Brake Testing with VBOX

The challenge of measuring braking distances accurately

There are many factors involved in ensuring brake testing accuracy. The first question you need to ask yourself is which distance do you actually want to measure? It might sound obvious, but in reality it is a complex subject.

Range Rover performing a brake test

There are two basic types of brake test. The first is between two speeds, for example: 100km/h to 0km/h. The second is from the initial application of the brakes to a standstill, which is often triggered by a sensor on the brake pedal.

It is very important how and where on the vehicle you measure the braking distance, as this can make a significant difference. Let's look at the first type of brake test in more detail.

Speed to speed brake testing

It may appear straight forward to just define a starting speed for this test, but the speed you pick is critical.

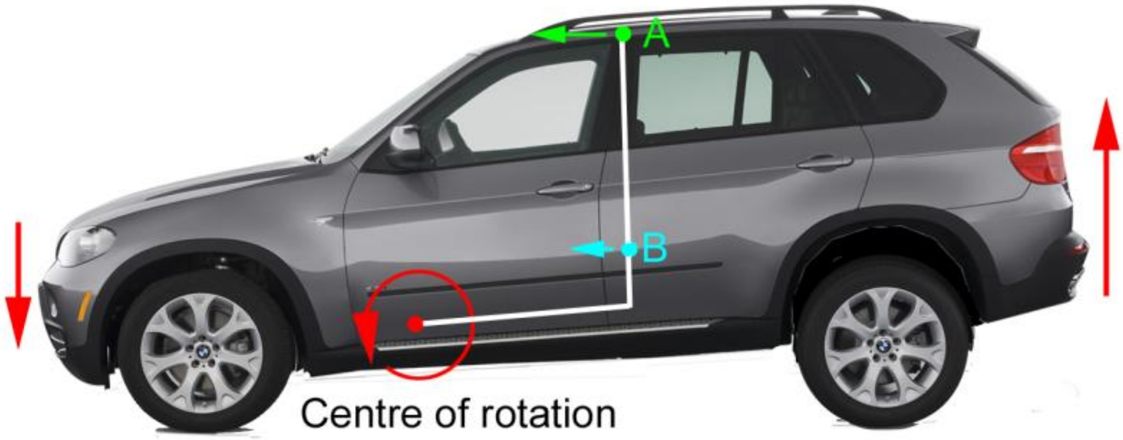
What speed are you actually measuring? You can only measure the speed at one point on the vehicle relative to a fixed reference (the earth or the test track).

Depending on the dynamics of the vehicle at the time, the speed can vary over the entire body of the vehicle. In a steady state condition, the speed is fairly uniform and easy to understand.

However, when the brakes are first applied the vehicle starts to pitch forward, rotating about a point forward of the centre of gravity.

It will also be yawing along the vehicle's centreline axis. Under such movement, there can be small but significant differences in speed across the length and width of the vehicle.

The image below shows that due to the lever arm effect, point A will be travelling faster than point B.



RACELOGIC VBOX
Unit 10, Swan Business Park, Osier Way, Buckingham, Bucks MK18 1TB, England
Tel: +44 (0)1280 823 803 Fax: +44 (0)1280 823 595 Email: vbox@racelogic.co.uk
www.velocitybox.co.uk

Differences in speed across the vehicle

In a test designed to highlight this difference in speed, two identical VBOXs were fitted to the same vehicle. One antenna was placed on the rear of the roof, and the other was placed on the front.

The chart (bottom left) shows the speed from both antennas. The blue trace is the front antenna and the red trace is the rear antenna.

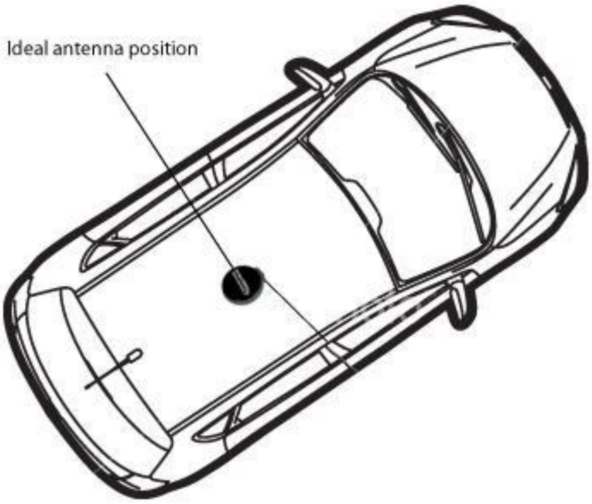
If you examine the highlighted area, which is when the car begins to decelerate, you can see that when one system is measuring 83 km/h, the other system is measuring 82.68km/h, which is a difference of 0.32km/h.

