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ENabling **S**af**E** **M**ulti-**B**rand p**L**atooning for **E**urope

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Revision history

Version	Date	Author	Summary of changes	Status
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0.2	27/09/2021	Alessandro Pezzano (IDIADA)	Second release of HARA with feedbacks from partners implemented	Draft
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1.0	22/12/2021	Alessandro Pezzano (IDIADA)	Final Release	Ready for WP Leader review
1.1	28/01/2022	Edoardo Mascalchi (CLEPA)	Final Release	Ready for Coordinator review
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2.0	04/03/2022	Marika Hoedemaeker (TNO)	Approved	Submitted

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EXECUTIVE SUMMARY

Context

Platooning technology has made significant advances in the last decade, but to achieve the next step towards deployment of truck platooning, an integral multi-brand approach is required. Aiming for Europe-wide deployment of platooning, 'multi-brand' solutions are paramount. It is the ambition of ENSEMBLE to realise pre-standards for interoperability between trucks, platoons and logistics solution providers, to speed up actual market pick-up of (sub)system development and implementation and to enable harmonisation of legal frameworks in the member states.

Project scope

The main goal of the ENSEMBLE project is to pave the way for the adoption of multi-brand truck platooning in Europe to improve traffic safety, fuel economy, and throughput. This has been demonstrated by driving up to seven differently branded trucks in one (or more) platoon(s) under real world traffic conditions. During the years, the project was organised as follows:

- Year 1: setting the specifications and developing a reference design;
- Year 2 and 3: implementing this reference design on the OEM own trucks, as well as performing impact assessments with several criteria;
- Year 4: focus on testing the multi-brand platoons on test tracks and public road.

The technical results were evaluated against the initial requirements, after which these were updated. Also, the impact on fuel consumption, drivers and other road users was established. In the end, all activities within the project aim to accelerate the deployment of multi-brand truck platooning in Europe.

The platoon levels as envisioned by the ENSEMBLE consortium and presented in D2.2 (J. Vissers, 2018) were revised after first results of the safety analyses. The safety analysis of the newly defined Platooning Support Function and the Platooning Autonomous Function (Willemsen, 2022) are fully detailed in this final deliverable. The Platooning Support Function is defined in line with the held demonstration on public road in September 2021.

Platooning levels

Two levels of platooning have been defined:

- **Platooning Support Function**: the driver is responsible for the driving task. Hence (s)he is also responsible to choose a safe following distance and monitor the system e.g. whether the right platooning partner is being followed (though supported by the system as much as possible). To give the driver sufficient time to react, minimum time gaps around 1.5 s have to be respected. The Platooning support function is a longitudinal control function, but

lateral driver assistance systems, such as e.g. lane keeping, might be optionally available as well.

- **Platooning Autonomous Function**: The lead truck has a driver responsible for the driving task, but the following trucks are fully automated, i.e. the system performs the complete driving task within the specified (limited) operational design domain. Taking the driver(s) out-of-the-loop offers the possibility to reduce time gaps to a minimum of 0.3 s.

In contrast to the Platooning Support Function, implementation of the Platooning Autonomous Function is not part of the ENSEMBLE project and the specification of the Platooning Autonomous Function and its use cases is solely done on theoretical considerations to sketch a future vision of platooning. The latter is also due to the low technology readiness level of certain required autonomous driving subfunctions at the time of writing.

Abstract of this Deliverable

This deliverable consists of the following two work products:

1) Hazard Analysis and Risk Assessment (HARA). The objectives of the HARA are:
   a. to identify and to categorise the hazardous events caused by malfunctioning behaviour of the item;
   b. to formulate the safety goals related to the prevention or mitigation of the hazardous events, in order to avoid unreasonable risk.

2) Functional Safety Concept (FSC). The objectives of the FSC are:
   a. to derive the functional safety requirements from the safety goals;
   b. to define the safe state strategy and/or the Minimum Risk Manoeuvre (MRM) for each functional safety requirement.

The above-mentioned activities have been undertaken separately for the Platooning Support Function (PSF) (Chapter 2) and the Platooning Autonomous Function (PAF) (Chapter 3).

For the PSF, a total of 43 cases (combination of operational situation and malfunction) were analysed. As a result, 2 cases having an ASIL above QM (Safety critical) have been identified, one classified with an ASIL A and the other one classified with ASIL B. The related hazardous event is the “unintended longitudinal deceleration by the ego vehicle”, and are of concern for other vehicles following the platoon closely. Therefore, “Rear end collision due to unintended braking of the platoon shall be prevented” has been defined as a Safety Goal, with an ASIL B.

For the PAF, Hazards arising from different malfunctions in the V2V communication, V2I communication, perception, braking, acceleration, steering and Human Machine Interface categories were considered for the analysis of the Platooning Autonomous Function. A total of 208 cases (combination of operational situation and malfunction) were analysed. As a result, 16 Safety Goals have been defined (10 classified with an ASIL D, 4 classified with an ASIL B,2 classified with an ASIL A). For these specific safety goals, 19 functional safety requirements have been defined. They define measures that are to be implemented by E/E technical solutions to prevent the violation of the corresponding Safety Goals. All them have an ASIL classification. ASIL D systems for the V2V communication and the autonomous control of steering, braking and propulsion will be needed to avoid/mitigate safety critical hazards. In some cases, redundant systems may be necessary to build a fault tolerant function.

1. INTRODUCTION

1.1. Background

This section provides an overview of the principles behind the activities undertaken.

The following analysis is performed on the two Platooning levels defined in ENSEMBLE:

- Platooning Support Function
- Platooning Autonomous Function

These two levels (and related use cases) are defined in D2.3 (Willemsen, 2022) and the related requirements and specifications are listed in D2.5 (Mascalchi E., 2022). Additional details on the communication protocol can be found in D2.8 (B. Atanassow, 2022a) and D2.9 (B. Atanassow, 2022b).

Furthermore, the Safety Of The Intended Functionality (SOTIF) of both levels can be found in D2.13 (P. Dhurjati, 2022a). The Item Definition can be found in D2.15 (P. Dhurjati, 2022b).

In ISO26262 (ISO26262, 2018) a risk (*R*) can be described as a function (*F*) of:

- the frequency of occurrence (*f*) of a hazardous event, and that in turn is influenced by the probability of exposure (*E*) of each operational situation and the failure rate (λ) of the item:

  $f = E \times \lambda$

- the controllability (*C*), that is the ability to avoid physical injury or damage to the health of persons through timely reactions of the persons involved, and
- the potential severity (*S*) of the resulting injury or damage

$R = F(f, C, S)$

Hazard analysis and risk assessment determine the minimum set of requirements on the item, in order to avoid unreasonable risk.

The failure rate of the item is not considered a priori in the risk assessment because an unreasonable residual risk is avoided through the implementation of the resulting safety requirements.

The hazard analysis and risk assessment sub phase comprises of three steps:

1) *Situation analysis and hazard identification:* the goal of the situation analysis and hazard identification is to identify the potential unintended behaviours of the item that could lead to

a hazardous event. The situation analysis and hazard identification activity is based on the item's behaviour; therefore a clear definition of the item, its functionality and its boundaries is needed.

2) *Classification of hazardous events and ASIL determination*: the hazard classification comprises the determination of the severity, the probability of exposure, and the controllability associated with the hazardous events of the item. The severity represents an estimate of the potential harm in a specific driving situation, while the probability of exposure is determined by the corresponding situation. The controllability rates how easy or difficult it is for the driver or other road traffic participants to avoid the considered accident type in the considered operational situation. For each hazard, depending on the number of related hazardous events, the classification will result in one or more combinations of severity, probability of exposure, and controllability. The required ASIL (Automotive Safety Integrity Level) will be defined according to these values.

3) *Safety Goals definition*: top-level safety requirements for the Item are called Safety Goals. For each hazardous event with an ASIL associated, a safety goal is determined. If similar safety goals are specified, then these can be combined into one safety goal and the highest found ASIL is assigned to it.

1.2. Hazard Identification

Hazard identification is supported through a functional hazard and operability analysis. This is a structured and systematic technique for identifying and evaluating malfunctioning behaviours of the item that could lead to hazards that create the potential for physical injury or damage to the health of persons.

The hazards will be determined systematically based on the possible malfunctioning behaviour of the item.

The Hazard and Operability analysis (HAZOP) approach is suitable to support hazard identification at the item level. This is an explorative type of analysis where applicable guidewords are applied to each of the functions/sub-functions of an item to postulate malfunctioning behaviours.

The HAZOP method can be applied during the different safety lifecycle phases of safety-related systems. At this phase of safety lifecycle, the concept phase, the requirements of the Item, including its boundary, interfaces and the assumptions concerning its interaction with its elements are defined, but the system architectural design and documentation required to conduct the HAZOP do not exist. Nevertheless, it is necessary to identify major hazards at this stage, to include them in the development process and to facilitate future hazard analysis studies.

1.3. Classification of hazardous events and ASIL determination

The hazards are classified with respect to severity (S), probability of exposure (E) and controllability (C).

When classification of a give hazard is difficult to make, then it is classified conservatively so that higher S, E or C classification are chosen.

The severity of potential physical injury or damage to the health of persons, the probability of exposure of each operational situation and the controllability of each hazardous event are estimated on a proper rationale for each hazard.

The severity is assigned to one of the severity class S0, S1, S2 or S3 in accordance with Table1.

Table 1. Classes of severity

	Severity category, ISO 26262-3 Annex B [Ref 1]			
	S0	**S1**	**S2**	**S3**
Description	No injuries	Light and moderate injuries	Severe and life-threatening injuries (survival probable)	Life-threatening injuries (survival uncertain), fatal injuries
Definition	AIS 0 and less than 10% probability of AIS 1-6	> 10% probability of AIS 1-6 (and not S2 or S3)	> 10% probability of AIS 3-6 (and not S3)	> 10% probability of AIS 5-6

Where AIS is the Abbreviated Injury Score. See table 2.

Table 2. Abbreviated Injury Score (AIS)

Abbreviated injury Score, ISO 26262-3 Annex B [Ref 1]		
AIS-Code	**Injury**	Example
0	No injuries	-
1	Minor	light injuries such as skin-deep wounds, muscle pains, whiplash, etc.;
2	Moderate	moderate injuries such as deep flesh wounds, concussion with up to 15 minutes of unconsciousness, uncomplicated long bone fractures, uncomplicated rib fractures, etc.;
3	Serious	severe but not life-threatening injuries such as skull fractures without brain injury, spinal dislocations below the fourth cervical vertebra without damage to the spinal cord, more than one fractured rib without paradoxical breathing, etc.;
4	Severe	severe injuries (life-threatening, survival probable) such as concussion with or without skull fractures with up to 12 hours of unconsciousness, paradoxical breathing;
5	Critical	critical injuries (life-threatening, survival uncertain) such as spinal fractures below the fourth cervical vertebra with damage to the spinal cord, intestinal tears, cardiac tears, more than 12 hours of unconsciousness including intracranial bleeding;
6	Unsurvivable	extremely critical or fatal injuries such as fractures of the cervical vertebrae above the third cervical vertebra with damage to the spinal cord, extremely critical open wounds of body cavities (thoracic and abdominal cavities), etc.

The probability of exposure is assigned to one of the probability classes E0, E1, E2, E3 or E4 in accordance with Table 3:

Table 3. Classes of probability of exposure regarding operational situations

	Exposure category, ISO 26262-3 Annex B [Ref 1]				
	E0	**E1**	**E2**	**E3**	**E4**
Description	Incredible	Very low probability	Low probability	Medium probability	High probability
Frequency of situation	-	Situation occurs less than once a year for great majority of drivers	Situation occurs a few times a year for great majority of drivers	Situation occurs once a month or more often for average driver	Situation almost every drive on average
Duration (of average operating time)	-	-	< 1%	1% to 10%	>10%

The exposure to a hazard is estimated in two ways, the fist is based on the duration of a situation, temporal overlap, and the second is based on the frequency of occurrence of a situation.

The controllability of each hazardous event is assigned to one of the controllability classes C0, C1, C2 or C3 in accordance with Table 4.

Table 4. Classes of controllability

	Controllability category, ISO 26262-3 Annex B [Ref 1]			
	C0	**C1**	**C2**	**C3**
Description	Controllable in general	Simply controllable	Normally controllable	Difficult to control or uncontrollable
Definition	Controllable in general	99% or more of drivers able to avoid harm	90% or more of drivers able to avoid harm	Less than 90% of drivers able to avoid harm

An ASIL (Automotive Safety Integrity Level) is assigned for each hazardous event based on the classification of severity, probability of exposure and controllability, in accordance with Table 5.

Table 5 – ASIL (Automotive Safety Integrity Level) determination

	ASIL determination, ISO 26262-3 Clause 7.4.4.1, ISO 26262-12 Clause 8.4.3.10 [Ref 1]			
Severity	**Exposure**	**Controllability**		
		C1	**C2**	**C3**
S1	**E1**	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	ASIL A
	E4	QM	ASIL A	ASIL B
S2	**E1**	QM	QM	QM
	E2	QM	QM	ASIL A
	E3	QM	ASIL A	ASIL B
	E4	ASIL A	ASIL B	ASIL C
S3	**E1**	QM	QM	ASIL A
	E2	QM	ASIL A	ASIL B
	E3	ASIL A	ASIL B	ASIL C
	E4	ASIL B	ASIL C	ASIL D

Where QM stands for Quality Management and indicates that a particular case is not safety relevant.

