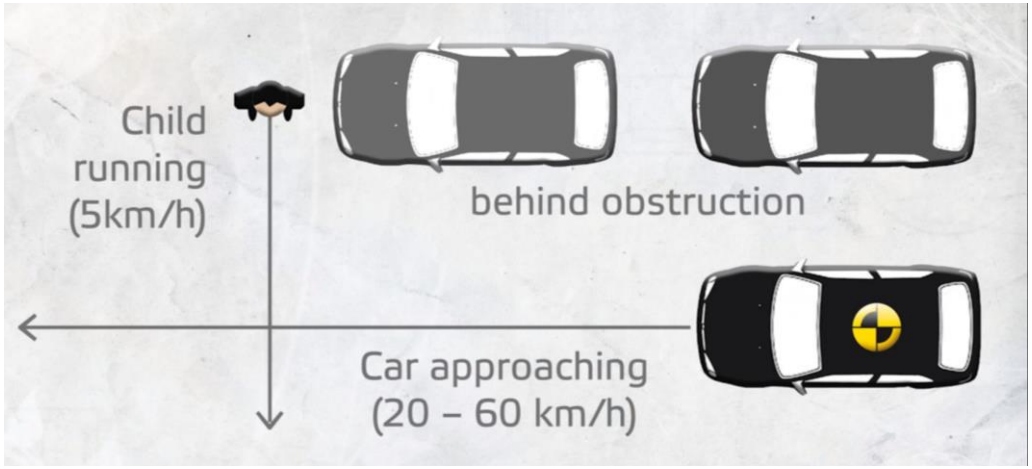
Path Following Safety Checklist
AN-6021 Rev 4

Path Following Safety Checklist

AB Dynamics' driving robots can be used to control a vehicle's speed and heading (Path Following). Due to the complex nature of the software and hardware, human error in the setup process or equipment malfunction can lead to **potentially dangerous situations,** even when there are no objects (e.g. vehicles or walls) in close proximity to the vehicle under test.

In general it is not recommended to run path following tests in close proximity to stationary objects due to the risk of collision. If such a test is unavoidable it is even more important to ensure that all available safety precautions are taken.

This application note describes a **safety checklist** which should be followed when running path following tests.



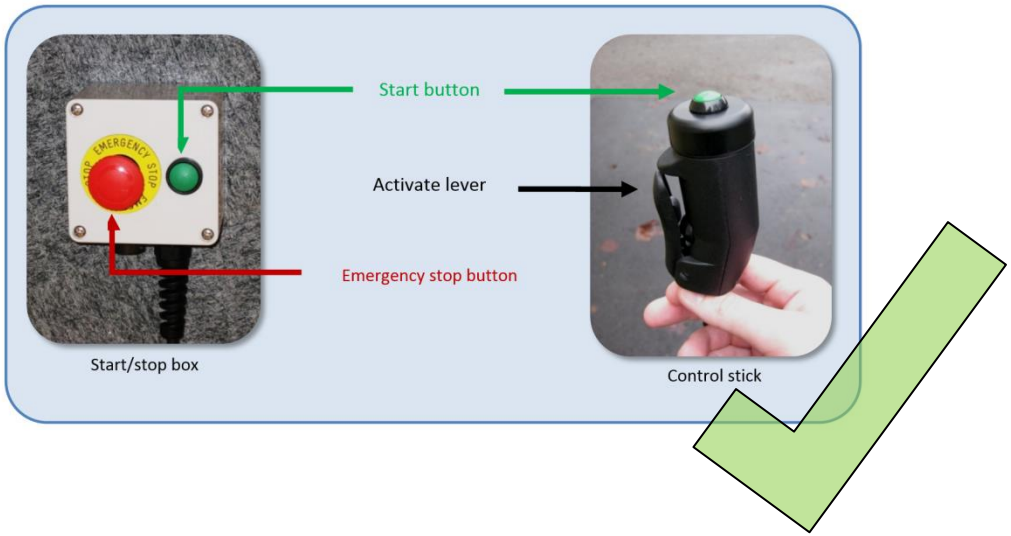
The EURO NCAP VRU test shown here requires close passing to stationary objects

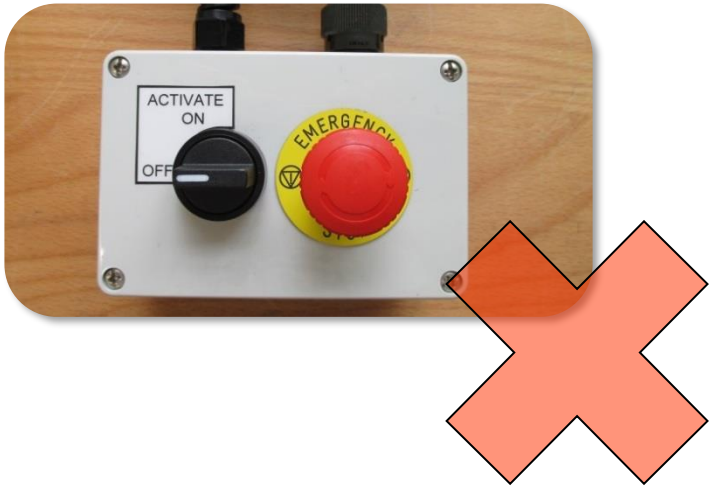
1 – Correct Control Box

It is important that the driver can easily regain control if judged necessary.

Only use the control stick (also known as “dead-man handle”) to activate the robot. Upon release, it will deactivate the steering robot and allow the driver to control the vehicle. It should be positioned within easy reach of the driver such that he/she can immediately take hold of the steering wheel upon releasing the control stick.

The activate/stop box should never be connected during a path following test. It is designed for use with other robots.





2 – Firmly Secure GPS Equipment

The motion pack must be **securely** positioned within the vehicle such that it will not move even during sudden dynamic manoeuvres.

