Safety Evaluation Report of MOBATSim -AEB

according to ISO 26262, ISO 21448, EuroNcap

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Chapter 1. Introduction

This is a safety evaluation report for MOBATSim which according to three standards and generate a case study.

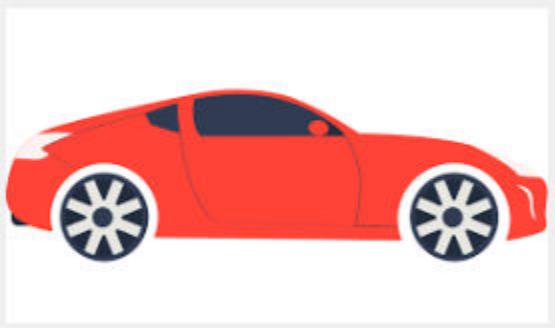

Figure 1.1. Style of the test vehicle.

Chapter 2. HARA

2.1. Scenario definition -laneMerge

The test scenario shows below which contains two traffic paticipants drive on a merged road, the trajectories of two vehicles are distinguished with different color .

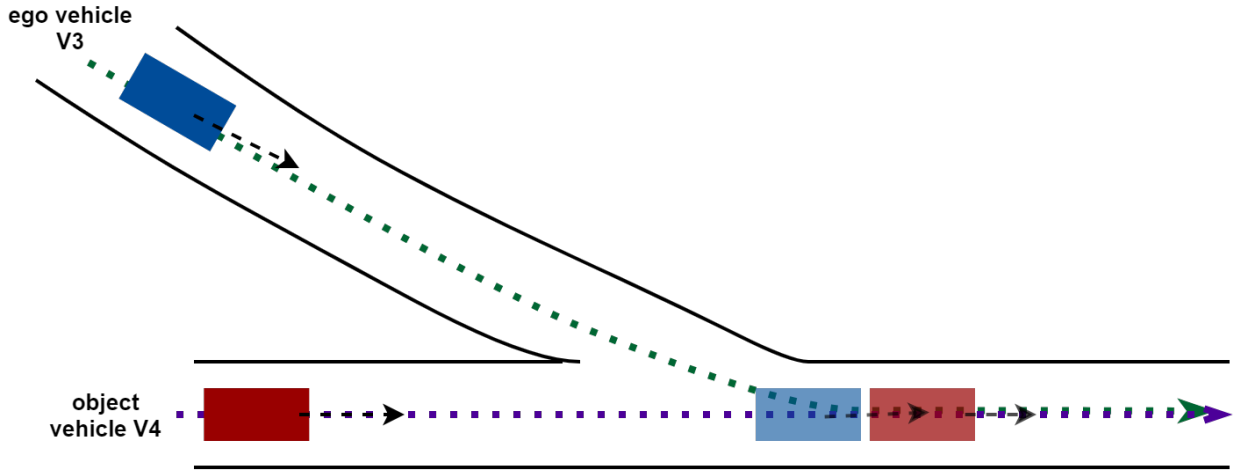

Figure 2.1. Test Scenario in MOBATSim

The road features of the test scenario are listed below:

1. Single lane
2. Road length
3. lane width 3.7m
4. No traffic signal and traffic signal controller

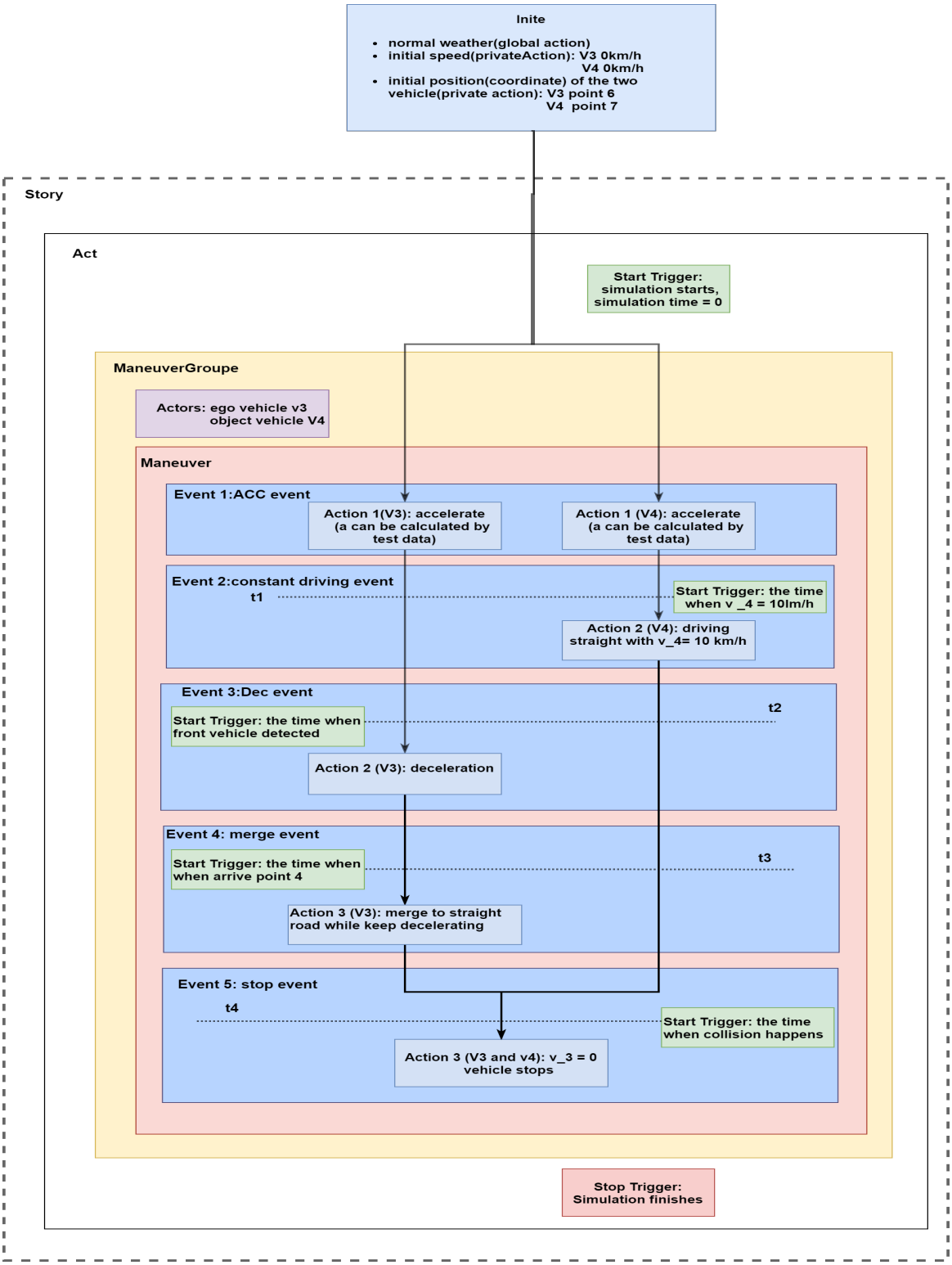

Figure 2.2. Scenario Definition under OpenScenario

2.2. Item Definition -AEB

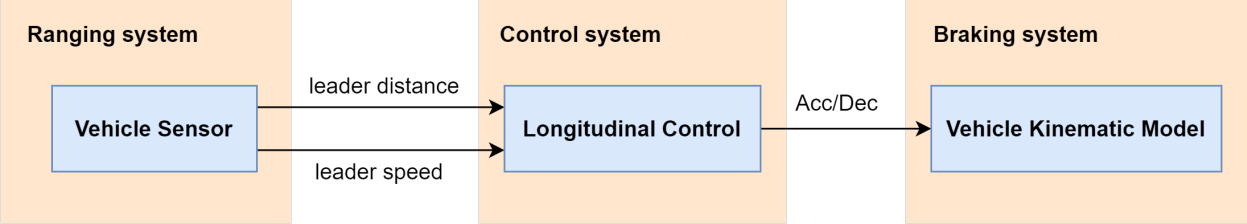

Figure 2.3. System block - Autonomous Emergency Brake (AEB) System in MOBATSim

1. Functionality: AEB detect leading vehicle with ranging system, with the caltulation of the control system, gives the braking command to the braking system.
2. Operational design domain: This AEB function is only appropriate for the MOBATSim platform, in which most of the roads are single lanes and no other vehicles drive alongside the leading vehicle.

2.3. Situation analysis and Hazard identification

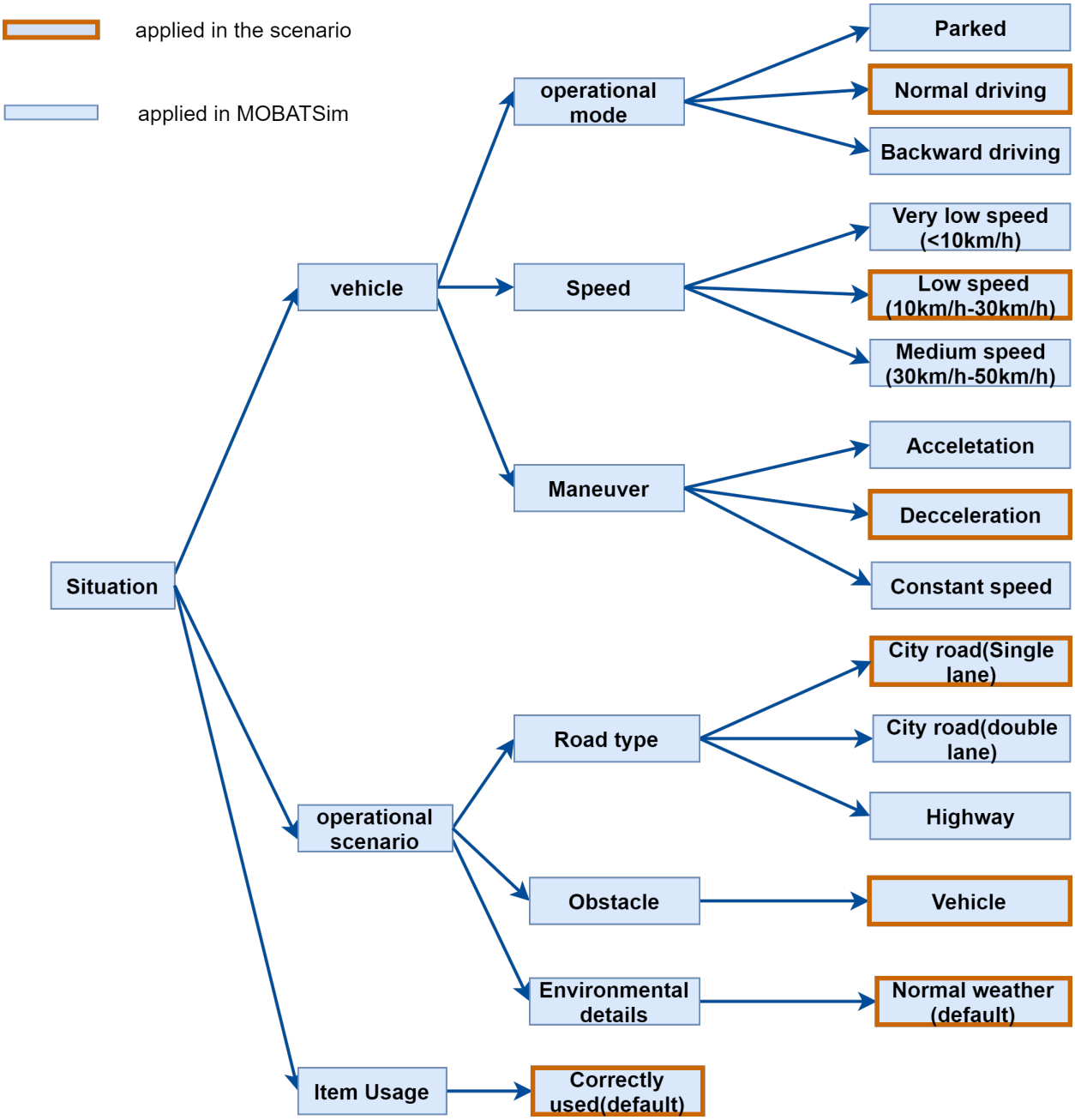

Figure 2.4. The situational analysis for specific scenario in MOBATSim

The situational analysis of the scenario "laneMerge" are listed below:

1. Operational mode: normal driving.
2. Operational scenario: Normal city road with single lane.
3. Environmental details: Normal weather (default)
4. Situational details: low speed (10km/h~30km/h)

5. Item usage: correctly used (default)

The exposure level is 3.