1.4. Safety Goals definition

For each hazardous event with an ASIL associated, a safety goal is determined. When similar safety goals are specified, then these can be combined into one safety goal and the highest found ASIL is

assigned to it. Safety goals are not expressed in terms of technological solutions, but in terms of functional objectives.

1.5. Functional Safety Concept

A list of Functional Safety Requirements (FSRs) is then defined for each Safety Goal to comply with it. A functional safety requirement is the “specification of implementation-independent safety behaviour, or implementation-independent safety measure, including its safety-related attributes”, as per ISO 26262-1:2018 clause 3.69.

For each FSR, a dedicated safe state strategy and/or a Minimum Risk Manoeuvre (MRM) are also defined in order to avoid risks for the road users in case of faults that might forbid the fulfilment of the required behaviour.

A “safe state” in functional safety is the “operating mode, in case of a failure, of an item without an unreasonable level of risk”, as per ISO 26262-1:2018 clause 3.131.

A Minimal Risk Manoeuvre is a “tactical or operational manoeuvre triggered and executed by the automated driving system or the human driver to achieve the minimal risk condition”, as per BSI Flex 1890 clause 2.1.41 (Flex, 2020). MRMs are specific to automated driving systems with situational awareness (perception) that can decide on the safest manoeuvre based on the surroundings. The form of the MRM will be highly dependent on (and should be within) the operational design domain of the automated vehicle; for example, the MRM performed by a vehicle performing automated driving at free flow speed on a highway may be very different to that performed by a low-speed automated shuttle operating in an urban environment. The manoeuvres include reducing speed, finding a parking lot to stop, stopping at a hard shoulder, performing emergency stop, etc. For the platooning platform, the safe state and/or the MRM have been defined depending on the hazard.

2. PLATOONING SUPPORT FUNCTION

2.1. Item to be analysed

This section illustrates and discusses the approach for analysing possible hazards caused by malfunctioning behaviour of the Platooning Support Item, including interaction of their systems, Figure 1.

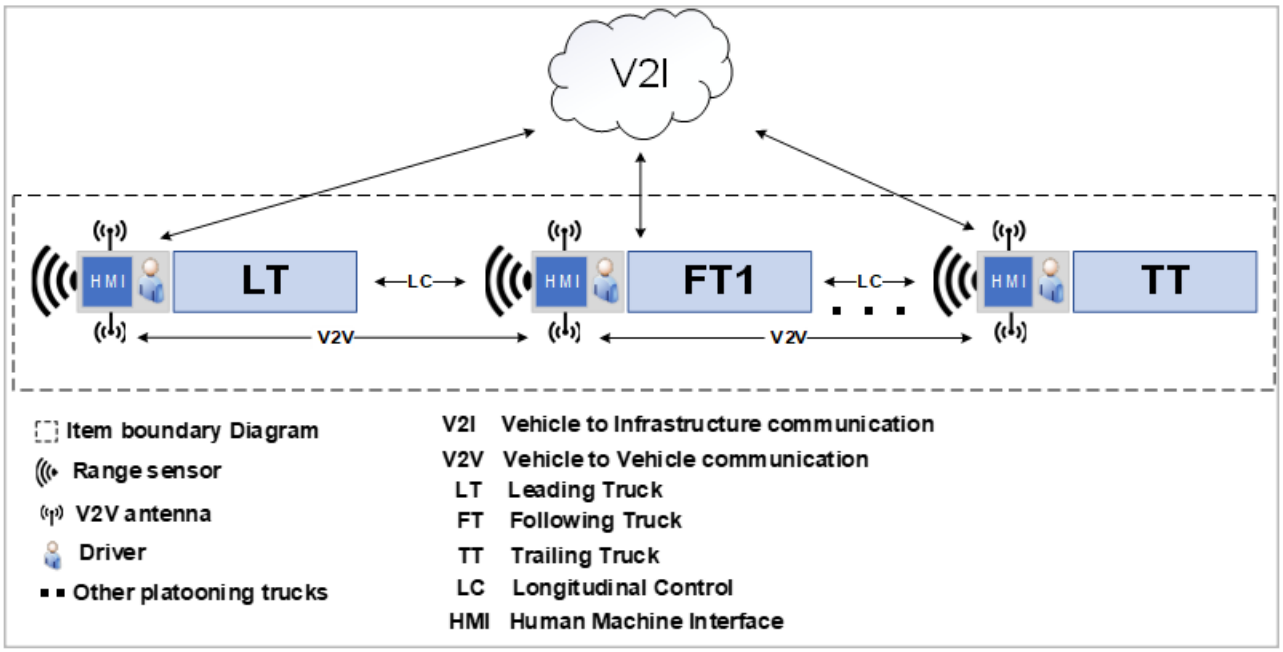

Figure 1 - Item definition – Platooning Support Function

2.2. Assumptions

The following assumptions have been made during the HARA (Hazard Analysis and Risk Assessment) analysis for the Platooning Support Function to ensure a safe platooning on public roads. In particular, the main scope of the analysis for the PSF has been to ensure a safe public road testing and final demonstration (held on 23/09/2021). For this reason, in this analysis, there will be references to the demonstration and testing activities.

A1 The demo will be carried out on public roads but in a controlled environment (e.g. no steep gradients, extreme weather conditions, etc…).

A2 The drivers used for the demo will be trained experts with lower reaction times than an average driver.

A3 The demo will only continue for approximately 3 hours during which the drivers are able to remain fully alert and react quickly against unintended behaviour of the function.

A4 As the test drivers are assumed to be expert and attentive, once a fault is detected, a reaction time of only 0.95 seconds (as per the Köller Model) is considered achievable by the driver.

A5 Overall reaction time of the test driver considered for the HARA is 1.8s, based on the following assumptions:

1) Forward vehicle starts to brake;

2) 0.40 seconds of increase of forward vehicle deceleration (ramp-up);

3) 0.45 seconds of driver realisation time of the malfunction (in this assumption the ego truck driver will notice the malfunction only when the forward vehicle reaches the target deceleration);

4) 0.95 seconds of driver reaction time (Köller Model).

A6 Only hazards associated with malfunctioning behaviour of the item are considered, every other external system (e.g. powertrain, ESC...) is presumed to be functioning correctly.

A7 The item is evaluated without internal safety mechanisms during the hazard analysis and risk assessment

A8 As a conservative value, all hazardous events that lead to a collision will be considered S3.

A9 The time gap of 1s or greater to the following traffic (behind the platoon) is assumed to have an Exposure E4.

A10 The time gap lower than 1s to the following traffic (behind the platoon) is assumed to have an Exposure E3.

A11 The following exposure ratings are assumed for braking situations in normal driving conditions on a highway:

- braking up to -2.0m/s² is assigned E4, the highest exposure level;
- braking more than -2.1m/s² up to -3,5m/s² is assigned E3 exposure level;
- braking more than -3.6m/s² to -5,0m/s² is assigned E2 exposure level;
- braking more than -5.1m/s² to -8,0m/s² is assigned E1 exposure level;

A12 Since the lead vehicle is controlled manually, acceleration and deceleration malfunctions of the lead vehicle will not be considered for HARA;

A13 Assumptions on controllability for test drivers are based on the required deceleration to avoid collision (deceleration required to avoid collision the time left after subtracting 1.8 seconds from the time to collision):

- deceleration less than 8.0 m/s² [full braking] after remove 1.8sec reaction time - C0-Controllable in General;

- deceleration greater than 8.0 m/s² [severe braking] - C3 - Uncontrollable;

A14 The overall reaction time used for external vehicles outside the platoon is: 1.55 sec (as per Köller Model for average attentive driver);

A15 New definition of the Platooning Support Function:

- The function is only support – Longitudinal control is not fully automated. Very similar to (C-)ACC.

- A minimum time gap of 1.4 seconds shall be maintained at all time. The driver still has the option of increasing the time gap if he desires but cannot decrease it below 1.4 s.

- A maximum deceleration of only 3.5 m/s^2 will be provided by the function. If more is required, then the driver will have to do it on his own or depend on other external functions like Autonomous Emergency Braking (AEB).

- When more deceleration than 3.5 m/s^2 is required to avoid collision, then the function will provide an HMI warning for the driver to react.

- All trucks can brake till standstill (as long as it is within -3.5 m/s^2). Accelerating from stand still is an option, i.e. OEM specific.

A16 It is assumed that all the trucks will meet a minimum brake performance of 5 m/s² in nominal driving conditions. It must be noted that 5 m/s² is the minimum performance legally allowed during a brake test inspection (under high-friction conditions; on a static brake testing machine or road test under dry conditions on a flat, straight road), see DIRECTIVE 2009/40/EC (2009/40/EC, 2009) on roadworthiness tests for motor vehicles and their trailers.

A17 Production approved AEB systems will be active in all the trucks. Due to the position and the clear visibility of the forward trucks, the AEB systems in the following trucks will always intervene to prevent collision in case of loss of braking by the platooning function.

A18 The controllability ratings assumed for braking situations in normal driving conditions on a highway for external vehicle´s drivers are the following:

- braking up to 3.0m/s² is assigned C0 level (controllable in general);
- braking more than 3.1m/s² up to 5.0m/s² is assigned C1 level (simply controllable);
- braking more than 5.1m/s² to 8.0m/s² is assigned C2 level (normally controllable);
- braking more than 8,0m/s² is assigned C3 level (difficult to control or uncontrollable).

A19 It is assumed that the system will be designed such that even if the platooning function asks for braking above 3.5 m/s^2, it will not be delivered by the braking system. So the onus of not braking more than 3.5 m/s^2 falls on the braking system with an ASIL D and not the platooning function.

2.3. Identified Hazards

The first step of the analysis is the identification of the malfunction categories, the malfunctions themselves, and the platooning states in which the malfunctions will be analysed. The hazard identification at the item level was performed using the HAZOP approach which was supported by brainstorming and analysis performed together with all the partners.

The following malfunction categories were considered for the HARA:

- Communication
- Braking
- Acceleration
- Human Machine Interface

Even though the malfunctions from the communication category can be observed at the acceleration, braking or HMI level, it was decided to analyse them in a separate category because the V2V communication is the main enabler of the platooning function and it is interesting to identify hazards resulting from malfunctions in communication at the concept phase instead of leaving them to the system level.

For each of the malfunction category, the identification of deviations from the design intent is achieved by a questioning process using guidewords tailored according to the scope and context of the analysis, Table 6.

Table 6 - Guide words and their meanings

Example HAZOP Guide Words which may be used to help determine hazards:	
No	This is the complete negation of the design intention. No part of the intention is achieved and nothing else happens.
More	This is a quantitative increase.
Less	This is a quantitative decrease.
Unintended	The design intention is achieved when not required.
As well as	All the design intention is achieved together with additions.
Part of	Only some of the design intention is achieved.
Reverse	The logical opposite of the intention is achieved.
Other than	Complete substitution where no part of the original intention is achieved but something quite different happens.
Early	Something happens earlier than expected relative to clock time.
Late	Something happens later than expected relative to clock time.
Before	Something happens before it is expected relating to order or sequence.
After	Something happens after it is expected relating to order or sequence.

The following malfunctions were selected for each category for the HARA analysis after the completion of the HAZOP study:

- Communication:
  - Loss/lack of braking information transmitted by the ego vehicle
  - Wrong braking information (less than actual value) from the ego vehicle
- Braking
  - Unintended braking by the ego vehicle
  - Insufficient braking by the ego vehicle
  - Lack of braking by the ego vehicle
- Acceleration
  - Unintended acceleration by the ego vehicle
- Driver information
  - False inactive status information of the platoon (status informed as inactive when active)

The above malfunctions were analysed under the following platooning modes:

- Platoon engaging
- Platooning (steady state)
- Platoon disengaging

During the brainstorming and analysis sessions, the safety team has examined each function of the item for deviation from the design intent, which can lead to malfunctioning behaviours.

Once the functions and their sub-functions were identified, the malfunctioning behaviours of the platooning support function that could lead to hazards have been postulated using appropriate guidewords, Table 6.

The following table (Table 7) outlines the sub-function categories, the malfunctions and the relevant hazards analysed for the HARA:

Table 7 – Sub-function categories, malfunctions and relevant hazards

S. No.	Sub-function	Malfunction	Relevant hazards	Hazard ID
1	Communication	Loss/lack of braking information transmitted by the ego vehicle	Lack of deceleration by the following truck	Haz_01
		Wrong braking information (less than actual value) from the ego vehicle	Insufficient deceleration by the following truck	Haz_02
2	Braking	Unintended braking by the ego vehicle	Unintended deceleration by the following truck	Haz_03
		Insufficient braking by the ego vehicle	Insufficient deceleration by the following truck	Haz_02
		Lack of braking by the ego vehicle	Lack of deceleration by the following truck	Haz_01
3	Acceleration	Unintended acceleration by the ego vehicle	Unintended acceleration by the following truck	Haz_04
4	Driver information	False inactive status information of the platoon (Status informed as inactive when active)	Lack of steering by the following truck drivers (Lead truck driver steers assuming platoon is inactive)	Haz_05

2.4. Risk Assessment

In total 43 different cases (combinations of malfunctions and operational situations) were analysed during the risk assessment activity.:

- the cases which resulted in Automotive Safety Integrity Levels (ASILs) above Quality Management (QM), described in section 2.4.1;

- the cases which resulted to be not safety relevant (cases for which Automotive Safety Integrity Levels (ASILs) are equal to Quality Management or cases for which ASIL assignment is not required). These cases are listed in the Appendix A;

The complete Risk Assessment of the Platooning Support Function can be found in the Appendix A.

