis of the data.
- Is there a balance problem in just one corner?
  - Or is it in all 'right handers'?
- Zoom into the corner(s) and look the damper position at each corner of the car with relation to the G trace and other channels



Damper settings represent an interesting part of fine tuning a racecar. Even if the basic principles are simple, without any tools it is almost impossible for the engineer to know if the dampers are really working at their best.

With four linear potentiometers on the car you can record where, when, and how each damper applies forces to the car.

The damper speed histogram is a simple tool allowing us to check how the dampers are working. It refines the ratio between low and high speed, as well as bump and rebound, front and rear, left and right. It is also very useful for checking that your dampers have been set up correctly.

The damper speed histogram shows the percentage of time (out of the lap time) that the shock is spending at certain speeds.

The damper histogram is made up of four parts. Low speed bump, Low speed rebound, High speed bump and High speed rebound. A damper should always spend more of its time around the change of direction (0mm/s) than any other point on the histogram. It should spend progressively less and less as the graph goes from low speed to high speed. The change over point from low to high speed is vehicle and damper dependant but on a circuit racing vehicle often around 25mm per second. A balanced histogram should show a symmetrical curve. If you want a damper to spend more time in one point on the histogram, you need to stiffen up the damper in that region. To spend less time there, you need to soften the damper in that area.

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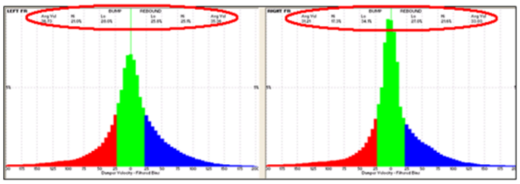
Damper Histogram Analysis

Setting dampers with histograms (1)



Left front	Low speed	High speed
Bump	28.0 %	21.0 %
Rebound	25.8 %	25.1 %

Right front	Low speed	High speed
Bump	34.1 %	17.3 %
Rebound	27.0 %	21.6 %

Left bump low speed is too stiff

Right low speed bump is too stiff

Right damper is stiffer than left damper

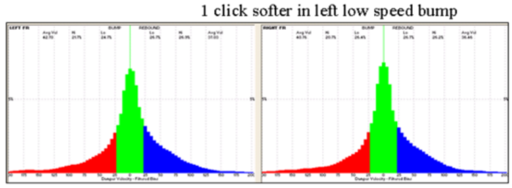
Damper histogram with initial bump/rebound settings

Example of gain made using Damper Histogram analysis

Damper Histogram with modified damper settings

Setting dampers with histograms (2)

Set-up modification : 2 clicks softer in right low speed bump
1 click softer in left low speed bump



Left front	Low speed	High speed
Bump	24.7 %	21.7 %
Rebound	26.7 %	26.9 %

3/10 sec. Gain with this setting!!

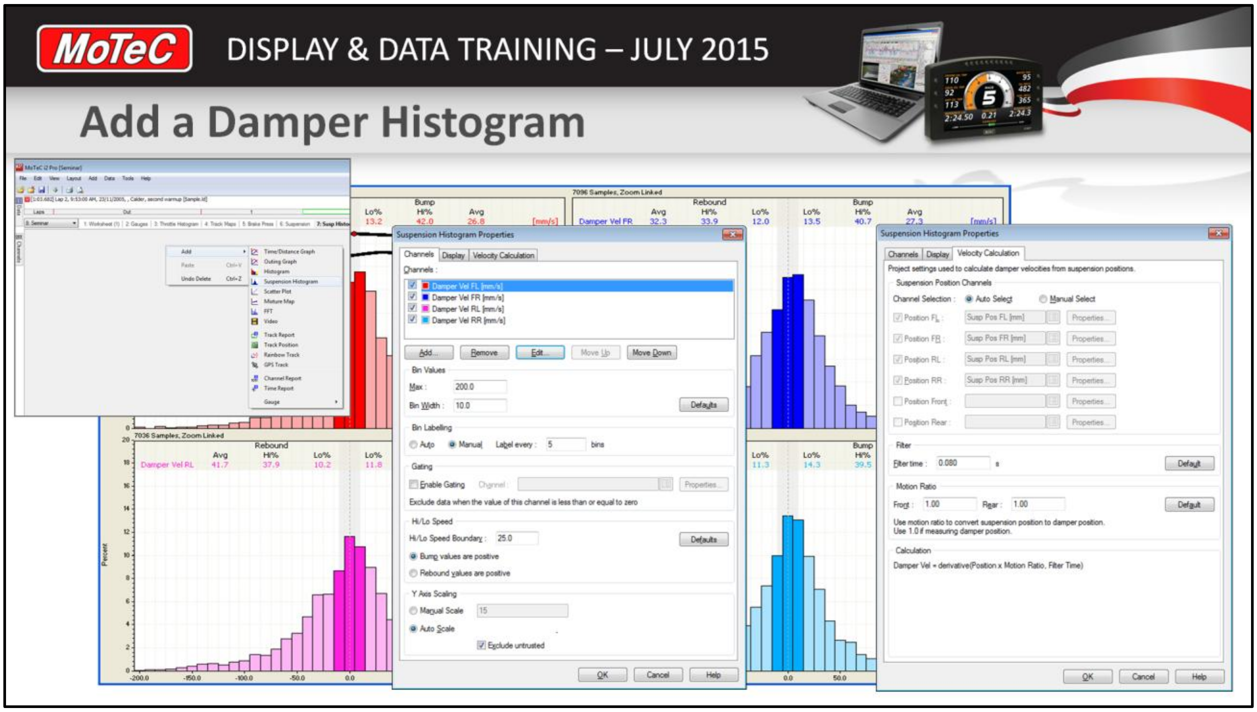
Right front	Low speed	High speed
Bump	26.4 %	20.7 %
Rebound	26.7 %	26.2 %

By simple observation we can see that the 2 front dampers shown in the top left histogram do not seem evenly balanced. A good shock histogram should show a symmetrical curve. If we take the values displayed at the top of the histogram we can observe the percentage of time spent in low or high speed bump or rebound.

When the histograms are compared to each other, we look at Low speed bump to Low speed rebound, then High speed bump versus High speed rebound. We can deduce from the above histogram of the front left damper that the low speed bump setting is too stiff, as it is spending too much time there compared to the low speed rebound. So to fix this we would soften the left low speed bump settings, and in this example we softened it just one click.

Looking at the front right damper, we can see that it is far more uneven. It is spending 34% of time in low speed bump, with only 27% in low speed rebound. To even this out, we would soften the right front low speed bump settings. That would increase the time spent in high speed bump, giving a far more even damper histogram distribution.

In this actual example, the car gained 3/10ths of a second after making this change to the damper settings.



The suspension histogram component displays histograms for a number of suspension velocity channels. The velocity channels are normally calculated from suspension or damper position channels. i2 includes built in velocity calculations. The calculations can be configured from the 'Velocity Calculation' page in the 'Suspension Histogram' properties. If needed these calculations can be turned off and the user can create their own maths functions to generate the velocity channels.

Filter

The velocity calculation includes filtering of the position channels to ensure good results when plotting the histogram. Without an appropriate amount of filtering the histograms may look "notchy". Note that too much filtering will reduce the high frequency content of the signal so too much filtering is also undesirable.

Style

The histogram can be displayed as either a line graph or a bar graph. The channels can also be overlapped or displayed in a grid of panels. The bar style looks more like a conventional histogram however the line style is much more useful when comparing one channel to another or when the channels are overlapped.

High Speed/ Low Speed Boundary

A velocity can be nominated as the Hi Speed/ Lo Speed boundary. This is normally set to match the high speed, low speed transition of the damper. This value is used in the various calculated info and is shown visually as band on the histogram.

Calculated Info

The suspension histograms calculate the following data:

Rebound Avg: The average velocity of all values of rebound

Rebound Hi %: Percentage of velocities falling in the rebound Hi speed area.

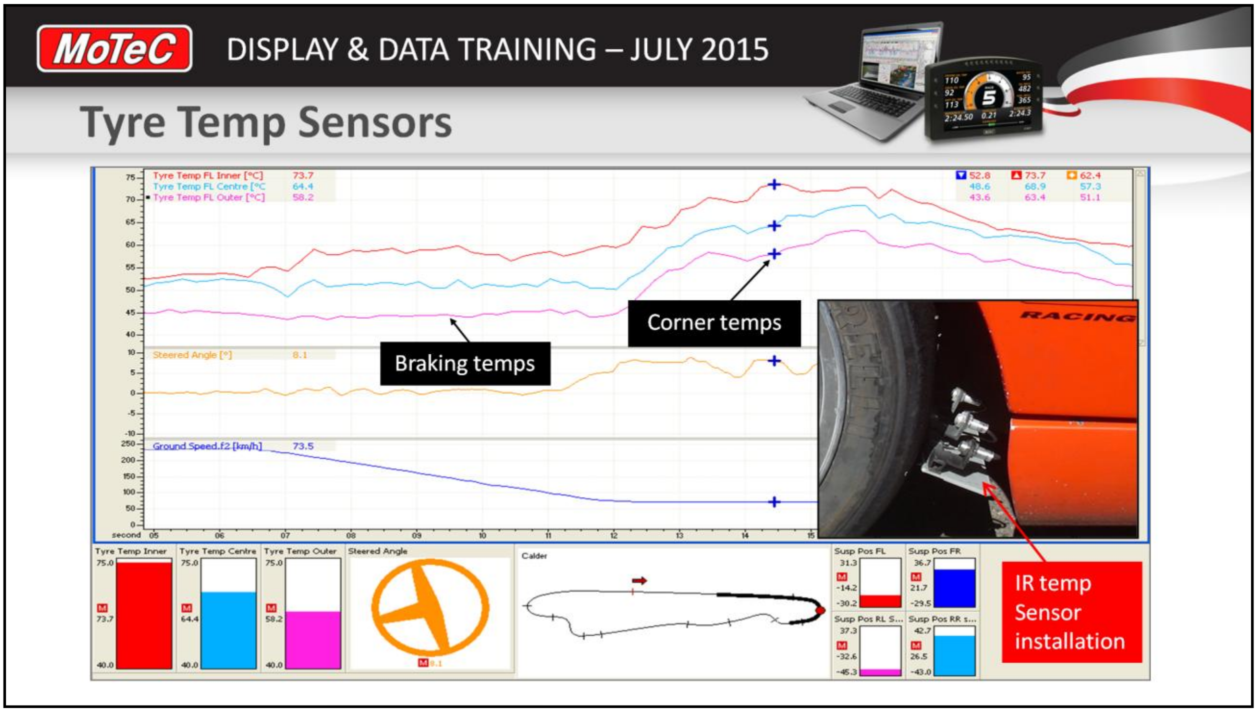
Rebound Lo %: Percentage of velocities falling in the rebound Lo speed area.

Bump Avg: The average velocity of all values of bump

Bump Hi %: Percentage of velocities falling in the bump Hi speed area.

Bump Lo %: Percentage of velocities falling in the bump Lo speed area.

Note that 'bump' velocities can be selected as either positive velocities or negative velocities (rebound will be the opposite).



Have you ever wondered how valuable the data is that comes from measurements made with a tyre temperature probe? Do you want to make critical setup decisions from data that is strongly influenced by the length of the pit lane, your position on the pit lane, and the position of the pit entry on the track? What happens if the pit entry is just after a heavy lateral G corner? And what would the temperature measure if this corner was oriented in another direction?

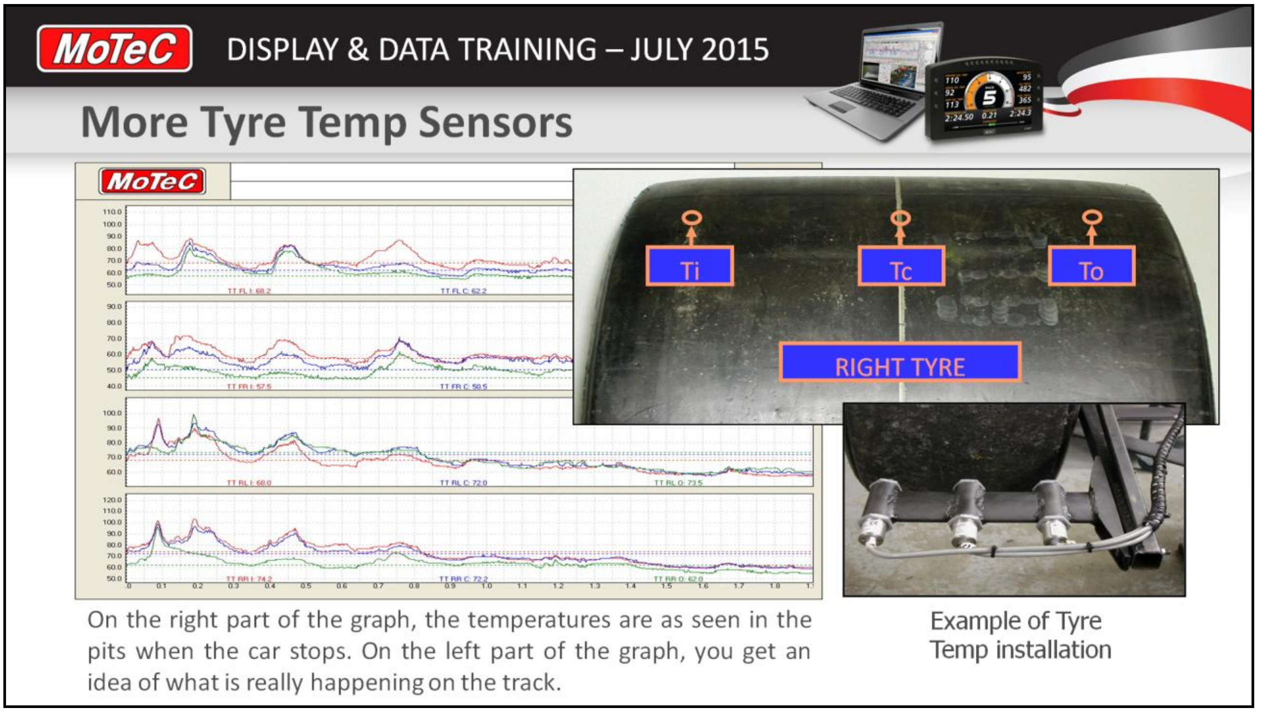
Your tyre temperatures, by the time that you get to measure them, are heavily skewed by the last thing that happened to the car. If the pitlane entry is long, the tires would have cooled down considerably, and the temperatures may have equalised whilst driving down the lane. Perhaps due to static camber, you may see very high temperatures on the inside of a tyre in a straight line, but the same car may be very good under brakes and through cornering due to the caster and camber curves in the suspension design. So you may end up pulling off camber due to the high inner temperatures read by a pyrometer in pit lane, where the car may in fact be well set up for where it matters, under brakes and through the corners.

