Proposal for amendments to

ECE/TRANS/WP.29/2020/81

The text reproduced below was prepared by the experts from the EC. The proposal is aimed at modifying the text of document ECE/TRANS/WP.29/2020/81 (Regulation 157 on ALKS). All modifications to ECE/TRANS/WP.29/2020/81 are given in **blue** text. Deletions are indicated by ~~red strikethrough~~ text.

I. Proposal

Annex 5, Paragraph 1., amend to read:

~~Test~~ Specification for ~~ALKS~~ Track testing of ADSs

1. Introduction

This annex defines **track** tests with the purpose to verify the technical requirements on ~~ALKS~~**ADS**.

Until such time that specific test provisions have been agreed, the ~~Technical Service~~ **approval authority** shall ensure that the ~~ALKS~~**ADS** is subject to at least the tests outlined in Annex**es** 5 **and 6**. The specific test parameters for each test shall be selected by the ~~Technical Service~~ **approval authority** and shall be recorded in the test report in such a manner that allows traceability and repeatability of the test setup.

~~Pass and Fail Criteria for tests are derived solely from the technical requirements in paragraphs 5 to 7 of the Regulation. These requirements are worded in a way that they allow the derivation of pass fail criteria not only for a given set of test parameters, but for any combination of parameters in which the system is designed to work (e.g. operating speed range, operating lateral acceleration range, curvature range as contained in the system boundaries).~~ **The requirements in this regulation are defined in such a way that the pass/fail criteria can be derived not only for a specific set of test parameters, but also for all safety-relevant combinations of parameters that may occur in the operating conditions covered by the type approval and the specified operating range (e.g., speed range, longitudinal and lateral acceleration range, radii of curvature, light conditions, number of lanes, etc.).**

The test ~~specifications~~ **specified** in this document ~~are meant to be~~ **shall be intended as** a minimum set of tests~~,~~**.** ~~t~~**T**he ~~technical service~~ **approval authorities** may perform ~~any other~~ **additional** test**s** within the system **ODD** ~~boundaries~~ and ~~may then~~ compare the measured results against the requirements.

Under Paragraph 3., insert to read:

3.1. Track testing

The authority shall verify the system in a fault-free condition on a closed-access testing ground with various scenario elements to test the capabilities and functioning of an ADS in critical and emergency conditions.

3.**2.** Test conditions

3.**2.**1. The tests shall be performed under conditions (e.g. environmental, road geometry) that allow the activation of the ~~ALKS~~**ADS. For conditions not**

tested that may occur within the defined operating range of the vehicle, the vehicle manufacturer shall demonstrate as part of the audit described in Annex 4 to the satisfaction of the relevant authorities that the vehicle is safely controlled.

3.2.2. If system modifications are required in order to allow testing, e.g. road type assessment criteria or road type information (map data), it shall be ensured that these modifications don't have an effect on the test results. These modifications shall in principle be documented and annexed to the test report. The description and the evidence of influence (if any) of these modifications shall be documented and annexed to the test report.

3.2.3. In order to test the requirements for failure of functions, self-testing and initialization of the system, and implementation of a minimal risk manoeuvre, errors may be artificially induced and the vehicle may be artificially brought into situations where it reaches the limits of the defined operating range (e.g., environmental conditions).

3.2.4. The test surface shall afford at least the adhesion required by the scenario in order to achieve the expected test result.

3.2.5. Vehicle conditions

3.2.5.1. Test mass

The subject vehicle shall be tested in a load condition agreed between the manufacturer and the approval authority. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.

3.2.5.2. The subject vehicle shall be tested at the tyre pressure recommended by the vehicle manufacturer.

3.**2.6.** Test ~~Targets~~ **Tools**

~~3.2.5.1. The target used for the vehicle detection tests shall be a regular high volume series production vehicle of Category M or N or alternatively a "soft target" representative of a vehicle in terms of its identification characteristics applicable to the sensor system of the ALKS under test according to ISO 19206-3:2018. The reference point for the location of the vehicle shall be the most rearward point on the centreline of the vehicle.~~

~~3.2.5.2. The target used for the Powered Two wheeler tests shall be a test device according to ISO CD 19206-5 or a type approved high volume series production motorcycle of Category L3 with an engine capacity not exceeding 600 cm3. The reference point for the location of the motorcycle shall be the most backward point on the centreline of the motorcycle.~~

~~3.2.5.3. The target used for the pedestrian detection tests shall be an "articulated soft target" and be representative of the human attributes applicable to the sensor system of the AEBS under test according to ISO 19206-2:2018.~~

3.2.6.1. In addition to real vehicles, state-of-the-art test tools may be used to carry out the tests, replacing real vehicles and other road users (e.g., soft targets, mobile platforms, etc.). Tests must not be carried out in such a way as to endanger the personnel involved.

3.2.6.2. Details that enable the target(s) to be specifically identified and reproduced shall be recorded in the vehicle type approval documentation.

3.**3.** Test parameter variation

The manufacturer shall declare the system boundaries to the ~~Technical Service~~ **approval authority**. The ~~Technical Service~~ **approval authority** shall define different combinations of test parameters (e.g. present speed of the ~~ALKS~~ **ADS** vehicle, type and offset of target, curvature of lane) in order

to cover scenarios in **accordance with paragraph 3.3.1 of the present annex**.

If this is deemed justified, the ~~Technical Service~~ **approval authority** may test additionally any other combination of parameters.

~~If a collision cannot be avoided for some test parameters, the manufacturer shall demonstrate either by documentation or, if possible, by verification/testing that the system doesn't unreasonably switch its control strategy.~~

3.3.1. **Safety critical scenarios shall be tested with multiple parameter sets in order to satisfy a certain ratio of difficulty levels, based e.g., on the definition of difficulty suggested in Appendix 1. Alternative classification methods may be agreed on between the approval authority and the manufacturer.**

The composition of a series of tests in a certain critical traffic scenario shall be as follows:

- **[30] % of all tests shall be in the "medium" parameter range;**
- **[60] % of all tests shall be in the "difficult" parameter range;**
- **[10] % of all test shall be in the "unavoidable collision" parameter range for the given scenario;**

With an accuracy of ± [5] % for each range.

3.3.2. **If a collision cannot be avoided, the approval authority shall verify that the system doesn't significantly switch its control strategy, unless the manufacturer can prove that by doing so the damage caused by the collision to both the ADS and the other road users can be reduced.**

Under Paragraph 4., insert to read:

4. **Test scenarios to assess the performance of the system with regard to the dynamic driving task**

The scenarios included in the following paragraphs have to be considered a minimum set of conditions under which the vehicle shall be tested. Under the request of the approval authority, additional scenarios in the ODD of the ADS, representative of situations that the vehicle might be reasonably confronted with can be executed.

Test scenarios shall be selected depending on the intended operating range (corresponding to an Operational Design Domain (ODD)).