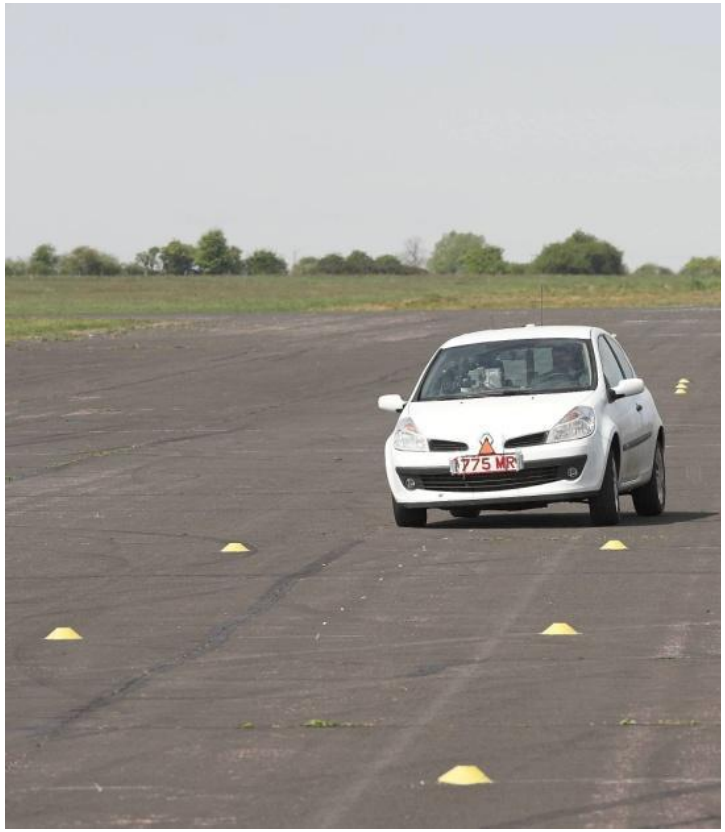
Ensure that no passengers will grab hold of the motion pack or the mounting strut under any circumstances.

Ensure that the GPS base station antenna will not be accidently moved or obstructed. On windy days the antenna must be sufficiently secured.

If the motion pack were to come loose, or the GPS base station antenna were to move, this would be likely to **cause a sudden and potentially dangerous change in the vehicle heading**.

If this were to happen at high speed it could cause the vehicle to lose control and/or rollover.

3 – Use Physical Road Markers

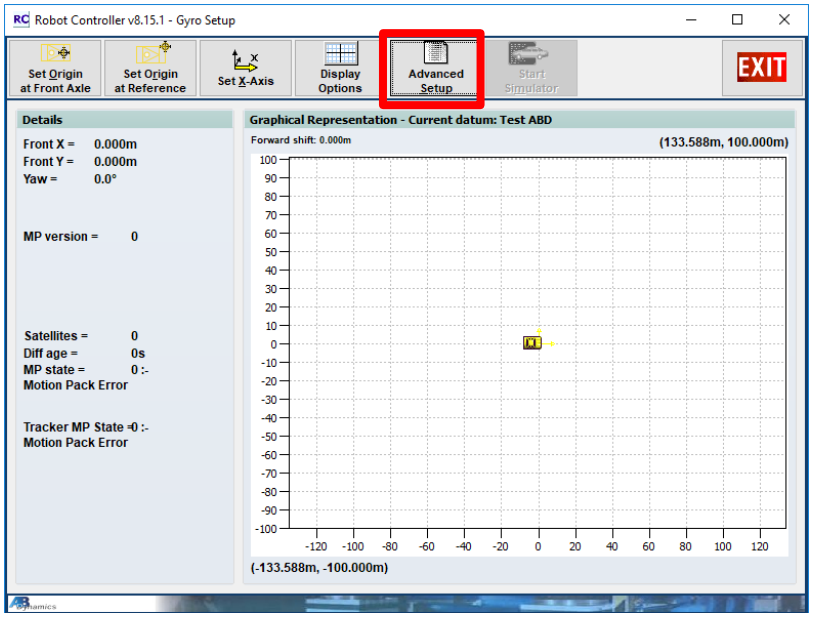


Use cones (or similar) to mark the correct entry path. This gives an early visual cue for the driver that the vehicle is on course.

If the vehicle is clearly not on the intended path, the driver can regain control and steer the vehicle to safety.

Note that the length of the test path must be such that any necessary ‘splining’ to path is completed well in advance of any nearby parked vehicles.