Making setup adjustments based upon data coming from a tyre temperature probe is unlikely to work because it is way too imprecise. The solution, as shown above, is to mount 3 infrared tyre temp sensors by the wheel, continuously monitoring the evolution, turn after turn, of the tyre temperature surface in the middle, the outer and the inner edge of the tire.

Even if these tyre temperature sensors are only taking the surface temperature of the rubber and not the core temperature like the probe, it can be easily demonstrated that the temperatures of the tyres measured in the pits are only giving a vague indication of what is really happening on the track.

The measured pyrometer readings in pit lane from the car represented by the data above were:
Inside 56 Centre 45 Outside 38

Pyrometers don't show you where the tyre temperature is coming from, whether it is down the straights (too much static camber), in corners (not enough roll on camber or caster), or under brakes (too much camber change under bump). Only data logged tyre temperature sensors can do that.



What Can I Learn From One or Three Tyre Temperature Sensors per Wheel?

Depending on the budget of the team, it is possible to install either one or three tyre temperature sensors per tyre. While it is possible to establish a clearer picture of how one tyre is working with three sensors installed across the face of the tyre, a large amount of information can be established by installing just one tyre temperature sensor. The following information can be obtained if one tyre temperature sensor is installed at the centre of each tyre:

- Load distribution
- Brake distribution and balance
- Wheel lock-up
- Wheel lift
- Traction loss/ wheel spin
- Cornering temperatures
- General dynamic operating temperature
- Oversteer and understeer indications

It is also possible to install three tyre temperature sensors across the face of the tyre to establish a clearer picture of how the tyre is working, as shown above.

The ability to understand temperature information across the face of a tyre will allow the race engineer to tune the car more effectively, as well as monitoring the results of each change. As well as obtaining the information mentioned above for one tyre temperature sensor, three tyre temperature sensors could also acquire the following data:

- Temperature distribution
- Tyre inflation (over/under)
- Camber adjustment (too much/little)
- Toe (too much/little)

Therefore, it is possible to conclude that one tyre temperature sensor on each wheel will provide us with general information about the chassis and tyre performance. Three temperature sensors will allow us to establish a greater understanding of how each tyre on the car is performing, and permit individual changes to be made to each wheel allowing for maximum performance.

i2 Data Overlay for Comparison

- What is an overlay?
- What can you learn from them?
- Creating a single overlay
- Realigning laps
- Explaining the delta
- Distance and beacon accuracy
- Variance
- Creating multiple overlays

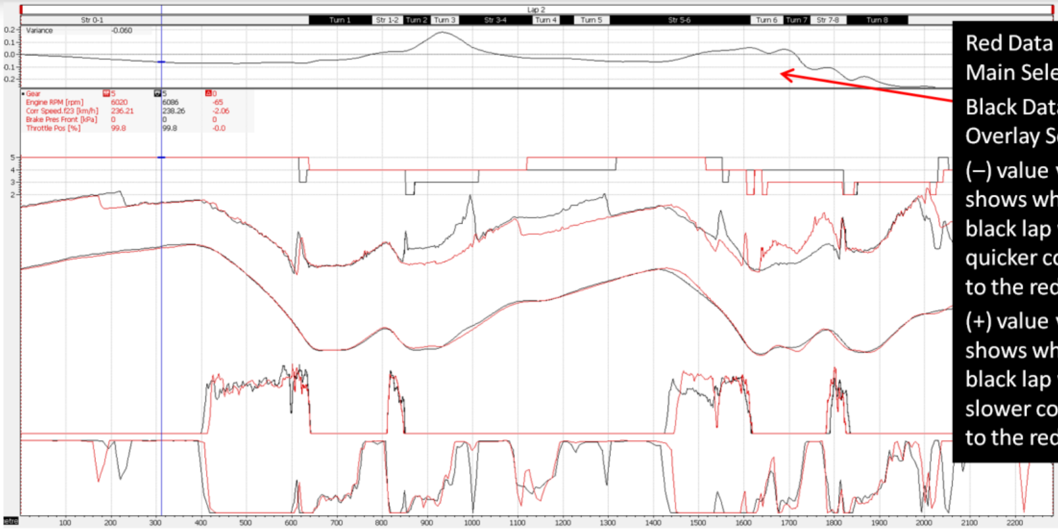
What is an Overlay & What Can You Learn?

- Viewing two pieces of similar data recorded at different times or from different vehicles.
- Accurate differences between the two data log files can then be identified.
- Driver, vehicle, engine performances, gains and losses

Creating an Overlay

- Open a file with multiple laps or two files with laps
- Open the Data Window (F8)
- Click on the main and overlay lap

Variance

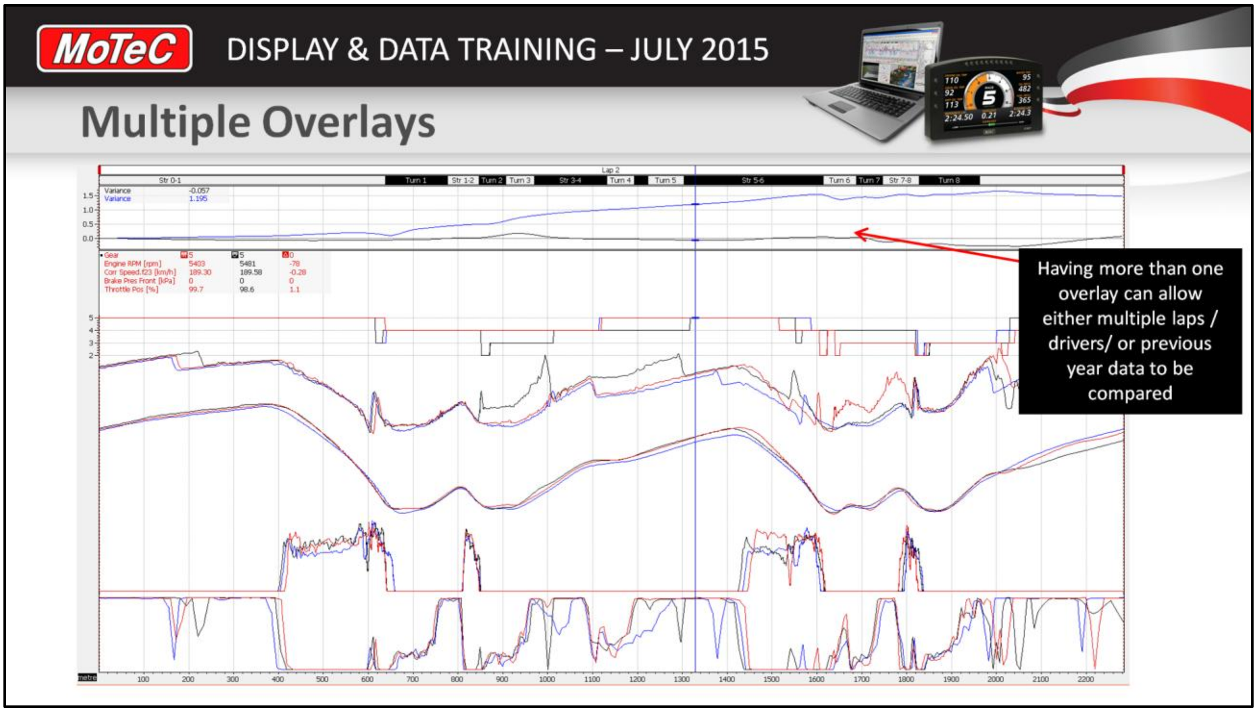


Red Data is the Main Selection,

Black Data is the Overlay Selection

(–) value variance shows where the black lap was quicker compared to the red lap

(+) value variance shows where the black lap was slower compared to the red lap


MoTeC
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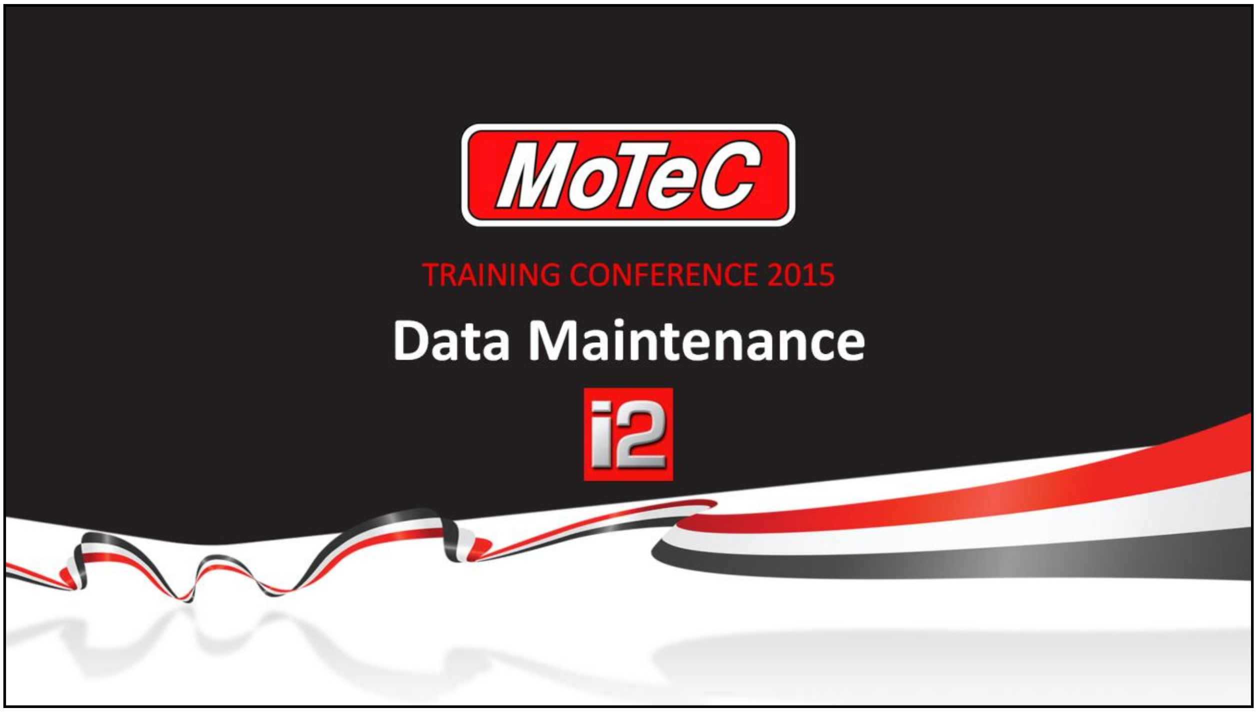
Multiple Overlays
Having more than one overlay can allow either multiple laps / drivers/ or previous year data to be compared


MoTeC
TRAINING CONFERENCE 2015
Data Maintenance
i2

Weekend Checklist

Start of Weekend

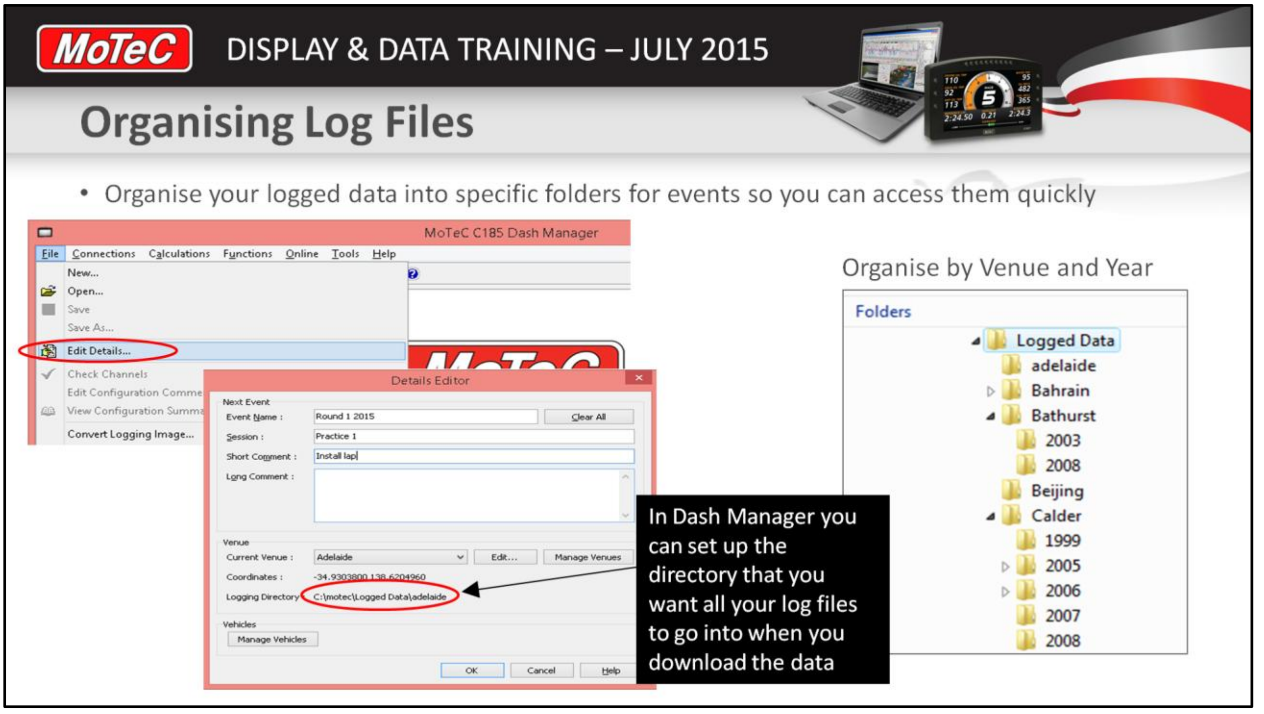
- Update Details Editor
  - Event: General comments about meeting/test
  - Venue: Track name and the directory to which log files will be placed (very important).
  - Vehicle: Update any changes since the vehicle last ran, including gear ratios.
- Check Sensors
  - Use Monitor Active Channels or scrolling through the Warm-up page on the Dash to check that all sensor values are appropriate for that sensor and fix any that are wrong.
- Zero Sensors
  - If required, zero G Sensors, Suspension Sensors, Steering etc.
- Logging
  - Check that logging templates are appropriate. A race logging template (slower rates and fewer channels than practice logging) might be loaded.
- Venue Dependant Variables
  - New Reference Laps for Lap Gain/Loss change.
- Beacons and Lap Times
  - Make sure Beacon Receiver is on correct side of car, or GPS coordinates are correct.