2.4.1. Malfunction Category: Braking

Classification of hazardous events and ASIL

Table 8 – Risk assessment of the hazard "Unintended deceleration" – Hazardous event PSF_H03_01

Hazardous event ID	PSF_H03_01
Platooning Mode	Steady state platooning
Operational Situation	Ego vehicle is the trailing truck Ego vehicle speed = 90 km/h Following external vehicle speed = 90 km/h Other vehicles closely following behind the platoon Time gap to the trailing traffic ≥ 1 sec
Malfunction:	Unintended braking by the ego vehicle
Hazard:	Unintended deceleration of -3.5m/s²
Assumptions:	A9, A14, A15, A18, A19
Possible consequences:	Rear-end collision
Severity Rating:	S3
Rationale Severity:	Externally following vehicle crashes into the platoon Impact speed 45.9 km/h. Since availability of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced.
Exposure Rating:	E4
Rationale Exposure:	Normal driving conditions where the external vehicles following the platoon are driving with a time gap of 1s.
Controllability Rating:	C1
Rationale Controllability:	TTC is 3.7 seconds. The overall delay in driver reaction is 1.55 sec, as per assumption A13. External vehicle's driver has around 2.15 s to react and avoid collision. A minimum deceleration of more than -4.2m/s² is required to avoid collision. Simply controllable (More than 99% of average drivers are able to avoid harm) as this is normal driving situation where only braking is required by the following driver to avoid harm
ASIL Classification:	B

Table 9 – Risk assessment of the hazard "Unintended deceleration" – Hazardous event PSF_H03_02

Hazardous event ID	HE_18
Platooning Mode	Steady state platooning
Operational Situation:	Ego vehicle is the trailing truck Ego vehicle speed = 90 km/h Following external vehicle speed = 90 km/h Other vehicles closely following behind the platoon Time gap to the trailing traffic < 1 sec
Malfunction:	Unintended braking by the ego vehicle
Hazard:	Unintended deceleration of -3.5m/s^2
Possible consequences:	Rear-end collision
Assumptions:	A10, A14, A15, A18, A19
Severity Rating:	S3
Rationale Severity:	Externally following vehicle crashes into the platoon Impact speed 40.8 km/h. Since availability of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced.
Exposure Rating:	E3
Rationale Exposure:	Medium probability of having external vehicles following the platoon with a time gap less than 1 sec on a highway
Controllability Rating:	C1
Rationale Controllability:	TTC is 3.3 seconds. The overall delay in driver reaction is 1.55 sec, as per assumption A13. External vehicle's driver has around 1.75s to react and avoid collision. A minimum deceleration of more than -4.5m/s^2 is required to avoid collision. Simply controllable (More than 99% of average drivers are able to avoid harm) as this is normal driving situation where only braking is required by the following driver to avoid harm.
ASIL Classification:	A

Safety Goals and Functional Safety Requirements

Table 10 – Safety Goals and FSRs for the hazard "Unintended deceleration"

Safety Goal	SG01: Rear end collision due to unintended braking of the platoon shall be prevented.
ASIL	B
Safe State	-
Functional Safety Requirements and allocation	**External measures:** ➢ Have information at the back of the trucks warning to maintain a safe distance to the trucks. ➢ Have a test vehicle following the platoon to warn/advice people to maintain safe distance if it is not obeyed. These FSRs are **external measures (no ASIL classification)**

3. PLATOONING AUTONOMOUS FUNCTION

3.1. Item to be analysed

This section illustrates and discusses the approach for analysing possible hazards caused by malfunctioning behaviour of the Platooning Autonomous Item, including interaction of their systems, Figure 2.

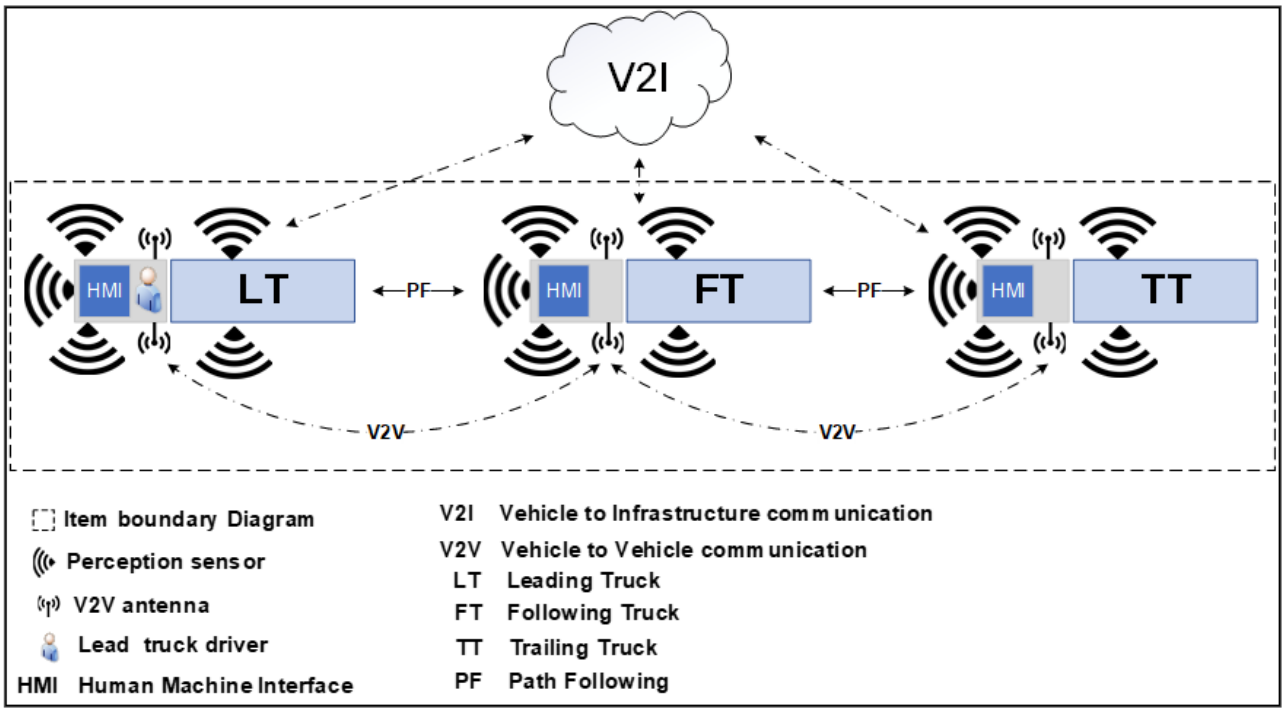

Figure 2 - Item definition – Platooning Autonomous Function

3.2. Assumptions

The following assumptions have been made during the HARA analysis for the Platooning Autonomous Function. The reader should note that this analysis refers to a concept that has been defined with implementation independent requirements. This analysis highlights the first potential issues with the functionality, and it will probably need future updates after a detailed definition of the function.

PAF_A1 Hazards are only considered that are in scope of ISO 26262.

PAF_A2 The system is as described in the item definition (P. Dhurjati, 2022b).

PAF_A3 The HARA does not include the foundational systems of the vehicle used for motion control. It is only limited to the autonomous function or the digital driver.

PAF_A4 The leading truck's driver is in an appropriate condition to drive, has the appropriate training and is complying with all applicable legal requirements, with only foreseeable misuse.

PAF_A5 The vehicle is in a good state of maintenance.

PAF_A6 ESC/ABS systems help to improve the stability of the vehicle and to maintain the intended path, avoiding wheels locking and unintended lateral motion events.

PAF_A7 A front/rear collision at medium/high speed within the platoon can lead the following trucks and other road vehicles involved in the collision to leave their current lane and can lead its trailer to force vehicles within and around the platoon to travel out of their own lane (e.g. into another lane or off the road).

PAF_A8 The following trucks are considered to be driverless for the safety analysis (only occupants, not responsible for driving tasks). i.e. driver will not be considered as the fallback for the automated system.

PAF_A9 Vehicles around the platoon (following vehicles, nearby vehicles) are considered manually driven.

PAF_A10 Intelligent infrastructures (e.g. intelligent traffic lights) are present in roundabouts, toll gates, junctions.

PAF_A11 For hazards related to braking, steering and acceleration we cannot consider corrective intervention within the platooning function as a backup. Potential faults debilitating part of braking, acceleration and steering system cannot be excluded. No chance for mitigation of them.

PAF_A12 The driver of the leading truck will ask for the platoon disengagement only when the platoon is at standstill and the platoon has reached a hub or an area to park. The driver will be attentive and concerned about the platoon status and he will not perform any driving manoeuvre until confirmation of successful disengagement.

PAF_A13 For the functional safety analysis, it is assumed that each following truck is responsible for its own safety. Consequently, the forward truck is not responsible for the Object and Event Detection and Response (OEDR) related functions of the following trucks. So, faults arising from one truck do not affect the OEDR functionality in the other trucks. In other words, functional safety only focuses on one independent malfunction at a time. For e.g. loss of path data from the forward truck will not result in accidents of the following trucks, as they can still perceive their surroundings and act safely. The OEDR related malfunctions in the individual trucks are only explored when faults of steering, braking and acceleration are analysed for the following trucks.

3.3. Identified Hazards

The first step of the analysis is the identification of the malfunction categories, the malfunctions themselves, and the platooning states in which the malfunctions will be analysed. The hazard identification at the item level was performed using the HAZOP approach which was supported by brainstorming and analysis performed together with all the partners.

The following malfunction categories were considered for the HARA:

- V2V Communication
- V2I Communication
- Perception
- Braking
- Acceleration
- Steering
- Human Machine Interface (following truck)
- Human Machine Interface (leading truck)

Even though the malfunctions from the communication category can be observed at the acceleration, braking or HMI level, it was decided to analyse them in a separate category because the V2V communication is the main enabler of the platooning function and it is interesting to identify hazards resulting from malfunctions in communication at the concept phase instead of leaving them to the system level.

For each of the malfunction category, the identification of deviations from the design intent is achieved by a questioning process using guidewords tailored according to the scope and context of the analysis, Table 11.

Table 11 - Guide words and their meanings

Example HAZOP Guide Words which may be used to help determine hazards:	
No	This is the complete negation of the design intention. No part of the intention is achieved and nothing else happens.
More	This is a quantitative increase.
Less	This is a quantitative decrease.
Unintended	The design intention is achieved when not required.
As well as	All the design intention is achieved together with additions.
Part of	Only some of the design intention is achieved.
Reverse	The logical opposite of the intention is achieved.
Other than	Complete substitution where no part of the original intention is achieved but something quite different happens.
Early	Something happens earlier than expected relative to clock time.
Late	Something happens later than expected relative to clock time.
Before	Something happens before it is expected relating to order or sequence.
After	Something happens after it is expected relating to order or sequence.

The following malfunctions were selected for each category for the HARA analysis after the completion of the HAZOP study:

- V2V Communication
  - Intended path is not communicated to the following trucks
  - The communicated data is incomplete/corrupted
  - The incorrect path is communicated to the following trucks
  - The intended path is communicated after a delay

- V2I Communication
  - Leading truck does not inform the platoon’s intention to cross to the intelligent infrastructure systems within its range
  - The communication is not complete
  - Leading truck sends incorrect information of the platoon's intention to cross to the intelligent infrastructure system within its range
  - The "approaching platoon" information is sent after a delay
  - Platoon's negotiation with infrastructure is stopped before crossing it
- Perception
  - No information regarding the surroundings is perceived by the following truck (complete loss of perception)
  - The following truck measures the obstacles/vehicles to be further away or faster than they actually are. Incorrect perception (insufficient deceleration by the following truck)
  - The field of view (FOV) is less than expected, so all the obstacles are not visible.
  - The following truck perceives partial information of the surrounding area
  - The environment model perceives the object/vehicles after a delay
- Braking
  - The following truck does not decelerate autonomously
  - The following truck decelerates less than needed
  - The following truck decelerates unexpectedly
  - The following truck accelerates instead of decelerating
  - The following truck decelerates after a delay

- Acceleration
  - The following truck does not accelerate autonomously
  - The following truck accelerates autonomously more than needed
  - The following truck accelerates autonomously less than needed
  - The following truck accelerates unexpectedly
  - The following truck decelerates instead of accelerating
  - The following truck accelerates after a delay
- Steering
  - The following truck does not steer autonomously
  - The following truck steers autonomously more than needed
  - The following truck steers autonomously less than needed
  - The following truck steers autonomously unexpectedly
  - The following truck steers autonomously in the opposite direction
  - The following truck steers later than required
- Human-Machine Interface (following truck)
  - The HMI commands an unexpected disengagement from the platoon without any request by the following truck's operator
  - The HMI allows the disengagement procedure, but the HMI does not communicate the successful disengagement
  - The HMI allows the disengagement procedure, but the HMI continues showing incorrect information regarding the platoon
  - The HMI provides the information of successful joining before the truck is actually engaged

- Human-Machine Interface (leading truck)
  - The HMI triggers the engage unexpectedly
  - The HMI triggers the disengage unexpectedly

Lastly, a loss of platooning control malfunction due to common failures (e.g. power loss of the platoon controller) has been considered. This can lead to the complete loss of steering, braking and propulsion control.

During the brainstorming and analysis sessions, the safety team has examined each function of the Item for deviation from the design intent which can lead to malfunctioning behaviours.