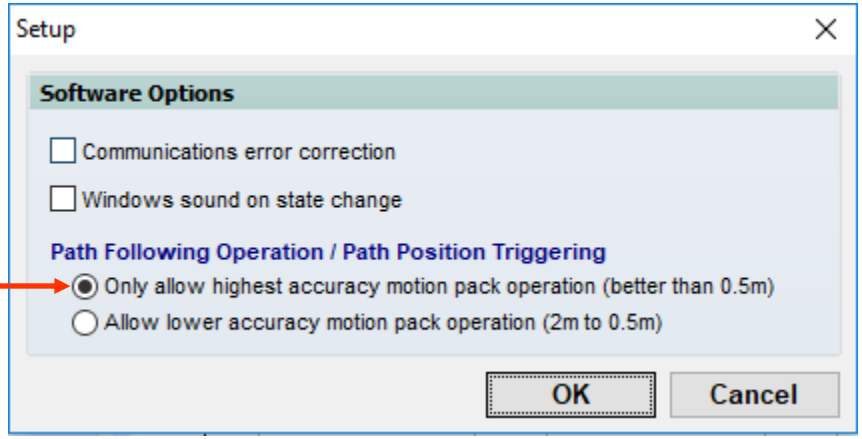
4 – Apply Motion Pack Limit



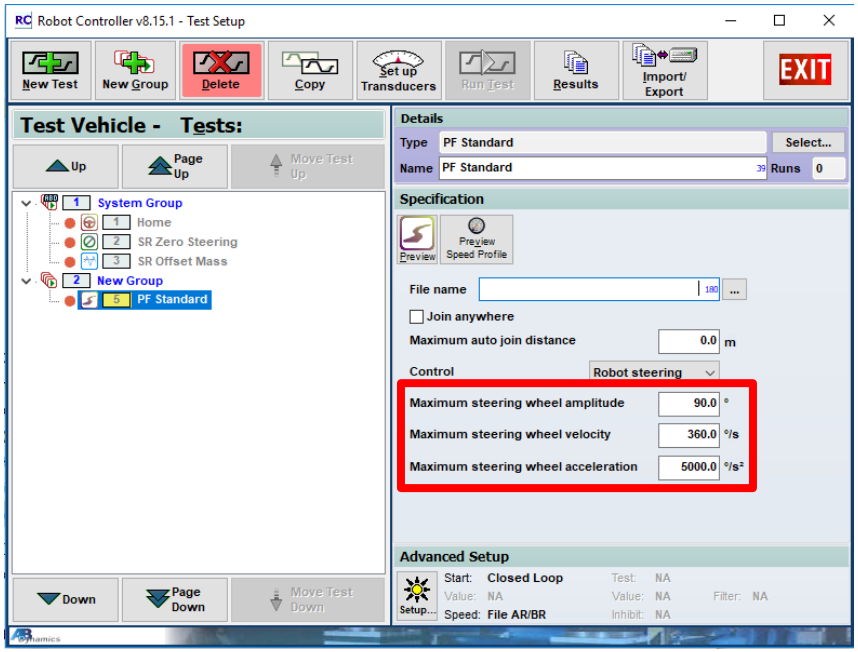
Setup > Transducer connections > Motion pack > Setup > Advanced Setup

Select 'Only allow highest accuracy motion pack operation'.

This will allow path following to be activated only when the motion pack is in differential correction mode and cause the test to abort if the accuracy drops.



5 – Apply Steering Limits



Vehicle Edit / Test > Tests & Results

Reduce the maximum steering wheel amplitude down from its default value, e.g. to 90°.

Reduce the maximum steering wheel velocity down from its default value, e.g. to 360°/s.

Reduce the maximum steering wheel acceleration down from its default value, e.g. to 5000°/s^2

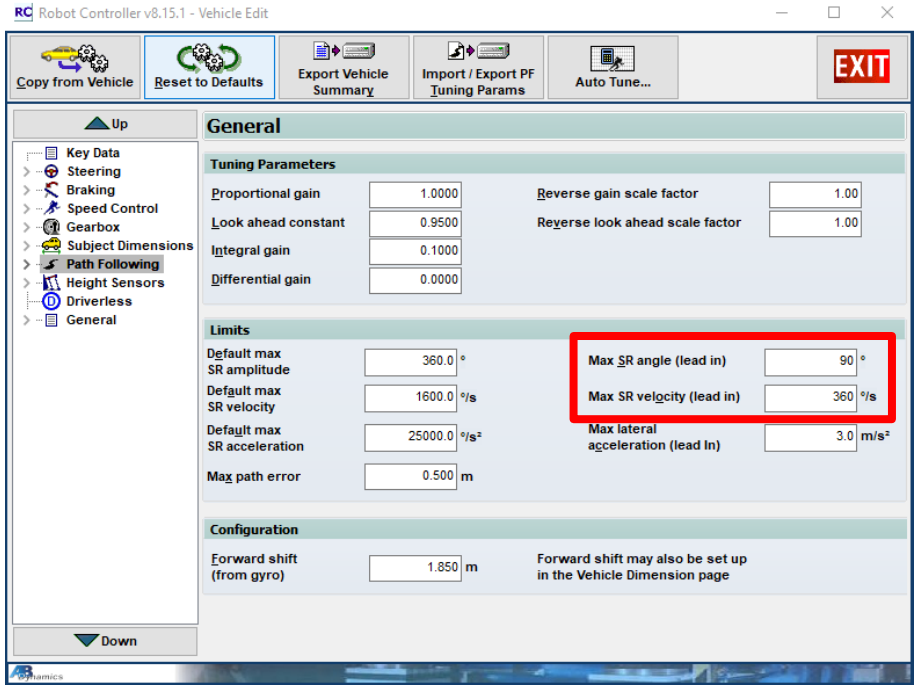
This will help to prevent any extreme heading change during the test.

Please set these limits appropriately for your test. For some tests (e.g. limit testing) it will be necessary to increase these values, otherwise the vehicle will be unable to follow the desired path and the test will fail.

Note that for Power PMAC systems from version 8.8.1 onwards, the steering wheel amplitude & velocity limits specified here **apply only during the test itself – not during the lead in**.

Lead in limits for these systems are detailed on the next page.

5 – Apply Steering Limits (cont.)



Vehicle Edit / Test > Edit Details > Path Following

For Power PMAC systems from version 8.8.1 onwards the steering wheel amplitude and velocity limits **during the lead in** are specified here.