Before/After Each Session

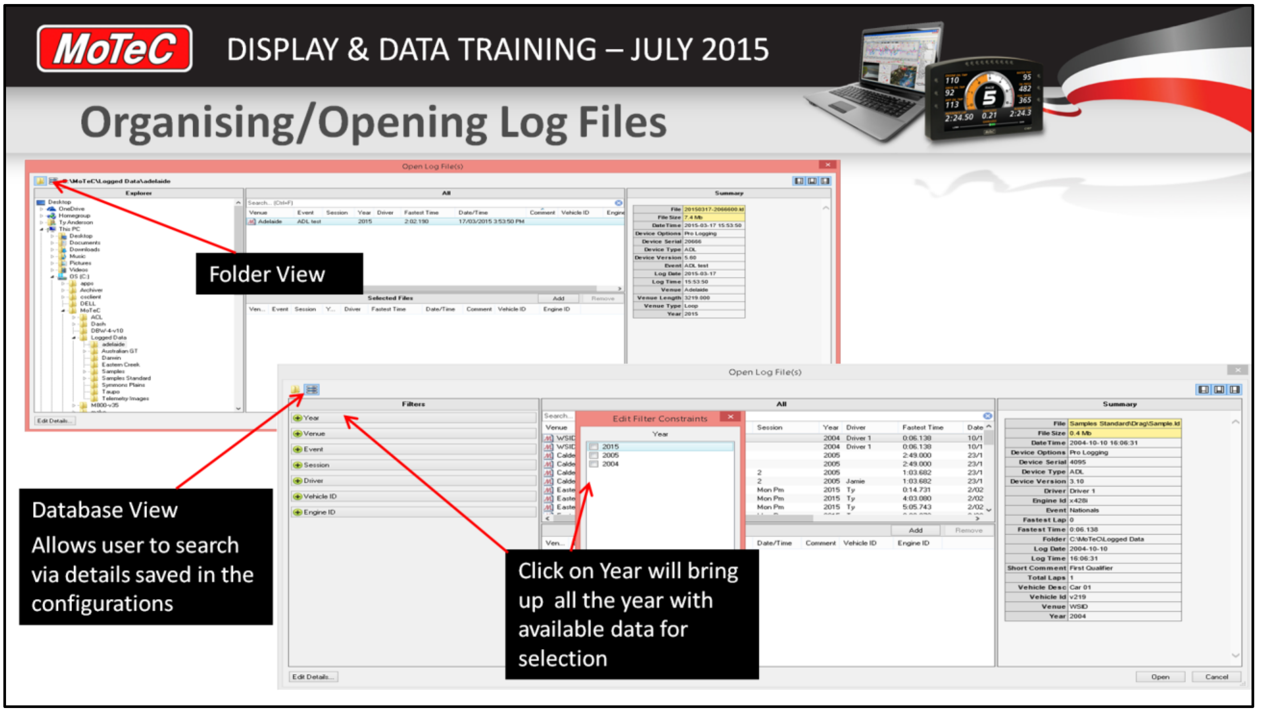
- Details Editor: Update changes made to car, enter session details (practice, qualifying, race, etc).

End of the Day

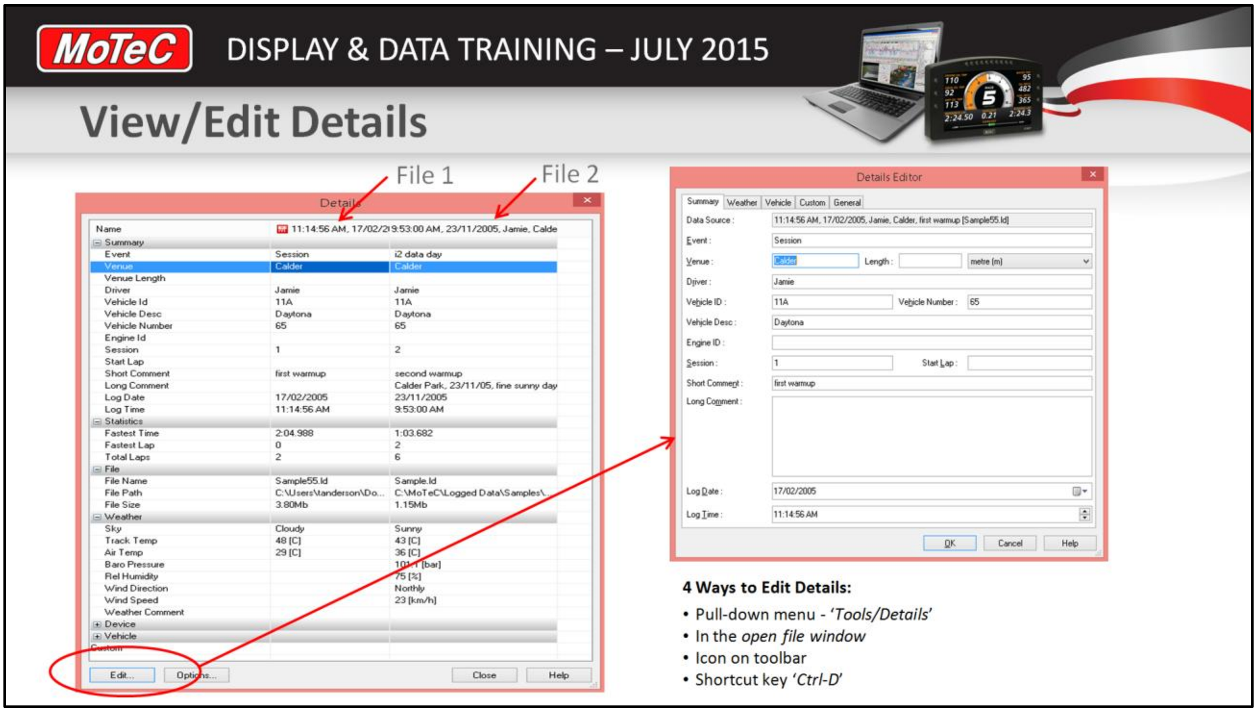
- Be sure to collect your Beacon Transmitter.



In Dash Manager you can go to file then details editor to setup where the log files should be stored when you download the data. Make sure you have folders organised by year and venue as well as session if you can, then you will quickly be able to find older data when you need to do comparisons.



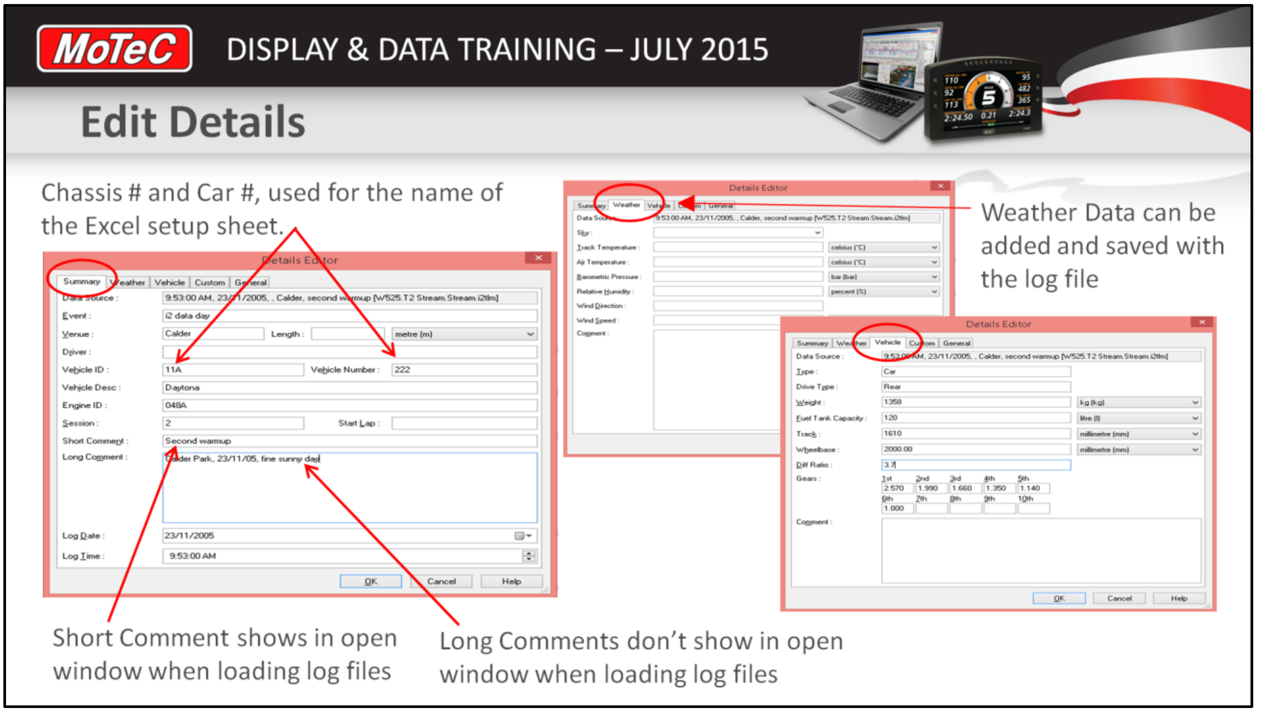
DISPLAY & DATA TRAINING – JULY 2015
Organising/Opening Log Files
Folder View
Database View
Allows user to search via details saved in the configurations
Click on Year will bring up all the year with available data for selection



If you forget to update the details in your Dash Manager before a session then you can amend the details in i2 to each of your log files.

The menu item 'Tool – Details', or 'Ctrl + D' keyboard shortcut will bring up a window with details for all the files that are currently open. Groups of detailed information can be expanded and collapsed using the +/- symbols on the left of the window.

Click on the 'Edit' button to bring up a 'Details Editor' window. Most of the details listed can be edited or added if they had been left empty. Details with numerical values such as gear and diff ratios can be used in maths expressions.



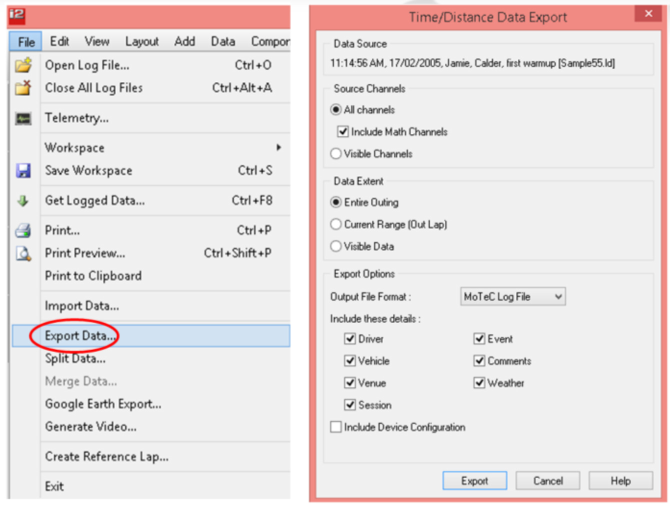
If you fill in the vehicle details you can use these for your maths calculations.

The short comment shows up when you 'open' window for logging files but long comment is not shown.

Exporting Data

- Export to Matlab, .csv file or to the clipboard for use in Excel etc.
- For 'Component' export, only the channels shown get exported.
- For 'File' export, all channels get exported.
- All data is exported at the same rate it is logged at.

Exporting to .ld file allows you to share your data with another competitor but only the channels you have graphed.



If you want to process your data using methods not available in i2, or perhaps you want to send someone part, but not all of your data, there is an export facility in i2. Export allows you to save your data in one of three formats: either CSV (Comma delimited text file) suitable for Microsoft Excel or other non MoTeC applications, the Matlab data format (i2 Pro), or the MoTeC log file format, which will let you open the new file in i2 again.

The File menu has an item called 'Export'. This will always export all of the channels in your file to another log file or a CSV file. Often people wish to export a subset of data, this is done by creating a graph with just those channels that you wish to export shown. Then right-click on the graph and select 'Export Data', only those channels on this graph will be exported.

Both functions allow you to select the timeframe over which to export data: Entire outing (the whole log file), Current Range (e.g. a lap), Visible Data - just the time/distance range shown on screen, e.g. after zooming in.