The hazards are caused by electronic malfunctions of target item shown below:

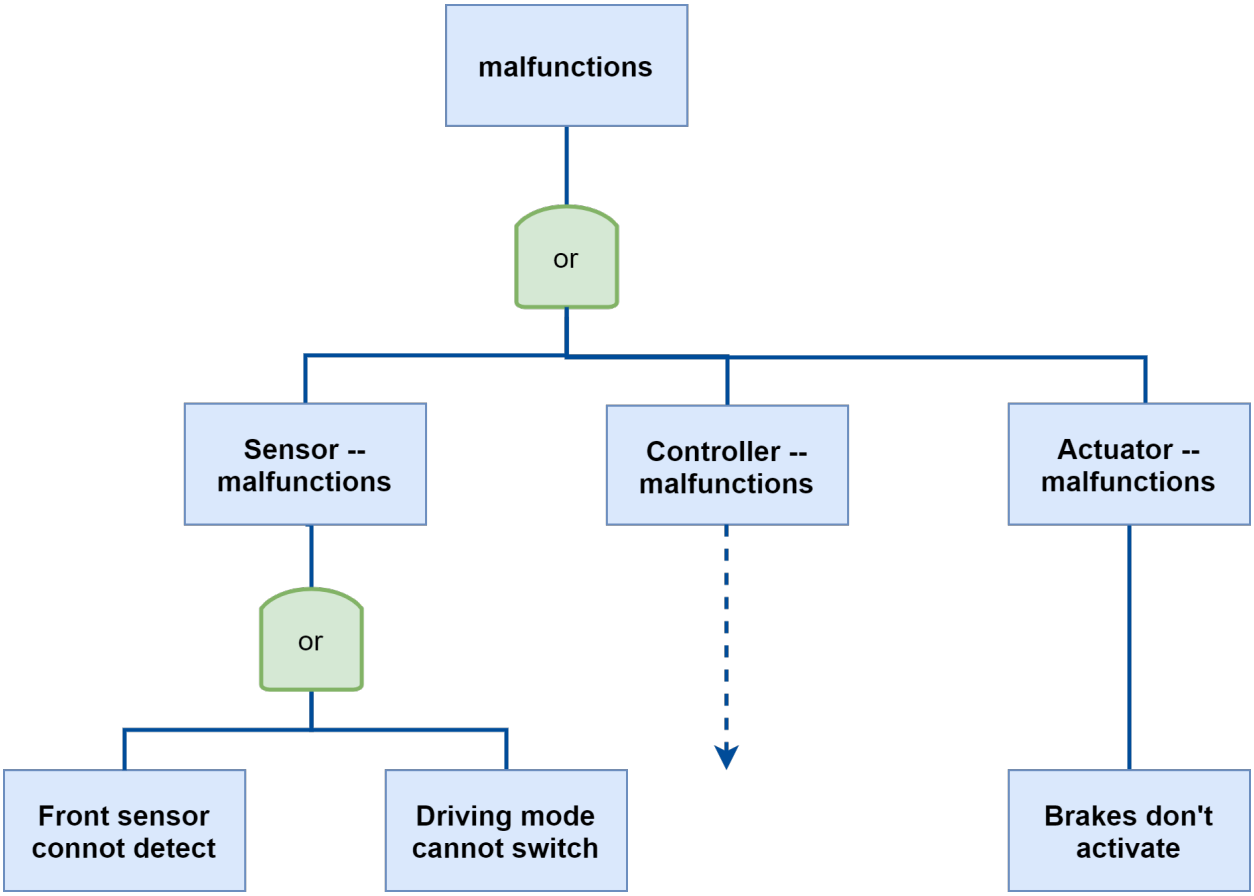

Figure 2.5. The malfunctions which should happends in AEB system in MOBATSim

The example of hazard identification of AEB is shown below:

1. Function: Autonomous Emergency Braking system shall apply a braking to slow down or stop, when there is a potential collision detected.
2. Malfunction: Function not activated. Eg: the sensor does not detected the front vehicle, or there is delay time for switching driving mode.
3. Malfunction details: The sensor of AEB does not detected the front vehicle, so there is no input data for control system, the control system has nosignal for braking system. The AEB function does not apply a braking.
4. Hazardous event: The ego vehicle has a front collision with the leading vehicle.
5. Event details: The unactivated AEB does not apply a braking when the ego vehicle is nearing the leading vehicle, the vehicle remains at the previous speed and has a crash with leading vehicle.