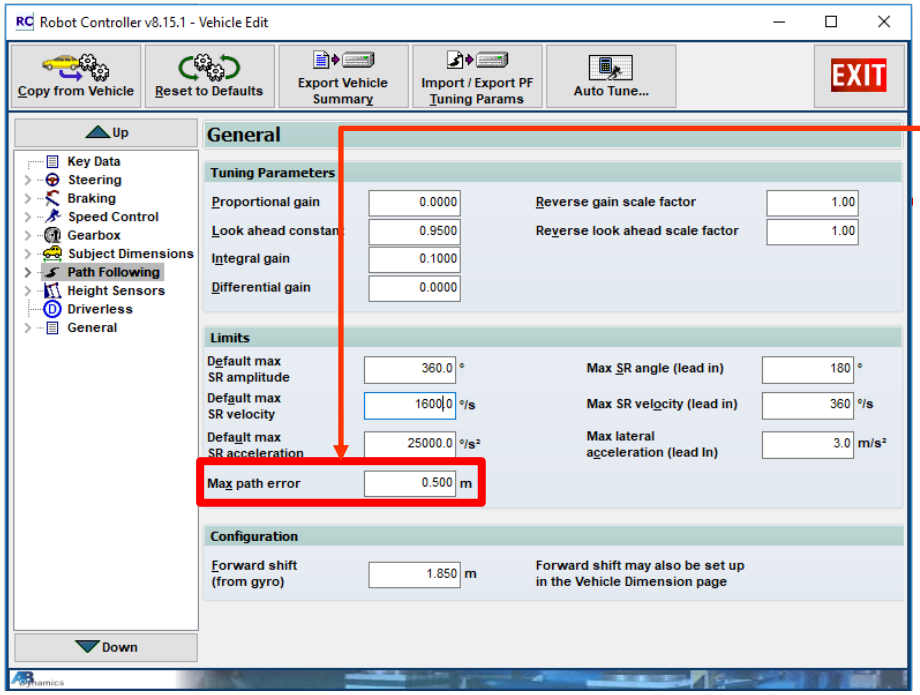
Limit the Max SR angle (lead in), e.g. to 90°.

Limit the Max SR velocity (lead in), e.g. to 360°/s.

Note that if 0 is entered into either of these fields:

- Max SR angle (lead in): the lock limit is used
- Max SR velocity (lead in): the SR Limit (specified in *Setup > Control Limits > SR Limits*) will be used.

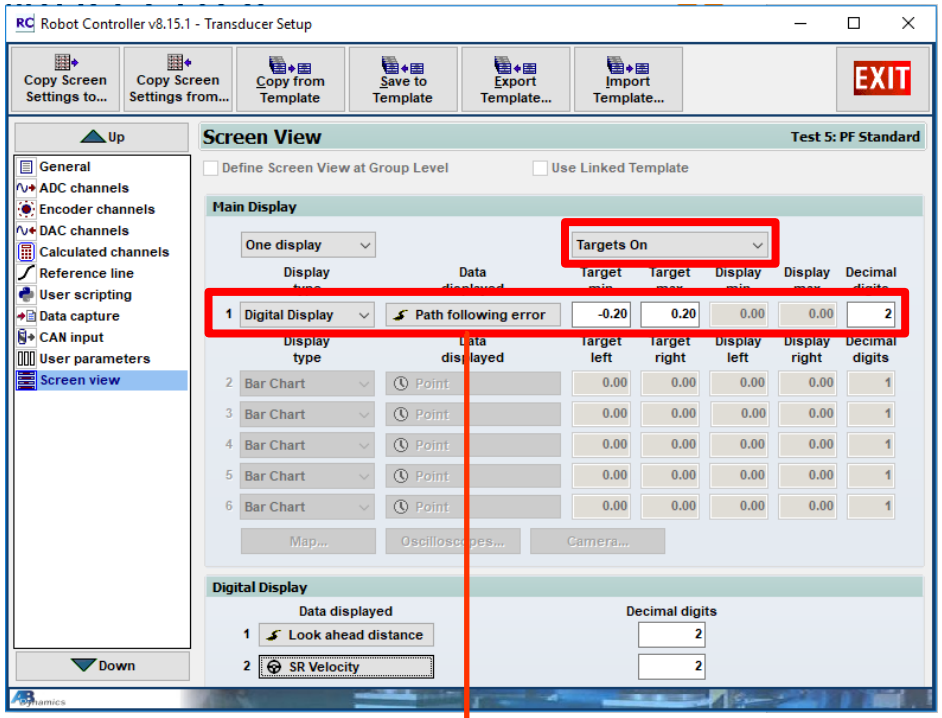
6 – Apply Path Following Error Limit



Vehicle Edit / Test > Edit Details > Path Following

Reduce the maximum path error to approximately 0.5m. If the vehicle error exceeds this value, the robot will indicate a failed test and will hold the steering angle until the driver releases the dead man handle. At this point, the driver can regain control of the vehicle and can steer to safety.