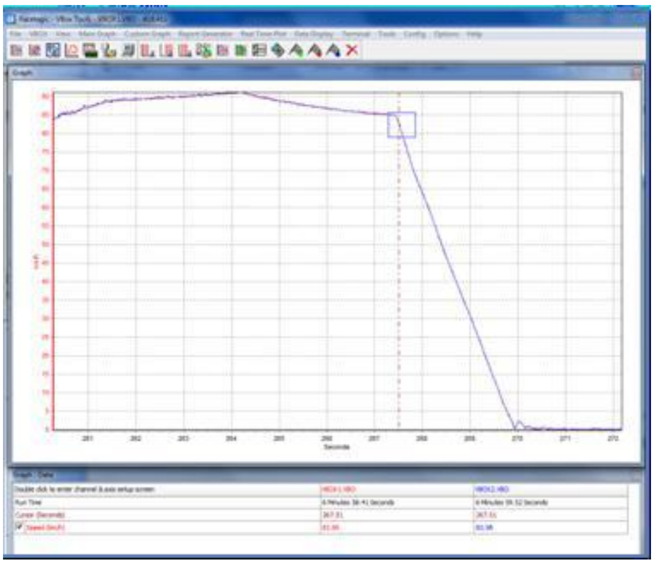
This is not down to inaccuracies of the measuring system, but a real difference in speed relative to the ground over the length of the vehicle.

As shown by the chart (bottom right), if you defined the start speed as 83 km/h, then the rear mounted antenna triggers first and produces a braking distance of 27.17m, whilst the front mounted antenna triggers later giving a braking distance of 27.01m.

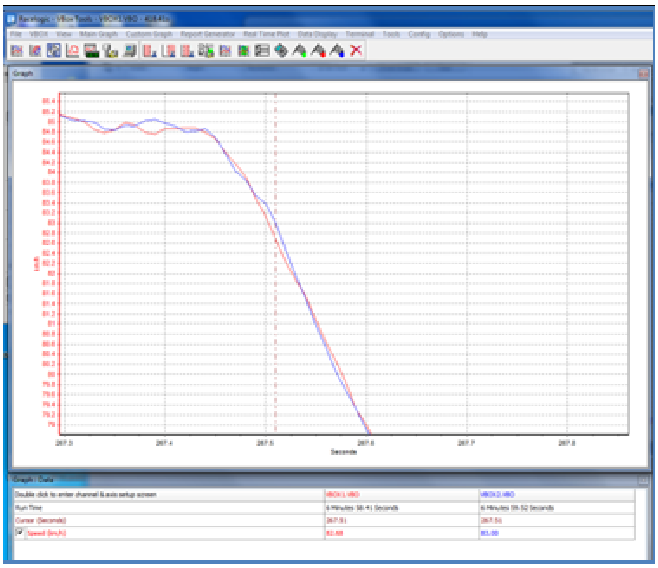
This is a stopping difference of 16cm, and could produce inaccurate results if the difference in speed along the vehicle is not accounted for.

Two antennas fixed to the front and rear of the vehicle with two VBOX 3i devices





Difference of speed between antennas during deceleration



Difference in relative braking distance between the two antennas

How to get a consistent brake distance measurement using speed to speed testing
If you want to measure braking distance consistently, you need to pick a representative point on all vehicles to take as the measurement point, and avoid the region of speed where the brakes are just being applied.

In our experience, a suitable measurement point would be the exact centre of the roof (as shown in the diagram above), and a suitable speed would be 90% of the brake application speed.

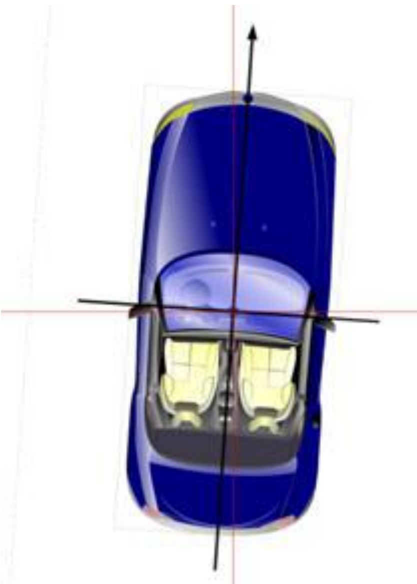
For example, if we choose 75km/h as the start speed, then braking distance difference between the two antennas reduces to 4cm.

However, because this test is started using a precise speed, any sensor noise (usually ±0.1km/h for GPS) or variation in the speed due to the movement of the vehicle (up to ±0.5 km/h) will result in a trigger point which is not perfectly repeatable.

Therefore the maximum accuracy you can expect from a speed top speed test is approximately ±5cm.