Data Export: All data or a portion (e.g. lap) may be exported. To export data to a MoTeC (.ld) file, CSV format file or .MAT Matlab file, on the Graph **Component** menu, click **Export Data**.

NOTE: Only the channels in the graph will be exported.

CSV Files: CSV stands for Comma Separated Value file. This is a common format that can be imported by many applications including spread sheet programs such as MS Excel.

MoTeC Log Files: Exporting to a MoTeC log file allows a small number of channels to be exported. This can be useful when you need to give someone some of your data but not all of it.

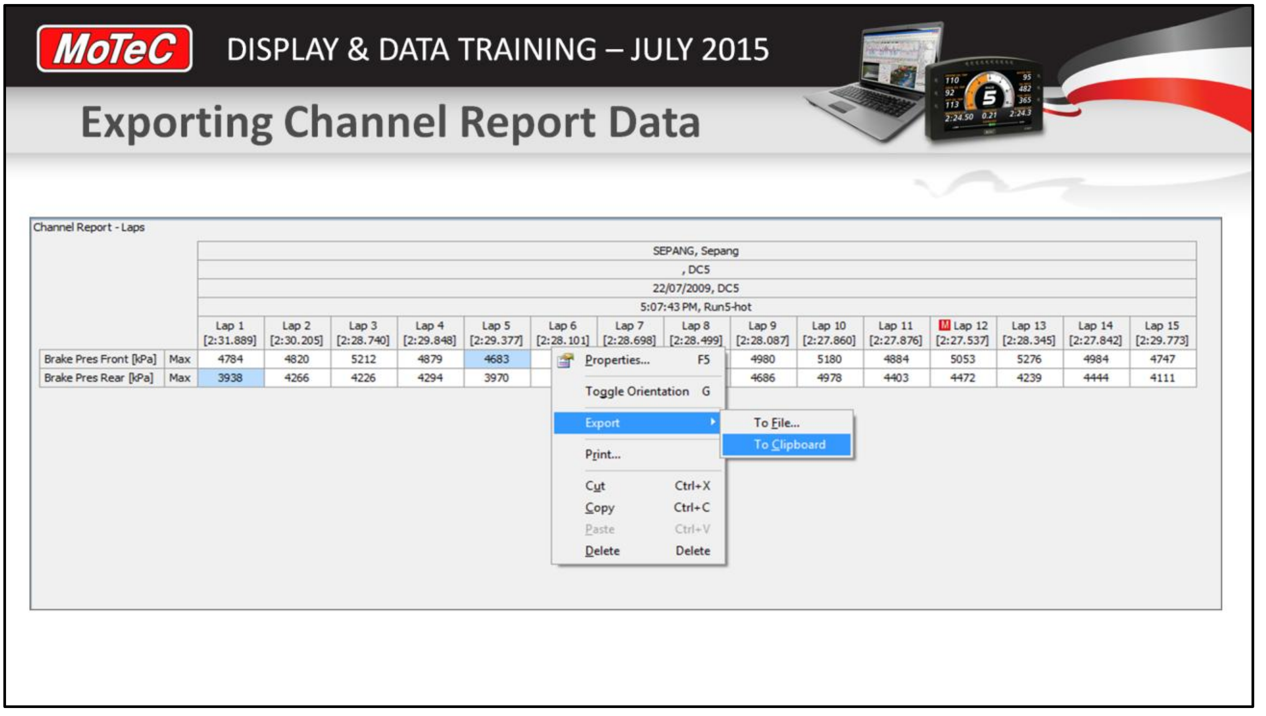
The device configuration can be included or excluded from the exported data.

The various details can also be included or excluded.

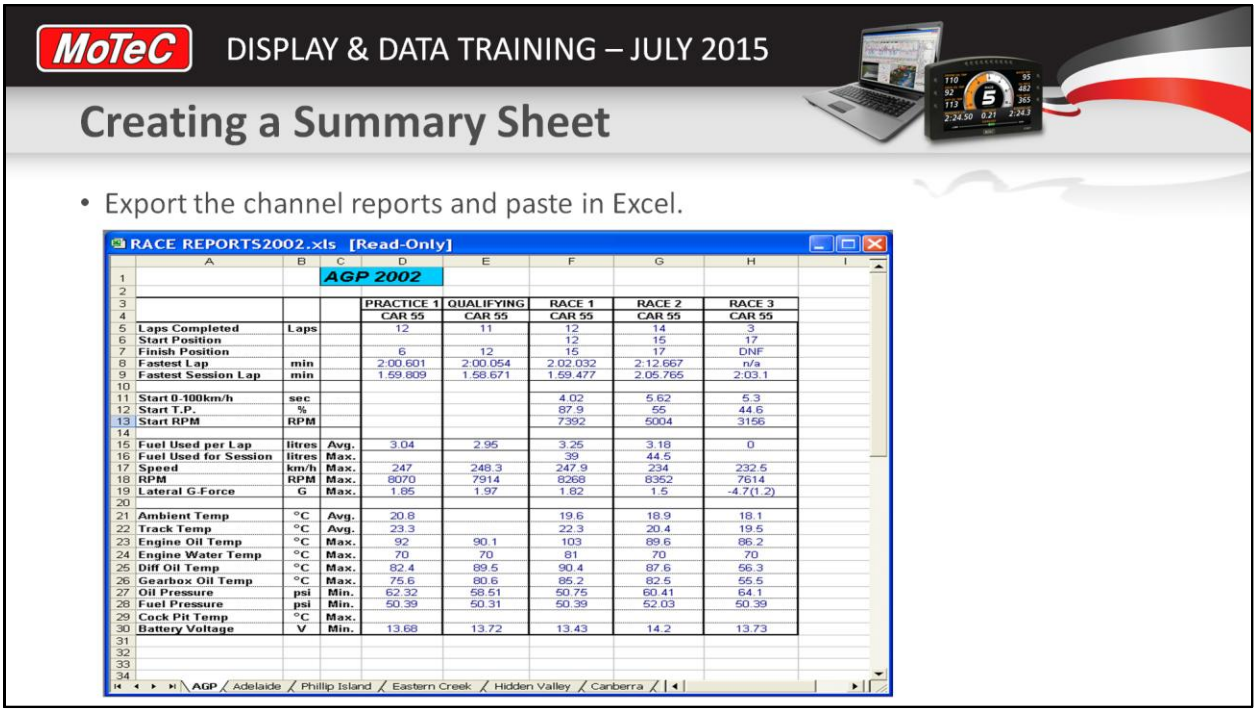
NOTE: When exporting the Current Range (Lap), we export slightly more data then the lap, to ensure the beacons are correctly positioned. This will result in a very small in and out lap.

MATLAB Files: All channels may be exported to a .MAT file. The .MAT file can be loaded into MATLAB and used in the usual way. The output sample rate may be specified as follows:

- Default: each channel is exported at it own rate.
- Fastest: All channels are up-sampled to the fastest channel rate.
- Custom: All channels are re-sampled to the specified rate.



It is also useful to then store the outing stats using the 'export to clipboard' function to create an ongoing spreadsheet of races and sessions. Right clicking in the Channel Report area will give you two options. Left click on To File if you want a .csv file or Left Click on To Clipboard if you want to paste the data into a spreadsheet.



			PRACTICE 1	QUALIFYING	RACE 1	RACE 2	RACE 3
			CAR 55	CAR 55	CAR 55	CAR 55	CAR 55
Laps Completed	Laps		12	11	12	14	3
Start Position					12	15	17
Finish Position			6	12	15	17	DNF
Fastest Lap	min		2:00.601	2:00.054	2.02.032	2:12.667	n/a
Fastest Session Lap	min		1.59.809	1.58.671	1.59.477	2.05.765	2:03.1
Start 0-100km/h	sec				4.02	5.62	5.3
Start T.P.	%				87.9	55	44.6
Start RPM	RPM				7392	5004	3156
Fuel Used per Lap	litres	Avg.	3.04	2.95	3.25	3.18	0
Fuel Used for Session	litres	Max.			39	44.5	
Speed	km/h	Max.	247	248.3	247.9	234	232.5
RPM	RPM	Max.	8070	7914	8268	8352	7614
Lateral G-Force	G	Max.	1.85	1.97	1.82	1.5	-4.7(1.2)
Ambient Temp	°C	Avg.	20.8		19.6	18.9	18.1
Track Temp	°C	Avg.	23.3		22.3	20.4	19.5
Engine Oil Temp	°C	Max.	92	90.1	103	89.6	86.2
Engine Water Temp	°C	Max.	70	70	81	70	70
Diff Oil Temp	°C	Max.	82.4	89.5	90.4	87.6	56.3
Gearbox Oil Temp	°C	Max.	75.6	80.6	85.2	82.5	55.5
Oil Pressure	psi	Min.	62.32	58.51	50.75	60.41	64.1
Fuel Pressure	psi	Min.	50.39	50.31	50.39	52.03	50.39
Cock Pit Temp	°C	Max.					
Battery Voltage	V	Min.	13.68	13.72	13.43	14.2	13.73

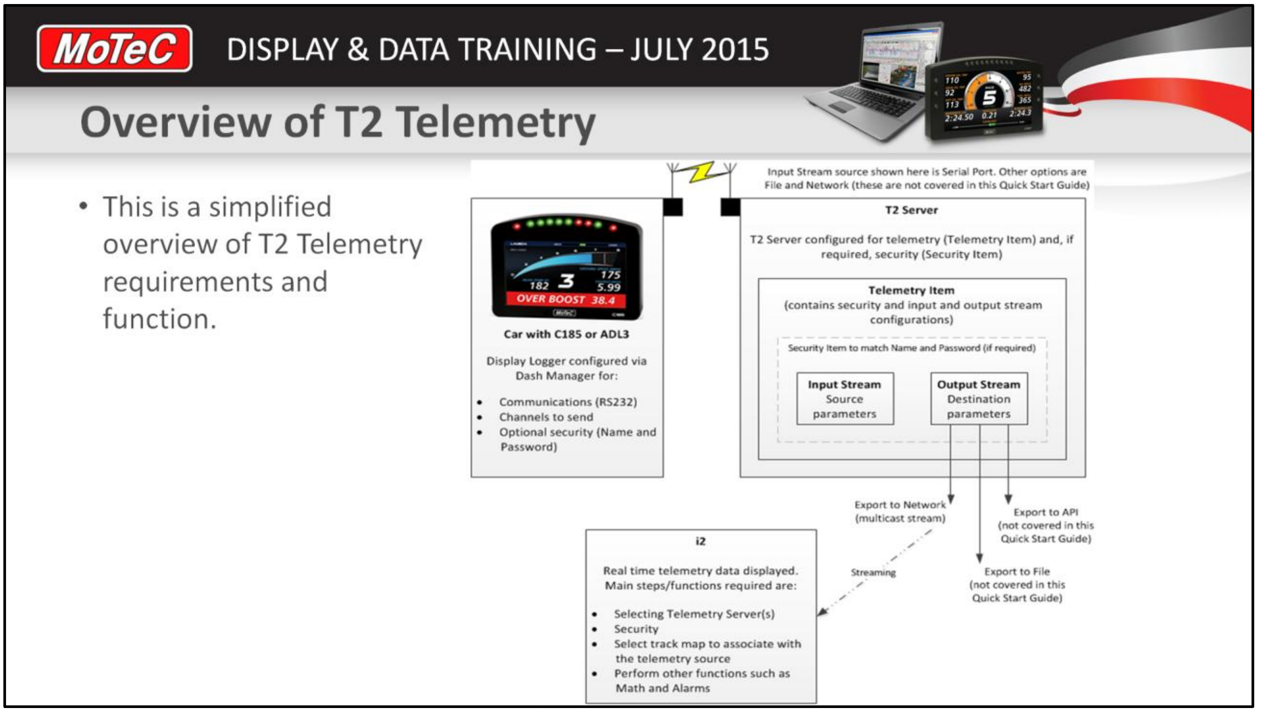
Here is a sample of a race summary sheet. You can see that it lists summary information of selected channels from each session of an event, and the tabs at the bottom show the other events of the year. The file is created by exporting out information from the Channel Report screen and pasting it into a spreadsheet. This gives you a useful, ongoing record of important pieces of information about your vehicle. It can be used to bring attention to trends in your data of changes in oil pressure, battery voltage, diff temps, gearbox temps, whatever is useful to measure for your particular vehicle. With this data, when you ask, “Is it normal for the gearbox to run at that temperature? At this track?”, you can quickly go over previous sessions, races, and years to see what you should expect from your vehicle. Using the i2 channel reports to create these summary sheets can help increase the reliability of your racing.

Note that it is very helpful to record information such as ambient air temperature and track temperature with your details and then include them with the summary spreadsheet.