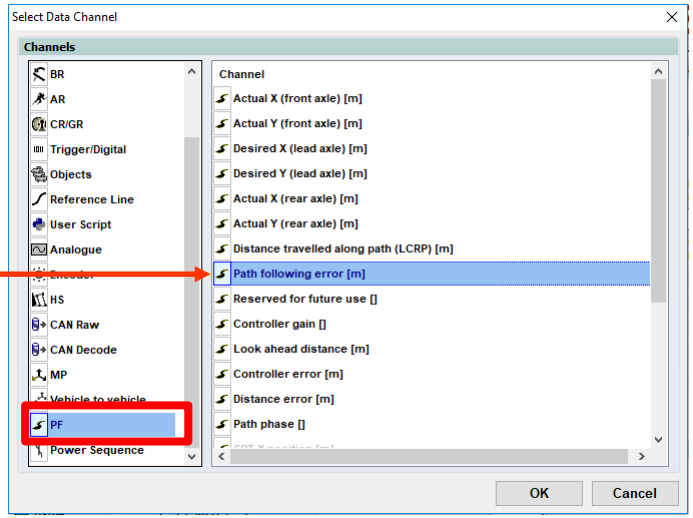
7 – Display Path Following Error



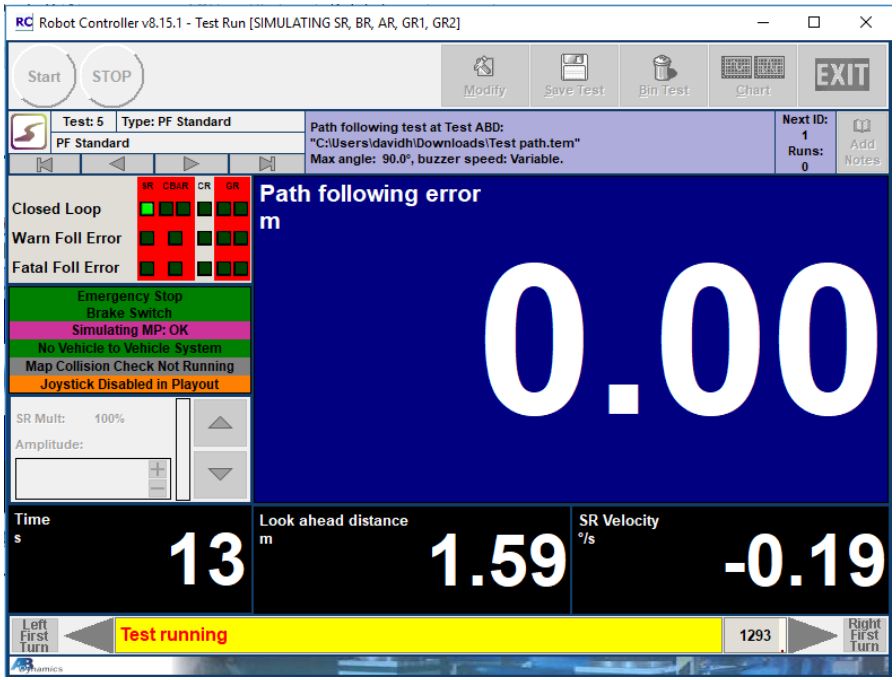
Vehicle Edit / Test > Tests & Results > Set up Transducers > Screen view

It is helpful for the driver to have a visual display of the real-time path following error during the test. Select '**Targets on**' to specify a tolerance window to notify the driver when outside these limits (see next page).

Be sure to select an appropriate number of decimal digits.



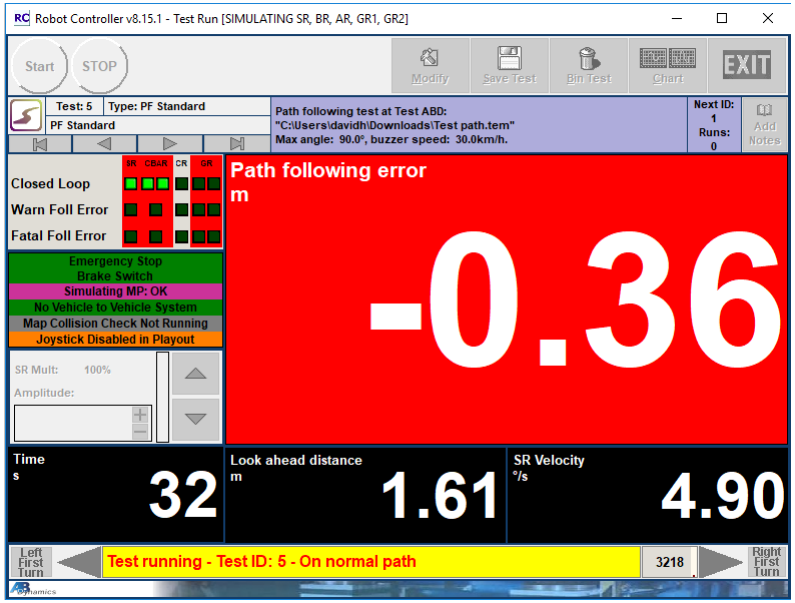
7 – Display Path Following Error (cont.)



Vehicle Edit / Test > Tests & Results > Run Test

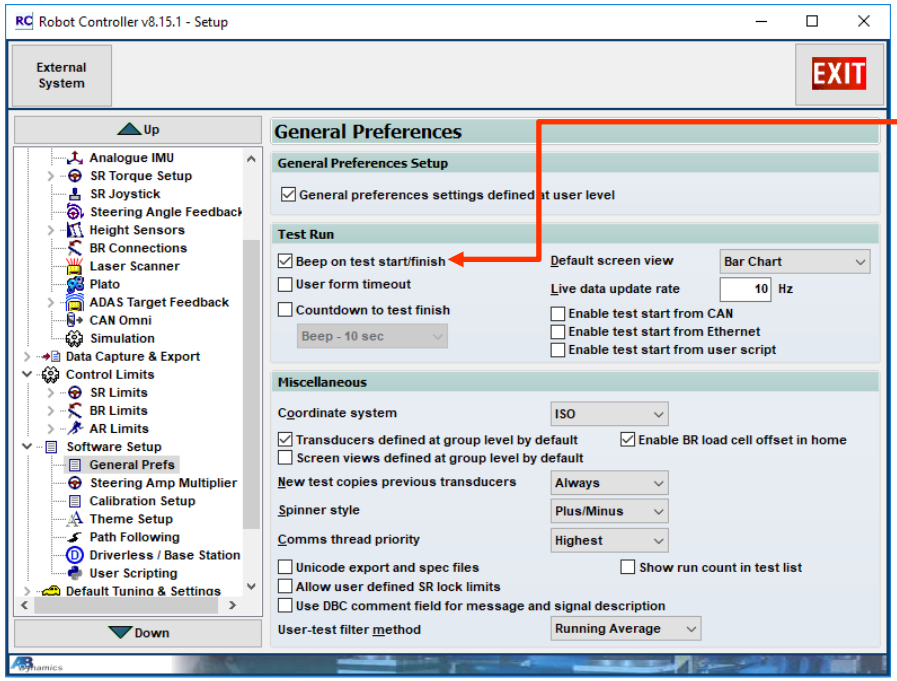
The path following error digital display turns red when outside the '**Targets on**' specified boundary.

In this example, the target min and target max were -0.20m and +0.20m respectively.