~~4.1. Lane Keeping~~

~~4.1.1. The test shall demonstrate that the ALKS does not leave its lane and maintains a stable position **motion** inside its ego lane across the speed range and different curvatures within its system boundaries.~~

~~4.1.2. The test shall be executed at least:~~

~~(a) With a minimum test duration of 5 minutes;~~

~~(b) With a passenger car target as well as a PTW target as the lead vehicle / other vehicle;~~

~~(c) With a lead vehicle swerving in the lane; and~~

~~(d) With another vehicle driving close beside in the adjacent lane.~~

4.~~2~~**1**.1. Avoid a collision with a road user or object blocking the lane

4.~~2~~**1**.1. The test shall demonstrate that the ~~ALKS~~**ADS** avoids a collision with a stationary vehicle, road user or fully or partially blocked lane up to the maximum specified speed of the system.

4.~~2~~1.2. This test shall be executed at least:

(a) With a stationary passenger car target;

(b) With a stationary powered two-wheeler target;

(c) With a stationary pedestrian target;

(d) With a pedestrian target crossing the lane with a speed of 5 km/h;

(e) With a target representing a blocked lane;

(f) With a target partially within the lane;

(g) With multiple consecutive obstacles blocking the lane (e.g. in the following order: ~~ego~~**ADS**-vehicle -motorcycle - car);

(h) On a curved section of road.

4.~~3~~2. Following a lead vehicle

4.~~3~~2.1. The test shall demonstrate that the ~~ALKS~~**ADS** is able to maintain and restore the required safety distance to a vehicle in front and is able to avoid a collision with a lead vehicle which decelerates up to its maximum deceleration.

4.~~3~~2.2. This test shall be executed at least:

(a) Across the entire speed range of the ~~ALKS~~**ADS**

(b) **Using**~~For~~ a passenger car target as well as a PTW target as lead vehicle, provided standardized PTW targets suitable to safely perform the test are available;

(c) For constant and varying lead vehicle velocities (e.g. following a realistic speed profile from existing driving database);

(d) For straight and curved sections of road;

(e) For different lateral positions of lead vehicle in the lane;

(f) With a deceleration of the lead vehicle of at least 6 m/s^2 mean fully developed deceleration until standstill.

4.~~4~~3. Lane change of another vehicle into lane

4.~~4~~3.1. The test shall demonstrate that the ~~ALKS~~**ADS** is capable of avoiding a collision with a vehicle cutting into the lane of the ~~ALKS~~**ADS** vehicle up to a certain criticality of the cut-in manoeuvre **in accordance with paragraph 4.3.2. of the present annex**.

4.~~4~~3.2. The criticality of the cut-in manoeuvre shall be determined according to TTC, longitudinal distance between rear-most point of the cutting in vehicle and front-most point of the ~~ALKS~~**ADS** vehicle, the lateral velocity of the cutting-in vehicle and the longitudinal movement of the cutting-in vehicle, as defined in paragraph ~~5.2.5.~~ 3 of Annex 4 Appendix 3 of this Regulation.

4.~~4~~3.3. This test shall be executed taking into consideration at least the following conditions:

(a) For different TTC, distance and relative velocity values of the cut-in manoeuvre, covering types of cut-in scenarios in which a collision can be avoided and those in which a collision cannot be avoided;

(b) For cutting-in vehicles travelling at constant longitudinal speed, accelerating and decelerating;

(c) For different lateral velocities, lateral accelerations of the cut-in vehicle;

(d) For passenger car as well as PTW targets as the cutting-in vehicle, provided standardized PTW targets suitable to safely perform the test are available.

4.~~5~~4. Stationary obstacle after lane change of the lead vehicle

4.~~5~~4.1. The test shall demonstrate that the ~~ALKS~~**ADS** is capable of avoiding a collision with a stationary vehicle, road user or blocked lane that becomes visible after a preceding vehicle avoided a collision by an evasive manoeuvre.

4.~~5~~4.2. The test shall be executed at least:

(a) With a stationary passenger car target centred in lane

(b) With a powered two-wheeler target centred in lane

(c) With a stationary pedestrian target centred in lane

(d) With a target representing a blocked lane centred in lane

(e) With multiple consecutive obstacles blocking the lane (e.g. in the following order: ~~ego~~**ADS**-vehicle – lane change vehicle – motorcycle – car)

~~4.6. Field of View test~~

~~4.6.1. The test shall demonstrate that the ALKS vehicle is capable of detecting another road user within the forward detection area up to the declared forward detection range and a vehicle beside within the lateral detection area up to at least the full width of the adjacent lane. If the ALKS vehicle is capable of performing lane changes, it shall additionally demonstrate that the system is capable of detecting another vehicle within the rear detection range.~~

~~4.6.2. The test for the forward detection range shall be executed at least:~~

~~(a) When approaching a motorcycle target positioned at the outer edge of each adjacent lane;~~

~~(b) When approaching a stationary pedestrian target positioned at the outer edge of each adjacent lane;~~

~~(c) When approaching a stationary motorcycle target positioned within the ego lane;~~

~~(d) When approaching a stationary pedestrian target positioned within the ego lane.~~

~~4.6.3. The test for the lateral detection range shall be executed at least:~~

~~(a) With a motorcycle target approaching the ALKS vehicle from the left adjacent lane;~~

~~(b) With a motorcycle target approaching the ALKS vehicle from the right adjacent lane.~~

~~4.6.4. The test for the rear detection range shall be executed at least:~~

~~(a) With a motorcycle approaching the ALKS from the rear outer edge of each adjacent lane;~~

~~4.7. Lane changing~~

~~4.7.1. The test shall demonstrate that the ALKS vehicle does not cause an unreasonable risk to safety of the vehicle occupants and other road users during a Lane Change Procedure (LCP), and that the system is able to correctly perform the assessment of the target lane in accordance with paragraph 5.2.6.6. of the present Regulation before starting the Lane Change Manoeuvre (LCM). The test is only required if the ALKS vehicle is capable of performing lane changes either during a Minimal Risk Manoeuvre or during regular operation.~~

~~4.7.2. The following tests shall be executed:~~

~~(a) With the ALKS vehicle performing lane change in the adjacent (target) lane;~~

~~(b) Merging at motorway entry;~~

~~(c) Merging at lane end;~~

~~(d) Merging into an occupied lane.~~

~~4.7.3. The tests shall be executed at least:~~

~~(a) With different vehicles, including a PTW approaching from the rear;~~

~~(b) In a scenario where a lane changing manoeuvre in regular operation is possible to be executed;~~

~~(c) In a scenario where a lane changing manoeuvre in regular operation is not possible due to a vehicle approaching from the rear;~~

~~(d) With an equally fast vehicle following behind in the adjacent lane, preventing a lane change;~~

~~(e) With a vehicle driving beside in the adjacent lane preventing a lane change;~~

~~(f) In a scenario where a LCM during a minimal risk manoeuvre is possible and executed.~~

