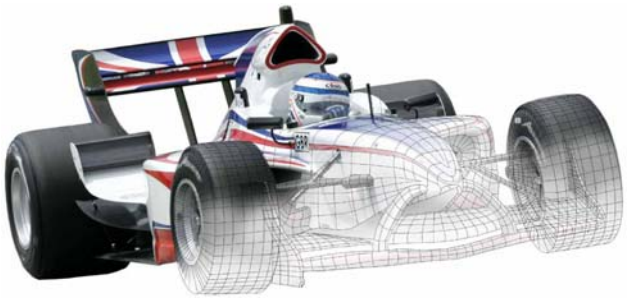

Race Technology
www.Race-Technology.com

# BRAKEBOX Instruction Manual



Version 1.2

# Introduction

The BRAKEBOX is a self contained and exceptionally accurate system for measuring braking distances of cars, bikes and trains, using the very latest GPS technology. The BRAKEBOX needs no connections to the car and so can be fitted and working in seconds. The system requires no calibration, and is engineered to very high standards, ensuring long reliable service in demanding industrial environments.

This manual provides a comprehensive guide to installing, using and interpreting the results from the BRAKEBOX. Additional documentation can be found online at the Race Technology website, http://www.race-technology.com. Follow the link to the "Knowledge Base", which contains the most up-to-date version of the company documentation, as well as additional material not always included in the printed documentation. If your query is not covered by the online documentation, a question or support request can be submitted via. the "Support" tab. We aim to answer all online support queries within 24hrs during the working week (Monday – Friday).

The CD included with the BRAKEBOX contains the latest version of the Race Technology standard software. The BRAKEBOX does not require any software to be installed; however, if it is installed, it will provide access to the documentation from the help system on the PC without the need for an internet connection, and it will need to be installed if you wish to reflash the BRAKEBOX with updated firmware at any point.

**Disclaimer: The BRAKEBOX is intended for off highway testing only and in a controlled test environment. Braking tests can be dangerous and all precautions should be taken to ensure that all equipment is properly secured in the car before proceeding with any test work.**


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# Contents

# What's in the Box?

The BRAKEBOX system is supplied with the following components:

- The core BRAKEBOX unit, containing Race Technology's own very high accuracy ***Pure*Phase** 20Hz GPS system.
- A DASH1 display with special firmware allowing it to interface to the BRAKEBOX.
- A cable loom to connect the BRAKEBOX unit to the peripherals.
- A heavy-duty Peli case to house the system.
- A 3.3V GPS active antenna.
- Full operating and installation instructions.
- A comprehensive software CD.
- A serial printer if specified by the purchaser.
- A null modem type serial cable.
- Lock tape for securing the unit.

# Introduction to the BRAKEBOX

## What the BRAKEBOX Can Do

The BRAKEBOX is a self-contained, exceptionally accurate braking performance testing system. It can be fitted in almost any vehicle in minutes, essentially requiring only a 12V DC power source and a suitable GPS antenna mounting location, and can be operated by either engineers or technicians with a minimum of training through a simple and intuitive menu system.

The BRAKEBOX measures time, speed, distance and acceleration during short duration tests, which will normally be braking tests. Tests can configured to start either when decelerating though a set speed, or in response to a trigger input, which would typically be triggered either by a brake pedal sensor or possibly an external laser barrier. Tests can be configured to end either when a certain speed is reached, which may be zero, or in response to a trigger input, which would typically be a laser barrier.

The BRAKEBOX uses an extremely accurate GPS engine, described in more detail in the next section, and as a result, accuracies of about 2 to 3cm in the distance measurement for a braking test from 100mph would be typical. The BRAKEBOX is also suitable for use in coast-down tests. Due to the nature of it's operation, it is less suitable for long time scale tests. Race Technology stock a range of alternative data loggers using the same core GPS technology that are suited to longer tests if required.

## How the BRAKEBOX Works

The BRAKEBOX uses an extremely sophisticated method to measure speed that goes well beyond the capabilities of typical "consumer" GPS units. The data broadcast by the GPS satellites is carried by a much higher frequency "carrier" wave. The carrier wave cannot be used to help calculate a more accurate absolute position, since it is impossible to know how many frequency cycles there are between the user and the satellite. However, by looking at the differences in the carrier wave cycle phase between successive measurement samples, the unit can in effect reference it's new position extremely accurately to it's last position, and


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hence calculate speed to a much greater accuracy than it can calculate position. In the event that a carrier lock cannot be obtained, the unit can also calculate speed by measuring the "doppler" effect, whereby the frequency of the transmitted data appears to shift depending of the relative speed of the transmitter and receiver. This method is not quite as accurate as the carrier method.

These highly accurate speed measurements are calculated in X, Y and Z directions, allowing the BRAKEBOX to calculate accurate path distance, heading, and either 2d or 3d speed. The distances are calculated by integrating the speeds, which leads to the stipulation that testing duration must be fairly short, since eventually error will creep in to the integration. Over the timescale of typical braking tests the method used provides unparalleled accuracy.

At rest, it can be observed that the 2d or 3d speed has noise present typically to about 0.1 or 0.2mph. At rest this noise is a bias in one direction to the speed, since regardless of the direction of the X, Y and Z velocities measured, the scalar speed is always positive. As soon the unit is moving, the noise is no longer a bias, since it then oscillates about the correct speed. In practice, the bias at zero speed makes no measurable difference to the result, since at the end of the test the vehicle is moving so slowly that the distance increment is negligible compared to the distances covered at the start of the test. The unit has an intelligent detection of zero speed built in, to ensure that noise does not prevent the test from ending properly.

# Installing the BRAKEBOX

## Installation Checklist

The following checklist is designed to be a quick reference for connecting the system in day-to-day usage. For the first use of the system, it is recommended that the more detailed explanations of each step are read in their entirety before installing the unit.