The Final Chapter

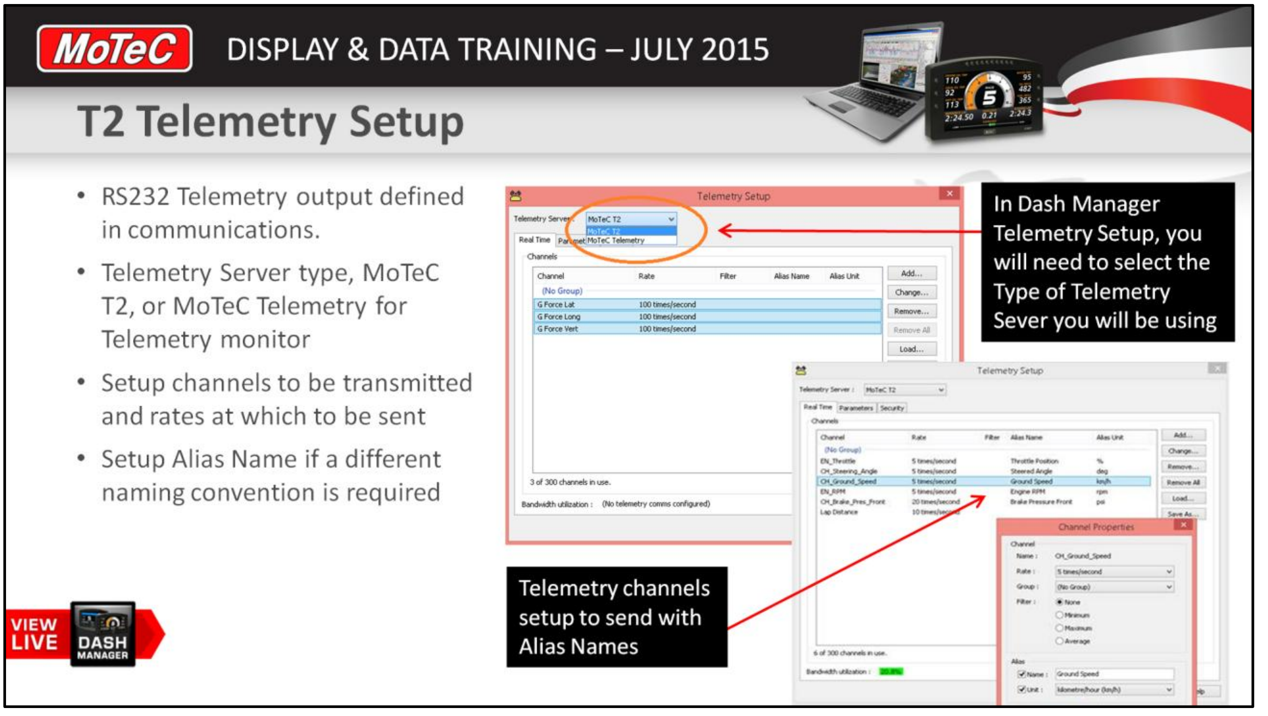
- If you need assistance, feel free to drop us a line at support@motec.com.au
- If you have suggestions on possible improvements, or feature requests, email us at the same address, and we can look into it for you
- Can be found wandering the paddock
- Eager to hear new applications
- In the extremely unlikely event that you have a Dash hardware or software crash, we would like to hear from you with the information so that we can continue to improve the product.
- Any Questions?


MoTeC
TRAINING CONFERENCE 2015
T2 Telemetry
i2
T2



With the aid of a radio device the Dash/Logger can send back live telemetry data to a computer back in the pits where a T2 Server application can decrypt the stream and rebroadcast on a network for multiple i2 Pro versions of software to receive.

T2 Server is capable of recording the incoming telemetry stream, for replay at a later time.



Dash Manager Setup

Communications Setup

Note: The T2 function upgrade must be enabled for the Data Logger to send telemetry data.

Current RS232 communication templates Telemetry Only or GPS & Telemetry can be used with T2.

Setup communications:

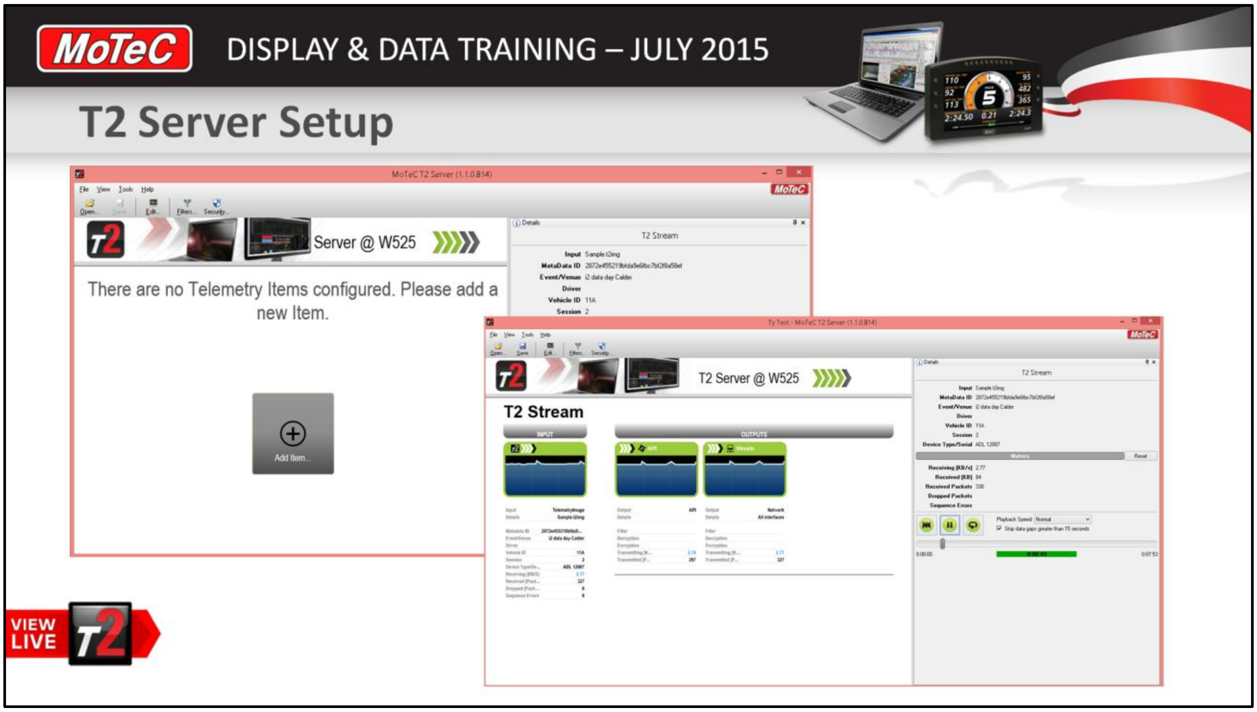
Go to the Connections > Communications menu.

In the Communicators Setup window, select an RS232 tab.

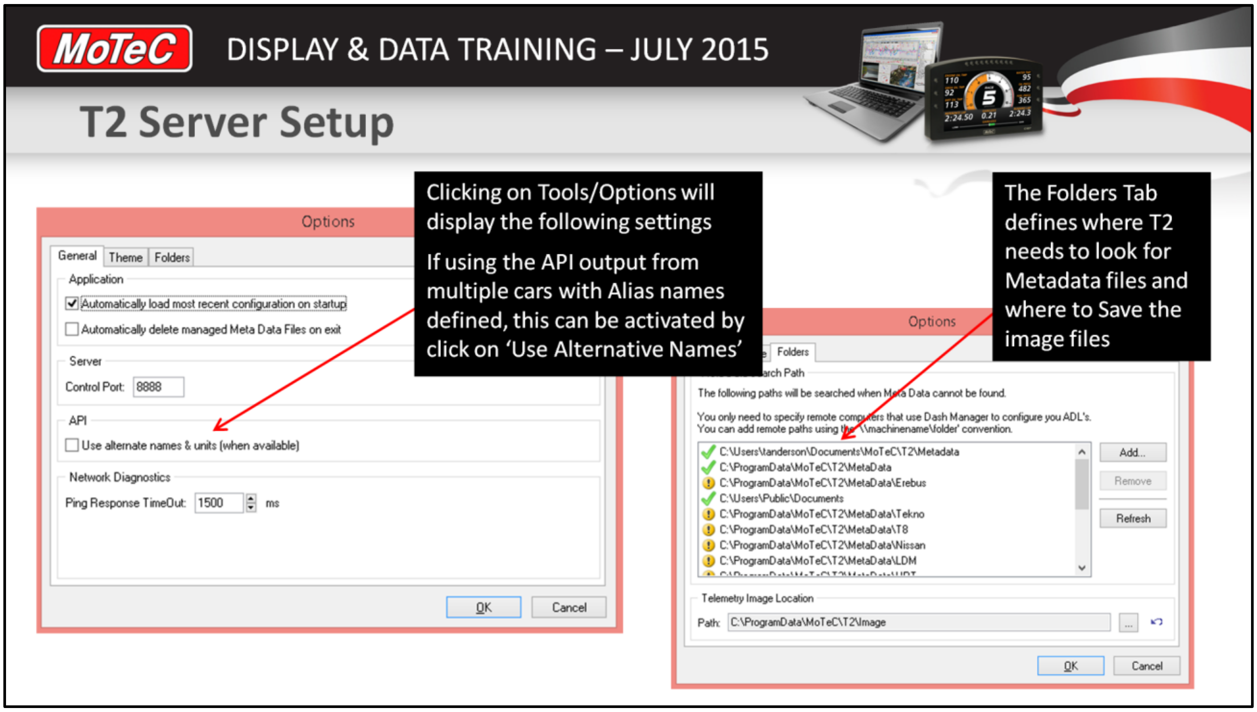
Set the applicable baud rate for the selected RS232 port.

Once the communications are set up, click on and open the telemetry setup. Here is where you define the T2 Telemetry option, what channels and at what rates they will be sent.

If receiving telemetry from multiple cars with different names, alias names can be used to make all incoming channels appear with the same name. This is more so used in category wide applications.



Adding inputs to receive the data telemetry source and defining outputs for where to send the data.



MetaData File

When a Data Manager Logger configuration file including T2 Telemetry setup is sent to the Data Logger, a Metadata file is created. This file is essential for T2 to operate it defines the channel names, and units.

Note: When Dash Manger and T2 Server are running on the same PC, and using the default location for the Metadata file, no intervention is required and access to the file is automatic.

MetaData Location

Dash Manager

By default, the Metadata file is saved in the **C:\ProgramData\MoTeC\T2\MetaData** folder of the Dash Manager PC.

To specify a different location: in Dash Manager **Tools > Options** menu **Telemetry** tab, specify the required location.

T2 Server

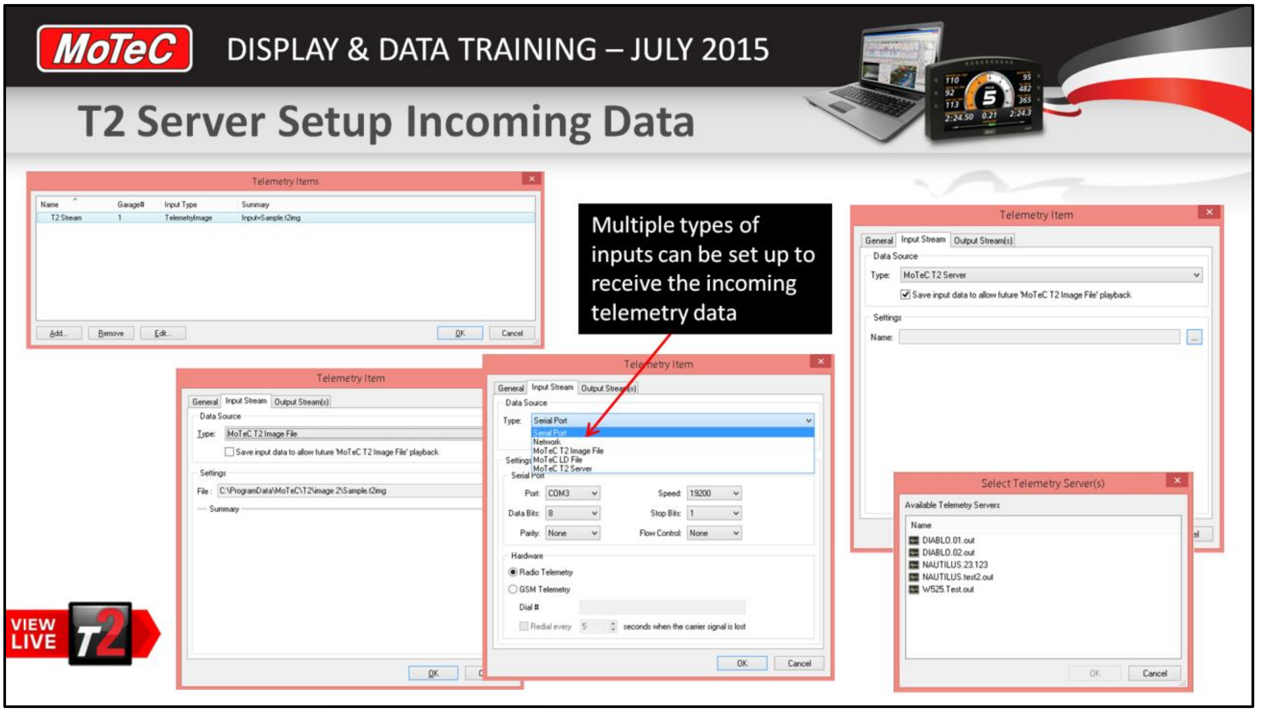
To receive and transmit telemetry data, the T2 server requires the Metadata file to be located in the **C:\ProgramData\MoTeC\T2\MetaData** folder on the PC that runs T2 Server.

T2 Server can be set up to automatically pull and copy the file to this location as follows:

In T2 Server, go to the **Tools > Options** menu **Folders** tab and specify the remote location for T2 Server to search.

Select the **Add** button to specify other locations.