~~(g) In a scenario where the ALKS vehicle should abort the LCM maneuver due to changing scenario conditions such as an upcoming accelerating vehicle~~

~~4.8 Detect and response to traffic rules and road furniture~~

~~4.8.1. These tests shall ensure that the ALKS respects traffic rules, detects and adapts to a variation of permanent and temporary road furniture.~~

~~4.8.2. The test shall be executed at least with the list of scenarios below, but based on the ODD of the given system:~~

~~(a) Different speed limit signs, so that the ALKS vehicle has to change its speed according to the indicated values;~~

~~(b) Signal lights of an ending lane. The signal lights are set above the belonging lanes, and the signal lights of adjacent lanes are kept in green state, while the one of the current lane for the ALKS vehicle is kept red.;~~

~~(c) Driving through a tunnel: at least [X]m long section of the road with no sunlight and availability of the positioning system.~~

~~(d) Toll station: a section of the motorway with toll station , speed limit signs and buildings (ticket machines, barriers, etc.).~~

~~(e) Temporary modifications: e.g., road maintenance operations indicated by traffic signs, cones and other modifications.~~

~~4.8.3. Each test shall be executed at least:~~

~~(a) Without a lead vehicle;~~

~~(b) With a passenger car target as well as a PTW target as the lead vehicle / other vehicle.~~

4.5. Avoid braking before a passable object in the lane

4.5.1. The test shall demonstrate that the ADS vehicle is not braking without a reason before a passable object in the lane (e.g., a manhole lid or a small branch).

4.5.2. The test shall be executed at least:

(a) Without a lead vehicle;

(b) With a passenger car target as well as a PTW target as the lead vehicle, provided standardized PTW target suitable to safely perform the test is available.

4.6. String stability

4.6.1. The tests shall demonstrate that the ADS is able to achieve string stable operations when following a car target proceeding with a speed lower than the speed the ADS would maintain in the same situation in the absence of the same target.

4.6.2. The tests can be executed with one or more ADS vehicles proceeding in platoon formation. The maximum number of ADS vehicles that the test can include is [5].

4.6.3. The following conditions shall be ensured for the correct execution of each test:

4.6.3.1. The initial speed of the car target shall be lower than the speed limit or of the speed the ADS would maintain in the same situation, whatever is the minimum.

4.6.3.2. The car target shall keep the constant initial speed for a time sufficient to ensure that all the ADS vehicles are able to maintain the same constant speed. A fluctuation of the speed of the ADS vehicles within a range of ± [1] m/s from the speed of the car target is allowed. When these conditions are achieved the platoon is in steady state formation and the test can be considered as started.

4.6.3.4. Each test shall comprise the deceleration of the car target from steady state platoon formation to achieve a speed reduction of at least [3] m/s. The speed of the car target at the end of the deceleration shall not be lower than [5] m/s. The deceleration adopted by the car target shall be in the range [1-5] m/s^2.

4.6.3.4. At the end of the deceleration, the car target shall maintain the new speed for a time sufficient to bring the platoon again in steady state formation according to the previsions of paragraph 4.10.3.2. When this is achieved the test can be considered as concluded.

4.6.3.5. At the end of the test the following quantities have to be computed.

(a) The difference between the maximum and the minimum speed achieved by the car target during the test (L_{target})

(b) The difference between the maximum and the minimum speed achieved by the last ADS vehicle in the platoon during the test (L_{ADS})

(c) The ratio between the two differences $L = \frac{L_{ADS}}{L_{target}}$

4.6.4. The test shall the executed for at least [5] different combinations of initial speed, final speed and deceleration adopted by the car target.

4.6.5. The string stability requirement is considered achieved if for all the tests the value of L is lower than 1.05.

4.7. Oncoming traffic / Wrong way driver

4.7.1. The test shall demonstrate that ADS is capable of detecting and reacting to oncoming traffic in an adjacent lane.

4.7.2. The test for oncoming vehicle shall be executed at least:

(a) Without a lead vehicle;

(b) With a passenger car target as well as a PTW target as the lead vehicle and wrong way driver vehicle, provided standardized PTW targets suitable to safely perform the test are available.

4.8. Transition demand

4.8.1. **The test shall demonstrate that ADS vehicle is capable of reacting to changes of the ODD and is able to safely carry out a transition demand and a MRM.**

4.8.2. **The test shall be executed at least:**

(a) With changing road conditions (e.g., end of highway);

(b) With changing weather or light conditions (e.g., rain or night if suitable).

Under Paragraph 5., delete to read:

5.3 Additional other test cases may be assessed if it is deemed justified by the Technical Service. Some of the cases may include:

(a) Y-split of highway lanes

~~(b) Vehicles entering or exiting the highway~~

~~(c) Partially blocked ego lane, tunnel~~

(~~d~~**b**) Traffic lights

(~~e~~**c**) Emergency vehicles

~~(f) Construction zones~~

(~~g~~**d**) Faded/erased/hidden lane markings

(~~h~~**e**) Emergency/Service personnel directing traffic

(~~i~~**f**) Change in road characteristics (no longer divided, pedestrians permitted, roundabout, intersection)

~~(j) Normal traffic flow resumed (i.e. all vehicles moving > 60km/h)~~

~~5.4 Real-world test~~

~~The Technical Service shall conduct, or shall witness, an assessment of the system, in a fault free condition, in the presence of traffic (a 'real world' test). The purpose of this test is to support the Technical Service in understanding the functionality of the system in its operating environment and to complement the assessment of the documentation provided under Annex 4.~~

~~Together, the assessment of Annex 4 and the real world test shall enable the Technical Service to identify areas of system performance that may require further assessment, either through testing or further review of Annex 4.~~

~~During the real-world assessment, the Technical Service shall assess at least:~~

~~(a) Prevention of activation when the system is outside of its technical boundaries/requirements for ALKS~~

~~(b) No violation of traffic rules~~

~~(c) Response to a planned event~~

~~(d) Response to an unplanned event~~

~~(e) Detection of the presence of other road users within the frontal and lateral detection ranges~~

~~(f) Vehicle behaviour in response to other road users (following distance, cut-in scenario, cut-out scenario etc).~~

~~(g) System override~~

~~The location and selection of the test route, time of day and environmental conditions shall be determined by the Technical Service.~~

~~The test drive shall be recorded and the test vehicle instrumented with non-perturbing equipment. The Technical Service may log, or request logs of any data channels used or generated by the system as deemed necessary for post-test evaluation.~~

~~It is recommended that the real-world test is undertaken once the system has passed all of the other tests outlined in this Annex and upon completion of a risk assessment by the Technical Service.~~

Appendix 1

A suggested approach for traffic critical scenario difficulty classification

Following data sheets are pictorial examples of simulations which determine~~s~~ conditions under which ~~ALKS~~**ADS** shall avoid a collision, taking into account the combination of every parameter, *at and below* the maximum permitted ~~ALKS~~**ADS** vehicle speed.