1. Ensure the power is OFF.
2. Connect the supplied antenna to "GPS 1" on the unit.
3. Connect the display lead to the D-sub labelled "Display" on the wiring loom.
4. Connect the 12-way Binder connector on the loom to "CONN 1" on the unit.
5. Mount the antenna on the vehicle roof – don't crush the cable in the doors or windows.
6. Secure the unit and the display safely in the vehicle – mounting orientation is not important.
7. Connect the power to a 12V DC supply, eg a "cigarette-lighter" type plug.
8. Use the up and down arrow buttons to navigate through menus and set values, the "SET" button to change a value or enter a submenu, and the "MENU" button to abort a change or leave a submenu.

## Mounting

The mounting location and orientation of the BRAKEBOX is not important as the unit contains no motion sensors. However, for safety reasons it is essential that the unit is securely fastened in the car prior to any test work. There are several methods that can be used to secure the brake box; the base plate has four 4mm holes which are suitable for taking M4

bolts, alternatively industrial "lock", "scotch", or "loop and hook" tape can be used on the base of the unit. It should be ensured that the BRAKEBOX is not subject to excessive vibration, since this may reduce the accuracy of the GPS unit.

## Data Display

The data display is a DASH1 with special firmware to allow it to interface with the BRAKEBOX. The display comes with the correct connections so it can be connected to the main BRAKEBOX immediately. If a longer lead between the 2 units is required then a simple 9 way serial lead extension can be used. The vacuum type windscreen mount that comes with the display is exceptionally strong and provides an excellent mount to clean glass provided it is used correctly. The display is backlit for use in all lighting conditions. Note that for correct operation the display must be connected to the BRAKEBOX **prior** to power being applied. If this is not done and the unit does not start up, simply cycle the power off and on.

## GPS

GPS speed and position readings are unaffected by mounting position of the main BRAKEBOX unit. The mounting position of the antenna, though, is of utmost importance in ensuring that the highest accuracy is achieved. The GPS unit requires a 3.3V active antenna (supplied) to be connected to the “GPS1 Antenna” connection on the BRAKEBOX, which must be mounted in a position giving a good view of the sky. On top of the vehicle is **strongly** recommended. Mounting the antenna on the bonnet or the boot of the vehicle may give substandard results due to the reduced number of satellites in view, and in particular the fact that any alteration in vehicle course will change the satellite constellation used, and the results from the BRAKEBOX cannot be warranted under these circumstances.

In addition to mounting the antenna on the roof of the vehicle, it should be ensured that the test environment gives a good view of the sky. A clear open space, such as a test track or airfield is ideal. Tall trees or buildings in the vicinity of the test are not ideal, and will degrade accuracy. Any overhead obstruction, such as a bridge, is unacceptable, and will result in invalid test data.

In view of the importance of the antenna mounting position, a full set of guidelines are set out below:

- The antenna must have a clear view of the sky in all directions. Note that it is **not** enough that the antenna can see vertically upwards towards the sky, it must also be able to see all the horizons as well. The GPS system actually gets very little positional or speed information from the satellites directly above, it gets far more information from satellites on, or near, the horizon. For example if the antenna was mounted in the bottom of a "bucket", so it could see upwards but no horizons, then the GPS system would lock and provide positional information - but the accuracy would be very poor. In practice this all means that the antenna must be mounted on the highest point on the vehicle.
- The antenna must be mounted on a horizontal surface. The antenna must be mounted on a horizontal orientation facing directly up. The underside of the antenna cannot receive GPS information, similarly don't mount the antenna on a vertical surface.


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- The antenna must not be covered in tape, in particular dark coloured tapes. Many tapes absorb the weak GPS radio signal. In general black tapes are the worst in this respect as they contain high amounts of carbon - however to be safe, avoid using any tapes.
- The antenna must not be subjected to high levels of vibration. Although the antenna is physically robust to vibration, it can and does effect GPS reception, so isolate it as much as possible.
- The antenna must be physically remote from sources of electrical noise. The GPS radio signal is very weak and can easily be blocked out by radio interference, so to get a good signal the antenna must be as far away from radio interference as possible. By far the biggest source of radio interference is a petrol engine's ignition system, so keep the antenna away from all aspects of it including the engine management system, coil, leads, distributor etc.
- Avoid trapping or pinching or kinking the antenna cable. The lead from the GPS antenna to the receiver is a special very high frequency cable and it is not normally practical to repair it - so if you do trap, pinch or cut it then the antenna will have to be replaced, and this isn't covered by the guarantee! - so don't try and fit it into a shut gap that is too small or compress it with a door seal etc.
- If at all possible, mount the antenna on a metal platform (mounting on the roof of the car satisfies this criterion). The GPS radio signal is amplified if the antenna is mounted on a metal plate (termed a ground plane), and the bigger the better. It is not essential for correct operation, but it is desirable.

Care must be taken not to crush the antenna lead with the vehicle window or door closure; if it is accidentally crushed then the cable may be permanently damaged even if there are no physical marks on the cable. Replacements are available from Race Technology at relatively low cost should they be required. Note that the “GPS2 Antenna” connection is unused on the BRAKEBOX, and does not need to be connected.

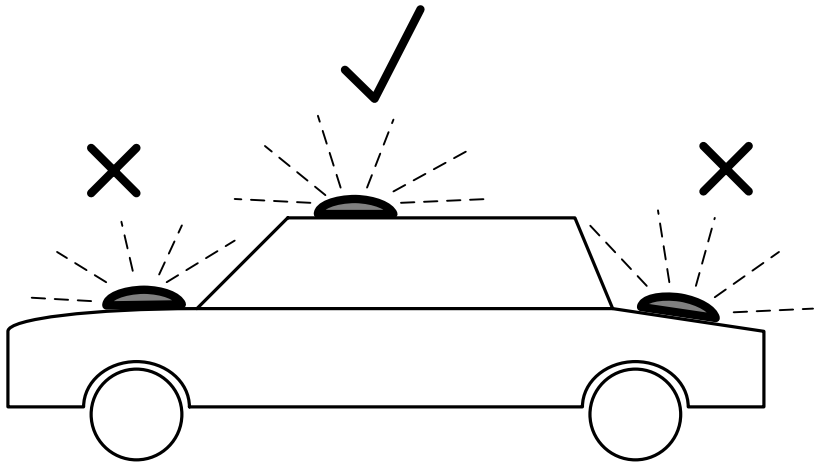

*Figure 1. Correct GPS antenna mounting position on the roof of the car giving full horizon to horizon visibility.*

## Power

12V DC power is required, to be connected to the supplied cable loom assembly. The power connection lead is clearly labelled. The +12V wire is black with a white stripe, and the ground wire is all black. If a cigarette-lighter type plug is used to draw power from the

vehicle electrical system, then please ensure that the unit is unplugged when not in use, since the unit draws power whenever it is connected, even when the display is removed, and continuous connection for an extended period will eventually flatten the battery. **Unreliable power supply is a common cause of problems.** In the event of any problems please try an alternative 12V source in the first instance.