The following table (Table 12) outlines the sub-function categories, the malfunctions and the relevant hazards analysed for the HARA:

Table 12. Sub-function categories, malfunctions and relevant hazards

S. No.	***Sub-function***	***Malfunction***	***Relevant hazards***	***Hazard ID***
1	V2V Communication	Intended path is not communicated to the following trucks	Loss of path data	Haz_01
		The communicated data is incomplete/corrupted	Loss of path data	Haz_01
		The incorrect path is communicated to the following trucks	Incorrect path data	Haz_02
		The intended path is communicated after a delay	Loss of path data	Haz_01
			Incorrect path data	Haz_02
2	V2I Communication	Leading truck does not inform the platoons intention to cross to the intelligent infrastructure systems within its range	Platoon's intention to cross not communicated to the relevant infrastructure	Haz_03
		The communication is not complete	Platoon's intention to cross not communicated to the relevant infrastructure	Haz_03

S. No.	*Sub-function*	*Malfunction*	*Relevant hazards*	*Hazard ID*
		Leading truck sends incorrect information of the platoon's intention to cross to the intelligent infrastructure system within its range	Incorrect intention to cross communicated to the relevant infrastructure	Haz_04
		The "approaching platoon" information is sent after a delay	Platoon's intention to cross not communicated to the relevant infrastructure (if the delay is too high)	Haz_03
			Incorrect intention to cross communicated to the relevant infrastructure	Haz_04
		Platoon's negotiation with infrastructure is stopped before crossing it	Platoon's intention to cross not communicated to the relevant infrastructure	Haz_03
3	Perception	No information regarding the surroundings is perceived by the following truck. Complete loss of perception.	Loss of deceleration by the following truck	Haz_05
			Unintended acceleration by the following truck	Haz_12
			Unintended lateral motion by the following truck	Haz_16
		The following trucks measures the obstacles/vehicles to be further away or faster than they actually are. Incorrect perception.	Insufficient deceleration by the following truck	Haz_11
			Loss of lateral motion by the following truck	Haz_13
			Unintended lateral motion by the following truck	Haz_16
			Insufficient deceleration by the following truck	Haz_11

S. No.	*Sub-function*	*Malfunction*	*Relevant hazards*	*Hazard ID*
		The field of view (FOV) is less than expected, so all the obstacles are not visible.	Loss of lateral motion by the following truck	Haz_13
			Insufficient lateral motion by the following truck	Haz_15
			Unintended lateral motion by the following truck	Haz_16
		The following trucks perceives partial information of the surrounding area.	Loss of deceleration by the following truck	Haz_05
			Unintended acceleration by the following truck	Haz_12
			Unintended lateral motion by the following truck	Haz_16
		The environment model perceives the object/vehicles after a delay.	Loss of deceleration by the following truck (if the delay is too high)	Haz_05
			Insufficient deceleration by the following truck	Haz_07
			Loss of lateral motion by the following truck (if the delay is too high)	Haz_13
			Unintended lateral motion by the following truck	Haz_16
4	Braking	The following truck does not decelerate autonomously	Loss of deceleration by the following truck	Haz_05

S. No.	***Sub-function***	***Malfunction***	***Relevant hazards***	***Hazard ID***
		The following truck decelerates less than needed	Insufficient deceleration by the following truck	Haz_07
		The following truck decelerates unexpectedly	Unintended deceleration by the following truck	Haz_08
		The following truck accelerates instead of decelerating	Unintended acceleration by the following truck	Haz_12
		The following trucks decelerate after a delay	Loss of deceleration by the following truck (if the delay is too high)	Haz_05
			Insufficient deceleration by the following truck	Haz_07
5	Acceleration	The following truck does not accelerate autonomously	Loss of acceleration by the following truck	Haz_09
		The following trucks accelerate autonomously more than needed	Excessive acceleration by the following truck	Haz_10
		The following trucks accelerates autonomously less than needed	Insufficient acceleration by the following truck	Haz_11
		The following truck accelerates unexpectedly	Unintended acceleration by the following truck	Haz_12
		The following truck decelerates instead of accelerating	Unintended deceleration by the following truck	Haz_08
		The following trucks accelerate after a delay	Loss of acceleration by the following truck (if the delay is too high)	Haz_09
			Insufficient acceleration by the following truck	Haz_11

S. No.	*Sub-function*	*Malfunction*	*Relevant hazards*	*Hazard ID*
6	Steering	The following trucks do not steer autonomously	Loss of lateral motion by the following truck	Haz_13
		The following trucks steer autonomously more than needed	Excessive lateral motion by the following truck	Haz_14
		The following trucks steer autonomously less than needed	Insufficient lateral motion by the following truck	Haz_15
		The following trucks steer autonomously unexpectedly	Unintended lateral motion by the following truck	Haz_16
		The following trucks steer autonomously in the opposite direction	Unintended lateral motion by the following truck	Haz_16
		The following truck steers later than required	Loss of lateral motion by the following truck (if the delay is too high)	Haz_13
			Insufficient lateral motion by the following truck	Haz_15
7	Human-Machine Interface (Following truck)	The HMI commands an unexpected disengagement from the platoon without any request by the following truck's operator	Unexpected disengagement of the following truck from the platoon	Haz_18
		The HMI allows the disengagement procedure, but the HMI does not communicate the successful disengagement	Disengagement completion not communicated to the following truck's operator	Haz_19
		The HMI allows the disengagement procedure, but the HMI continues	Disengagement completion not communicated to the following truck's operator	Haz_19

S. No.	*Sub-function*	*Malfunction*	*Relevant hazards*	*Hazard ID*
		showing incorrect information regarding the platoon		
		The HMI provides the information of successful joining before the truck is actually engaged	Engaged status informed to the following truck's operator before initiation of autonomous control	Haz_20
8	Human-Machine Interface (Leading truck)	The HMI triggers the engage unexpectedly	Unexpected engagement of a platoon	Haz_21
		The HMI triggers the disengage unexpectedly	Unexpected disengagement of the platoon (platoon does not exist anymore)	Haz_22

3.4. Risk Assessment

In total 208 different cases (combinations of malfunctions and operational situations) were analysed during the risk assessment activity. The following section summarises the results of the risk assessment activity, showing for each one of the identified hazards the "worst-case" driving scenarios under which the highest ASILs has been established.

The complete Risk Assessment of the Platooning Autonomous Function can be found in the Appendix B.

3.4.1. Malfunction Category: V2V Communication

Hazard: Loss of Path Data – Risk Assessment

Table 13. Risk assessment of the hazard "Loss of path data" – Hazardous event PAF_H01_08

Hazardous event ID	[PAF_HE01_08]
Operational Situation	Dry road – Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode
Comments / possible effects	The following truck perceives information regarding the surrounding environment, but it does not have information regarding the path to follow. This will lead the following truck to drive based only on the perceived information regarding the surrounding environment (e.g. road lanes, other vehicles) (ref[PAF_A13]). While changing lanes, then the truck might switch to the goal to move within its lane only, and this might lead the truck to go back to the previous road lane and stop. This can be a risky manoeuvre, if the truck was moving to another lane to overtake other vehicles or due to a roadway narrowing.
Severity Rating:	S3
Rationale Severity:	Potential impact at medium speed, as per ISO 26262 (ISO26262, 2018) Part 3 – Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E3
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), as per VDA 702 Situation Catalogue
Controllability Rating:	C2
Rationale Controllability:	Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.
ASIL Classification:	B

Hazard: Loss of Path Data - Safety Goals and Functional Safety Requirements

Table 14. Safety Goals and FSRs for the hazard "Loss of path data"

Safety Goals	**PAF_SG01:** Avoid collision due to a loss of path data from the forward truck.
ASIL	**B**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_01:** The forward truck shall provide its current path data in real-time to the following truck via V2V communication. **Rationale:** This FSR assigns an ASIL to the function of providing the current path data for each truck, so that the following trucks can provide coherent steering, braking and throttle actions that do not confuse the traffic external to the platoon and cause accidents **Safe state:** Stop on hard shoulder. **Rationale:** Even if the path to follow is not received by the following truck, it is still able to perceive, localize itself correctly and control the vehicle, so the safest manoeuvre is to find a hard shoulder and stop the truck safely. This would avoid unexpected accidents with other participants of the traffic due to in-lane stationary trucks

Hazard: Incorrect Path Data – Risk Assessment

Table 15. Risk assessment of the hazard "Incorrect path data" – Hazardous event PAF_H02_13

Hazardous event ID	[PAF_HE02_13]
Operational Situation	Dry road – Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck has wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions may cause an increase in the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This can also result in an unintended full braking of the following truck. Risk of collision if the following external vehicles do not react safety.
Severity Rating:	S3
Rationale Severity:	Potential front collision at medium/high speed with other vehicles.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control at high speed. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights, he may have to perform an evasive manoeuvre to avoid collision.
ASIL Classification:	D

Hazard: Incorrect Path Data – Safety Goals and Functional Safety Requirements

Table 16. Safety Goals and FSRs for the hazard "Incorrect path data"

Safety Goals	**PAF_SG02:** Avoid collision due to a provision of incorrect path data from the forward truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_01:** The forward truck shall provide its current path data in real-time to the following truck via V2V communication. **Rationale:** This FSR assigns an ASIL to the function of providing the current path data for each truck, so that the following trucks can provide coherent steering, braking and throttle actions that do not confuse the traffic external to the platoon and cause accidents. **Safe state:** Stop on hard shoulder. **Rationale:** Even if the path to follow is not received by the following truck, it is still able to perceive, localize itself correctly and control the vehicle, so the safest manoeuvre is to find a hard shoulder and stop the truck safely. This would avoid unexpected accidents with other participants of the traffic due to in-lane stationary trucks
	PAF_FSR_02: Each following truck shall be able to independently validate path information coming from the forward truck. **Rationale:** This FSR assigns an ASIL to the function of confirming the current path data for each truck. In this way the following trucks will at least be able to confirm that the values provided by the forward truck are within the range observed and confirm that the forward truck is in the same lane as observed. **Safe state:** Stop on hard shoulder. **Rationale:** Even if the path values received by the following truck cannot be validated, it is still able to perceive, localize itself correctly and control the vehicle, so the safest manoeuvre is to find a hard shoulder and stop the truck safely. This would avoid unexpected accidents with other participants of the traffic due to in-lane stationary trucks.

	PAF_FSR_03: The path data communicated by the truck shall have an accuracy of at least 10 cm in lateral and longitudinal axes. **Rationale:** This FSR aims to define the accuracy with which the path data shall be provided to allow the following truck to accurately localize the lane and the trajectory of the forward truck. The required accuracy is similar to the localization accuracy expected from autonomous vehicles. ***NOTE: the analysis has not considered all the possible scenarios. The "10 cm" value is an indicative value, based on engineering judgments and previous projects' experience; it shall be confirmed through validation.*** **Safe state:** Stop on hard shoulder. **Rationale:** Even if the path to follow is not received by the following truck with the required accuracy, it is still able to perceive, localize itself correctly and control the vehicle, so the safest manoeuvre is to find a hard shoulder and stop the truck safely. This would avoid unexpected accidents with other participants of the traffic due to in-lane stationary trucks.

3.4.2. Malfunction Category: Braking

Hazard: Loss of deceleration by the following truck – Risk Assessment

Table 17. Risk assessment of the hazard "Loss of deceleration by the following truck" - [PAF_HE05_01]

Hazardous event ID	[PAF_HE05_01]
Operational Situation	Dry road – Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed or to stop in order to avoid a collision, but it doesn't. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail (ref[PAF_A07]). Potential multiple-vehicle collisions at high speed and potential injuries for the occupants of the trucks and for the other road users.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Uncontrollable. The following truck is driverless (ref[PAF_A08]),so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.
ASIL Classification:	D

Table 18. Risk assessment of the hazard "Loss of deceleration by the following truck" - [PAF_HE05_02]

Hazardous event ID	[PAF_HE05_02]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed or to stop in order to avoid a collision, but it doesn't. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail (ref[PAF_A07]). Potential multiple-vehicle collisions at high speed and potential injuries for the occupants of the trucks and for the other road users.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3..
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time)
Controllability Rating:	C3
Rationale Controllability:	Uncontrollable. The following truck is driverless (ref[PAF_A08]),so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.
ASIL Classification:	D

Table 19. Risk assessment of the hazard "Loss of deceleration by the following truck" - [PAF_HE05_11]

Hazardous event ID	[PAF_HE05_11]
Operational Situation	Dry road - Cut-in High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed and keep a safe distance to the in-front vehicle, but it doesn't. The following truck can have a rear-end collision with the forward vehicle at high speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4.
Controllability Rating:	C3
Rationale Controllability:	Uncontrollable. The following truck is driverless (ref[PAF_A08]), so a deceleration to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The driver of the in-front vehicle cannot foresee and avoid that impact.
ASIL Classification:	D

Hazard: Loss of deceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 20. Safety Goals and FSRs for the hazard "Loss of deceleration by the following truck"

Safety Goals	**PAF_SG03:** Avoid collision due to a loss of deceleration by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_04:** The following truck shall brake autonomously to maintain a safe distance to the forward truck. **Rationale:** This FSR aims to ensure the following trucks always decelerate to maintain a safe distance to the forward truck. **Safe state:** Restore target deceleration. **Rationale:** Since there are no drivers in the following trucks to react (e.g. steer), loss of deceleration is not acceptable. i.e. the system has to be fault tolerant. ***A redundant braking system may be required to enter this safe state.***
	PAF_FSR_05: The following trucks shall brake autonomously to maintain a safe distance to intruders. **Rationale:** This FSR aims to ensure that the following truck always decelerate to maintain safe distance to intruders (e.g. cut-in vehicles, motorcyclists, pedestrians, etc..). **Safe state:** Restore target deceleration. **Rationale:** Since there are no drivers in the following trucks to react (e.g. steer), loss of deceleration is not acceptable. i.e. the system has to be fault tolerant. ***A redundant braking system may be required to enter this safe state***.
	PAF_FSR_03: The path data communicated by the truck shall have an accuracy of at least 10 cm in each axis. **Rationale:** This FSR aims to define the accuracy with which the path data shall be provided to allow the following truck to accurately localize the lane and the trajectory of the forward truck. The required accuracy is similar to the localization accuracy expected from autonomous vehicles.