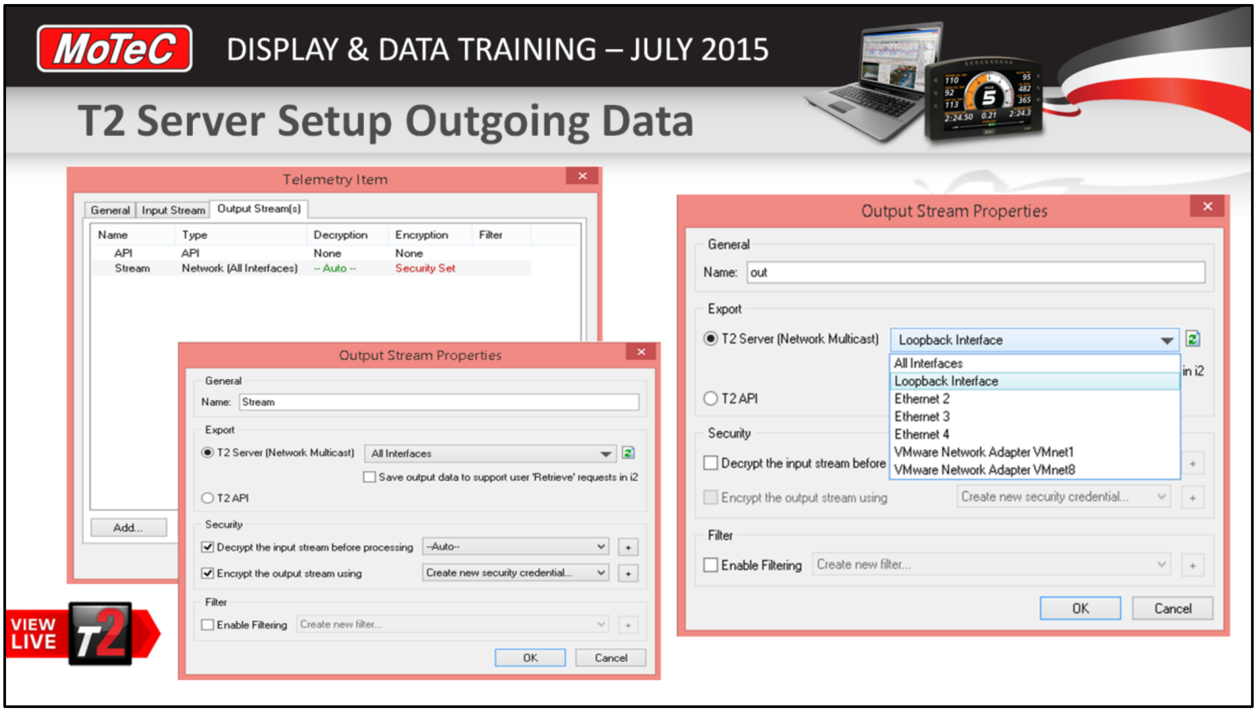
As each Metadata file has a unique identifier, T2 server monitors all specified locations and pulls the Metadata file once it is available.



To record the incoming data stream the tick box ‘Save input data’ needs to be ticked.

A Network or Serial port allows for a physical port to be configured to receive the stream, A MoTeC LD or MoTeC Image file allow pre-recorded or logged files to be replayed.

A T2 Server allows for a connection from another T2 server distributing the stream.



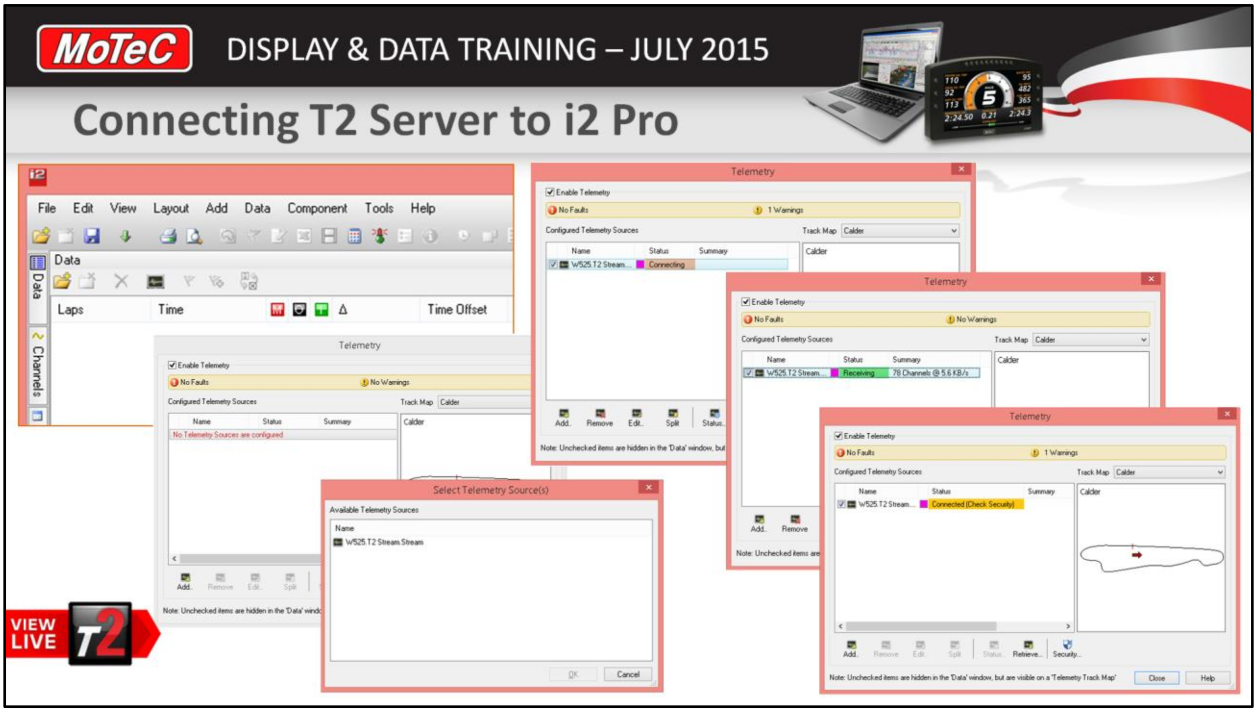
T2 Server can have muliple outputs for the single incoming stream.

These outputs can be setup with different encryption, filters and or sent to different networks.

Data can be sent to ‘All interfaces’ this will send data to all network connections.

‘Loopback Interface’ will only distribute on the local machine.

Otherwise you can select a specific network to send the data.



Telemetry: The Telemetry window is used to add, edit and manage telemetry sources.

Add: Displays the Select Telemetry Sources window, from where available telemetry sources a can be selected and added to the Telemetry window.

Remove: Removes the highlighted telemetry source from the Telemetry window.

Edit: Displays the Edit Telemetry Source window, from where the source details can be adjusted.

Split: Split data into a logged source and telemetry source.

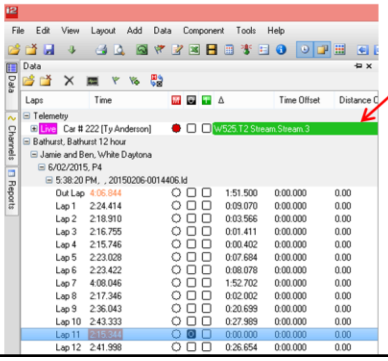
Status: Display the status of the telemetry source.

Retrieve: Retrieve logged data for the telemetry source from the telemetry server.

Security: Manage telemetry source passwords.

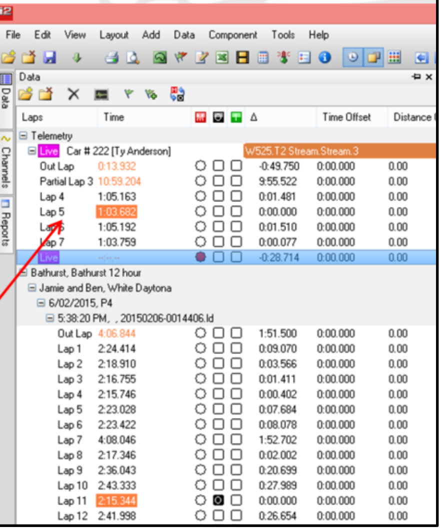
i2 Pro Telemetry View

- An incoming Telemetry stream will appear at the top of the i2 data window in a collapsed position
- The Telemetry stream can be exploded by hitting the + symbol, this will expose laps completed with the live at the bottom
- Logged data will appear at the bottom



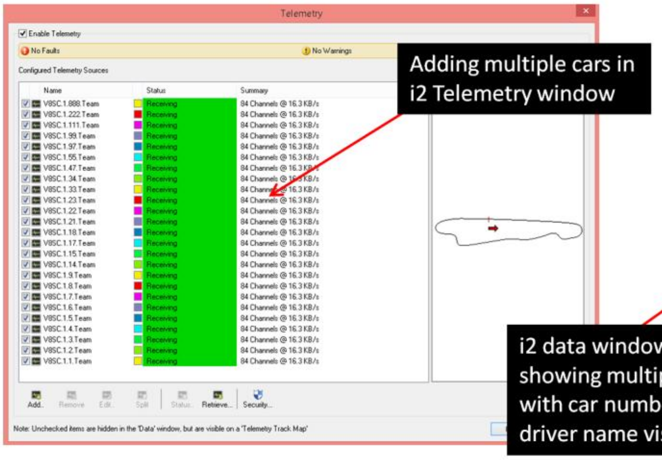
Normal Collapsed view, Highlighted green to show its connected to live data

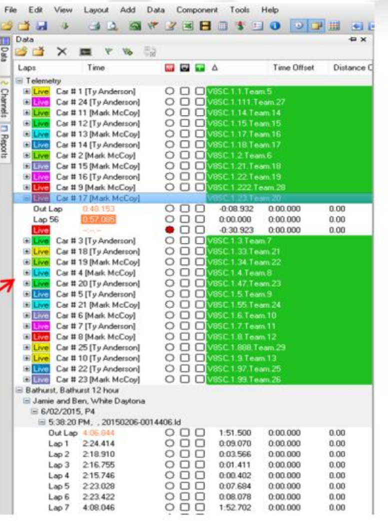
Exploded view showing completed laps in this live outing, Highlighted orange to show there is no live data is coming in

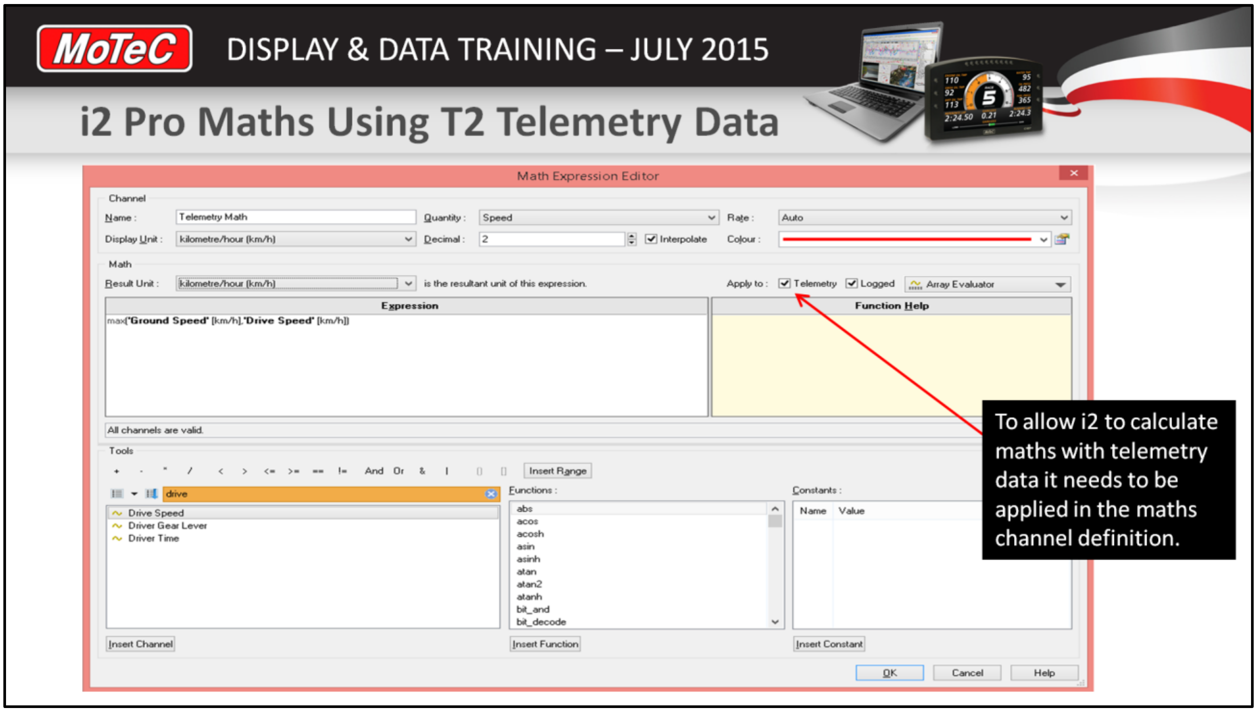


i2 Pro Telemetry View

- Multiple cars can be added and viewed live







Math Channels

In telemetry mode, Math Channels can calculate their values live. To do this, in the Math Expressions Editor, select the Apply to: Telemetry checkbox.

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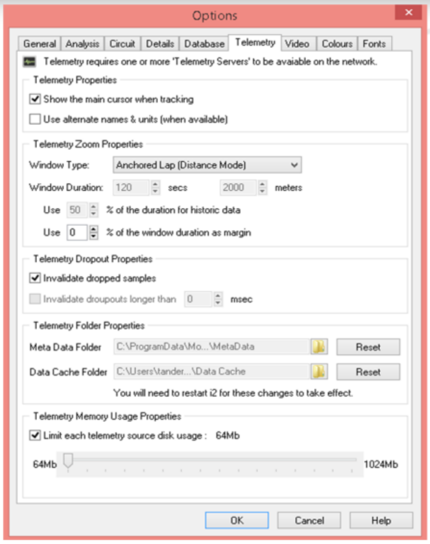
Telemetry Options in i2 Pro

Clicking on Tools/Options and moving to the Telemetry Tab will bring up the options to define how the telemetry data is handled within i2



If a channel has been sent over telemetry with an Allais name configured, to use this name in the i2 as the name of the channel Click on Tools | Options from the i2 menu,

In the Options box, Click on the Telemetry Tab and Tick on the option 'Use alternative names & units'. If the Use alternative names and units boxes are not ticked in either T2 or i2Pro the standard channel name will be used.