## Trigger

The trigger input can be used to define the start and/or the end of the brake measurement. To activate the trigger input this pin need to be connected to ground. If the start and end of brake testing is instead defined by speed thresholds then no trigger needs to be connected, and the state of this pin will be ignored.

## Printer

If the unit has been supplied with a serial printer, there should also be a 25 way to 9 way D-sub adaptor supplied. This is used to connect the 25 pin D-sub connection on the printer to the 9 pin D-sub connection on the main wiring loom labelled “Printer/PC”. Power to the printer is supplied through this connection, and hence no other power supply to the printer is required.

## Connections

There are 3 connections on the unit; one main connector block, labelled "Conn1", and two GPS antenna connections, labelled "GPS1 Antenna" and "GPS2 Antenna" respectively. The main connector block, Conn1, should be connected to the large connector on the supplied cable loom. The other connectors on the loom are all individually labelled. The positive wire on the power lead has a grey or white stripe.

A 3.3V active GPS antenna must be connected to "GPS1 Antenna". GPS2 is not used on the BRAKEBOX.

## Testing the Installation

To test the installation, connect the power, GPS antenna and display to the unit as described above, and switch the unit on. The red power LED on the unit and the backlight on the display should light immediately, and after a few seconds the display should show “RACE TECHNOLOGY ** BRAKEBOX **” briefly, before changing to show “Display”.

Assuming that the power and display are OK, wait for the unit to obtain a GPS lock. This should occur within about a minute, and will be signified by the green light on the unit and the leftmost red LED on the DASH1 display lighting, either flashing at 1Hz to indicate a doppler lock, or continuously lit to indicate a carrier lock. The number of satellites used can be viewed by entering the Display menu and selecting “Satellite Status”. For best accuracy, a carrier lock with at least 7 satellites used would be desirable.

If a trigger input is connected, the best way to test it is to configure both the start and end of brake testing to be triggered by pulse instead of speed. A dummy brake test can then be performed whilst stationary by arming the unit and then activating the start and end of the test


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using the trigger input. Refer to the configuration and operation instructions later in the manual for details.

### Installing the Supplied Software

It is not necessary to install any software on the PC in order to use the BRAKEBOX, since the BRAKEBOX is a completely self-contained system. However, it may be desired to install the Race Technology help system documentation on the PC in order to view documentation when no internet connection is available, and if it is required to reflash the BRAKEBOX with new firmware, then it will be necessary to install the software on the CD. The enclosed CD contains the full Race Technology software suite, including the help system documentation and the reflashing utility. To install the software, first check if any earlier versions of the Race Technology software are installed (Start->Settings->Control Panel->Add or Remove Programs), and uninstall them **before** installing the latest version. Insert the CD and run the installer program, and verify that the software is installed, which should be under Start->Programs->Race Technology v7.

## Operating the BRAKEBOX

### Using the BRAKEBOX Menu System

The BRAKEBOX is operated using a simple menu system on the DASH1 display, using the UP, DOWN, SET and MENU buttons. Pressing UP and DOWN moves between the menus or cycles settable values, pressing SET enters a submenu or sets a value, and pressing MENU exits the current submenu without setting any values.

There are four main modes of "root" menus for operating the unit, namely:

- **Display Mode**

  This mode allows you to monitor the current status of the GPS receiver, or simply display speed, heading or position on the display. No results are stored to memory, nor available to print. This mode is typically used to check the operation of the GPS system or as a simple in-car display of speed etc.

- **Brake Test**

  This is the mode for testing braking performance. Before using this mode, make sure that the BRAKEBOX has been configured as required in the configuration menu.

- **Configuration**

  This allows the user to configure many aspects of the brake test including how the test is performed, what results are displayed, default units, whether results are printed and stored by default, and many other parameters.

- **Recall Results**

  This mode allows the user to review braking tests that are currently stored in the memory of the unit.

The full structure of the menu system is shown in figures 2 and 3, showing the non-configuration-related and the configuration-related aspects of the menus respectively.

## Configuring the BRAKEBOX

The configuration menu allows you to set up all aspects of the behaviour and operation of the BRAKEBOX. All configuration options are persistent, hence there is a slight pause when setting an option as the new value is written into the unit's flash memory. An option exists to reset the unit to the factory defaults if required. Each of the available options is discussed below. The full configuration menu structure is shown in figure 3, in which the factory defaults are indicated by being underlined.

- **Units**

  This option allows the units for the display and printing of speed, distance and acceleration to be set. The units of speed can be set to miles per hour (mph), kilometres per hour (kph) or metres per second (m/s). The units of distance can be set to be feet (ft) or metres (m). Acceleration can be set to g (defined internally as $9.81 m/s^2$) or $m/s^2$.

- **Set Language**

  This sets the language for the menus and options.

- **Configure Brake Test**

  These options configure the behaviour of the actual brake test, and control the measurement that is taken.

  **Trigger Mode.** This sets whether the brake test starts on a speed threshold or an electrical pulse, typically from a brake pedal input or possibly an optical barrier.

  **End Trigger Mode.** This sets whether the brake test is ended by a speed threshold or an electrical pulse, typically from an optical barrier.