Collision in low speed, the severity level is 2

2.4. Hazardous event classification

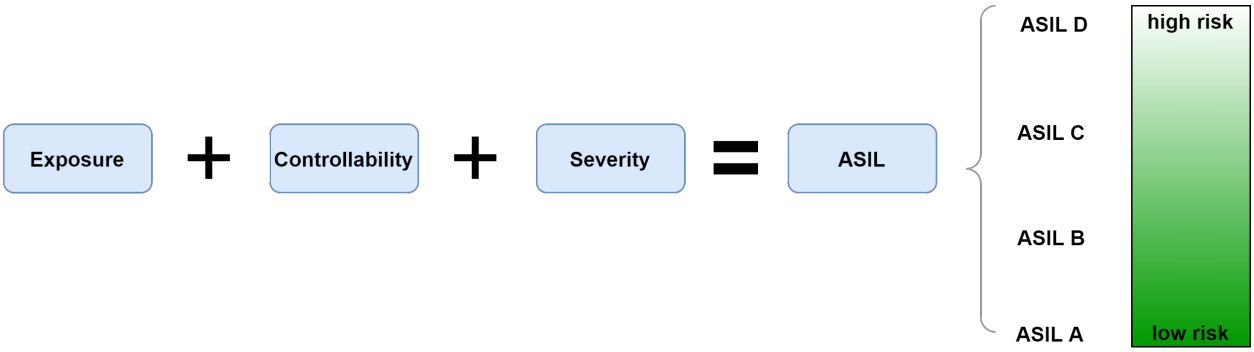

Figure 2.6. Exposure, Severity, and Controllability determin the ASIL level from low risk to high risk

According to above (Controllability level is 3, because the driver is out of the driving loop), the ASIL level of AEB in specific scenario shows below:

The ASIL level is ASIL B.

2.5. Safety goal and functional safety requirement

The Safety goal and functional safety requirements is shown in the list below:

1. Safety goal: The vehicle sensor of the AEB system shall reach the normal sensitivity.
2. Functional safety requirement 1: The AEB system shall ensure the accuracy of the algorithm in ranking system.
3. Malfunction details: The AEB system shall ensure the connection between vehicle model and control system has the proper functioning.

Chapter 3. SOTIF

Chapter 4. Case study

In this chapter, the test results of several cases are presented. For the sake of simplicity, only the data from vehicle_3 is shown here The performance of the AEB is determined by KPIs: minimum TTC, minimum distance, and relative impact speed .

Table 4.1. Test result of vehicle 3 under the situation without collision.

maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
8.0499999999999989	0	10.607506876449616	4.8714441883805248	15.42
7.6499999999999995	0	16.122151524468379	8.5267705592262963	15.359999999999999
7.2499999999999991	0	21.515144876154523	13.467025122227833	19.800000000000001
6.8499999999999996	0	26.630350537917515	20.645102362289823	15.5
6.4499999999999993	0	31.424846149971128	34.916490452444897	16.34

Table 4.2. Test result of vehicle 3 under the situation without collision with malfunction 1: driving mode delay.

delay_time	maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
0.5	8.0499999999999989	0	9.3926123629348481	4.1206316809669898	15.82
1	8.0499999999999989	0	8.1512065797046986	3.6318022340614875	16.32
1.5	8.0499999999999989	0	6.8957289420041983	3.1322403268097392	16.82
0.5	7.6499999999999995	0	15.173877123368882	7.5299433453255267	15.800000000000001
1	7.6499999999999995	0	14.178071985584445	7.0756701713954833	16.300000000000001

delay_time	maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
1.5	7.6499999999999995	0	13.149642049681496	6.599475086542238	16.800000000000001
0.5	7.2499999999999991	0	20.845291205777364	12.487366637541831	15.780000000000001
1	7.2499999999999991	0	20.125415731749663	12.088794541243685	16.280000000000001
1.5	7.2499999999999991	0	19.355935485769653	11.660700308690178	16.780000000000001
0.5	6.8499999999999996	0	24.613994319891411	17.841917282285607	20.02
1	6.8499999999999996	0	23.467699275471162	18.378913459343956	18.5
1.5	6.8499999999999996	0	22.831335447595013	17.828726068956314	18.98
0.5	6.4499999999999993	0	31.353282295254491	34.916490452444897	16.34
1	6.4499999999999993	0	29.258471867077223	32.509413303255485	20.02
1.5	6.4499999999999993	0	29.258471867077223	32.509413303255485	20.02