Vehicle Edit / Test > Tests & Results > Run Test

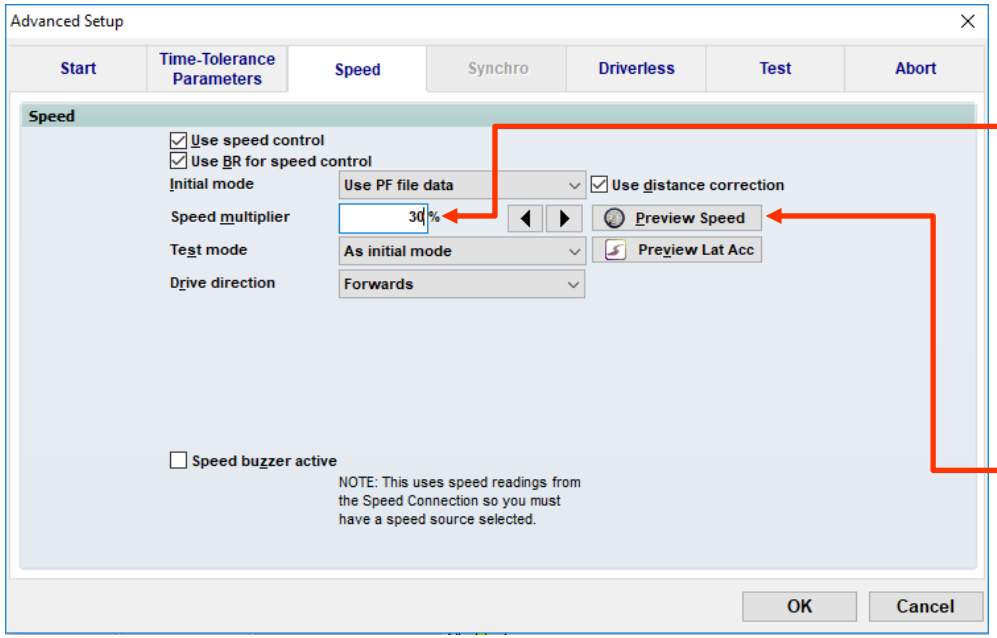
8 – Enable Beeping to Signal End of Test



Setup > Software Setup > General Prefs

Tick the 'Beep on test start/finish' checkbox. This alerts the driver if the test has finished prematurely (e.g. path following error has exceeded limit). The driver can then regain manual control and steer the vehicle to safety.

9 – Reduce Speed Multiplier

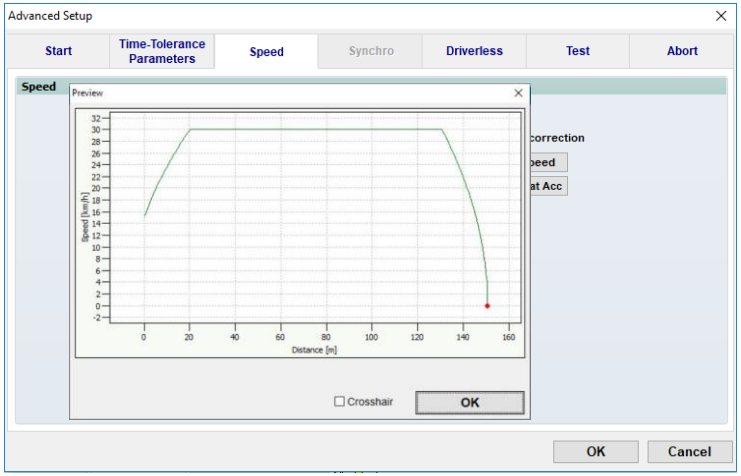


Vehicle Edit / Test > Test & Results > Setup > Speed

It is important to initially run the test at a reduced speed.

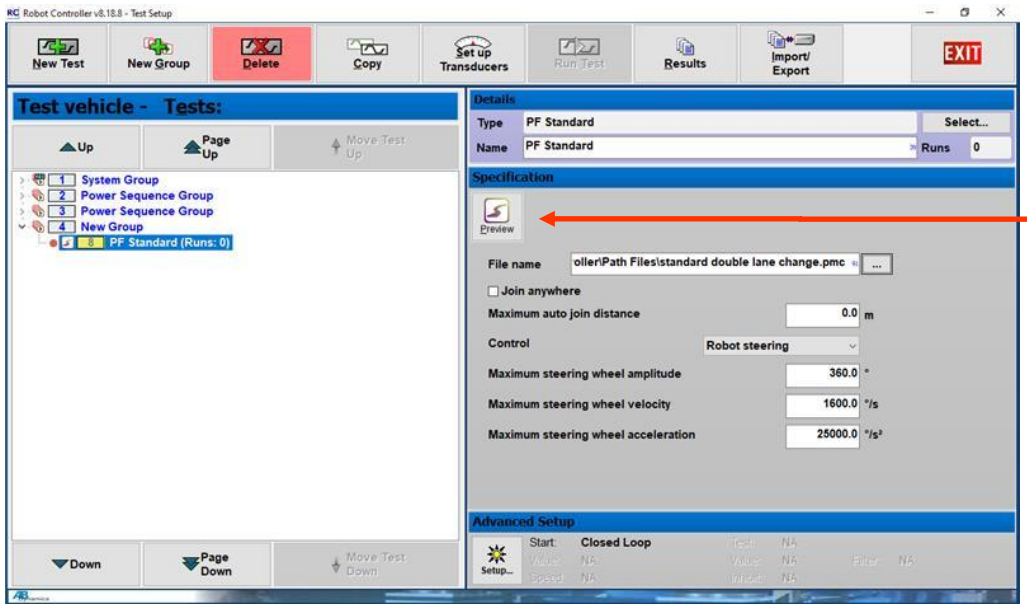
If the test is at high speed, conduct a trial run at a much lower speed in order to check correct path alignment etc.