  **Start Speed.** If the trigger mode is set to “Trigger on Speed” then you have the option of setting the speed at which the braking distance measurement will start. The units of the speed threshold are as set in the configuration menu.

  **End Speed.** If the end trigger mode is set to “Trigger on Speed” this sets the speed at which the brake test finishes. Typically this is set to zero (0 MPH) meaning that the brake test completes once the car is stationary, however you can set a higher speed if required.

  **Use 2D or 3D Speeds.** The BRAKEBOX can use either 2D or 3D velocity to calculate the braking distances. In theory 3D velocity is more accurate as it includes any inclines of the road, however in practice using 2D velocity can give more repeatable results as the


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effects of small pot-holes and other minor road surface imperfections are reduced. Most competitor brake measurement systems use 2D velocity, however in practice the velocities are so accurate from the BRAKEBOX that both modes will give very similar results.

**Set MFDD Thresholds.** MFDD (Mean fully-developed deceleration) is the average deceleration recorded between two user-settable proportions of the test start speed, by default 80 – 10%. These values can both be set by the user, with the limitation that the lower threshold must remain lower than the upper threshold. It is necessary to press SET at the upper threshold screen to progress to the lower threshold screen.

**Set Start Exceed.** When the BRAKEBOX is configured to start the brake test at a given speed ("Trigger on Speed"), this speed must initially be exceeded by a certain margin before the BRAKEBOX will arm, to ensure that the test is not started by noise on the speed signal whilst accelerating upwards through the start speed. This margin is set here. The units are as set in the configuration menu, and in common with other user-set speeds, the value will not be changed when the units are changed.

- **Tables to Generate**

The BRAKEBOX can generate a number of tables following a brake test. The following options control whether or not tables are printed at the end of a test, and if so which tables are generated, and the intervals used.

**Print Results.** This first option allows you to set if the results of the brake test are printed through the serial connection labelled "printer" once the test has completed. You can set the system to always print the results, never print the results, or prompt the user to see if results should be printed. If a serial printer is not available, the results tables can be viewed by connecting the "printer" serial connection to a PC, and using Hyperterminal to view the results, set to connect at a baud rate of 9600.

**Speed Table, Path Distance Table, Time Table.** The tables generated have one independent variable down the left hand side with the values spaced at regular intervals and then up to three additional dependant variables. The three independent variables that can be used in the tables are speed, path distance and time. Each of these can set activated as required:

• Calc Speed Table. This option enables the braking results to be tabulated as a function of speeds.

• Calc Path Distance Table. The option enables the braking results to be tabulated as a function of distance.

• Calc Time Table. This option enables the braking results to be tabulated as a function of time.

When you activate a table, then you are prompted to enter the interval for the table.

- **Variables to Show**

  Whilst speed, path distance and time results are always shown, there are also another six variables that are optional:

  • Forward distance. This is the distance that the vehicle has travelled during the test in the direction of the initial heading.

  • Deviation distance. This is the deviation laterally from a straight line in the direction of the initial heading. Note that this is the deviation at the end of the test, NOT the maximum deviation recorded. Deviation during the test may be seen using the tables. The sign convention is that deviation to the right is positive, and to the left is negative.

  • Direct Distance. This is the distance directly from the start point of the test to the end point of the test.

  • Average Acceleration. The sign convention used is that acceleration is positive, and deceleration is negative.

  • MFDD (Mean fully-developed deceleration). This is the average deceleration recorded between two user-settable proportions of the test start speed, by default 80 – 10%.

  • Initial Heading. This is the heading recorded at the start of the test.

  Each of these variables can be used or hidden. If they are used then they will be displayed on the screen immediately following a braking test and included in the printed tables of results, if printing is enabled. A more detailed explanation of the various distance metrics used can be found in the "Explanation of Results" section later in the manual.

- **Store Data**

  This option allows you to set if the results of the brake test are stored to internal memory once the test has completed. If enabled, the unit stores the complete set of raw data recorded during the test, and so the full set of available parameters can be viewed at a later date. For instance, even if the unit is set to not display forward and deviation distance at the end of a test, these parameters can still be viewed later if the data is stored, simply by changing the configuration to display these parameters, and recalling the results.

  The system can be configured to always store the results, never store the results, or prompt the user to see if results should be stored. Once the results are stored they will be retained until the memory is cleared. If there is insufficient space to store the results at the end of a run, the user will be offered the option of clearing the memory of existing results, or discarding the current data. Note that selecting the clear memory option clears the memory of **all** saved results, and is **irreversible**.


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- **Set Run Name.**

  To identify the test files, you can set a name for them to be stored under. This is used as a basis for the internal "file name" and can be up to 5 characters long. The characters are typically the initials of the test driver or car registration code. A 3 digit number is automatically appended to the name by the BRAKEBOX when saving the run in order to differentiate separate runs. This starts at 001, and automatically increments each time another run with the same name is saved.

- **Clear Memory.**

  This clears the entire internal memory. This is 100% permanent; once the memory has been cleared there is **no way to recall the data**.

- **Set LED Brightness.**

  This screen allows the user to set the LED brightness, to a value between 1 and 8. All of the LEDs are lit whilst adjusting the brightness to show the brightness selected.

- **Restore Default.**

  This resets all configuration options to the factory defaults, except for the language option which will remain in the language selected by the user.

- **Version.**

  The firmware version is displayed here.

## Performing a Brake Test

This is the main mode of the BRAKEBOX and is the mode used to measure, store and print braking distances. There are two brake testing modes available: single test or continuous testing. In single test mode, arming the BRAKEBOX causes it to start one test sequence, which ends either when the test is successfully completed, or is aborted. Results are displayed following a successfully completed test. In continuous testing mode, the BRAKEBOX will continuously test, save the results of successful tests, and then automatically re-arm for the next test, until the user manually stops testing. Results of successful tests are not displayed until the user exits continuous testing. The sequence of events for a brake test is described below.

Once "Brake Test" mode is selected, the display will show:

```
Single Test
Press SET to Arm
```

Use the up and down arrows to select either Single Test or Continuous Tests, and then press the SET button to arm the BRAKEBOX. Note that if continuous testing is chosen when the unit is configured not to save data, then the unit will issue a warning, and if the user chooses to proceed will then enter continuous testing mode, but without saving any results.