Trigger activated brake test

By using a physical switch on the brake pedal, a precise 'start of braking event' can be captured which gives a more repeatable result than a speed to speed test.
The position of the antenna is still critical, as the pitching and yawing movement of the vehicle means that different parts of the roof will still travel different distances by the end of the brake stop.



Yaw and Pitch angle on a vehicle when braking

Yaw
For example, if a vehicle 1.8 metres wide has yawed by 1.5 degrees when it comes to a halt (which is within the typical range for an ABS stop), there would be a 4.7cm difference in measured stopping distance between the right hand side and left hand side of the vehicle.
To eliminate this measurement inaccuracy, it is therefore critical that the measurement point is on the centre line of the vehicle. This measurement point needs to be as consistent as possible on comparative tests.

Pitch
During the brake stop the vehicle will go from having almost zero pitch angle before the brakes are applied, to a steeply pitched state (4-5 degrees is normal) at the point when the wheels stop turning. Once the vehicle has stopped, the vehicle will then rock backwards to zero pitch angle, moving the antenna on the roof approximately 3-5cm depending on the vehicle height.

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How to get a consistent brake distance measurement using trigger activated testing

So which distance do you want to measure? Do you want to measure the distance as the car comes to a halt, or once it has rocked back? Do you want to measure the left hand side of the vehicle or the centre of the vehicle? These are important questions you should understand before you can achieve the most repeatable and representative measurements.

In our experience of getting consistent results, we define the braking distance measuring from the centre of the roof of the vehicle, from the point of brake trigger activation to when the car passes through 0.8km/h, ignoring the rock back period. Using these parameters, we get around 2cm repeatability in measurement accuracy.

VBOX brake test components
VBOX 3i
VBOX 3i records data at 100 samples per second (100Hz) using GPS.
It has proved popular with test engineers due to its high level of accuracy.
Using a brake pedal mounted trigger input (as shown below) a VBOX 3i will measure the braking distance of a vehicle to within ±1.8cm.

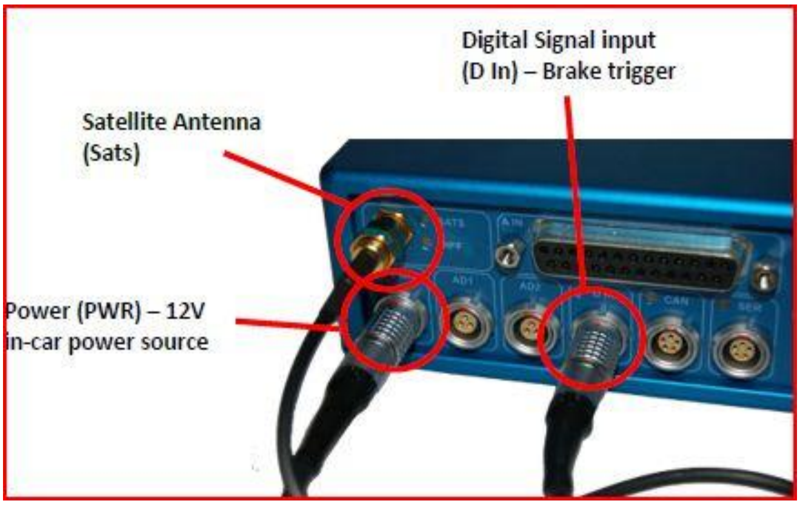
Brake Trigger
By using an electronic trigger to begin a brake test scenario it enables you to gain consistently comparable results to test the whole braking package (including hydraulics, electronics and tyres). Simply mount the trigger to the brake pedal using elastic strips as shown above.

Antenna (ACS158)
For optimum GPS signal reception, ensure the antenna is fitted to the highest point of the vehicle away from any obstructions. Objects in the surrounding area, such as tall buildings or trees, can block GPS signal, causing a reduction in the number of satellites being tracked and decreasing the accuracy of the VBOX.

In-car Power (CAB10)
VBOX is simply powered by a 12V cigar adapter with 2 pin LEMO connection.

Brake Testing with VBOX

Brake Testing Setup with VBOX 3i



How accurate is VBOX for brake testing?

In a recent test with a major motor manufacturer, we checked the accuracy of VBOX against a light barrier, laser, and RTK DGPS setup with BaseStation, all of which confirmed under 2cm accuracy.

We also captured the tests on our LabSat GPS simulator, which records the raw GPS signals and the brake trigger input, and allows us to replay these tests through any VBOX on the bench.

This allows us to have a repeatable reference to check against any new firmware or hardware updates, and maintains a high standard of brake testing accuracy.

For more information on VBOX and to find the right VBOX GPS data logger for you, go to www.velocitybox.co.uk or contact us at vbox@racelogic.co.uk.