Where collision is deemed to be avoidable, three subsets are defined, to differentiate between the parameter sets based on their difficulty in accordance to the performance model laid down in paragraph 3 of Annex 4 Appendix 3:

- **"Easy" conditions are highlighted by green colour,**
- **"Medium" conditions are highlighted by yellow colour,**
- **"Difficult" conditions are highlighted by red colour, while**
- **"Unavoidable collision" is highlighted by red colour with black "X".**

1. Cut in

Classification of difficulty of the scenarios based on the initial parameters is done the following way in accordance to the performance model laid down in paragraph 3 of Annex 4 Appendix 3:

- **Easy: PFS <= 0.85;**
- **Medium: PFS > 0.85 and CFS < 0.9;**
- **Difficult: CFS => 0.9.**

Based on these equations the classification may be done for any parameter set; to show some examples, a number of figures are presented below with different ego vehicle speeds.

Figure 1

For Ve0 = 130 kph

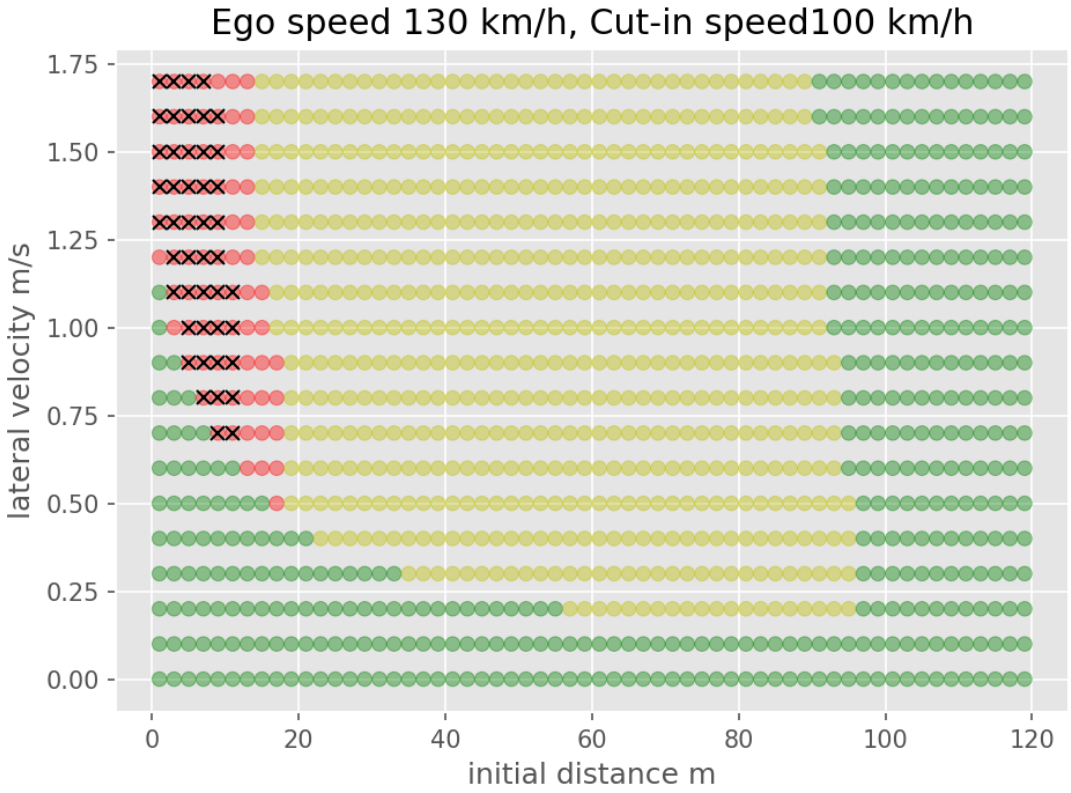


Figure 2

For Ve0 = 110 kph

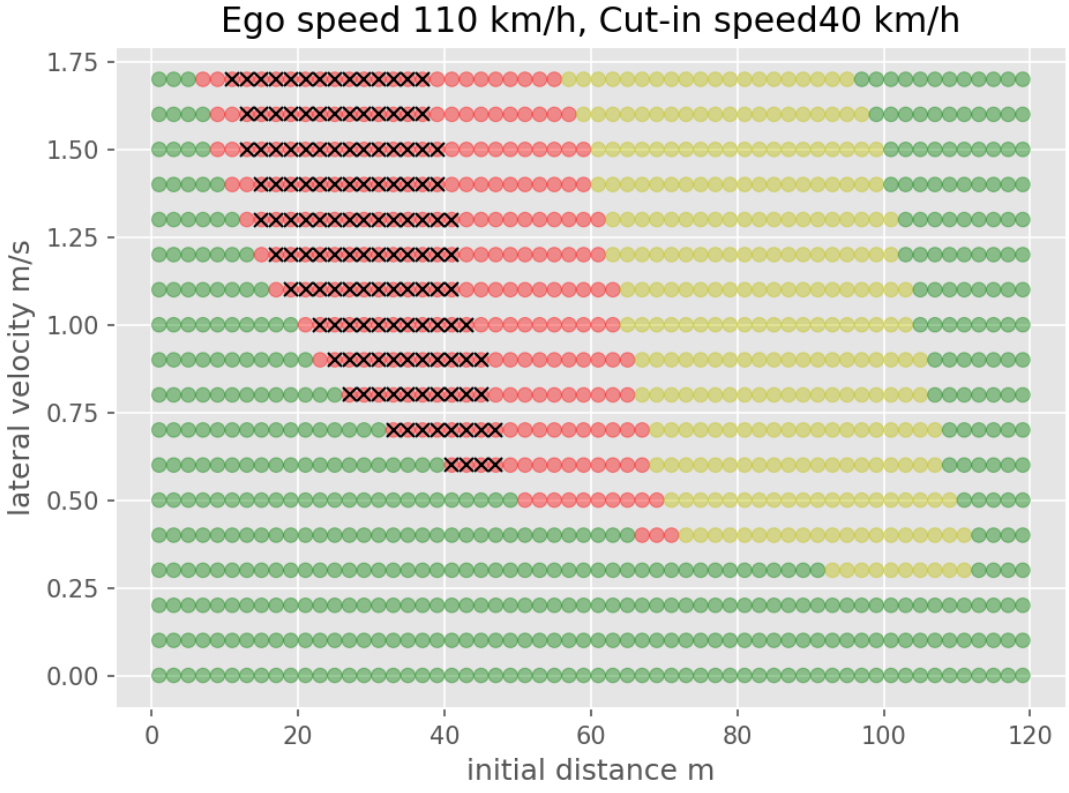


Figure 3
For Ve0 = 90 kph

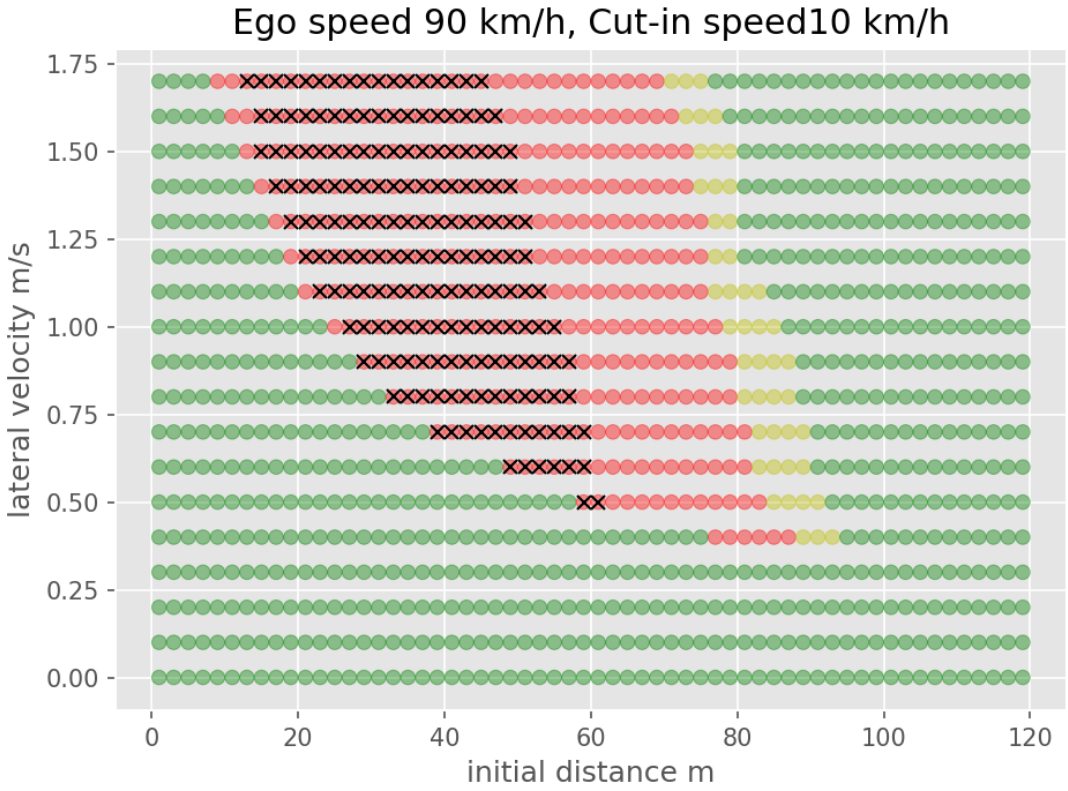
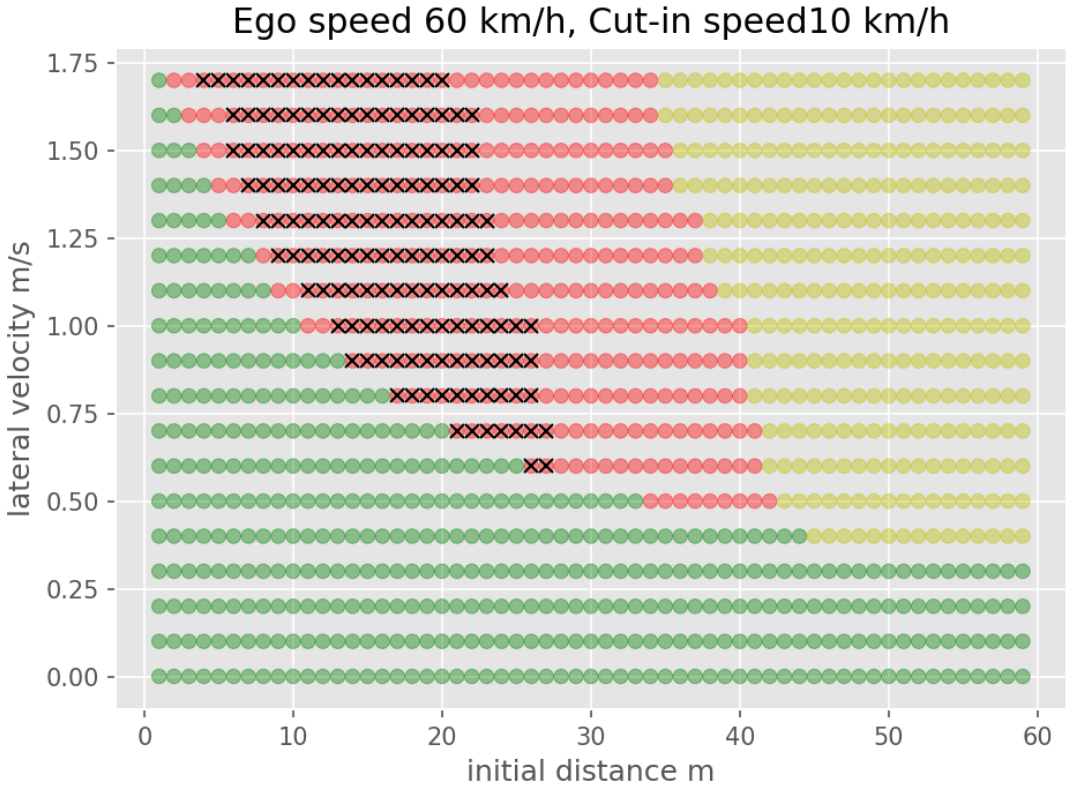


Figure 4
For Ve0 = 60 kph



2. Cut out

Classification of difficulty of the scenarios based on the initial parameters is done the following way:

- **Easy: PFS = 0;**
- **Medium: PFS > 0 and CFS < 0.5;**
- **Difficult: CFS => 0.5.**

Based on these equations the classification may be done for any parameter set; to show some examples, a number of figures are presented below with different ego vehicle speeds.