Once the SET button is pressed, the BRAKEBOX is "armed" and the brake test is waiting for the trigger to commence braking distance measurement. LED 2 on the display unit will light to indicate the armed status of the unit. If you wish to leave the brake test menu, for instance to change the configuration parameters, then the BRAKEBOX can be de-armed by pressing the MENU button.

If the system is configured to start at a particular speed then LED2 will not light until the target speed is reached, and the display will show:

```
Accelerate to xxx MPH
```

The target speed shown is the start speed **plus** the configurable speed to exceed the start speed by. The BRAKEBOX will only fully arm once the start speed has been exceeded by the configurable start exceed speed, in order to avoid the start of the test being triggered by noise whilst accelerating upwards through the trigger speed.

In the case that the trigger mode is set to pulse, or the vehicle speed is already above the trigger threshold then the display will change to:

```
**BRAKEBOX armed**
```

As soon as the brake test is triggered then the distance measurement will begin. Whilst the brake test is in progress, LEDs 3, 4 and 5 on the display will light to indicate that the test is live, and the display will show time and speed (with appropriate units):

```
Time: x.xxS Speed: xx.x MPH
```

The level and accuracy of the GPS reception obtained is continuously monitored by the unit during the test. In the event of inadequate GPS reception, the unit will automatically abort the test, and display a message to alert the user. Pressing any button will clear the message and return the unit to the idle state. In continuous testing mode, the unit will automatically re-arm after a few seconds after alerting the user to loss of lock. The test can also be aborted by the user if required with a long press of the MENU button.

In single test mode, the summary results will be displayed once the end condition for the brake test has been met. Use the down and up arrows to scroll through the results. Depending on the configuration, the user will then get options to store the data to internal memory and/or print the results. Once the test is fully complete, the BRAKEBOX will return to the "idle" state, and will need to be armed again in order to commence another test.

In continuous testing mode, the results will be automatically saved to memory at the end of each test (unless the unit is configured to not save data), and then the unit will re-arm automatically ready for the next test. To finish testing, and to view and/or print the results, press the MENU button when the unit is armed, or make a long press of the MENU button if a test is in progress and you wish to stop testing. The unit will return to the “idle” state once viewing and/or printing of the results is complete.


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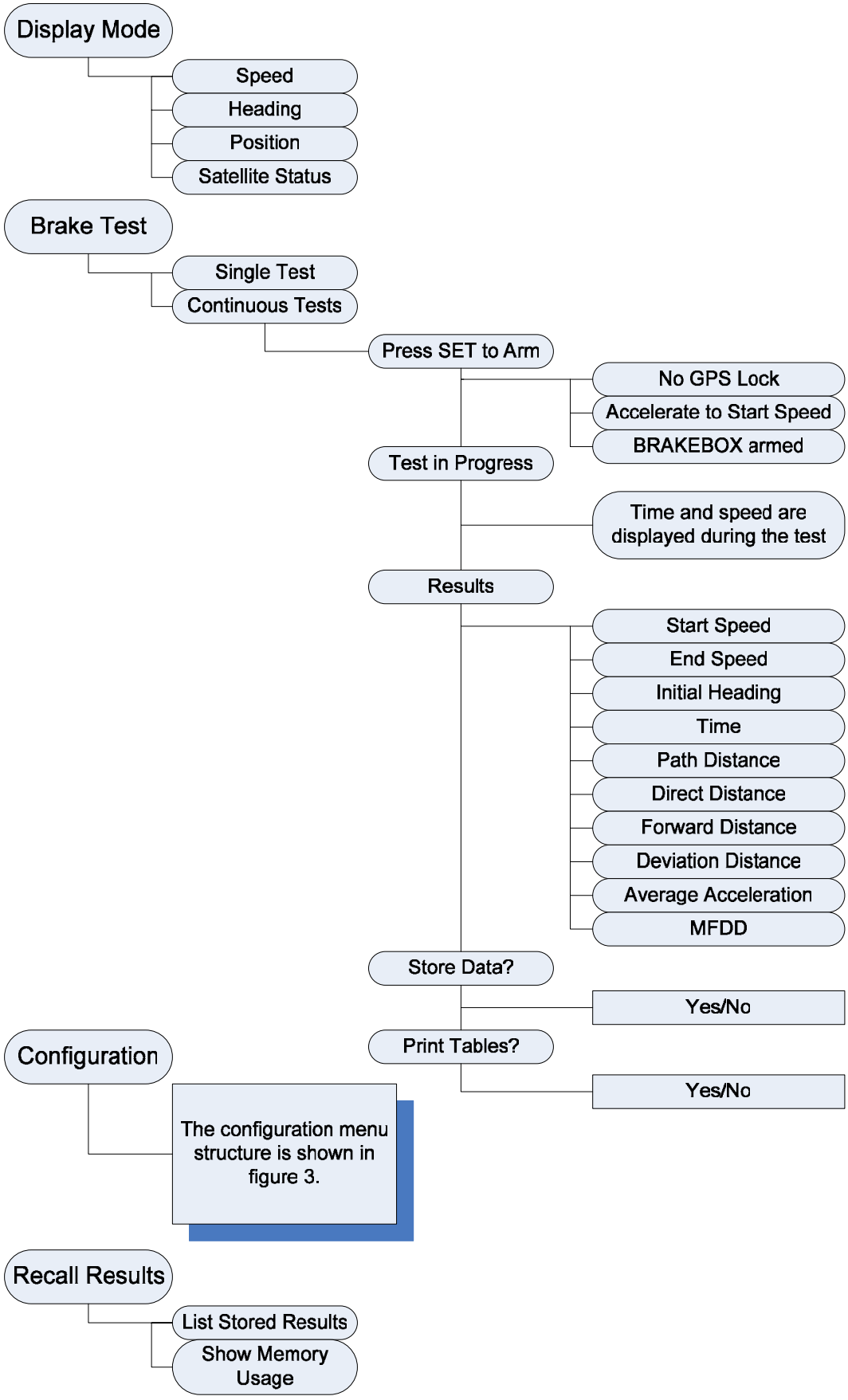