	NOTE: the analysis has not considered all the possible scenarios. The "10 cm" value is an indicative value, based on engineering judgments and previous projects experience, that shall be confirmed through validation. **Safe state:** Stop on hard shoulder. **Rationale:** Even if the path to follow is not received with the required accuracy, it is still able to perceive, localize itself correctly and control the vehicle, so the safest manoeuvre is to find a hard shoulder and stop the truck safely. This would avoid unexpected accidents with other participants of the traffic due to in-lane stationary trucks.

Hazard: Excessive deceleration by the following truck – Risk Assessment

Table 21. Risk assessment of the hazard "Excessive deceleration by the following truck" - [PAF_HE06_05]

Hazardous event ID	[PAF_HE06_05]
Operational Situation	Driving at darkness without road visible - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles may not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E3
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), as per VDA 702 Situation Catalogue.
Controllability Rating:	C1
Rationale Controllability:	Simply controllable at high speed without road visible (99% or more of drivers are able to avoid harm). It is assumed that the

	vehicles around the platoon are manually driven (ref[PAF_A09]). Since this is a true braking situation, the following drive can notice the brake lights and the truck braking and react appropriately.
ASIL Classification:	A

Hazard: Excessive deceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 22. Safety Goals and FSRs for the hazard "Excessive deceleration by the following truck"

Safety Goals	**PAF_SG04:** Avoid collision due to an excessive deceleration by the following truck.
ASIL	**A**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_06:** When decelerating above 4m/s^2 (emergency braking limits), the actual deceleration of the truck shall not exceed by more than 10% of the required deceleration. **Rationale:** Excessive braking at lower deceleration values (i.e. 10% error at 0.2g) is controllable in general and it does not cause rear end collisions. This FSR aims to avoid excessive braking of large values and to define an upper-bound threshold for functional safety (10%). ***NOTE: the analysis has not considered all the possible scenarios. The 10% value is an indicative value, based on engineering judgments and previous projects experience; it shall be confirmed through validation.*** **Safe state:** Restore target deceleration. **Rationale:** Restoring target deceleration will allow the following truck to maintain control and avoid rear/end collision with the following road users. ***A redundant braking system may be required to enter this safe state.***

Hazard: Insufficient deceleration by the following truck – Risk Assessment

Table 23. Risk assessment of the hazard "Insufficient deceleration by the following truck" - [PAF_HE07_01]

Hazardous event ID	[PAF_HE07_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed or to stop in order to avoid collision, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail (ref[PAF_A07]). Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).
Severity Rating:	S3
Rationale Severity:	Fatal injuries due to a potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]),so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Difficult for them to perform corrective manoeuvres and avoid collision.
ASIL Classification:	D

Table 24. Risk assessment of the hazard "Insufficient deceleration by the following truck" - [PAF_HE07_02]

Hazardous event ID	[PAF_HE07_02]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed or to stop in order to avoid a collision, but the following truck decelerates less than required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail (ref[PAF_A07]). Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).
Severity Rating:	S3
Rationale Severity:	Fatal injuries due to a potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time)
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]),so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Difficult for them to perform corrective manoeuvres and avoid collision.
ASIL Classification:	D

Table 25. Risk assessment of the hazard "Insufficient deceleration by the following truck" - [PAF_HE07_10]

Hazardous event ID	[PAF_HE07_10]
Operational Situation	Dry road - Cut-in High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to reduce the speed and keep a safe distance to the in- vehicle in front, but the following truck decelerates less than required. The following truck can have a rear-end collision with the forward vehicle at medium relative speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail. Potential fatal injuries for the road users.
Severity Rating:	S3
Rationale Severity:	Potential impact at medium speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4.
Controllability Rating:	C3
Rationale Controllability:	Uncontrollable. The following truck is driverless (ref[PAF_A08]), so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The driver of the in-front vehicle cannot foresee and avoid that impact.
ASIL Classification:	D

Hazard: Insufficient deceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 26. Safety Goals and FSRs for the hazard "Insufficient deceleration by the following truck"

Safety Goals	**PAF_SG05:** Avoid collision due to an insufficient deceleration by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_07:** When decelerating, the actual deceleration of the truck shall not be less than 10% of the required deceleration. **Rationale:** An insufficient deceleration can be critical at any deceleration value. The FSR aims to avoid insufficient braking defining a lower-bound threshold for functional safety. ***NOTE: the analysis has not considered all the possible scenarios. The 10% value is an indicative value, based on engineering judgments and previous projects' experience; it shall be confirmed through validation.*** **Safe state:** Restore target deceleration. **Rationale:** Restoring target deceleration will allow the following truck to maintain a safe distance to the forward truck. ***A redundant braking system may be required to enter this safe state.***

Hazard: Unintended deceleration by the following truck – Risk Assessment

Table 27. Risk assessment of the hazard "Unintended deceleration by the following truck" - [PAF_HE08_11]

Hazardous event ID	[PAF_HE08_11]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck decelerates unexpectedly forcing the following vehicle to react (brake/steer) quickly to avoid collision. Possible collision at medium/high speed.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The platooning function cannot perform corrective manoeuvre (ref[PAF_A11]). It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect a deceleration. Even when he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights, he should perform an evasive manoeuvre to avoid collision.
ASIL Classification:	D

Hazard: Unintended deceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 28. Safety Goals and FSRs for the hazard "Unintended deceleration by the following truck"

Safety Goals	**PAF_SG06:** Avoid collision due to an unintended deceleration by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_08:** The following truck shall not decelerate unless the platooning controller requests deceleration. **Rationale:** Deceleration shall be provided only when needed, in accordance with the current driving situation. **Safe state:** Restore target deceleration. **Rationale:** This will avoid unexpected manoeuvres by the following trucks that might result in loss of the vehicle control or collisions with following vehicles**.**

3.4.3. Malfunction Category: Acceleration

Hazard: Excessive acceleration by the following truck – Risk Assessment

Table 29. Risk assessment of the hazard "Excessive acceleration by the following truck" - [PAF_HE10_01]

Hazardous event ID	[PAF_HE10_01]
Operational Situation	Dry road – Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to increase the speed of the following truck, but the acceleration of the following truck is excessive. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail. Potential multiple-vehicle collisions at high speed.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The nearby and following vehicles have limited time to react. The following vehicles shall apply the needed brake pressure/steering and perform a corrective manoeuvre to avoid a collision. .
ASIL Classification:	D

Table 30. Risk assessment of the hazard "Excessive acceleration by the following truck" - [PAF_HE10_02]

Hazardous event	[PAF_HE10_02]
Operational Situation	Dry road – Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to increase the speed of the following truck, but the acceleration is excessive. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intended path and move towards other lanes or the guard rail. Potential multiple-vehicle collisions at high speed.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The nearby and following vehicles have limited time to react. The following vehicles shall apply the needed brake pressure/steering and perform a corrective manoeuvre to avoid a collision.
ASIL Classification:	D

Table 31. Risk assessment of the hazard "Excessive acceleration by the following truck" - [PAF_HE10_06]

Hazardous event ID	[PAF_HE10_06]
Operational Situation	Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The following truck accelerates more than needed. The following truck may have a collision with the forward truck. After the impact, the truck may invade another lane or go off the road, having a collision at low speed with other road users. Potential collisions with pedestrians or side impact with other vehicles at low speed.
Severity Rating:	S3
Rationale Severity:	Pedestrian/bicycle accident and side impact with low speed, as per [Ref 1] Part 3 - Table B.2.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.
ASIL Classification:	D

Table 32. Risk assessment of the hazard "Excessive acceleration by the following truck" - [PAF_HE10_10]

Hazardous event ID	[PAF_HE10_10]
Operational Situation	Dry road - Approaching a junction/intersection with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	While approaching a junction, the following truck accelerates more than required. The following truck can have a rear-end collision with the forward truck at low speed. After the impact, the truck may invade another lane or go off the road at low speed. Potential injuries for the occupants of the following truck and for the pedestrians.
Severity Rating:	S3
Rationale Severity:	Pedestrian accident
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.
ASIL Classification:	D

Hazard: Excessive acceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 33. Safety Goals and FSRs for the hazard "Excessive acceleration by the following truck"

Safety Goals	**PAF_SG08:** Avoid collision due to an excessive acceleration by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_09:** The requested acceleration shall maintain safe distance to the forward truck and/or intruders. **Rationale:** An excessive acceleration can lead to front/rear collision. Acceleration shall be such as to always keep a safe distance with the other road users. **Safe state:** Disable acceleration. **Rationale:** When the system cannot accelerate correctly, acceleration shall be disabled, and the other systems shall be informed. No redundancy is expected from the propulsion system. So, loss of acceleration is acceptable when safe throttle control can be guaranteed.
	PAF_FSR_10: The requested acceleration shall maintain traction in all weather conditions. **Rationale:** An excessive acceleration in adverse weather conditions (rain, snow) can lead to a loss of control of the vehicle. This FSR aims to avoid that. **Safe state:** Disable acceleration. **Rationale:** When the system cannot correct the excessive acceleration, acceleration shall be disabled, and the other systems shall be informed. No redundancy is expected from the propulsion system. So, loss of acceleration is acceptable when safe throttle control cannot be guaranteed.
	PAF_FSR_11: The requested acceleration shall maintain yaw stability in all road types and conditions. **Rationale:** An excessive acceleration shall not generate unintended yaw as this could result in the truck shifting from the centre of the lane to the right or to the left. This FSR aims to prevent unstable yaw of the truck. **Safe state:** Disable acceleration.

	Rationale: When the system cannot correct the excessive acceleration, acceleration shall be disabled, and the other systems shall be informed**.**

Hazard: Unintended acceleration by the following truck – Risk Assessment

Table 34. Risk assessment of the hazard "Unintended acceleration by the following truck" - [PAF_HE12_05]

Hazardous event ID	[PAF_HE12_05]
Operational Situation	Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The following truck accelerates unexpectedly. The vehicle might invade the opposite lane or go off the road. This might lead to a possible collision with other vehicles or stationary objects. Potential injuries for the occupants of the following truck.
Severity Rating:	S2
Rationale Severity:	Potential impact at low speed, as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.
Exposure Rating:	E3
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),as per VDA 702 Situation Catalogue.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a corrective manoeuvre is not possible.
ASIL Classification:	B

Hazard: Unintended acceleration by the following truck – Safety Goals and Functional Safety Requirements

Table 35. Safety Goals and FSRs for the hazard "Unintended acceleration by the following truck"

Safety Goals	**PAF_SG09:** Avoid collision due to an excessive acceleration by the following truck.
ASIL	**B**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_09:** The requested acceleration shall maintain safe distance to the forward truck and/or intruders. **Rationale:** An unintended acceleration can lead to front/rear collision. Acceleration shall be such as to always keep a safe distance to the forward road users. **Safe state:** Disable acceleration. **Rationale:** When the system cannot accelerate correctly, acceleration shall be disabled, and the other systems shall be informed. No redundancy is expected from the propulsion system. So, loss of acceleration is acceptable when safe throttle control can be guaranteed.

3.4.4. Malfunction Category: Steering

Hazard: Loss of lateral motion by the following truck – Risk Assessment

Table 36. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_01]

Hazardous event ID	[PAF_HE13_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to steer the following truck, but it doesn't. The loss of steering may result in the following truck leaving its current lane and enter other lanes or the side of the road.
Severity Rating:	S3
Rationale Severity:	Potential fatal injuries due to impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]), but it is difficult to perform an evasive manoeuvre and avoid an impact at high speed.
ASIL Classification:	D

Table 37. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_02]

Hazardous event ID	[PAF_HE13_02]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to steer the following truck, but it doesn't. The loss of steering may result in the following truck leaving its current lane and enter other lanes or the side of the road.
Severity Rating:	S3
Rationale Severity:	Potential fatal injuries due to impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time).
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]), but it is difficult to perform an evasive manoeuvre and avoid an impact at high speed.
ASIL Classification:	D

Table 38. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_04]

Hazardous event ID	[PAF_HE13_04]
Operational Situation	Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to steer the following truck within a roundabout, but it doesn't. The loss of lateral displacement control can lead the following truck to move from the lane centre to other lanes or the side road.
Severity Rating:	S3
Rationale Severity:	Pedestrian accident and side impact for other vehicles Intelligent traffic lights are present (ref[PAF_A10]) and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.
ASIL Classification:	D

Table 39. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_06]

Hazardous event ID	[PAF_HE13_06]
Operational Situation	Dry road - Approaching a junction/intersection with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to steer the following truck approaching a junction/intersection, but it doesn't. The loss of lateral displacement control can lead the following truck to move from the lane centre to other lanes or the side road. The following truck might go off the road or have a collision with other vehicles, pedestrians and stationary objects (e.g. guard rail) at low speed.
Severity Rating:	S3
Rationale Severity:	Pedestrian accident and side impact for other vehicles Intelligent traffic lights are present (ref[PAF_A10]) and can regulate the access of other vehicles within the junction, but not prevent the presence of pedestrians.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.
ASIL Classification:	D

Table 40. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_12]

Hazardous event ID	[PAF_HE13_12]
Operational Situation	Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck loses the lateral displacement control. Due to this, it cannot anymore change lane and follow the forward truck. This might lead to a split of the platoon.
Severity Rating:	S3
Rationale Severity:	Potential fatal injuries due to impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The other road users have little time to react and perform an evasive manoeuvre.
ASIL Classification:	D