Figure 5

For Ve0 = 130 kph

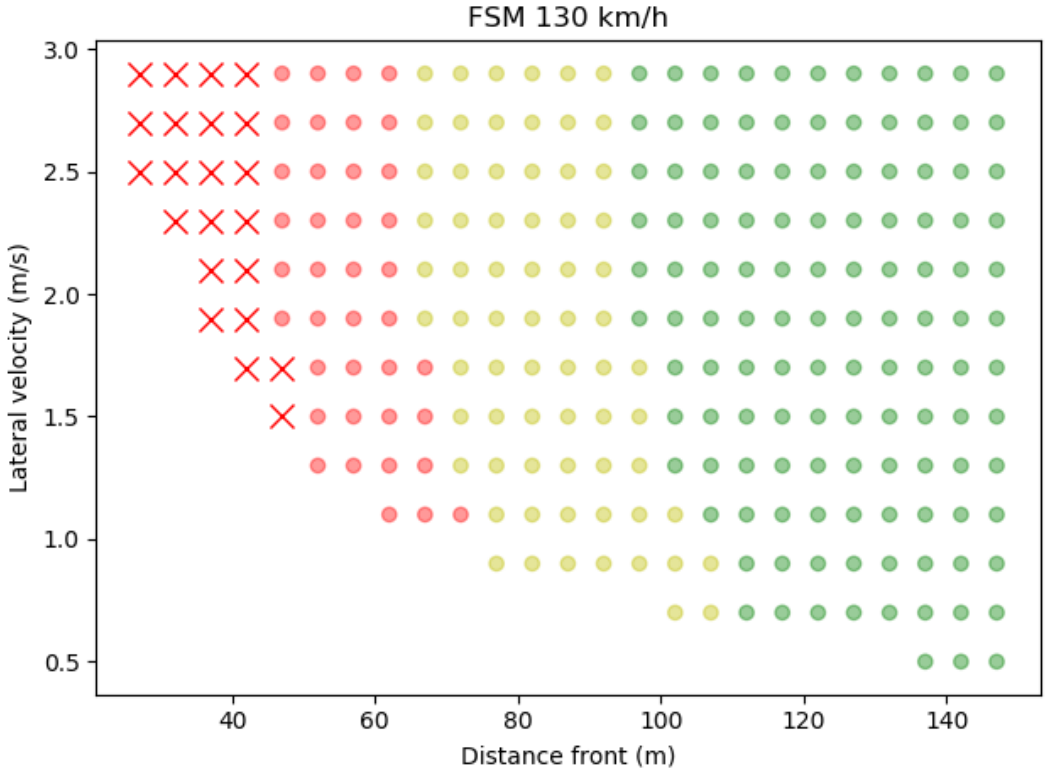


Figure 6

For Ve0 = 120 kph

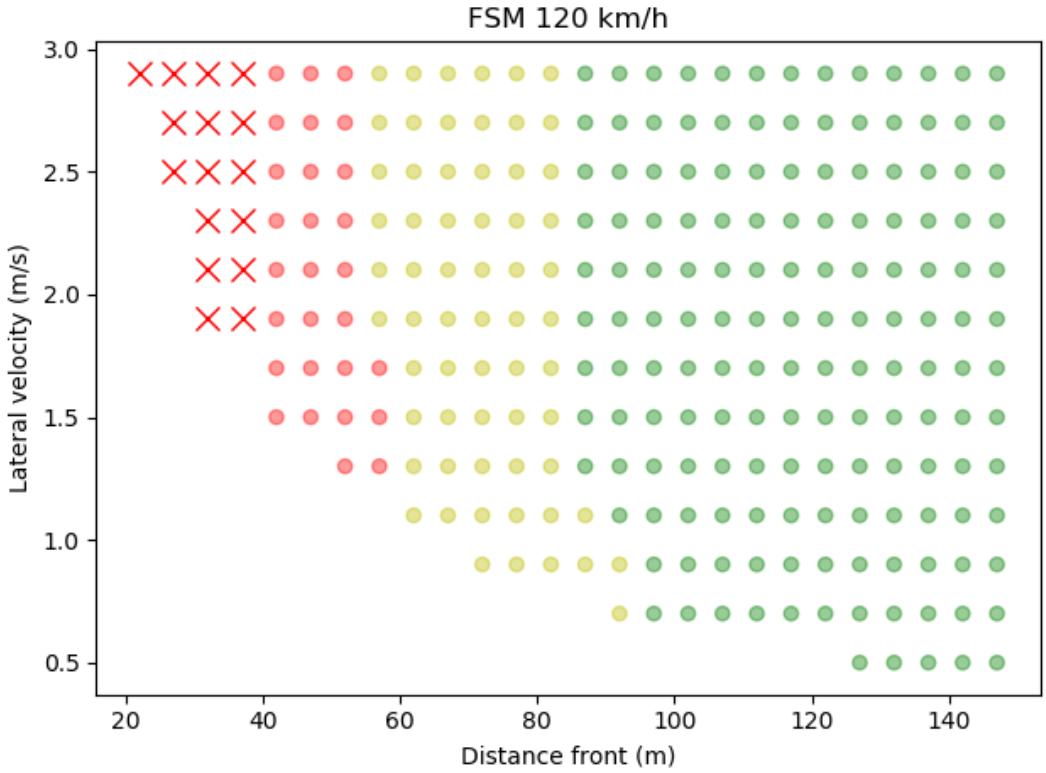


Figure 7

For Ve0 = 110 kph

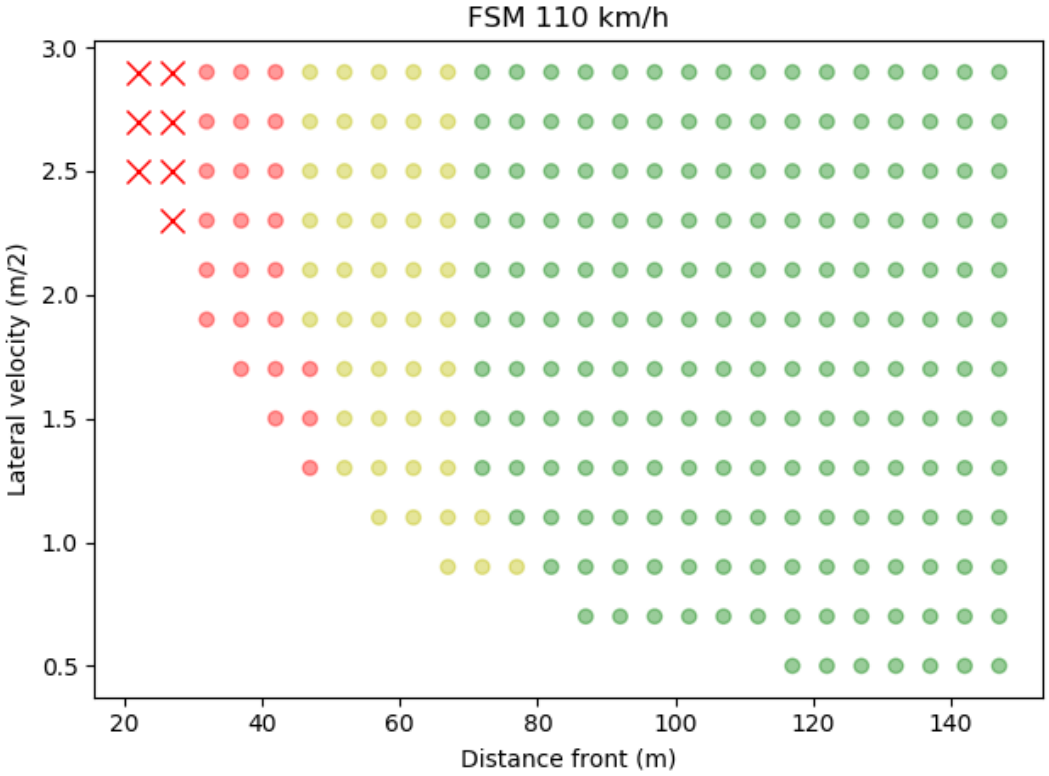


Figure 8

For Ve0 = 100 kph

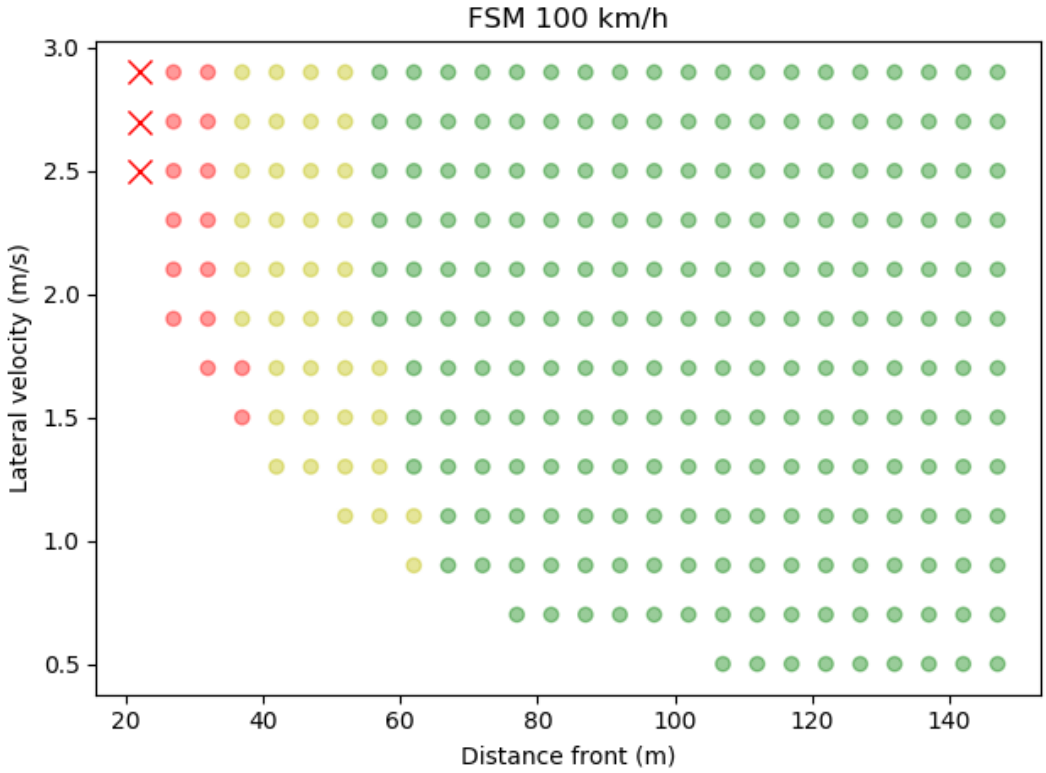


Figure 9

For Ve0 = 90 kph