*Figure 2. BRAKEBOX menu structure (excluding configuration).*

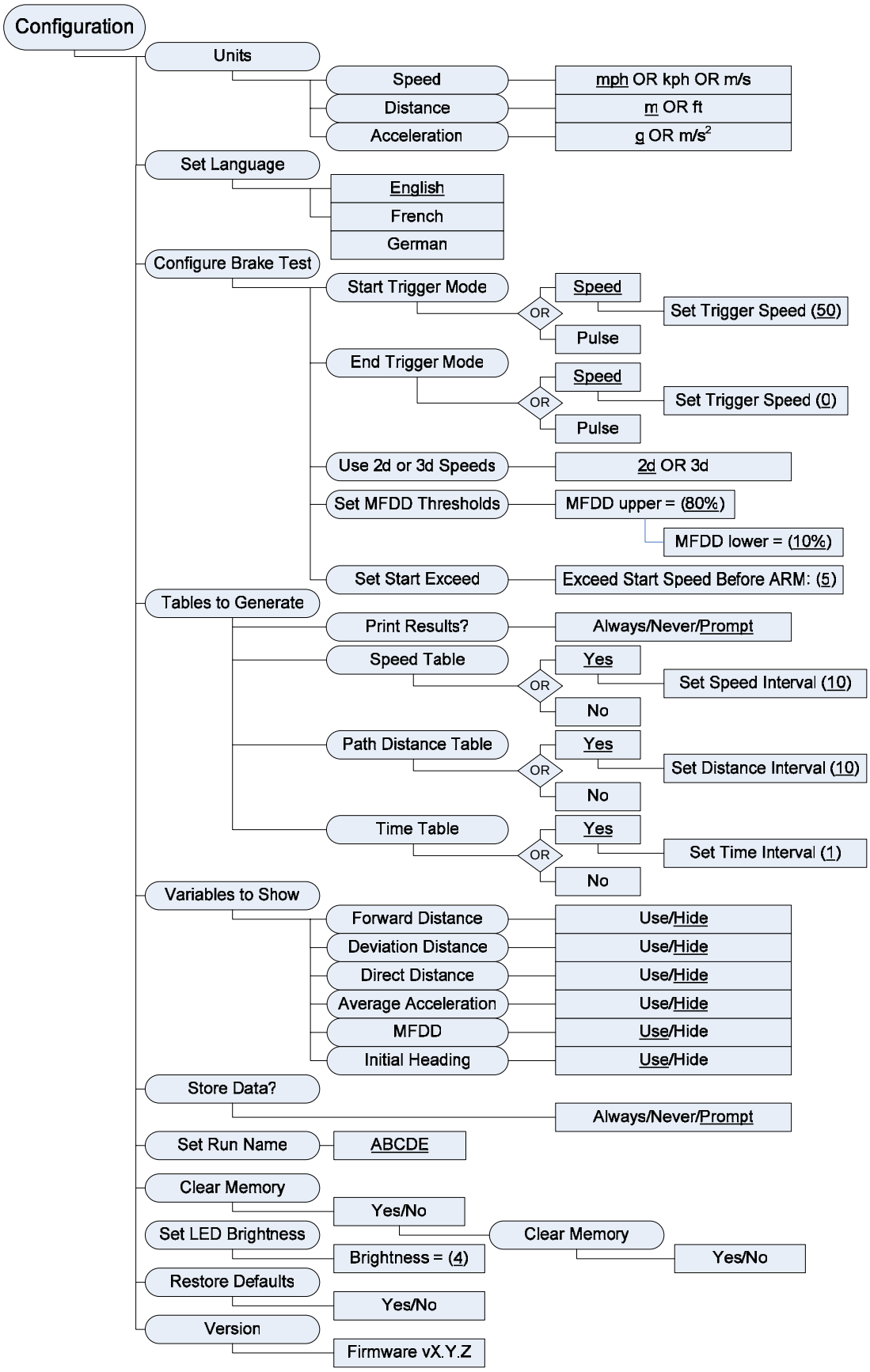


***Figure 3.*** *Configuration menu structure.*
*Factory default settings are underlined.*



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# Explanation of Results

There are 8 variables that can be measured using the BRAKEBOX:

- Time
- Speed
- Average acceleration
- Mean fully developed deceleration (MFDD)
- Path distance
- Forward distance
- Deviation distance
- Direct distance

Of these time and speed are self explanatory. Average acceleration is simply calculated from:

*Average acceleration = change in measured 3d speed / time interval.*

The sign convention used is that acceleration is positive, and deceleration is negative.

Mean fully developed deceleration (MFDD) is defined as the average deceleration between 2 set proportions of the vehicle speed at the start of the test; 80% to 10%, 80% to 20% and 70% to 30% are all typical values. The MFDD thresholds can be set by the user using the configuration menu. The rational behind the use of MFDD is that is measures the deceleration during the fully braked part of the test, without including the entry to the test and the final stopping of the vehicle, both of which are affected by pitching moments, and in the case of entry to the test by the time to develop full braking pressure. Only one value of MFDD is produced per test, and hence this variable is not tabulated. The sign of MFDD is opposite to that of average acceleration (above) in that the deceleration value is positive. Some tests may not produce a valid MFDD value, such as when the end speed of the test is set higher than the lower proportion of the start speed, and in this instance no value of MFDD will be shown.