Table 41. Risk assessment of the hazard "Loss of lateral motion by the following truck" - [PAF_HE13_14]

Hazardous event ID	[PAF_HE13_14]
Operational Situation	Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The following truck cannot control its lateral displacement due to a pre-existing fault of the platooning function. The following truck might go off its own lane and have collision with other road users or the guard rail. Potential collisions also with oncoming vehicles.
Severity Rating:	S3
Rationale Severity:	Potential fatal injuries due to impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per Table B.3, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The oncoming vehicles have little time to react and to perform an evasive manoeuvre.
ASIL Classification:	D

Hazard: Loss of lateral motion by the following truck – Safety Goals and Functional Safety Requirements

Table 42. Safety Goals and FSRs for the hazard "Loss of lateral motion by the following truck"

Safety Goals	**PAF_SG10:** Avoid collision due to a loss of lateral motion by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_12:** The following truck shall steer autonomously to keep following the path. **Rationale:** This FSR aims to ensure the lateral motion control of the truck is always available. **Safe state:** Restore target steering value. **Rationale:** Restore target steering will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system may be required to enter this safe state.***
	PAF_FSR_13: The following trucks shall steer autonomously to follow the path/trajectory requested by autonomous controller. **Rationale:** The following trucks shall steer correctly to follow the requested trajectory. ***NOTE: The current definition of the PAF does not provide enough details on the Autonomous Emergency steering to be able to define safety requirements for this function. Therefore, it has not been considered for the preliminary Functional safety analysis.*** **Safe state:** Restore target steering value. **Rationale:** Restore target steering will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system may be required to enter this safe state.***
	PAF_FSR_14: The trajectory/path to follow defined by the following trucks shall avoid collision with objects the next to path, the forward truck, intruders and other big size obstacles. **Rationale:** This FSR aims to ensure the path to follow is generated correctly by the following trucks for their internal

	motion controls. This requirement is specifically aimed at the following trucks, since it is assumed that the leading truck is manually driven. Each truck only communicates its current path to the following trucks, not the target path. **Safe state:** Restore target steering value. **Rationale:** Restore target steering will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system may be required to enter this safe state.***

Hazard: Excessive lateral motion by the following truck – Risk Assessment

Table 43. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_01]

Hazardous event ID	[PAF_HE14_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck is driving at high speed on the highway and controlling its lateral displacement within the lane, but the correction is excessive. This might lead the following truck to move out from the lane. The other road users may suffer a side impact.
Severity Rating:	S3
Rationale Severity:	Side impact for other vehicles.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control at high speed. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Table 44. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_02]

Hazardous event ID	[PAF_HE14_02]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck is driving at high speed on the highway and controlling its lateral displacement within the lane, but the correction is excessive. This might lead the following truck to move out from the lane. The other road users may suffer a side impact.
Severity Rating:	S3
Rationale Severity:	Side impact for other vehicles.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time).
Controllability Rating:	C3
Rationale Controllability:	Difficult to control at high speed. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Table 45. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_04]

Hazardous event ID	[PAF_HE14_04]
Operational Situation	Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The following truck steers excessively within a roundabout. This might lead the following truck to invade another lane. The other road users may suffer a side impact. Possible collision also with pedestrians.
Severity Rating:	S3
Rationale Severity:	Pedestrians accident. Intelligent traffic lights are present (ref[PAF_A10]) and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.
ASIL Classification:	D

Table 46. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_06]

Hazardous event ID	[PAF_HE14_06]
Operational Situation	Dry road - Approaching a junction/intersection with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The following truck steers excessively approaching a junction/intersection. This might lead the following truck to go off the lane. The worst case can be a collision at low speed with other vehicles or pedestrians.
Severity Rating:	S3
Rationale Severity:	Pedestrians accident. Intelligent traffic lights are present (ref[PAF_A10]) and can regulate the access of other vehicles to the junction, but not prevent the presence of pedestrians.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.
ASIL Classification:	D

Table 47. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_08]

Hazardous event ID	[PAF_HE14_08]
Operational Situation	Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode
Comments / possible effects	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).
Severity Rating:	S3
Rationale Severity:	Side impact for other vehicles.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform corrective manoeuvre at medium speed to avoid collision.
ASIL Classification:	D

Table 48. Risk assessment of the hazard "Excessive lateral motion by the following truck" - [PAF_HE14_10]

Hazardous event ID	[PAF_HE14_10]
Operational Situation	Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).
Severity Rating:	S3
Rationale Severity:	Side impact for other vehicles.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per VDA 702 Situation Catalogue.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control at high speed. Difficult for the road users to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Hazard: Excessive lateral motion by the following truck – Safety Goals and Functional Safety Requirements

Table 49. Safety Goals and FSRs for the hazard "Excessive lateral motion by the following truck"

Safety Goals	**PAF_SG11:** Avoid collision due to an excessive lateral motion by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_15:** While driving autonomously, the steering shall be provided such that the position of the ego truck shall not deviate from the intended path by more than 20 cm in the lateral direction. **Rationale:** This FSR aims to limit the deviation from the path provided to an acceptable level, since that could result in the truck moving out of the target lane. ***NOTE: the analysis has not considered all the possible scenarios. The "20 cm" value is an indicative value, based on engineering judgments and previous projects experience, that shall be confirmed through validation*** **Safe state:** Vehicle maintains target path. **Rationale:** Maintaining the target path (e.g. restoring target steering) will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system is required to enter this safe state.***

Hazard: Insufficient lateral motion by the following truck – Risk Assessment

Table 50. Risk assessment of the hazard "Insufficient lateral motion by the following truck" - [PAF_HE15_01]

Hazardous event ID	[PAF_HE15_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck is driving at high speed on the highway and controlling its lateral displacement to stay within the lane, but the lateral control is not sufficient. The following truck might leave its lane and move close to the other road users or the guard rail.
Severity Rating:	S3
Rationale Severity:	Potential collisions at high speed with other road users and potential injuries for the occupants, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Table 51. Risk assessment of the hazard "Insufficient lateral motion by the following truck" - [PAF_HE15_02]

Hazardous event ID	[PAF_HE15_02]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The following truck is driving at high speed on the highway and controlling its lateral displacement to stay within the lane, but the lateral control is not sufficient. The following truck might leaveits lane and move close to the other road users or the guard rail.
Severity Rating:	S3
Rationale Severity:	Potential collisions at high speed with other road users and potential injuries for the occupants, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time).
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Table 52. Risk assessment of the hazard "Insufficient lateral motion by the following truck" - [PAF_HE15_12]

Hazardous event ID	[PAF_HE15_12]
Operational Situation	Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode
Comments / possible effects	The platoon is expected to turn, but the lateral displacement is not sufficient. The following truck might move towards another lane being exposed in a vulnerable position and representing an obstacle for the other road users. The worst case might be a potential collision with oncoming vehicles at low speed.
Severity Rating:	S3
Rationale Severity:	Fatal injuries due to a front collision.
Exposure Rating:	E4
Rationale Exposure:	Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, as per Table B.3, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The oncoming vehicle have very little time to apply brake and steer to avoid a collision.
ASIL Classification:	D

Hazard: Insufficient lateral motion by the following truck – Safety Goals and Functional Safety Requirements

Table 53. Safety Goals and FSRs for the hazard "Insufficient lateral motion by the following truck"

Safety Goals	**PAF_SG12:** Avoid collision due to an insufficient lateral motion by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_15:** While driving autonomously, the steering shall be provided such that the position of the ego truck shall not deviate from the intended path by more than 20 cm in the lateral direction. **Rationale:** This FSR aims to limit the deviation from the path provided to an acceptable level, since that could result in the truck moving out of the target lane. ***NOTE: the analysis has not considered all the possible scenarios. The "20 cm" value is an indicative value, based on engineering judgments and previous projects experience, that shall be confirmed through validation.*** **Safe state:** Vehicle maintains target path. **Rationale:** Maintaining the target path (e.g. restoring target steering) will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system is required to enter this safe state.***

Hazard: Unintended lateral motion by the following truck – Risk Assessment

Table 54. Risk assessment of the hazard "Unintended lateral motion by the following truck" - [PAF_HE16_01]

Hazardous event ID	[PAF_HE16_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platooning function command an unexpected lateral displacement of the following truck. The following truck can move from the centre of the lane to the right or to the left. This might lead to a collision with other road users or the guard rail at high speed.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other vehicles' drivers to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Hazard: Unintended lateral motion by the following truck – Safety Goals and Functional Safety Requirements

Table 55. Safety Goals and FSRs for the hazard "Unintended lateral motion by the following truck"

Safety Goals	**PAF_SG13:** Avoid collision due to an unintended lateral motion by the following truck.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_14:** The trajectory/path to follow defined by the following trucks shall avoid collision with objects next to the path, the forward truck, intruders and other big size obstacles. **Rationale:** This FSR aims to ensure the path is provided correctly. **Safe state:** Restore target steering value. **Rationale:** Restore target steering will allow to maintain the control of the vehicle and to not deviate from the path. NOTE: ***A redundant steering system may be required to enter this safe state.***
	PAF_FSR_15: While driving autonomously, the steering shall be provided such that the position of the ego truck shall not deviate from the intended path by more than 20 cm in the lateral direction. **Rationale:** This FSR aims to limit the deviation from the path provided to an acceptable level, since that could result in the truck moving out of the target lane. ***NOTE: the analysis has not considered all the possible scenarios. The "20 cm" value is an indicative value, based on engineering judgments and previous projects experience; it shall be confirmed through validation*** **Safe state:** Vehicle maintains target path. **Rationale:** Maintaining the target path (e.g. restoring target steering) will allow to maintain the control of the vehicle and to not deviate from the path. ***A redundant steering system is required to enter this safe state.***

3.4.5. Malfunction Category: Human Machine Interface (Following Truck)

Hazard: Unexpected disengagement of the following truck from the platoon – Risk Assessment

Table 56. Risk assessment of the hazard "Unexpected disengagement of the following truck" - [PAF_HE18_09]

Hazardous event ID	[PAF_HE18_09]
Operational Situation	Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode
Comments / possible effects	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment, but it has not a path to follow. This will result in the truck stopping in its path. While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to stop wherever it is. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.
Severity Rating:	S3
Rationale Severity:	Potential impact at medium speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E3
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),as per VDA 702 Situation Catalogue.
Controllability Rating:	C2
Rationale Controllability:	Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.
ASIL Classification:	B

Hazard: Unexpected disengagement of the following truck from the platoon – Safety Goals and Functional Safety Requirements

Table 57. Safety Goals and FSRs for the hazard "Unexpected disengagement of the following truck"

Safety Goals	**PAF_SG15:** Avoid unintended disengagement by the following truck.
ASIL	**B**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_17:** The following truck shall initiate disengage only when any of the below conditions are met: a) disengage is requested by a human operator when stationary. b) disengage is requested by the on-board driver. **Rationale:** This FSR aims to avoid the following truck from disengaging unexpectedly, allowing it only if requested by the driver or while stationary. **Safe state:** N/A. **Rationale:** N/A.

3.4.6. Malfunction Category: Human Machine Interface (Leading Truck)

Hazard: Unexpected engagement of a platoon – Risk Assessment

Table 58. Risk assessment of the hazard "Unexpected engagement of a platoon" - [PAF_HE21_01]

Hazardous event ID	[PAF_HE21_01]
Operational Situation	Dry road - Stopped at the hub No platoon engaged
Comments / possible effects	A platoon is formed unexpectedly and as a consequence the following truck might start moving unexpectedly. People might be present working on the following trucks or loading/unloading cargo and experience a fall/impact due to the unexpected movement.
Severity Rating:	S3
Rationale Severity:	Potential injuries for people working on the following trucks or loading/unloading cargo.
Exposure Rating:	E1
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). Since the driving situation considered is "truck stopped at the hub and people present in front of it", the exposure may be lower. Exposure reduced to the lower value (E1).
Controllability Rating:	C3
Rationale Controllability:	People will be occupied working. They will not be expecting the truck to move and they might have no time to react and avoid injuries.
ASIL Classification:	A

Hazard: Unexpected engagement of a platoon – Safety Goals and Functional Safety Requirements

Table 59. Safety Goals and FSRs for the hazard "Unexpected engagement of platoon"

Safety Goals	**PAF_SG16:** Avoid unexpected engagement of the platoon.
ASIL	**A**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_18:** The following truck shall initiate engaging only when all of the below conditions are met: a) engage is requested by the following truck when stationary. b) trucks are ready to be driven. c) engaging is requested by a human operator. **Rationale:** This FSR aims to allow the engagement procedure only under specific conditions in order to avoid unintended movement of the truck while people are loading/unloading the trucks. **Safe state:** Vehicle kept disengaged and/or stationary. **Rationale:** If one of the required conditions cannot be confirmed, platooning shall not be activated.