Note that before running the test you should always view the speed profile in this window, to check that the programmed speed is as expected:



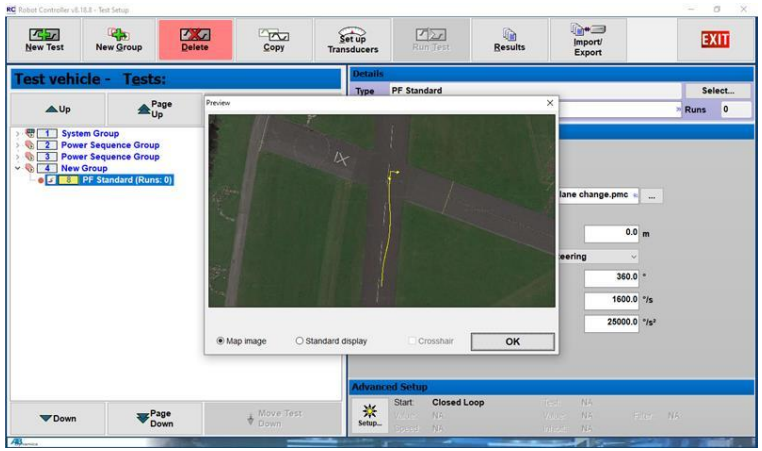
Vehicle Edit / Test > Test & Results > Setup > Speed > Preview Speed

10 – Preview Path & Speed Profile



Vehicle Edit / Test > Test & Results

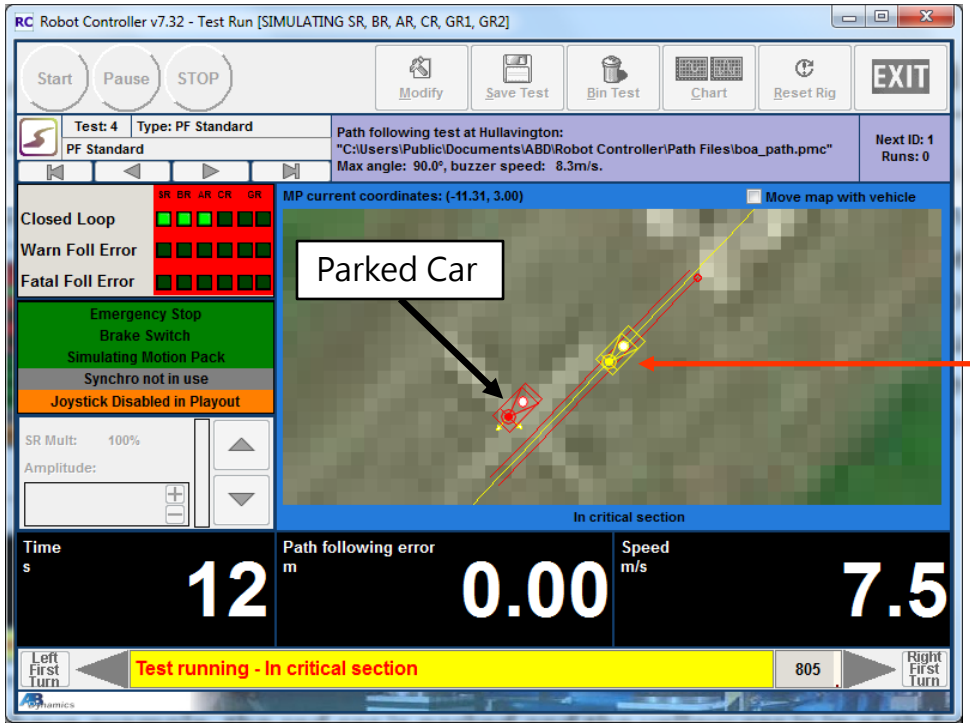
For **Path Following** tests the programmed path should always be checked by previewing the path prior to running the test. This is achieved using the Preview button:



Vehicle Edit / Test > Test & Results > Preview

In addition, for **all** tests, the programmed speed should be previewed as detailed on the previous page.

11 – Critical Sections



Vehicle Edit / Test > Test & Results > Run Test

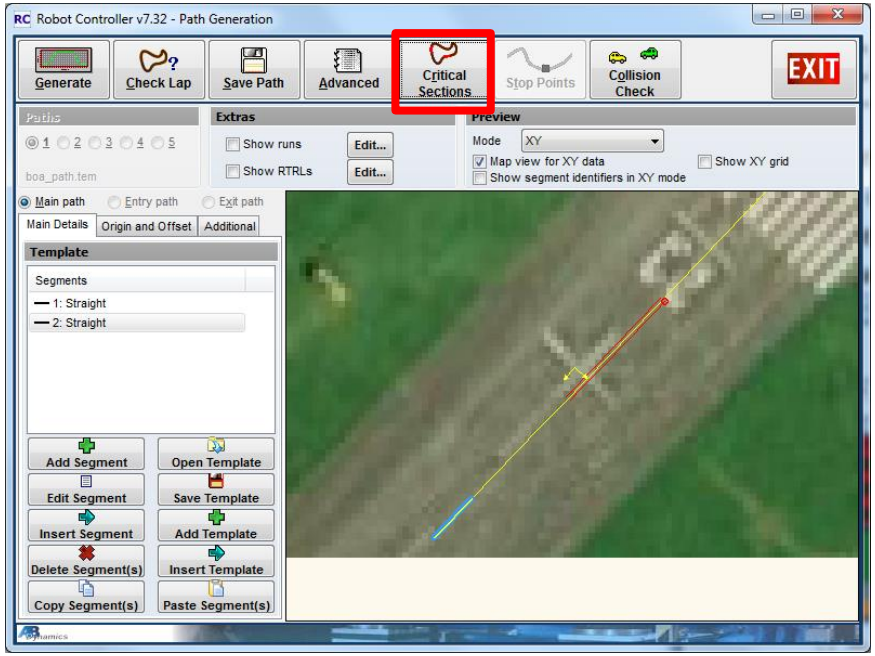
In the path generation utility, sections of path can be defined as **critical sections**. These are regions which, if the path following error exceeds a given value, a user-defined abort procedure will occur. This needs to be tailored to each specific test.