The last four are four distinct distance measurements, as shown in figure 4, and described below:

- **Path distance.** This is the distance that the car actually travels between the point at which the test starts and where the vehicle comes to a rest. For further clarity, imagine that as the vehicle braked it traced a line of chalk on the road. The path distance is the length of this line.
- **Direct distance.** This is the straight line distance between the point at which the braking test starts and where the vehicle comes to a rest. This is the distance that would be measured by a tape measure stretched between the start and end points of the brake test.
- **Forward distance.** This is the distance that the car moves forward in the direction of the initial heading during the test. The direction that is defined as forward in this instance is taken from the 0.5 second period before the brake test starts, so for this result to be meaningful care must be taken to make sure that the car is moving in a straight line immediately before the test starts.
- **Deviation Distance.** This is the distance that the vehicle deviated from a straight line during the test. As with the “forward distance” forward is defined as the direction of travel

for the 0.5 second period before the brake test starts, so for this result to be meaningful care must be taken to make sure that the car is moving in a straight line immediately before the test starts. The sign convention used is that deviation to the right is positive, and deviation to the left is negative.

The distinct distance measurements are not independent, in particular by simple Pythagoras:

$$Direct\ distance^2 = Forward\ distance^2 + Deviation\ Distance^2$$

It should also be clear from figure 4 (overleaf) that if the vehicle travels in a straight line whilst braking then

$$Direct\ distance = Forward\ distance = Path\ distance$$

and

$$Deviation\ Distance = 0$$



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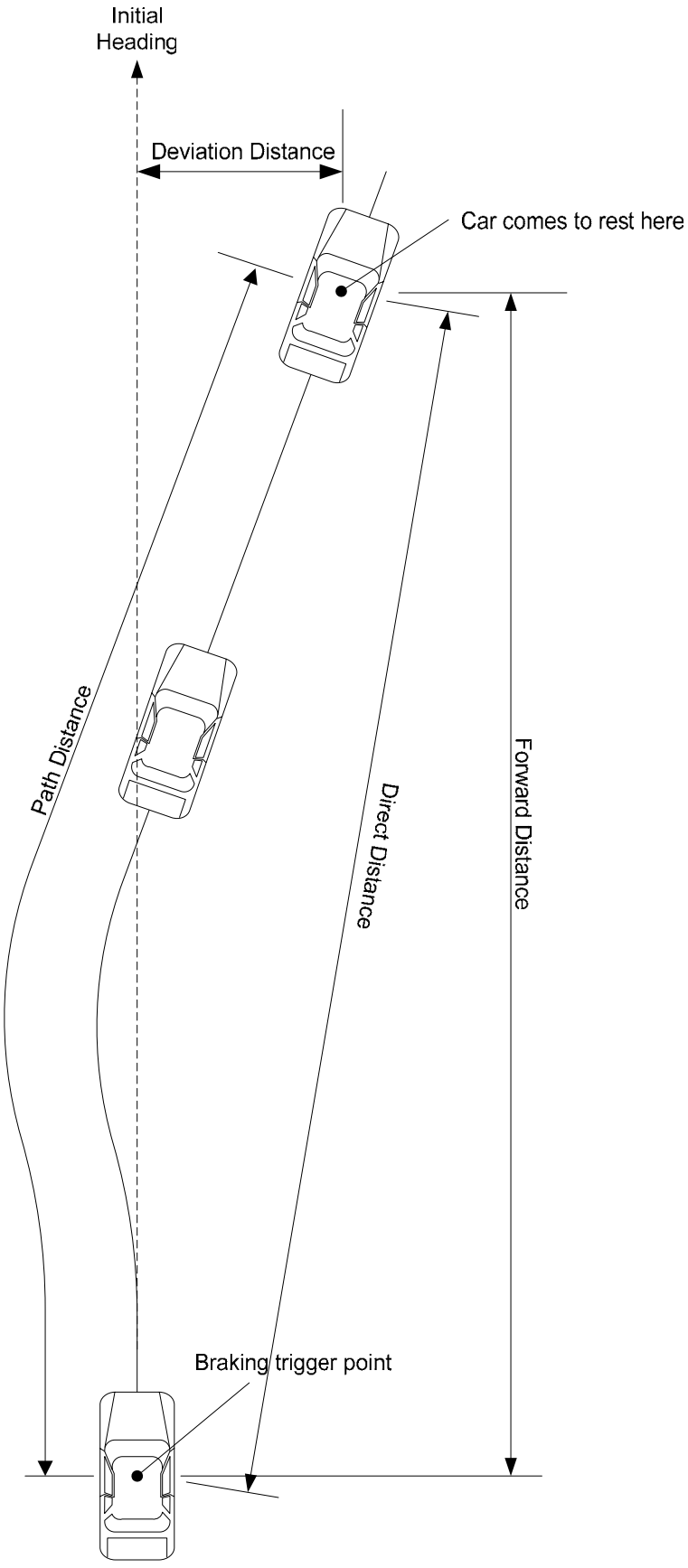



*Figure 4. Brake test distance measurements.*

# Storing and Reviewing Results from the BRAKEBOX

The BRAKEBOX can be set up to store the results of brake testing into the internal non-volatile memory of the unit, for later viewing and/or printing. Setting up the BRAKEBOX to do this is covered in the configuration menu section of the manual.

To recall a saved run using the BRAKEBOX, enter the "Recall Results" menu from the root menu. Two options are available under Recall Results – "List Results" and "Show Memory Usage". By selecting "List Results", the user is presented with a chronological list of saved test results. The List is automatically positioned at the start (the oldest test) when first entered, but one useful feature of the list is that it wraps, so the latest test can be selected with one press of the UP button.

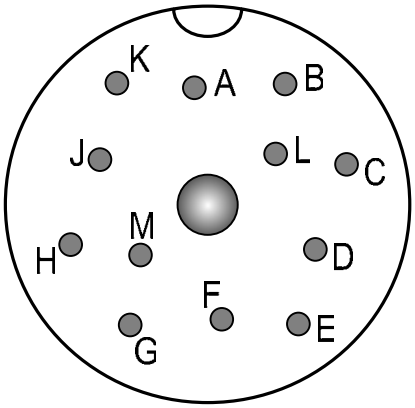
Use the UP and DOWN buttons to find the test required for review, and then press SET to select it. The results will then be displayed in a similar manner as at the end of a test, but using the current configuration settings when selecting which variables to show and generating the tables. Note that you will be prompted whether printing is required regardless of the configuration setting when reviewing results, so it is not necessary to turn off automatic printing should you merely with to view old results on the screen.