Hazard: Unexpected disengagement of the platoon by the lead truck – Risk Assessment

Table 60. Risk assessment of the hazard "Unexpected disengagement of the platoon by the lead truck" - [PAF_HE22_08]

Hazardous event ID	[PAF_HE22_08]
Operational Situation	Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode
Comments / possible effects	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path (ref[PAF_A13]). While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to stop wherever it is. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.
Severity Rating:	S3
Rationale Severity:	Potential impact at medium speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E3
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),as per VDA 702 Situation Catalogue.
Controllability Rating:	C2
Rationale Controllability:	Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.
ASIL Classification:	B

Hazard: Unexpected disengagement of the platoon by the lead truck – Safety Goals and Functional Safety Requirements

Table 61. Safety Goals and FSRs for the hazard "Unexpected disengagement of platoon by the lead truck"

Safety Goals	**PAF_SG17:** Avoid unexpected disengagement of the platoon by the lead truck.
ASIL	**B**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_19:** The lead truck shall initiate disengage only when the platoon is stationary. **Rationale:** An unexpected disengagement can result in the following truck driving only based on the perceived information. Depending on the driving situation, this might lead to unexpected manoeuvres of the truck (e.g. sudden stop in the path). This FSR aims to allow the disengagement procedure by the lead truck only while platoon is stationary. **Safe state:** N/A. **Rationale:** N/A.

3.4.7. Other Malfunctions (coming from common failures)

Hazard: Total Loss of vehicle control – Risk Assessment

Table 62. Risk assessment of the hazard "Total loss of vehicle control" - [PAF_HE17_01]

Hazardous event ID	[PAF_HE17_01]
Operational Situation	Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode
Comments / possible effects	The platooning function loses the control of acceleration, braking and steering of the following truck. This will result in the truck driving without any control, moving out of its lane and having a collision with other road users or stationary objects.
Severity Rating:	S3
Rationale Severity:	Potential impact at high speed, as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.
Exposure Rating:	E4
Rationale Exposure:	Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), as per Table B.2, ISO 26262-3.
Controllability Rating:	C3
Rationale Controllability:	Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other vehicles' drivers to perform a corrective manoeuvre at high speed to avoid collision.
ASIL Classification:	D

Hazard: Total Loss of vehicle control – Safety Goals and Functional Safety Requirements

Table 63. Safety Goals and FSRs for the hazard "Total loss of vehicle control"

Safety Goals	**PAF_SG14:** Avoid collision due to complete loss of vehicle control.
ASIL	**D**
Functional Safety Requirements, Rationale and Safe state	**PAF_FSR_16:** While driving in autonomous mode, the following vehicle platooning controller shall always be available for vehicle control. **Rationale:** This FSR assures that all the 3 functions of steering, braking and throttle control are not lost simultaneously due to a failure (e.g. power loss) of the autonomous controller. **Safe state:** Restore platooning controller. **Rationale:** This safe state aims to ensure the presence of a redundant controller in order to avoid a complete loss of vehicle control due to power loss, etc…

4. SUMMARY AND CONCLUSION

The Hazard Analysis and Risk Assessment activity was carried out to understand the safety critical malfunctions arising from the Platooning Support Function and the Platooning Autonomous Function. Based on their associated risk, ASIL levels have been assigned and top-level safety requirements have been derived for the safety critical hazards in the form of safety goals.

As an iterative development process has been followed for the safety analysis of the platooning support function; the HARA and the associated top-level safety requirements generated at each stage of the project has been continuously updated throughout the project.

Since the V2V communication is the fundamental enabler of the platooning function, malfunctions communicated by one truck via V2V can result in hazards for the other members of the platoon. Therefore, even though their consequences can be covered by the malfunctions of braking, acceleration or HMI categories, the V2V communication related malfunctions were especially separately analysed at the concept level in the HARA activity.

4.1. Platooning Support Function (PSF)

Hazards arising from different malfunctions of the PSF in the communication, braking, acceleration and HMI categories were considered for the analysis. A total of 43 cases (combination of operational situation and malfunction) were analysed. As a result, 2 cases having an ASIL above QM (Safety critical) have been identified, one classified with an ASIL A and the other one classified with ASIL B. The related hazardous event is the “unintended longitudinal deceleration by the ego vehicle”, and are of concern for other vehicles following the platoon closely. Therefore, “Rear end collision due to unintended braking of the platoon shall be prevented” has been defined as a Safety Goal, with an ASIL B. For this specific safety goal, two functional safety requirements have been defined, FSR_01 and FSR_02:

- FSR_01: The trucks shall have information at the back warning to maintain a safe distance.
- FSR_02: A test vehicle shall follow the platoon to warn/advice road users to maintain safe distance if it is not obeyed.

They define external measures, including other technologies (not electric/electronic technologies); it means they are separate and distinct from the item and they reduce the risks resulting from the malfunctions of the item. For this reason, these FSRs have not an ASIL classification.

4.2. Platooning Autonomous Function (PAF)

Hazards arising from different malfunctions in the V2V communication, V2I communication, perception, braking, acceleration, steering and Human Machine Interface categories were considered for the analysis of the Platooning Autonomous Function. A total of 208 cases

(combination of operational situation and malfunction) were analysed. As a result, 16 Safety Goals have been defined:

- 10 classified with an ASIL D:
  - Avoid collision due to a provision of incorrect path data from the forward truck,
  - Avoid collision due to a loss of deceleration by the following truck,
  - Avoid collision due to an insufficient deceleration by the following truck,
  - Avoid collision due to an unintended deceleration by the following truck,
  - Avoid collision due to an excessive acceleration by the following truck,
  - Avoid collision due to a loss of lateral motion by the following truck,
  - Avoid collision due to an excessive lateral motion by the following truck,
  - Avoid collision due to an insufficient lateral motion by the following truck,
  - Avoid collision due to an unintended lateral motion by the following truck,
  - Avoid collision due to complete loss of vehicle control.
- 4 classified with an ASIL B:
  - Avoid collision due to a loss of path data from the forward truck,
  - Avoid collision due to an unintended acceleration by the following truck,
  - Avoid unintended disengagement by the following truck,
  - Avoid unexpected disengagement of the platoon by the leading truck.
- 2 classified with an ASIL A:
  - Avoid collision due to an excessive deceleration by the following truck,
  - Avoid unexpected engagement of a platoon.

For these specific safety goals, 19 functional safety requirements have been defined. They define measures that are to be implemented by E/E technical solutions to prevent the violation of the corresponding Safety Goals. All them have an ASIL classification.

ASIL D systems for the V2V communication and the autonomous control of steering, braking and propulsion will be needed to avoid/mitigate safety critical hazards. In some cases, redundant systems may be necessary to build a fault tolerant function.

4.3. Next Steps

Since the Platooning Autonomous Function is only a vision for the future of autonomous platooning and no system design or implementation details are available, assumptions made on the requirements and values of ranges and accuracies defined for the requirements are only indicative and are based on engineering judgement. Further research is required to validate the requirements and refine them.

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APPENDIX A – PSF RISK ASSESSMENT

Risk Assessment of Hazard PSF_H01 - Loss of deceleration by the following truck

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -2 m/s² Following vehicle is not informed of braking. [PSF_HE01_01]	T - 1.4s S - 90 km/h Hazard due to a loss/lack of braking information transmitted by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 41.33 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -3,5 m/s² Following vehicle is not informed of braking. [PSF_HE01_02]	T - 1.4s S - 90 km/h Hazard due to a loss/lack of braking information transmitted by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 54.72 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -5 m/s² Following vehicle is not informed of braking. [PSF_HE01_03]	T - 1.4s S - 90 km/h Hazard due to a loss/lack of braking information transmitted by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 65.55 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -8 m/s² Following vehicle is not informed of braking. [PSF_HE01_04]	T - 1.4s S - 90 km/h Hazard due to a loss/lack of braking information transmitted by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 81.83 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -2 m/s² Ego vehicle is not braking [PSF_HE01_05]	T - 1.4s S - 90 km/h Hazard due to a lack of braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 41.33 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -3.5 m/s² Ego vehicle is not braking [PSF_HE01_06]	T - 1.4s S - 90 km/h Hazard due to a lack of braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 54.72 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -5 m/s² Ego vehicle is not braking [PSF_HE01_07]	T - 1.4s S - 90 km/h Hazard due to a lack of braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 65.55 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -8 m/s² Ego vehicle is not braking [PSF_HE01_08]	T - 1.4s S - 90 km/h Hazard due to a lack of braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 81.83 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Risk Assessment of Hazard PSF_H02 - Insufficient deceleration by the following truck

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -2m/s² Following vehicle is informed of braking at -1.5 m/s² [PSF_HE02_01]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 21.13 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -2m/s² Following vehicle is informed of braking at -1.0 m/s² [PSF_HE02_02]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 29.67 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -2m/s² Following vehicle is informed of braking at -0.5m/s² [PSF_HE02_03]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 36.22 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -3.5m/s² Following vehicle is informed of braking at -2.625 m/s² [PSF_HE02_04]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - No collision. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -3.5m/s² Following vehicle is informed of braking at -1.75 m/s2 [PSF_HE02_05]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 38.7 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -3.5m/s² Following vehicle is informed of braking at -0.875 m/s² [PSF_HE02_06]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 47.34 km/h.But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -5 m/s² Following vehicle is informed of braking at -3.75 m/s² [PSF_HE02_07]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - No collision. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -5m/s² Following vehicle is informed of braking at -2.5 m/s2 [PSF_HE02_08]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 46.26 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -5m/s² Following vehicle is informed of braking at -1.25 m/s² [PSF_HE02_09]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 56.81 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -8 m/s² Following vehicle is informed of braking at -6m/s² [PSF_HE02_10]	T - 1.4s S - 90 km/h Platooning function's braking is limited to -3.5 m/s². After this warning will be given to the driver to react.	S0 - No collision. Driver will be warned correctly when deceleration of more than -3.5 m/s² is required. No hazardous consequence in the following truck. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -8m/s² Following vehicle is informed of braking at -4 m/s2 [PSF_HE02_11]	T - 1.4s S - 90 km/h Platooning function's braking is limited to -3.5 m/s². After this warning will be given to the driver to react.	S0 - Will lead to a collision. Impact speed 33.24 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. Driver will be warned correctly when deceleration of more than -3.5 m/s² is required. No hazardous consequence in the following truck. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any vehicle other than the trailing truck Ego vehicle is braking at -8m/s² Following vehicle is informed of braking at -2 m/s² [PSF_HE02_12]	T - 1.4s S - 90 km/h Hazard due to a wrong braking information (less than actual value) from the ego vehicle. Possible Rear-end collision	S0 - Will lead to a collision. Impact speed 68.11 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -2 m/s² Ego vehicle is only braking at -1.5 m/s² [PSF_HE02_13]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 21.13 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -2 m/s² Ego vehicle is only braking at -1 m/s2 [PSF_HE02_14]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 29.67 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -2m/s² Ego vehicle is only braking at -0.5 m/s² [PSF_HE02_15]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 36.22 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -3.5m/s² Ego vehicle is only braking at -2.625 m/s² [PSF_HE02_16]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - No collision. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -3.5m/s² Ego vehicle is only braking at -1.75 m/s2 [PSF_HE02_17]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 38.7 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -3.5m/s² Ego vehicle is only braking at -0.875 m/s² [PSF_HE02_18]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 47.34 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -5m/s² Ego vehicle is only braking at -2.5 m/s2 [PSF_HE02_19]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 46.26 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -5m/s² Ego vehicle is only braking at -1.25 m/s² [PSF_HE02_20]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 56.81 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Forward vehicle is braking at -8m/s² Ego vehicle is only braking at -2 m/s² [PSF_HE02_21]	T - 1.4s S - 90 km/h Hazard due to insufficient braking by the ego vehicle. Possible rear-end collision	S0 - Will lead to a collision. Impact speed 68.11 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Risk Assessment of Hazard PSF_H03 - Unintended deceleration by the following truck

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Other vehicles closely following behind the platoon Time gap to the trailing traffic ≥ 1 sec (foreseeable misuse) [PSF_H03_01]	T - 1.0s (with respect to the trailing traffic) S - 90 km/h Rear-end collision	S3 - Externally following vehicle crashes into the platoon. Impact speed 45.9 km/h. Since availablilty of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced. E4 - Normal driving conditions where the external vehicles following the platoon are driving with a timegap of 1s. C1 - TTC is 3.7 seconds. The overall delay in driver reaction: 1.55 sec. (1.55 s of reaction time- Köller Model (attentive following vehicle's driver)). External vehicle's driver has around 2.15 s to react and avoid collision. A minimum deceleration of more than -4.2 m/s2 is required to avoid collision. Simply controllable (More than 99% of average drivers are able to avoid harm) as this is normal driving situation where only braking is required by the following driver to avoid harm.	B
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Other vehicles closely following behind the platoon Time gap to the trailing traffic < 1 sec [PSF_H03_02]	T - 0.8s (with respect to the trailing traffic) S - 90 km/h Rear-end collision	S3 - Externally following vehicle crashes into the platoon. Impact speed 40.86 km/h. Since availablilty of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced. E3 - Medium probability of having external vehicles following the platoon with a time gap less than 1 sec on a highway C1 - TTC is 3.3 seconds. The overall delay in driver reaction: 1.55 sec. (1.55 s of reaction time- Köller Model (attentive following vehicle's driver)). External vehicle's driver has around 1.75 s to react and avoid collision. A minimum deceleration of more than -4.5 m/s2 is required to avoid collision. It is not controllable. Simply controllable (More than 99% of average drivers are able to avoid harm) as this is normal driving situation where only braking is required by the following driver to avoid harm.	A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Other vehicles closely following behind the platoon Time gap to the trailing traffic ≥ 1 sec (foreseeable misuse) [PSF_H03_03]	T - 1.0s (with respect to the trailing traffic) S - 90 km/h Rear-end collision	S3 - Externally following vehicle crashes into the platoon. Impact speed 34.85 km/h. Since availablilty of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced. E4 - Normal driving conditions where the external vehicles following the platoon are driving with a timegap of 1s. C0 - TTC is 4.9 seconds. The overall delay in driver reaction: 1.55 sec. (1.55 s of reaction time- Köller Model (attentive following vehicle's driver)). External vehicle's driver has around 3.35 s to react and avoid collision. A minimum deceleration of -2.2 m/s2 is required to avoid collision. Controllable in general.	QM
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Other vehicles closely following behind the platoon Time gap to the trailing traffic < 1 sec [PSF_H03_04]	T - 0.8s (with respect to the trailing traffic) S - 90 km/h Rear-end collision	S3 - Externally following vehicle crashes into the platoon. Impact speed 31.25 km/h. Since availablilty of AEB cannot be assumed for the vehicles outside the platoon, severity cannot be reduced. E3 - Medium probability of having external vehicles following the platoon with a time gap less than 1 sec on a highway. C0 - TTC is 4.4 seconds. The overall delay in driver reaction: 1.55 sec. (1.55 s of reaction time- Köller Model (attentive following vehicle's driver)). External vehicle's driver has around 2.85 s to react and avoid collision. A minimum deceleration of -2.3 m/s2 is required to avoid collision. Controllable in general.	QM