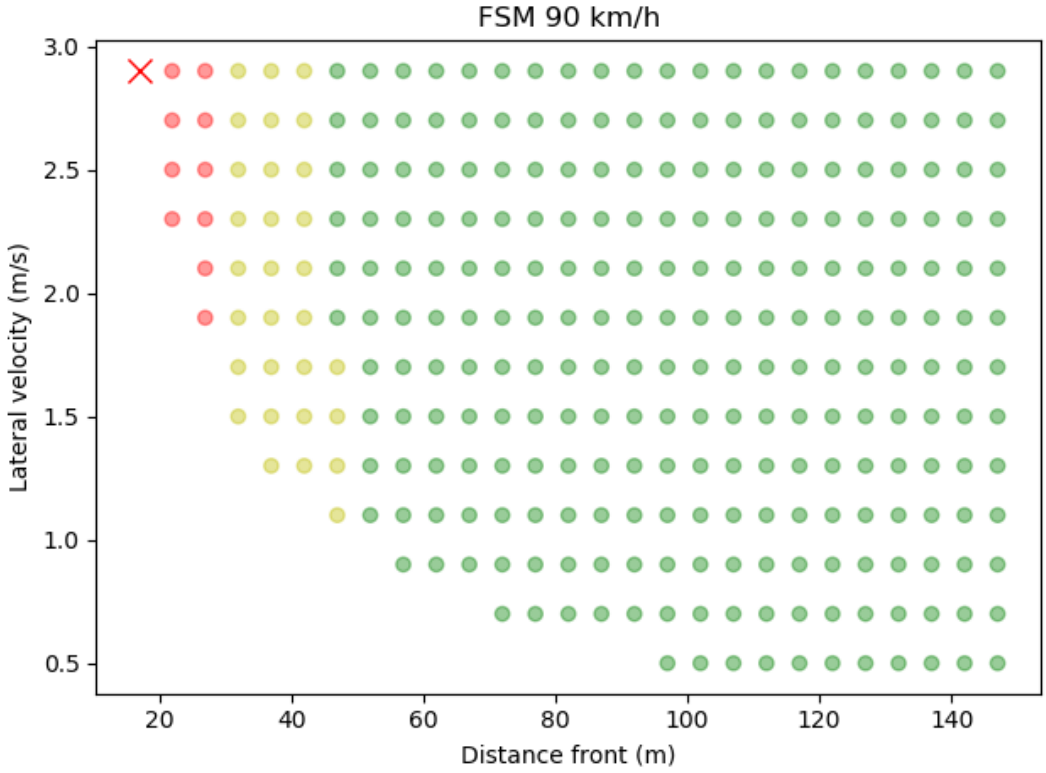


Figure 10

For Ve0 = 80 kph

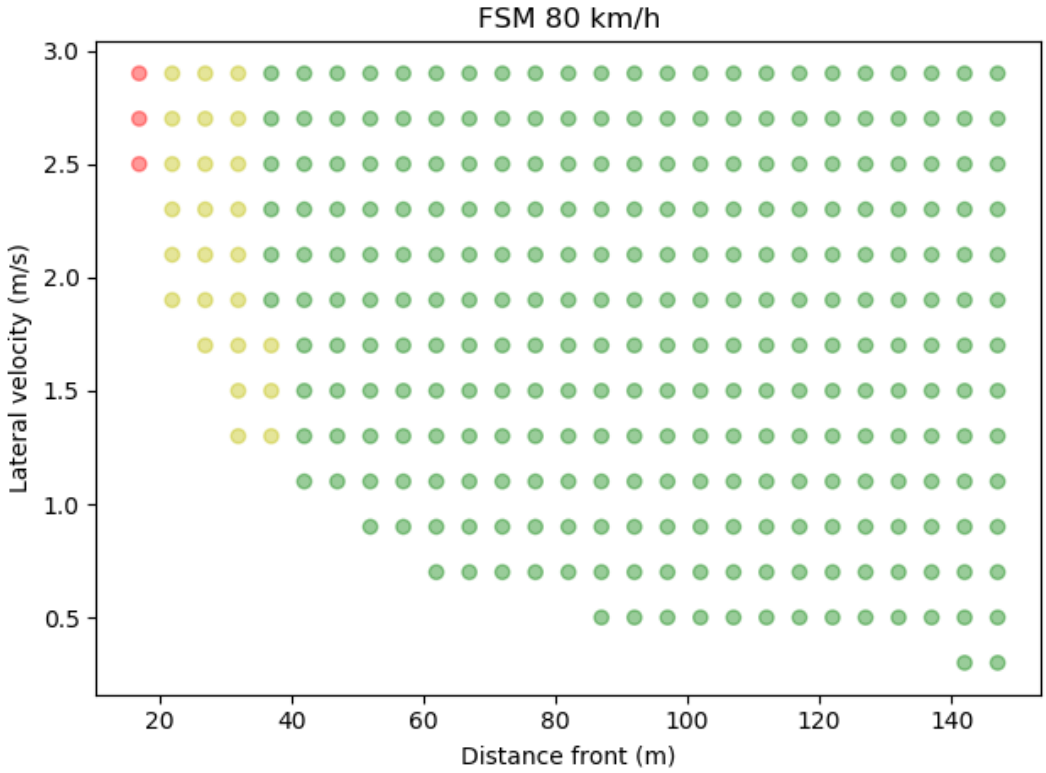


Figure 11

For Ve0 = 70 kph

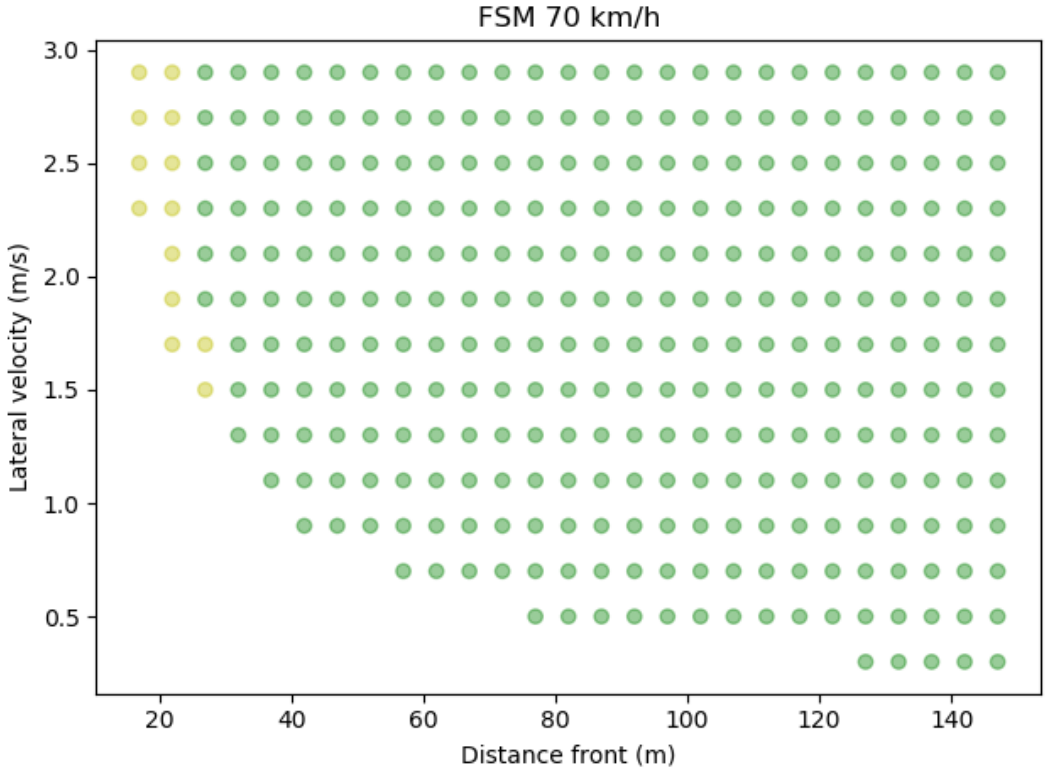
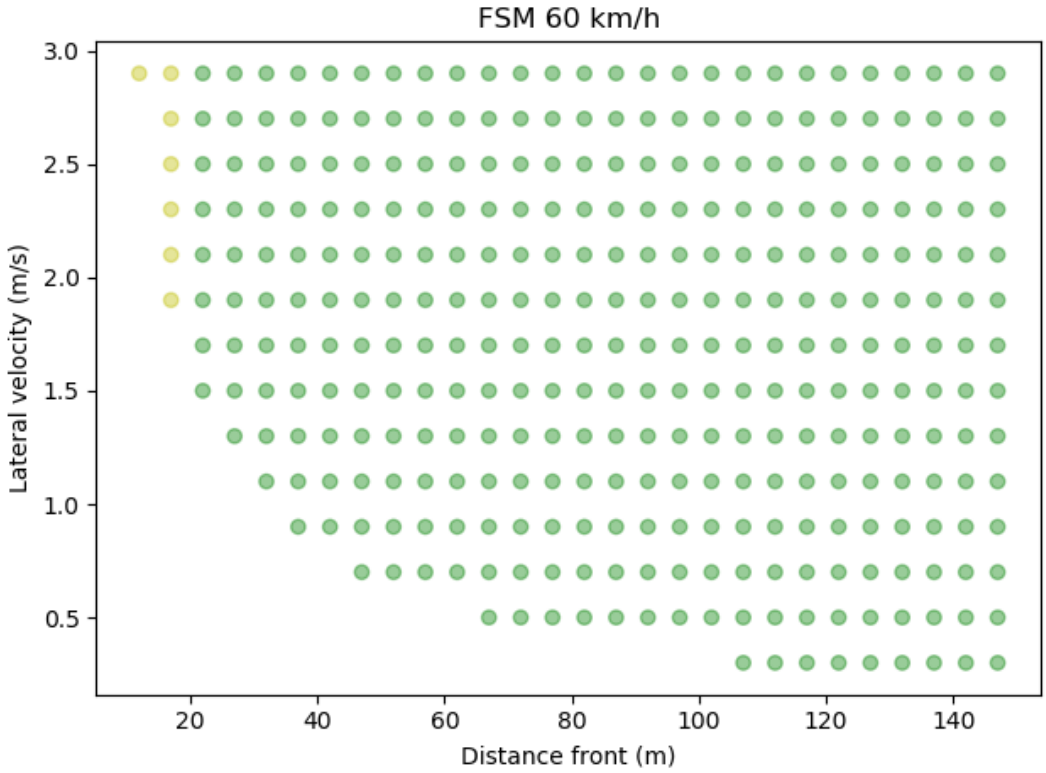


Figure 12

For Ve0 = 60 kph



3. Deceleration

Classification of difficulty of the scenarios based on the initial parameters is done the following way:

- **Easy: PFS = 0;**
- **Medium: PFS > 0 and CFS < 0.5;**
- **Difficult: CFS => 0.5.**

Based on these equations the classification may be done for any parameter set. The classification matrix for the different cases is presented below in Fig. 13.

Figure 13

Deceleration