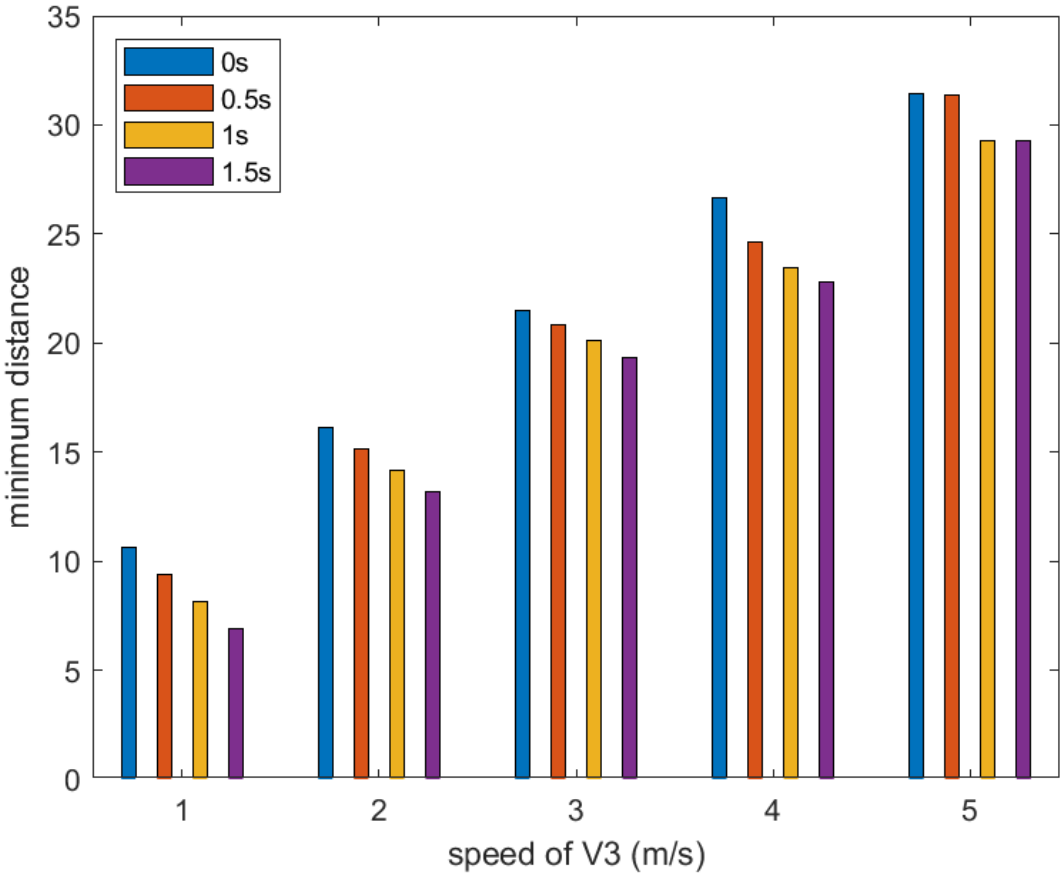

Figure 4.1. The minimum distance between two vehicles under different time delay of vehicle 3. groupe 1 = 8.05m/s, groupe 2 = 7.65m/s, groupe 3 = 7.25m/s, groupe 4 = 6.85m/s, groupe 5 = 6.45m/s.

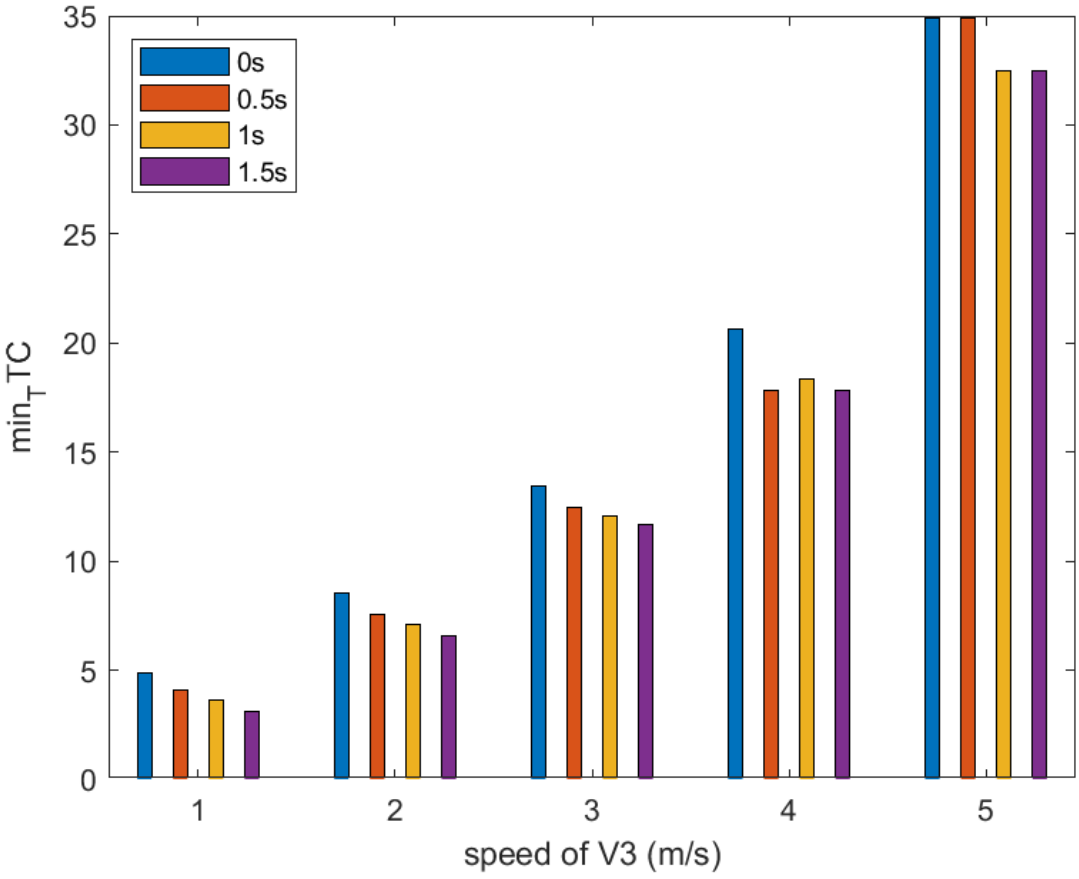

Figure 4.2. The minimum TTC under different time delay of vehicle 3. groupe 1 = 8.05m/s, groupe 2 = 7.65m/s, groupe 3 = 7.25m/s, groupe 4 = 6.85m/s, groupe 5 = 6.45m/s.

Table 4.3. Test result of vehicle 3 under the situation without collision with malfunction 2: sensor failure.

failure_rate	maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
0.2999999999999999	8.049999999999989	0	10.306495135154893	4.651519558127 0596	15.44
0.5	8.049999999999989	0	10.29207914587457	4.708885282556 4933	15.44
0.6999999999999996	8.049999999999989	0	8.750520086062 2239	4.374055802247 5815	15.56
0.9000000000 0000013	8.049999999999989	0	4.129767995089 3587	3.554705983549 6881	20.02

failure_rate	maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
0.29999999999999995	7.649999999999995	0	16.011155552989528	8.4560210583343132	15.42
0.5	7.649999999999995	0	15.694724852727635	8.2769703228097402	15.42
0.69999999999999996	7.649999999999995	0	15.080526924825218	7.9467297307689497	15.42
0.90000000000000013	7.649999999999995	0	9.9744899490508772	6.7270871600020009	19.98
0.29999999999999995	7.249999999999991	0	21.367413266946784	13.707952533426461	15.34
0.5	7.249999999999991	0	21.380176113800935	13.668632709942973	15.359999999999999
0.69999999999999996	7.249999999999991	0	21.113643573775516	13.288600079108962	15.44
0.90000000000000013	7.249999999999991	0	17.298842251746933	13.015791784758614	15.4
0.29999999999999995	6.849999999999996	0	26.592041514902625	20.645102362289823	15.5
0.5	6.849999999999996	0	26.439815912827296	20.665477449011188	15.52
0.69999999999999996	6.849999999999996	0	26.293758872825961	20.592033088067197	15.58
0.90000000000000013	6.849999999999996	0	24.782817586728296	20.618647365936766	15.540000000000001
0.29999999999999995	6.449999999999993	0	31.424846149971128	34.916490452444897	16.34
0.5	6.449999999999993	0	31.424846149971128	34.916490452444897	16.34
0.69999999999999996	6.449999999999993	0	31.424846149971128	34.916490452444897	16.34
0.90000000000000013	6.449999999999993	0	30.785461164783751	35.030412261742455	16.699999999999999