Telemetry Tab

Zoom Properties Window Types

Sliding: The cursor stays at the right edge of the graph and as the data comes in the window is continuously slides to the right . The size of the window is defined by Window Duration in seconds for time mode and in metres for distance mode.

Anchored: When anchored mode is selected the window is static and for the defined duration time/distance. The window is divided into two parts: historic data (with user definable duration) and live data. When live data is received, the cursor moves inside the live data part until it reaches right edge of the window, at which point the window jumps to the left and the live data becomes the new historic data. The new live data continues to be drawn in the new live data part.

Anchored Lap (Distance Mode) - Anchored Lap Type is valid only for distance mode and uses lap distance as the Window Duration and margin to show historic data.

Invalidate dropped samples: When this check box is unchecked, channels hold the last valid value when samples are dropped.

Invalidate dropouts longer than: When this check box is checked, channel values are invalidated if the samples were dropped for longer than the user defined duration.

Meta Data Folder: The folder where telemetry MetaData file is saved.

Data Cache Folder: The folder where telemetry data is cached.

Limit each telemetry source disk usage.

When this check box is checked, the cache will grow until it reaches the user defined size. After that the cache memory is overwritten from the start of the data.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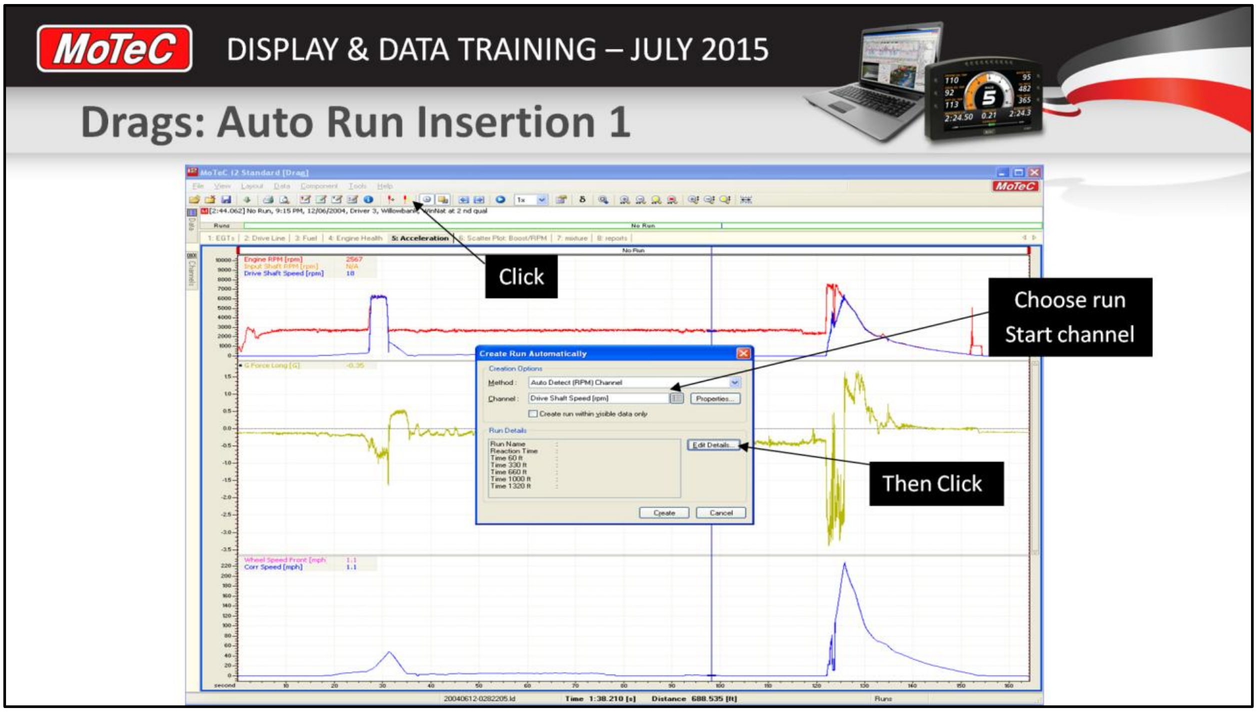
Appendix
i2

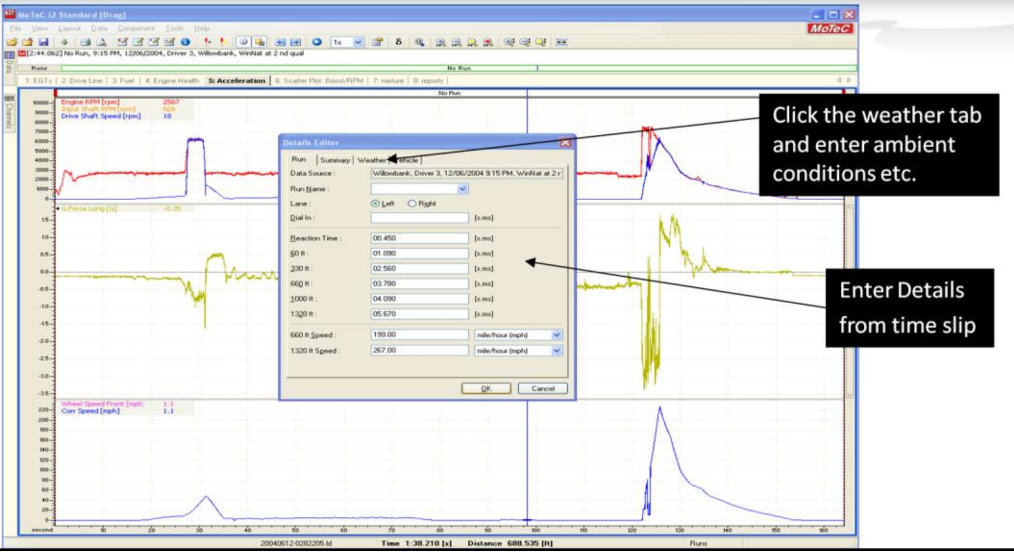


i2 features an all new auto run insert function. With a few clicks of the mouse button the software can automatically insert the pass into the data with all relevant incremental times shown.

Once set up, all your runs will start from exactly the same moment in each file, triggered from an event that occurs on the vehicle. This can be the first pulse from the drive shaft speed sensor or a signal from an on off switch such as a Wide Open Throttle switch. It is best to choose an event that indicates the actual forward movement of the vehicle. Testing suggests this is around the point where data shows a Longitudinal G force greater than 0.2g

The default method is to use the point where 'Drive Shaft Speed' starts to move. Though this can be changed to another channel.

Drags: Auto Run Insertion 2

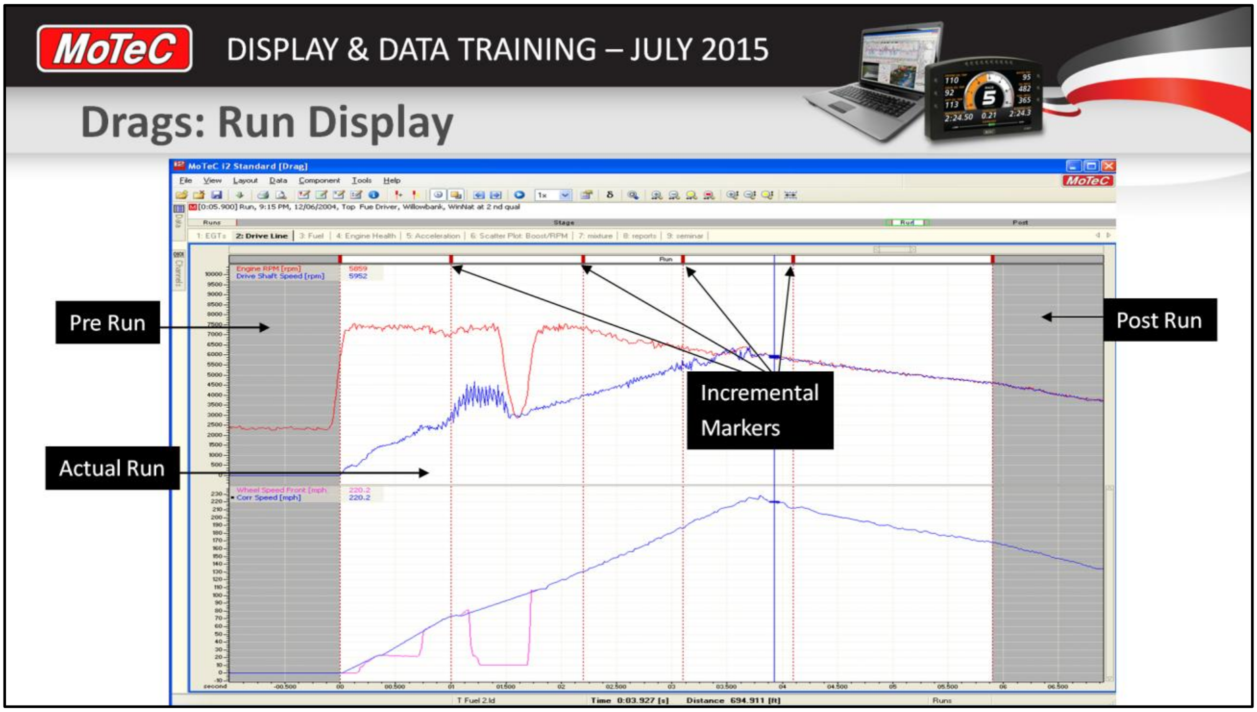


Once the start point of the run has been determined, we can enter information from the timeslip into i2, that will also be shown on the graph.

Go into the ‘Tools’ menu and choose the ‘Run Editor’. From here choose ‘Edit Details’, and enter the time slip information into the cells. At the completion of entering the time slip information press OK.

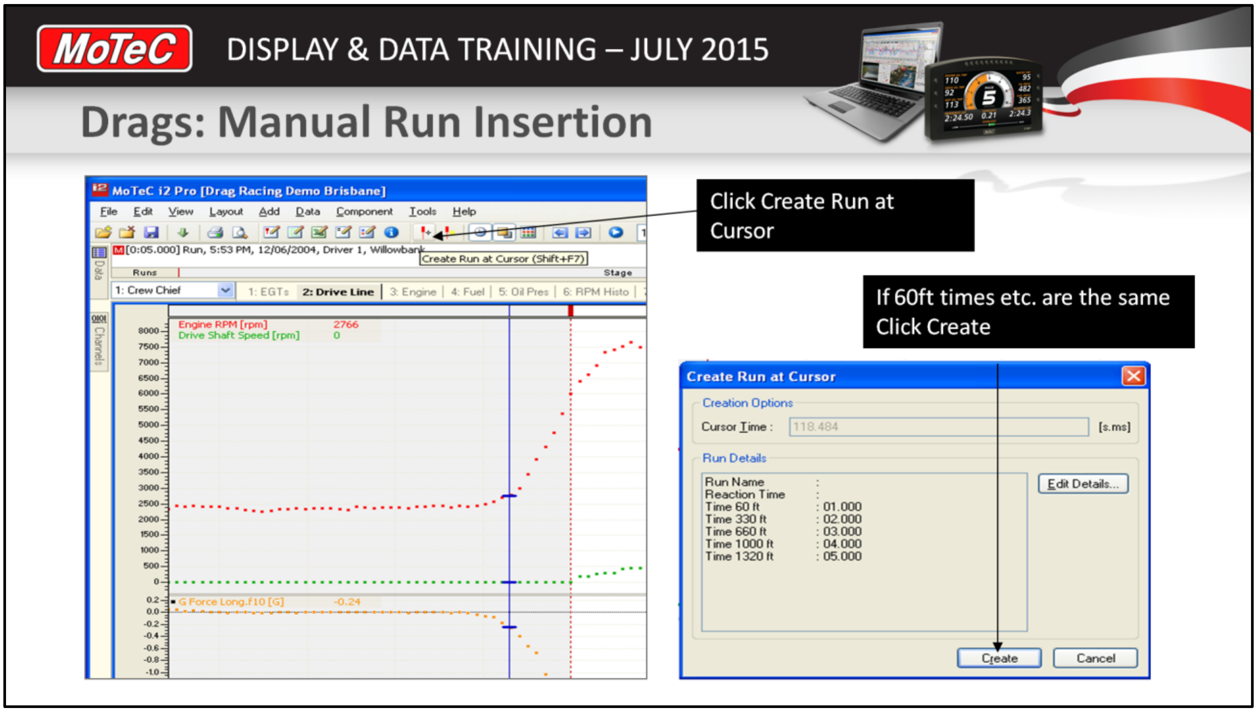
In here you can also store other important details about the run, such as the weather at the time of the run, tyre temps, pressures, gearing etc. so that later you can go back and see what contributed to a better or worse run that time.

This will return you to the ‘create run’ screen where all that remains is to click ‘create’ and the run will be highlighted in the data. To select the run press W for ‘whole run’.



Back in the data, the exact run is then displayed along with 1 second of data pre and post run with a grey background. Also displayed is the entered time sheet information, i.e. 60/330/1000 ft times.

In the example above, the blue corrected speed line on the bottom group shows the corrected speed and therefore distance travelled. This becomes particularly important for overlaying other files and reading Time and Distance reports.



If there is already a run on screen and it is not in the right place you can easily shift it by using the Create Run at Cursor feature.

In the above example the run has been previously auto created using the first drive shaft speed data point. Depending on the number of teeth on the drive shaft this point can be a long time after the car has actually started to move.

In the above picture we have changed the properties of the time/distance graph to show data points rather than lines. After some limited testing we have made a rough conclusion that most cars actually start to cross the beam somewhere around 0.25 G Longitudinal. The cursor (blue line) has been placed at this point and now by clicking the 'Create Run at Cursor' icon (Hot Key: Shift + F7) the run start point will be corrected. Assuming all increments are the same, click the create button and the run will shift to this point.