In this example, the red car is parked and the yellow car is in path following mode. The two red lines either side of the main path show the critical section and are the user-defined boundaries.

If the yellow vehicle's lateral error travels outside these boundaries, the Steering Robot has been programmed to perform a left turn in order to avoid the collision (see following pages).

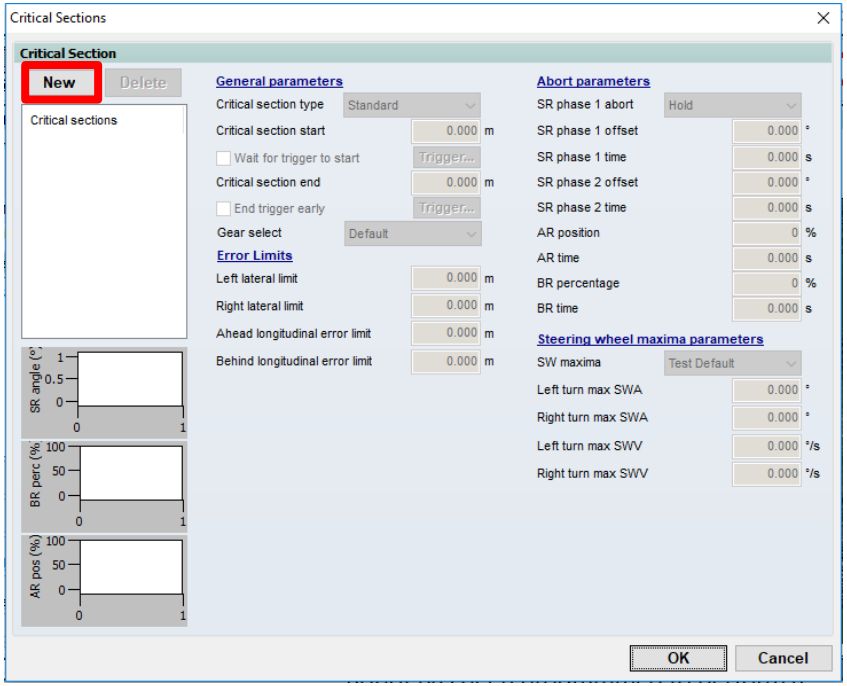
*A comprehensive guide to critical sections is provided in the AB Dynamics Path Following User Guide which **must be carefully read and understood** before using Critical Sections. The following slides provide only a very brief introduction.*

11 – Critical Sections (cont.)



Utilities > Path Generation > Use Template

To create a critical section in the Path Generation Utility, select 'Critical sections' and then 'New' in the dialog window.

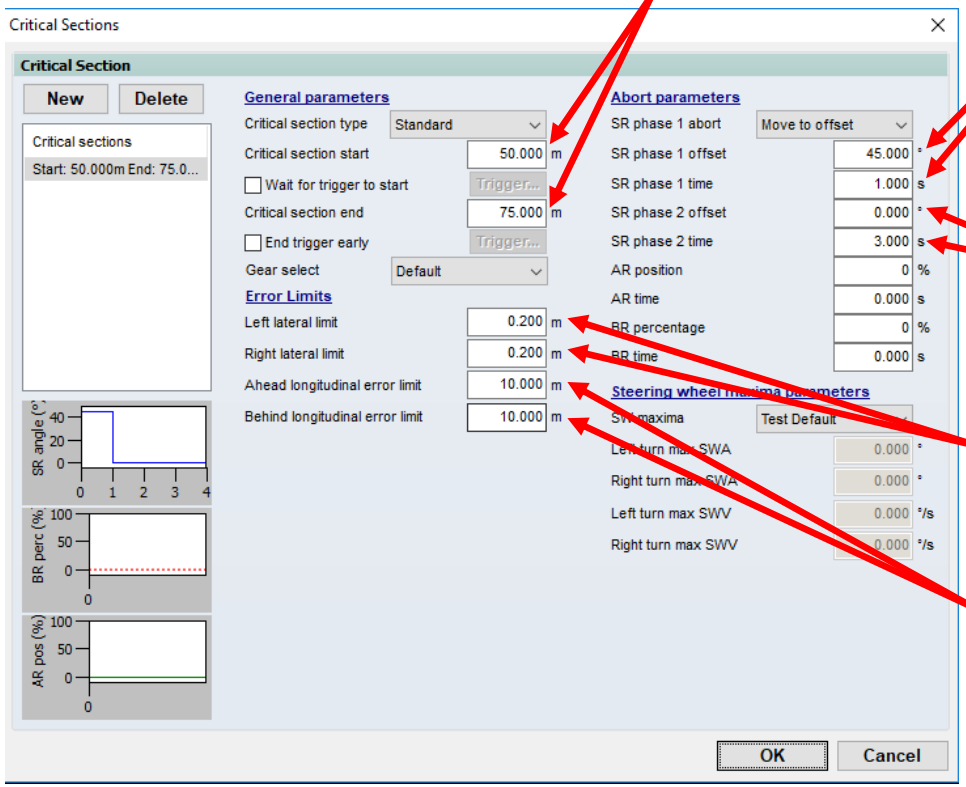


Utilities > Path Generation > Use Template > Critical Sections

11 – Critical Sections (cont.)

Note that the values shown here are examples. All parameters need to be configured specifically for each test.

Critical section will be 25m long



In this example when the abort is triggered the steering wheel turns +45 degrees (to the left) for 1 second. Note: Set to a negative value for a right turn.

Ensure steering is in correct direction to avoid vehicle turning into danger.

Steering wheel then straightens for a further 3 seconds.

Abort will occur at 20cm lateral error

Set to a large number (since safety will not be affected in this case)

Utilities > Path Generation > Use Template > Critical Sections

12 – Additional Safety Precautions

For high-sided vehicles, or where there is a significant risk of the vehicle overturning, additional safety precautions should be considered, including:

- Use of outriggers
- Use of a roll cage
- Additional safety equipment for the driver