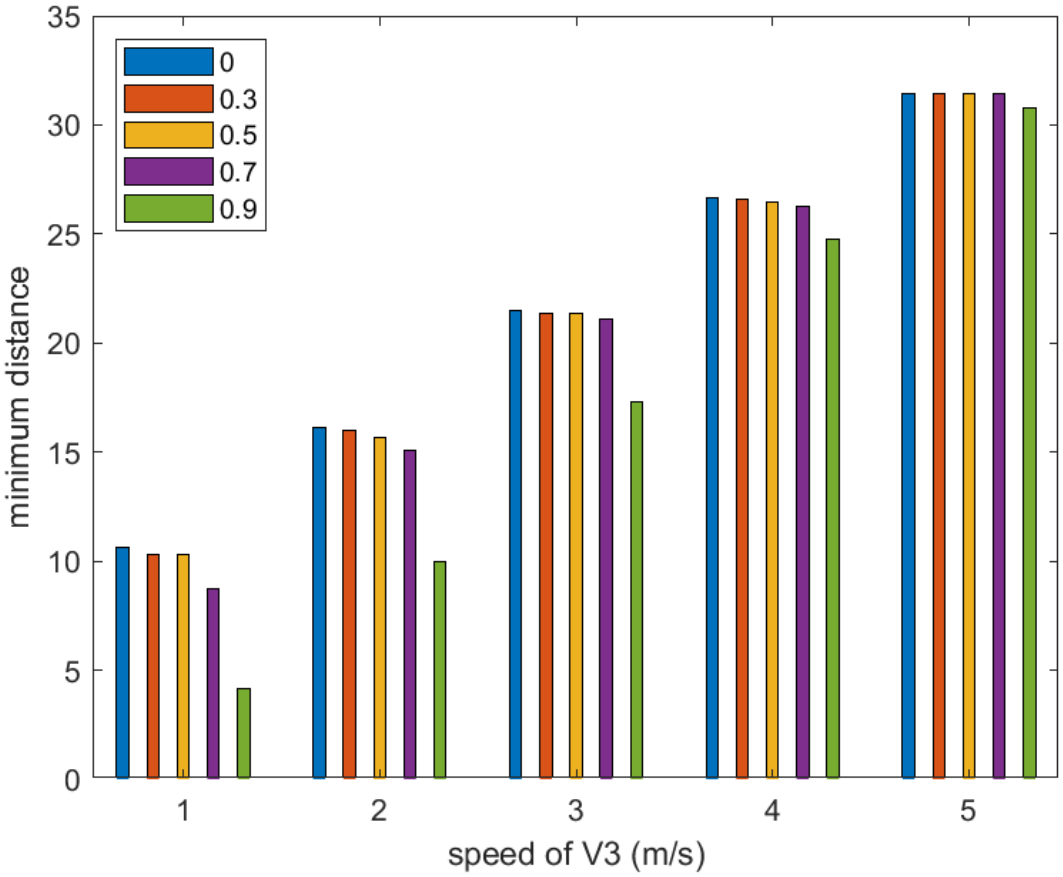

Figure 4.3. The minimum distance between two vehicles under different failure rate of vehicle 3. groupe 1 = 8.05m/s, groupe 2 = 7.65m/s, groupe 3 = 7.25m/s, groupe 4 = 6.85m/s, groupe 5 = 6.45m/s.