Advanced Features

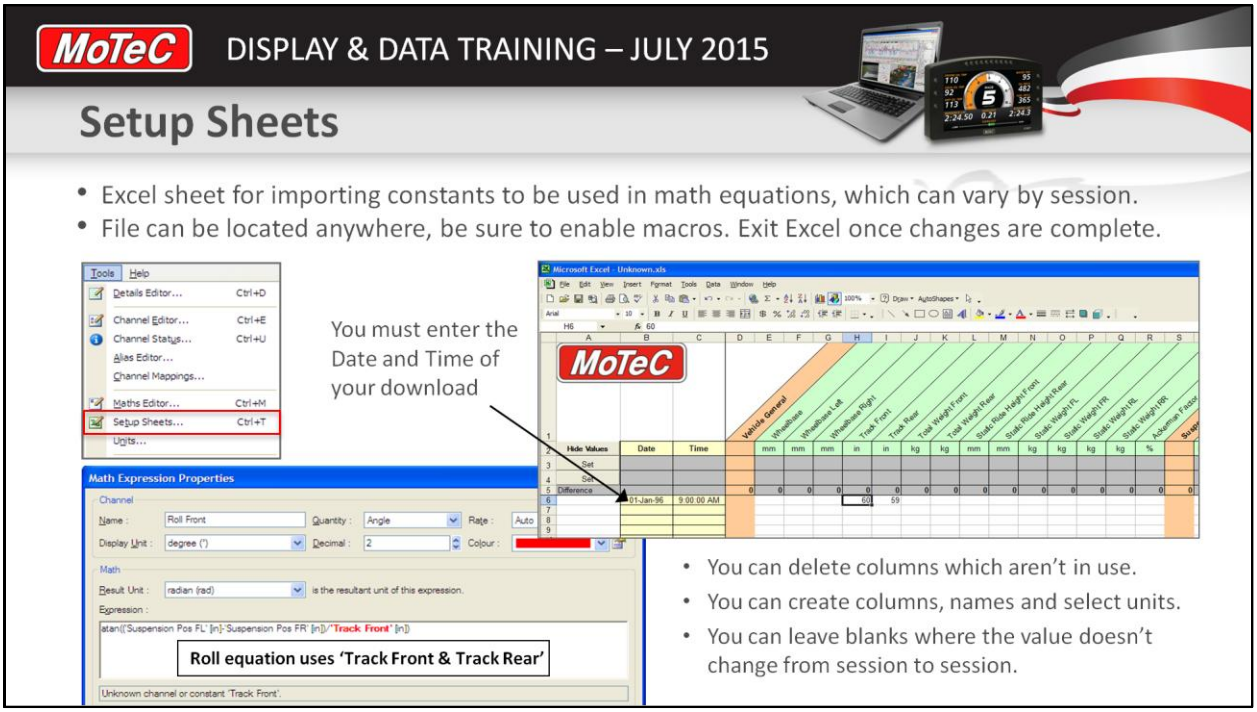
- Gating
- User Sections
- Alias Editor
- Channel Mapping

Gating : The gating channel allows data to be rejected based on the value of a channel. Data is rejected if the channel value is less than or equal to zero. The gating channel is normally generated by a maths expression. For example a maths channel defined as abs('G Force Lat') > 0.5 would result in a value of 1 during corners and 0 during straights and would therefore reject any data in straights. Gating can be used with Scatter Plots, Mixture Maps, Histograms and Suspension Histograms, with the same or a different gating expression for each. This is similar to how you can turn on and off trace colors in a histogram.

User Sections: In addition to modifying the auto created sections, users can define a new section category and define sections from scratch, e.g. track sectors. These can then be used in channel reports, track reports and time reports.

Alias Editor: allows a channel to be created that will use the data from the first available channel in the corresponding alias list. This can be useful if the name of a channel varies between log files. For example an alias channel could be created called Vehicle Speed that uses either Ground Speed, Wheel Speed FL or Wheel Speed FR. Note that the first available channel is used so the order of the list can be important.

Channel Mapping: allows a channel to be renamed and/or the units of a channel to be overridden. This can be useful if a channel is named differently in some log files. It is also useful for channels that were logged without units (for example a Wheel Speed from an ECU).



Setup Sheets

Allows the user to import a list of values relevant to a particular session, e.g. Corner weights, Spring Rates, Tyre pressures. As well as being linked to the relevant log file, the data can be used in maths expressions.

Setup Sheets are a method by which users are able to track changes to their car, along with making these changes available to be used as a constants within i2 for Maths calculations. It can be thought of as a flexible extension to the details editor area per car and session. The sheet is built and pre formatted by i2, and there is one created per car id. In your log file details, you specify an ID for your vehicle. This id must be unique to that vehicle, as this is used for the name of the setup sheet. To start a setup sheet, click on the "Create" button, which then becomes the "Edit" button. This creates the setup sheet named {Vehicleid}.xls, and opens it for editing.

The sheet, once created, is relatively free format, you can change or add any channel name, it just needs to start in column A. You can choose from any of the available channel units that i2 recognises for your channel, if there are no suitable units, leave it blank and it will come across as unitless. Next, add the time/date stamp for your data. To decide which constant is suitable for the currently selected log file, i2 looks at the download time of the log file, and finds the last column that the log file was created after. If there is a value in that row, it takes that value. If it is blank, then it goes back one column at a time until it finds a value, which it uses as the value for that channel. So you can see in the above example, that the file date of 23/11/2005 would make it use the column 'E'. Here it chooses the 'Wheelbase' of 2010, 'Wheelbase Left' of 2010, but has to go back to column 'D' to find a value for 'Wheelbase Right'[, at 2005mm.

There are a few more things to note about setup sheets. If two blank cells are seen in a row in column A (after row 10), it is deemed that there are no more channels to process.

There is one sheet per vehicle ID per project, so be sure to use the same project each time. You can use formulas to create values in the cells; only the final result is used within i2.

If you have further calculations to do for your formula, do them on another sheet, as it only looks at the first sheet of the Workbook when looking for the setup sheet.

To view the setup sheet, click on the 'Tools' menu, then 'Setup Sheets', or Control+T
If there is a button called create, click that to create a sheet, or use Edit if it already exists
Add some numbers into cells C11, C12, C13 and C14
Save and close the spreadsheet.

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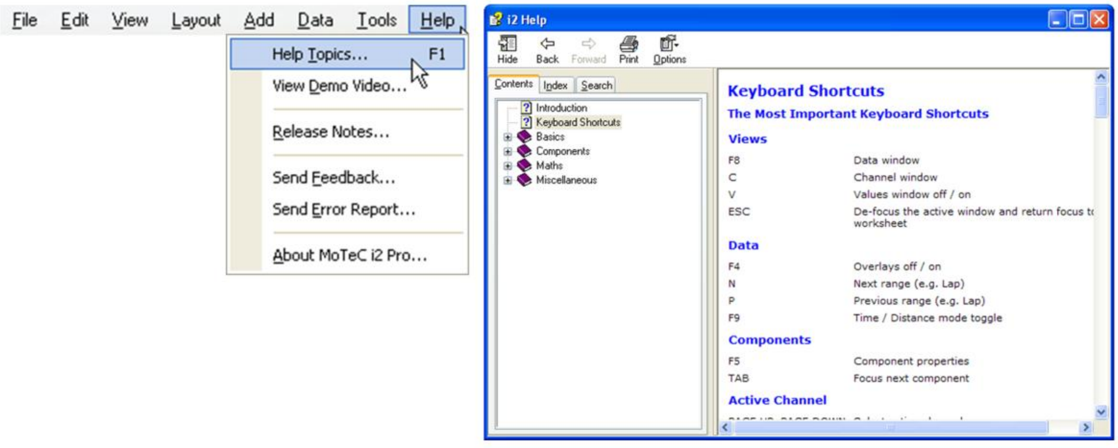
Keyboard Shortcuts

- See the Help File for a complete list of Keyboard Shortcuts



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Keyboard Shortcuts

Views

F8	Data window
C	Channel window
V	Values window off / on
ESC	De-focus the active window and return focus to the worksheet

Data

F4	Overlays off / on
N	Next range (e.g. Lap)
P	Previous range (e.g. Lap)
F9	Time / Distance mode toggle

Components

F5	Component properties
TAB	Focus next component

Active Channel

PAGE UP, PAGE DOWN	Select active channel

Graph

LEFT / RIGHT ARROW	Cursor movement
CTRL + LEFT / RIGHT ARROW	Fast cursor movement
UP / DOWN ARROW	Horizontal zoom in / out
F2	Horizontal zoom full out
W	Horizontal zoom to default (e.g. 1 Lap)
SHIFT + LEFT / RIGHT ARROW	Pan left / right
F3	Variance off / on
E	Status and Errors off / on
G	Overlapped / Tiled

Windows

ALT+Letter	Activate a main menu item that has the letter underlined. Or, if a dialog window is active, focus an item or activate a button with a label that has the letter underlined.
TAB	Move to the next item
SHIFT+TAB	Move to the previous item
ENTER	Activate the default button
ESC	Close or cancel an open window
ARROW Keys	Move up and down in a list, select a dropdown item, select an option button
SPACEBAR	Activate a button or toggle a check box select / clear
CTRL+TAB	Next page on a tabbed window
SHIFT+CTRL+TAB	Previous page on a tabbed window

File

CTRL+O	Open log file
CTRL+A	Close all log files
CTRL+S	Save project
CTRL+F8	Unload logged data

General

CTRL+P	Print worksheet
F1	Help

Edit

CTRL+X	Cut component
CTRL+C	Copy component
CTRL+V	Paste component
DELETE	Delete component

DISPLAY & DATA TRAINING – JULY 2015

Keyboard Shortcuts

Views

F8	Data window
C	Channel window
V	Values window off / on
ESC	De-focus the active window and return focus to the worksheet

Data

F8	Select Lap / Outing / Run (shows Data window)
F9	Time / Distance mode toggle
F4	Overlays off / on
J	Single colour for main (shows all channels in the same colour for the main data)
P	Previous range (e.g. Lap)
N	Next range (e.g. Lap)
CTRL+F	Select fastest lap in current file
Q	Swap Main and Overlay 0
F2	Horizontal zoom full out
W	Horizontal zoom to default (e.g. 1 Lap)
A	Animate Start / Stop

Data Window

ENTER	Make the selected item Main
CTRL+ENTER	Make the selected item Overlay 0
ALT+ENTER	Make the selected item an Overlay

Layout

F7	Select worksheet
CTRL+F7	Activate Layout Manager
0..9	Select corresponding worksheet
CTRL+0..9	Select corresponding workbook
F11	Previous worksheet
F12	Next worksheet
CTRL+F11	Previous workbook
CTRL+F12	Next workbook

Tools

CTRL+D	Details editor
CTRL+E	Channel editor
CTRL+U	Channel status
CTRL+M	Maths editor
CTRL+T	Setup sheets

Active Channel

PgUP, PgDn	Select active channel
CTRL+H	Hide active channel
CTRL+Delete	Remove active channel
CTRL+SHIFT+M	Edit active channel maths (if maths channel)
CTRL+SHIFT+S	View active channel status (if maths channel)
CTRL+SHIFT+F	Filter active channel
CTRL+SHIFT+O	Scale and offset active channel
CTRL+SHIFT+Z	Zero at cursor active channel
CTRL+N	Properties of active channel

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Keyboard Shortcuts

Components General

F5	Component properties
Tab	Focus next component
SHIFT+Tab	Focus previous component
L	Channel legend off / on
K	Colour channel legend off / on
G	Cycle layout (Overlap / Tiled)
S	Cycle display style
ALT+0..9	Corresponding colour band off / on
Delete	Delete selected component

GRAPH

Graph Display

E	Status and Errors off / on
F3	Variance off / on
L	Show channel legend off / on
M	Show measurements off / on
G	Overlapped groups off / on
S	Toggle trace style

Graph Zoom

Keyboard

UP / DOWN ARROW	Zoom in / out
F2	Zoom full out
W	Zoom to default (e.g. 1 Lap)
Z	Zoom to datum and main cursors
ALT+UP / DOWN ARROW	Vertical zoom in / out
ALT+F2	Vertical zoom full out

Mouse

Double-click, move, click	Horizontal zoom
ALT + Double-click, move, click	Vertical zoom
CTRL + Double-click, move, click	Window zoom
Double-click on the horizontal scroll bar	Horizontal zoom full
Double-click on the vertical scroll bar	Vertical zoom full

Graph Pan

Keyboard

SHIFT + LEFT / RIGHT ARROW	Pan left / right
SHIFT + UP / DOWN ARROW	Pan up / down (if vertically zoomed)
F	Pan forward
B	Pan back
H	Centre on cursor

Mouse

Click + drag on the horizontal axis	Horizontal pan
Click + drag on the vertical axis	Vertical pan
Click + drag on the horizontal scroll bar	Horizontal pan
Click + drag on the vertical scroll bar	Vertical pan

Graph Cursor

Keyboard

LEFT / RIGHT ARROW	Cursor movement
CTRL + LEFT / RIGHT ARROW	Fast cursor movement
SHIFT+F7	Place beacon at cursor (if Circuit Project)
	Place run at cursor (if Drag Project)
	Place stage at cursor (if Rally Project)
Y	Cursor style
HOME	Cursor to left of screen
END	Cursor to right of screen

Graph Datum Cursor

Keyboard

D	Datum cursor off / on
SPACEBAR	Place datum cursor
X	Swap datum and main cursor

Graph Alignment Offsetting

Keyboard

O	Offsetting axis off / on
CTRL+SHIFT+ARROW	Offset the main lap (offset axis must be on)
ALT+SHIFT+ARROW	Offset the ref lap (offset axis must be on)

Mouse

Drag the main or ref offsetting axis