# TCR Lambda Monitoring Method

**2020-09-04** | This document describes the lambda monitoring method applicable in TCR series. For clarification requests, please contact the authors. Changes since last version are <mark>marked</mark>.

## 1 Method Description

The purpose of this monitoring method is the detection of advantages gained by competitors beyond the parameters set by the Balance of Performance definition. For practical purposes in the context of engine lambda (air-fuel equivalence ratio), the following is defined:

*The competitor can gain an advantage when the lambda observed in the powertrain of the car deviates by more than* $0.04$ *from the value measured by WSC technical department during the certification tests on more than* $0.5\,\%$ *of all valid measured data points per lap.*

### 1.1 Measurement

Measurements of lambda are currently taken by the car's built-in lambda sensor and sent to the scrutineering data logger via CAN, as requested by WSC technical department during certification procedures for the car. The sampling rate must be 100 Hz for lambda. Engine speed (RPM) is sampled at 100 Hz.

In the following, the lambda sensor values are also referred to as *rLambda*, as this name is the name of the channel in the scrutineering data logger.

### 1.2 Conditions

The monitoring will be applied if

- pedal position exceeds 95 %

- <mark>the launch limiter is not active</mark>

- *fEngRpm* is within the range where interpolation points for the nominal value are given

- <mark>the speed of fastest front wheel does not exceed speed of fastest rear wheel by more than 8 km/h (wheel spin detection)</mark>

- more than 500 ms have passed since

- – the last gear shift request
- – the launch limiter was deactivated
- – the last wheel spin detection ended

## 1.3 Smoothing

The lambda value is smoothed using *Exponential Moving Average* with an alpha of 0.1, i.e.

$$rLambdaSmoothed(0) = rLambda(0) \tag{1}$$
$$rLambdaSmoothed(t) = 0.1 \cdot rLambda(t) + (1 - 0.1) \cdot rLambdaSmoothed(t-1) \tag{2}$$

where *rLambdaSmoothed* is the smoothed value and *t* is one time step.

## 1.4 Nominal Value

The nominal lambda value as defined by WSC is given by a set of equally spaced interpolation points for nominal values of lambda at different engine speeds ([1 / min]) and calculated by linear interpolation between the interpolation points using current engine speed at each time step.

Thus, the nominal value is calculated with the following formula:

$$rLambdaNominal(fEngRpm(t)) = interpolation(fEngRpm(t)) \tag{3}$$

## 1.5 Violation

A violation is registered for a lap if *rLambdaSmoothed* deviates by more than 0.04 from *rLambdaNominal* at more than 0.5 % of all time steps t in a lap. A "lap" is defined as the collection of data points at all time steps between two lap trigger events as recorded by the scrutineering data logger.

# 2 Block Diagram

The following block diagram is executed for every time step. The *counter* is initialized with the value 0 and reset to 0 after each lap.
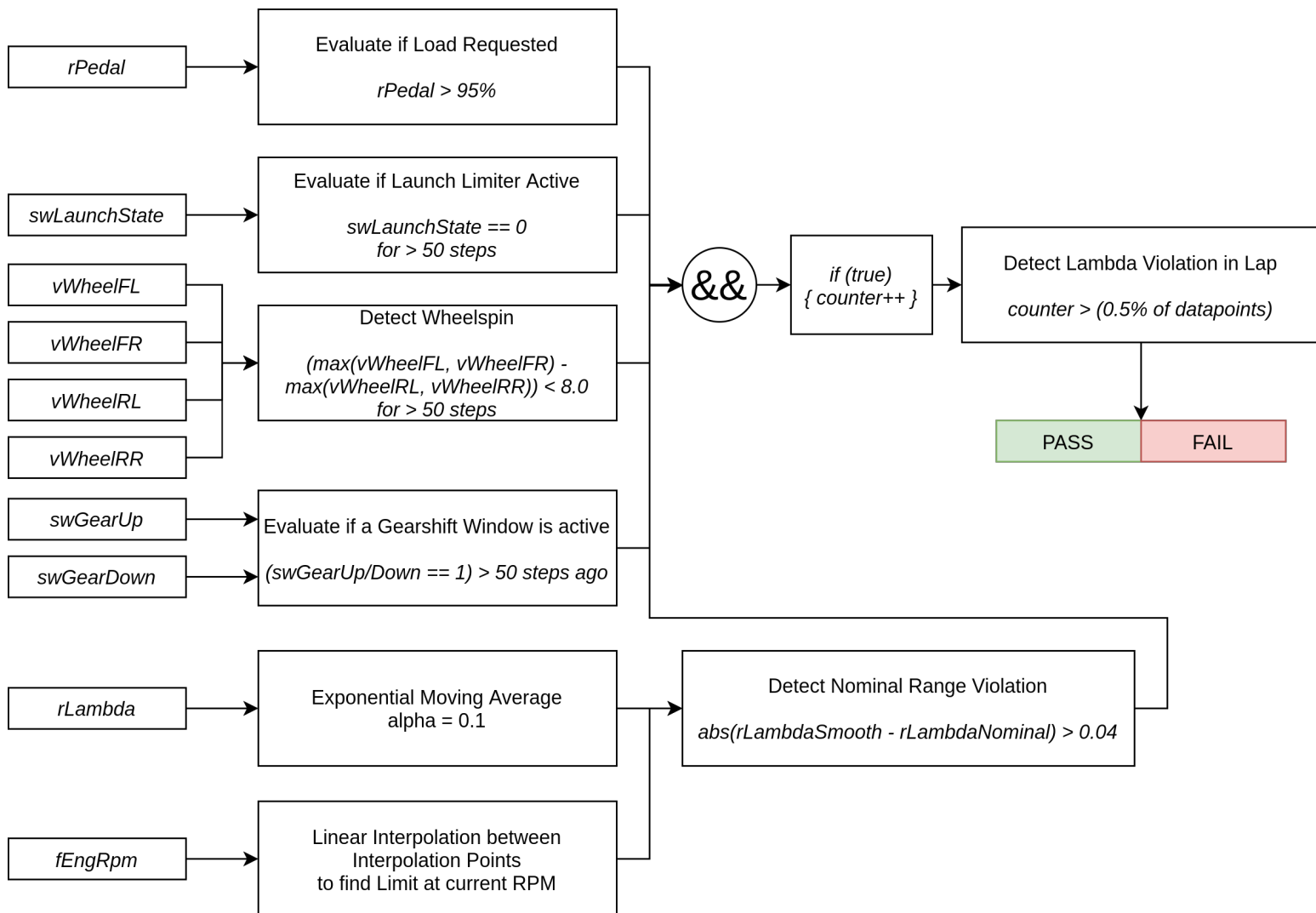


Figure 1: Lambda Monitoring Method Block Diagram

3

# 3  Document Information

**This decision is with immediate application and valid until further notice on the subject.**

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