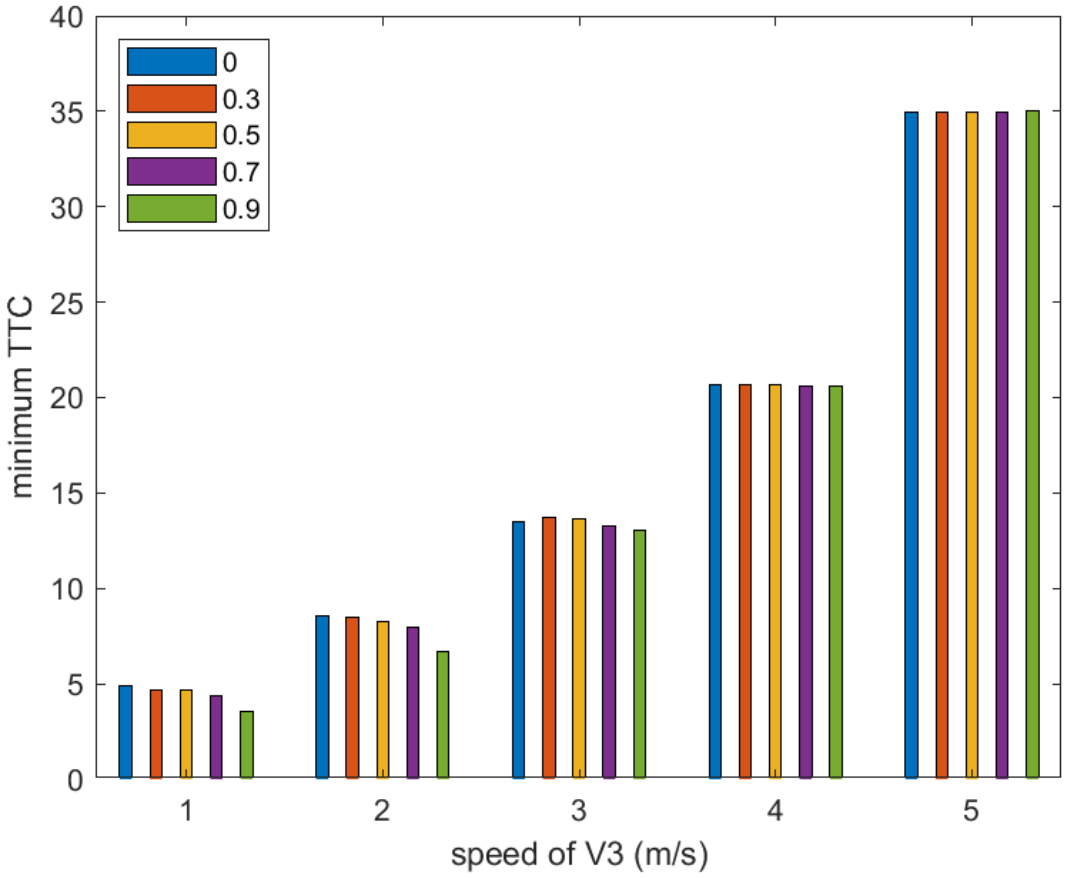

Figure 4.4. The minimum TTC under different failure rate of vehicle 3. groupe 1 = 8.05m/s, groupe 2 = 7.65m/s, groupe 3 = 7.25m/s, groupe 4 = 6.85m/s, groupe 5 = 6.45m/s.

Table 4.4. Test result of vehicle 3 under the situation without collision with malfunction 2: sensor failure.

delay_time	maxspeed_rearVehicle	has_collision	min_distance	min_TTC	min_TTCtime
2	8.049999999999999	0	5.6395245603152651	2.6254191039645778	17.34
2	7.649999999999995	0	12.102683048292644	6.1082705974611935	17.300000000000001
2	7.249999999999991	0	18.54826888287754	11.204683189573052	17.280000000000001
2	6.849999999999996	0	22.183151021448488	17.332852914883905	19.48
2	6.449999999999993	0	29.258471867077223	32.509413303255485	20.02

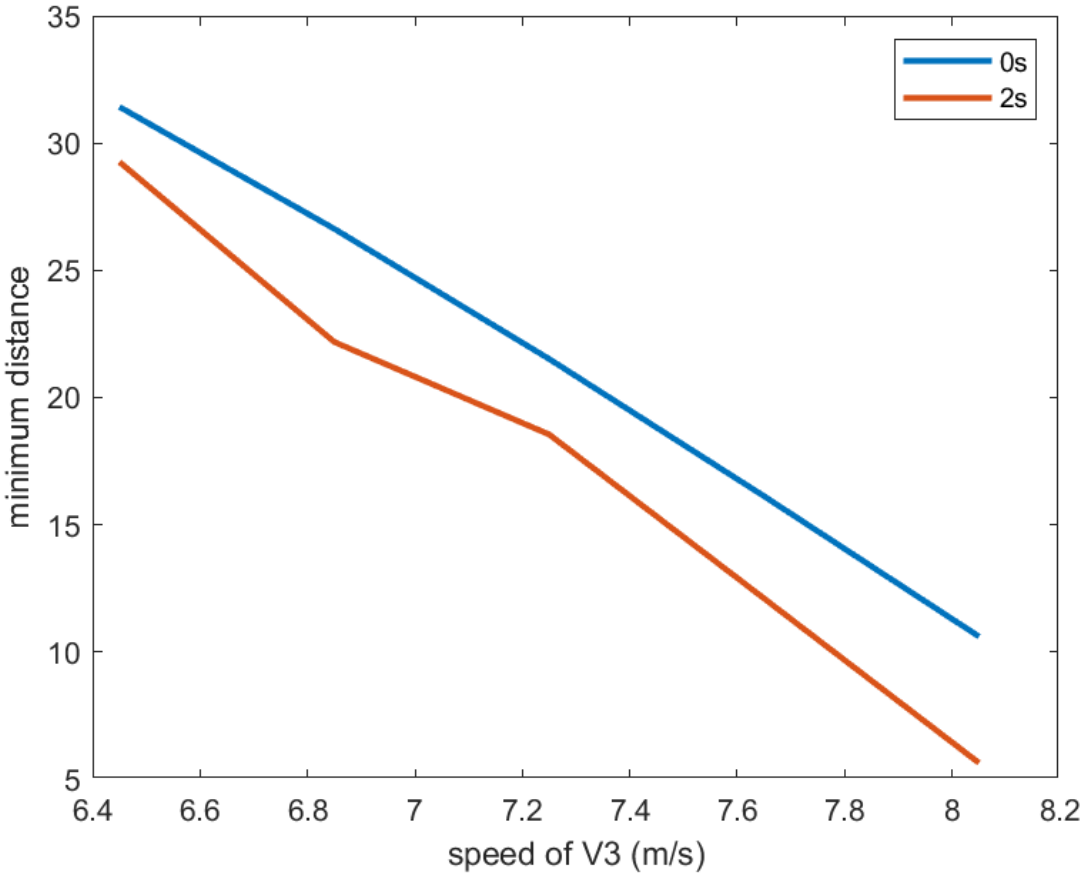

Figure 4.5. The minimum distance between two vehicles under sensor limitation-time delay of 2s.