The "Show Memory Usage" menu entry can be used to give an indication of the memory remaining. The BRAKEBOX has storage for a maximum 55 minutes of data, but in practice the figure will be slightly lower due to the necessity of saving header information with each run.

# Connector and Wiring Loom Details

## Connector Pinout

The BRAKEBOX unit has 3 connectors: CONN1, GPS1 and GPS2. Only CONN1 and GPS1 are used, GPS2 is simply terminated internally to keep the case waterproof. GPS1 is a female SMA connector, and the required antenna is a 3.3V active GPS antenna. CONN1 is a 12 pin male Binder 723-series connector. The pinout of CONN1 is shown below in figure 7.




| | |
|---|---|
| A | GND |
| B | RS232 1 Tx |
| C | TRIGGER |
| D | No connect |
| E | RS232 2 Rx |
| F | RS232 2 Tx |
| G | No connect |
| H | No connect |
| J | +12V |
| K | RS232 1 Rx |
| L | No connect |
| M | No connect |

*Figure 7. CONN1 (12 pole male Binder 723-series) pinout*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## Wiring Loom Pinout

The wiring loom supplied with the BRAKEBOX contains a 12 pole female connector to connect to CONN1, a female BNC connector for the trigger input, 2 9-pin male D-sub connectors for RS232, and tinned wire for connecting to +12V DC supply. RS232-1 is to connect to the display, and is also used to reflash new firmware onto the unit if necessary, and RS232-2 is to connect to a serial printer. The full pinout of the wiring loom is shown in figure 8.

# Re-flashing the BRAKEBOX

The BRAKEBOX firmware can be re-flashed to take advantage of any software changes or new features introduced. New firmware upgrades may be introduced from time to time either to fix bugs or to introduce new features. These will be available for download and installation from the Race Technology website. Re-flashing is done through a serial connection to a PC. The PC must be connected to the BRAKEBOX serial port labelled "Display", **not** the port labelled "Printer/PC". Full details of how to perform the re-flashing process are provided with all firmware updates, or from the Race Technology Online Help System.

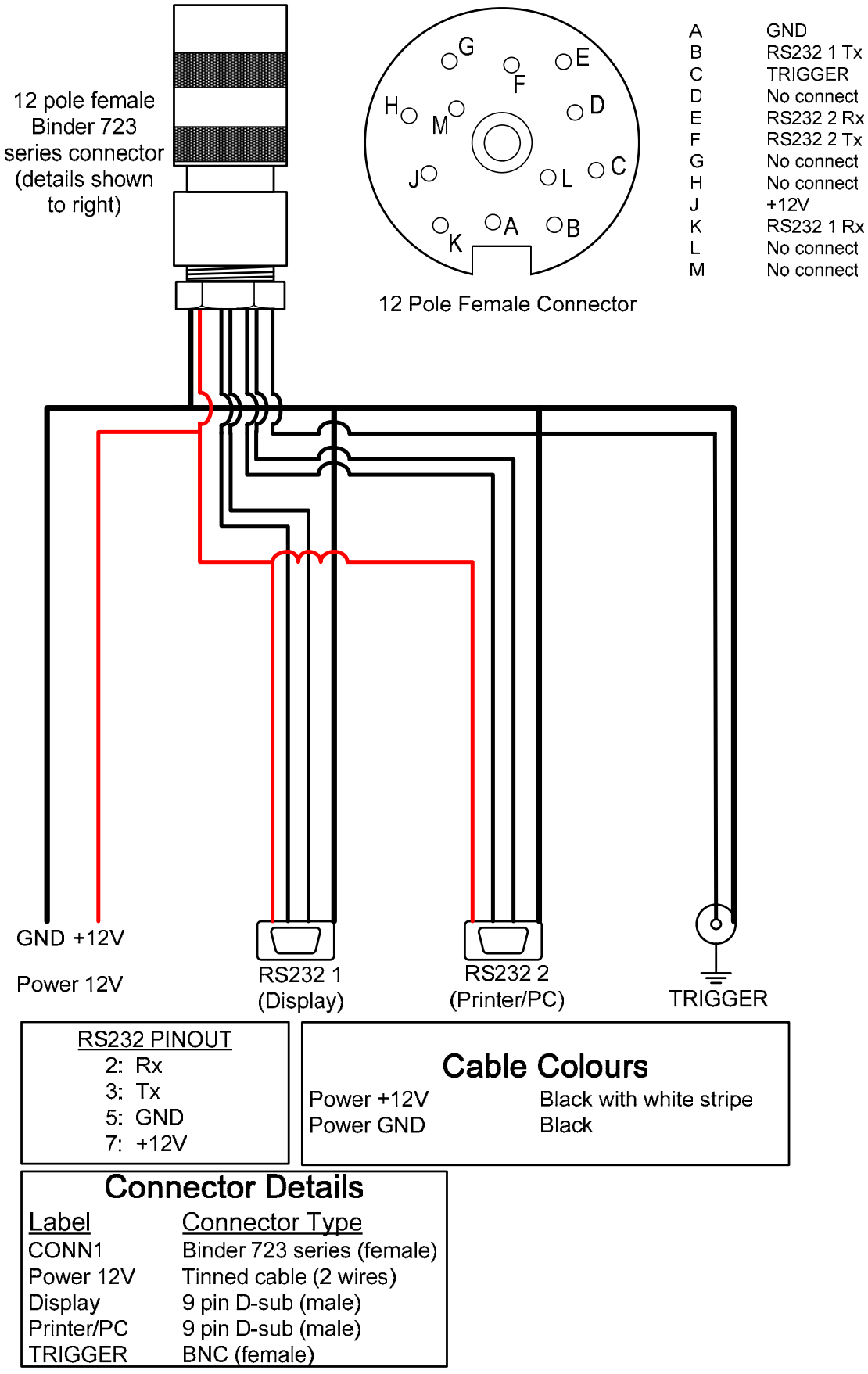


*Figure 8. BRAKEBOX wiring loom pinout*



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