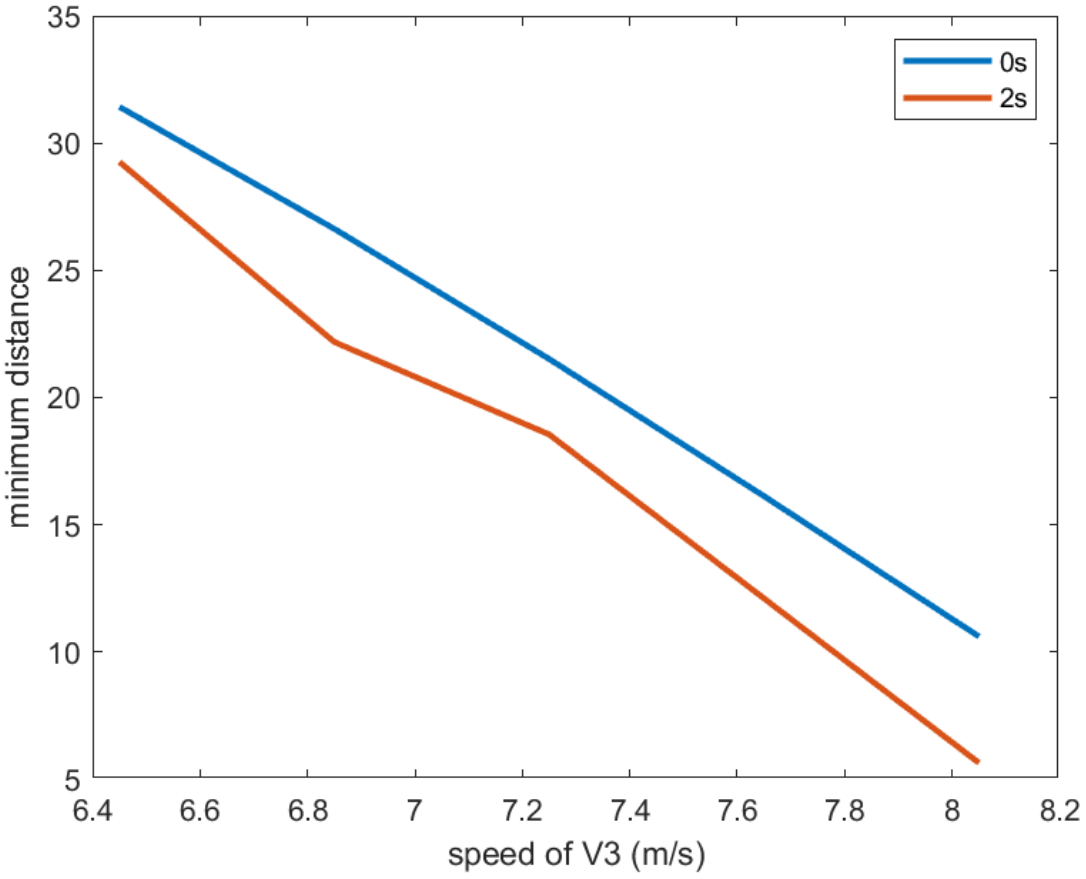

Figure 4.6. The minimum TTC under sensor limitation-time delay of 2s.

Table 4.5. Test result of vehicle 3 under the situation with collision.

maxspeed_rearVehicle	has_collision	rela_impactSpeed	collisionTime
8.8999999999999986	1	3.2944422523684143	15.359999999999999
9.3499999999999996	1	3.7999887579244067	13.82
9.7999999999999989	1	4.2499838213637986	13.200000000000001
10.25	1	4.6999931204442191	12.76

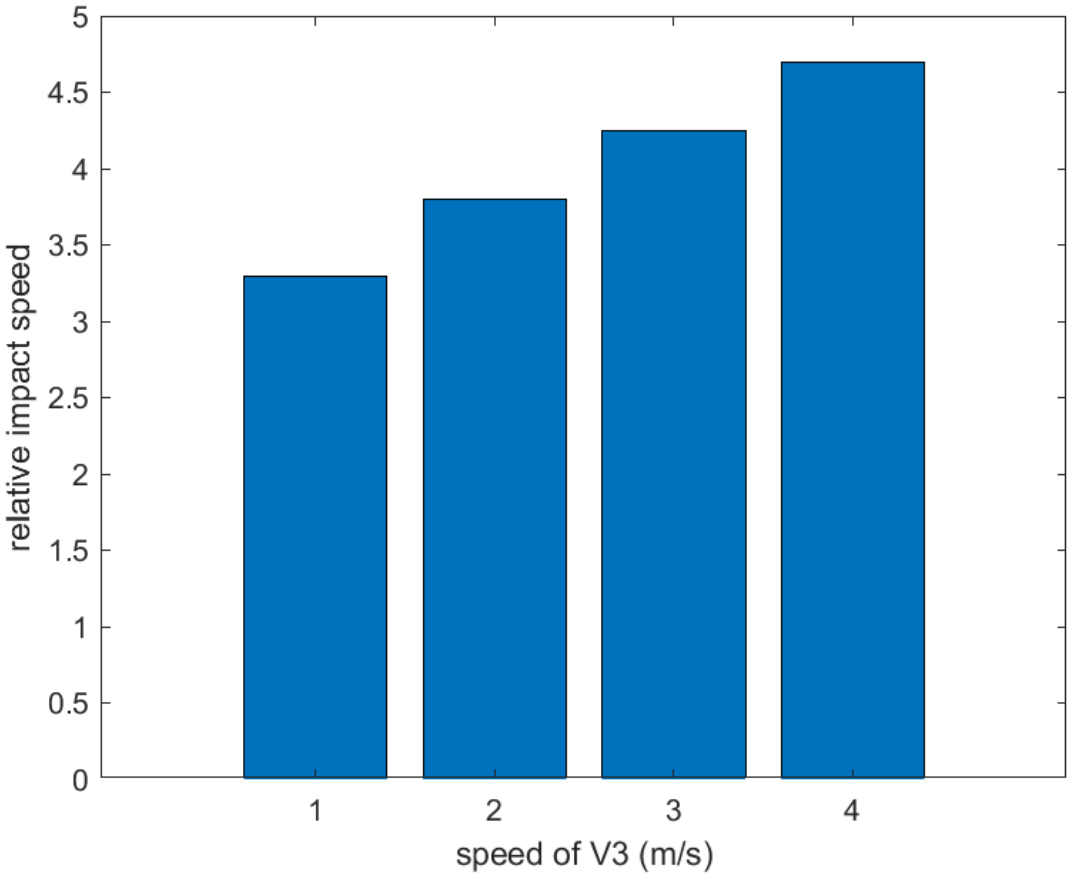

Figure 4.7. The relative impact speed of vehicle 3. groupe 1 = 8.05m/s, groupe 2 = 7.65m/s, groupe 3 = 7.25m/s, groupe 4 = 6.85m/s, groupe 5 = 6.45m/s.

Chapter 5. Chapter 5: Summary