Risk Assessment of Hazard PSF_H04 - Unintended acceleration by following truck

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Engaging to Platoon Ego vehicle is any truck in the platoon other than the leading truck Ego vehicle speed is 35 km/h Forward vehicle speed is 30 km/h Unintended longitudinal acceleration of 0.9 m/s² This is a situation where the tracks agree to platoon in a parking lot and start together. The forward truck is going at slower speed for the following truck to catch-up. [PSF_H04_01]	T - 1.0s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 15.19 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Ego vehicle speed is 30 km/h Forward vehicle speed is 30 km/h Unintended longitudinal acceleration of 0.9 m/s² [PSF_H04_02]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 11.96 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Ego vehicle speed is 80 km/h Forward vehicle speed is 80 km/h Unintended longitudinal acceleration of 0.4 m/s² [PSF_H04_03]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 17.77 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Small downhill (7% gradient) Ego vehicle speed is 30 km/h Forward vehicle speed is 30 km/h Unintended longitudinal acceleration of 2 m/s² [PSF_H04_04]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 23.34 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Platooning (Steady state) Ego vehicle is any truck in the platoon other than the leading truck Platooning in downhill (7% gradient) Ego vehicle speed is 80 km/h Forward vehicle speed is 80 km/h Unintended longitudinal acceleration of 2 m/s² [PSF_H04_05]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 39.18 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Situation & [Hazardous Event ID]	Time Gap(T)/Speed(S)/Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is any vehicle other than the leading truck Ego vehicle speed is 80 km/h Preceding vehicle starts decelerating at -0.5 m/s^2 (due to any driving situation) Ego vehicle malfunctions (Unintended longitudinal acceleration of 0.5 m/s^2) [PSF_H04_06]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 27.87 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Disengage Platoon Ego vehicle is any vehicle other than the leading truck Ego vehicle speed is 80 km/h Preceding vehicle starts decelerating at -2.0 m/s^2 (due to any driving situation) Ego vehicle malfunctions (Unintended longitudinal acceleration of 0.5 m/s^2) [PSF_H04_07]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 43.22 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A
Disengage Platoon Ego vehicle is any vehicle other than the leading truck Ego vehicle speed is 80 km/h Preceding vehicle starts decelerating at -3.5 m/s^2 (due to any driving situation) Ego vehicle malfunctions (Unintended longitudinal acceleration of 0.5 m/s^2) [PSF_H04_08]	T - 1.4s S - 90 km/h Rear-end collision	S0 - Will lead to a collision. Impact speed 54.96 km/h. But since each truck is fitted with production approved AEB system which works independently of the platooning function, the collision will be prevented within the platoon. E - N/A C - N/A	N/A

Risk Assessment of Hazard PSF_H05 - Lack of steering by the following truck drivers (Lead truck driver steers assuming platoon is inactive)

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Platooning (Steady state) Ego vehicle is the lead vehicle Lane change required due to road conditions (blocked, construction, etc..) - Or over taking scenario after disengage request was sent [PSF_H05_01]	T - 1.4s S - 90 km/h Following trucks may collide with the obstacle	S3 - Collisions between trucks and other road obstacle like construction zones, etc can be life threatening. E - How often does the driver need to perform steering manoeuvre to avoid collision. Exposure for overtaking as per Table B3, part 3 C0 - Controllable in general by trained test drivers.	N/A
Platooning (Steady state) Ego vehicle is the lead vehicle Steering manoeuvre (in the same lane) required to avoid collision with the obstacle on the road shoulder [PSF_H05_02]	T - 1.4s S - 90 km/h Following trucks may collide with the obstacle	S3 - Collisions with obstacles on the lane can be life threatening. E2 - Exposure for Evasive manoeuvre as per the table B3, part 3 C0 - Controllable in general by trained test drivers.	N/A

APPENDIX B – PAF RISK ASSESSMENT

Risk Assessment of Hazard PAF_H01 - Loss of path data

Note – *Exposure based on frequency is not required for cases of loss of path data because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE01_01]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. On highway, this might leave the platoon in a vulnerable position.	S3 - Potential impact at high speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following drivers does not expect such deceleration of the truck/platoon, but they are keeping a safe distance and can notice the deceleration of the platoon, so they have time to react appropriately applying brake and steering or overtaking to to avoid possible collisions.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE01_02]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Within a roundabout/intersection, this might leave the platoon in a vulnerable position.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the roundabout/intersection, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access, allowing it temporarily only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue** C0 - Controllable in general. The intelligent infrastructures prevents other vehicles from closely following the platoon inside the roundabout, so there is enough time to react safely. In case of following vehicles present, the drivers can apply brake and steer if needed.	-
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE01_03]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Driving in an onramp, this might lead the truck to stop within the acceleration lane without taking the highway, leaving the platoon in a vulnerable position. In case of offramp, this might lead the following truck to stop in the deceleration lane, leaving the platoon in a vulnerable position.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C1 - Simply controllable (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven ***(ref[PAF_A09])***. The following drivers are usually attentive and keep a safe distance, so they have time to react appropriately applying brake and steering to avoid possible collisions.	QM

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE01_04]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path once detected the obstacles related to the construction site (ref[PAF_A13]). The trailing truck is informed about the deceleration, so it will perform the needed corrective manoeuvre. This can result in having stopped trucks in the construction zone.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** Following vehicles can collide with the trucks if not controlled. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.4, ISO 26262-3.** C0 - Controllable in general. In construction zones, following vehicle drivers are more attentive, so they can apply brake and steer if needed to avoid collision.	-
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE01_05]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE01_06]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1. A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE01_07]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). While changing lanes, this can be a risky manoeuvre if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C1 - Simply controllable at low speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	QM
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE01_08]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will lead the following truck to stop and to drive based only on the perceived information regarding the surrounding environment (e.g. road lanes, other vehicles) (ref[PAF_A13]). While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to go back to the previous road lane and stop. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C2 - Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Performing overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE01_09]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). This might lead the truck to remain in the fast lane once completed the overtaking manoeuvre, putting the truck in a vulnerable situation.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, **as per Table B.4, ISO 26262-3.** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The nearby road users does not expect such manoeuvre of the truck while overtaking. They have little time to react and perform an evasive manoeuvre.	A
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE01_10]	The following truck perceives information regarding the surrounding environment but it does not have information regarding the path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck is informed about the deceleration, so it will perform the needed corrective manoeuvre.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the junction, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the junction, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C0 - Controllable in general. The following truck can still detect the surrounding environment and react accordingly.	-

Risk Assessment of Hazard PAF_H02 - Incorrect of path data

Note – *Exposure based on frequency is not required for cases of incorrect path data because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE02_01]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), ***as per Table B.2, ISO 26262-3.*** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven ***(ref[PAF_A09]).*** The following drivers does not expect such deceleration of the truck/platoon, but they are keeping a safe distance and can notice the deceleration of the platoon, so they have time to react appropriately applying brake and steering or overtaking to to avoid possible collisions.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE02_02]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the roundabout, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the roundabout, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),***as per VDA 702 Situation Catalogue.*** C0 - Controllable in general. At low speed the road users can keep distance and brake and steer to avoid possible collisions.	-
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE02_03]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), ***as per Table B.2, ISO 26262-3.*** C1 - Simply controllable (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following drivers are usually attentive and keep a safe distance, so they have time to react appropriately applying brake and steering to avoid possible collisions.	QM

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_04]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time), ***as per VDA 702 Situation Catalogue***. C0 - Controllable in general. At low speed the road users can keep distance and brake and steer to avoid possible collisions.	-
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_05]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S0 - No collision E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), ***as per Table B.4, ISO 26262-3.*** C0 - Controllable in general.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE02_06]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S0 - No collision E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. People nearby can move away from the truck if needed.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE02_07]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S0 - No collision E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. People nearby can move away from the truck if needed.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_08]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S2 - Potential collision at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), as per VDA 702 Situation Catalogue C1 - Simply controllable. At low speed the road users have time to react, braking and steering to avoid possible collisions.	QM
Dry road - Changing lanes Medium speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_09]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S3 - Potential collision at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),as per VDA 702 Situation Catalogue C2 - Normally controllable at medium speed. At medium speed the road users have lower time to react, braking and steering to avoid possible collisions.	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_10]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S3 - Potential front collision at low speed with other vehicles E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), ***as per VDA 702 Situation Catalogue*** C2 - Normally controllable. At low speed the following driver's vehicle might not be able to estimate the position of the stopped truck in a curve (on the hard shoulder or in lane). He might have little time to react, braking and steering to avoid possible collisions.	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Performing overtaking manoeuvre High speed (>80km/h, <=90 km/h) Platooning driving mode [PAF_HE02_11]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, ***as per Table B.4, ISO 26262-3.*** C3 - Difficult to control at high speed. The other road users have very little time to perform evasive manoeuvres.	A
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE02_12]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This will result in the truck stopping in its path (ref[PAF_A13]). The trailing truck can notice the deceleration of the forward truck, so it will decelerate accordingly. Risk of collision if the following external vehicles do not react safety.	S0 - No collision E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C0 - Controllable in general.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE02_13]	The following truck have wrong information regarding the path to follow. This will lead the following truck to take a different path, but it will follow to perceive information from the environment sensing (e.g. road lanes, other vehicles). So, these conditions will increase the distance between the ego vehicle and the platoon (leader or the follower) and finally result in loss of communication and splitting of the platoon. This can result in an unintended full braking of the following truck. Risk of collision if the following external vehicles do not react safety.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), ***as per Table B.2, ISO 26262-3.*** C3 - Difficult to control at high speed. It is assumed that the vehicles around the platoon are manually driven ***(ref[PAF_A09]).*** The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights, he should perform an evasive manoeuvre to avoid collision.	D

Risk Assessment of Hazard PAF_H03 Platoon's intention to cross not communicated to the relevant infrastructures

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_01]	The intelligent traffic lights are not informed about the presence of the platoon. Consequently, the traffic light timing is not adapted to avoid external traffic while the platoon is crossing the roundabout. Possible cut-ins and a split of the platoon.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** The platoon may split and then the trucks remain stranded in the middle of the road. Vehicles nearby might have a collision with them. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The driver of the leading truck will adapt his driving to facilitate the reconnection. It is assumed that the nearby vehicles are manually driven **(ref[PAF_A09]).** The drivers can notice the truck and apply brake and steer to avoid a possible collision.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_02]	The intelligent traffic lights are not informed about the presence of the platoon. Consequently, the traffic light timing is not adapted to avoid external traffic while the platoon is crossing the roundabout. Possible cut-ins and a split of the platoon.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** The platoon may split and then the trucks remain stranded in the middle of the road. Vehicles nearby might have a collision with them. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue**. C0 - Controllable in general. The driver of the leading truck will adapt his driving to facilitate the reconnection. It is assumed that the nearby vehicles are manually driven **(ref[PAF_A09])**. The drivers can notice the truck and apply brake and steer to avoid a possible collision.	-
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE03_03]	The toll gate infrastructure is not informed about the presence of the platoon. This might make more difficult to maintain the cohesion of the platoon and lead to a split fo the platoon.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** The platoon may split and then the trucks remain stranded in the middle of the road. Vehicles nearby might have a collision with them. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time), **as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The lead truck driver can interrupt the travel and contact the service provider.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE03_04]	The toll gate infrastructure is not informed about the presence of the platoon. This might make more difficult to maintain the cohesion of the platoon and lead to a split fo the platoon.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** The platoon may split and then the trucks remain stranded in the middle of the road. Vehicles nearby might have a collision with them. E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, **as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The lead truck driver can interrupt the travel and contact the service provider.	-
Dry road - Border crossing Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE03_05]	The infrastructure present between two countries are not informed about the presence of the platoon. The infrastructures (e.g. toll gates) will not adapt their behaviour to the platoon access. Possible split of the platoon	S0 - The following truck can still perceive information from the environment sensing (e.g. road lanes, other vehicles) and avoid collision with other road users or stationary objects. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. The lead truck driver can detect the platoon split and interrupt the travel to attempt the reconnection of the platoon.	-
Dry road - Border crossing Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE03_06]	The infrastructure present between two countries are not informed about the presence of the platoon. The infrastructures (e.g. toll gates) will not adapt their behaviour to the platoon access. Possible split of the platoon	S0 - The following truck can still perceive information from the environment sensing (e.g. road lanes, other vehicles) and avoid collision with other road users or stationary objects. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C0 - Controllable in general. The lead truck driver can detect the platoon split and interrupt the travel to attempt the reconnection of the platoon.	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a traffic light on highway Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_07]	The intelligent traffic lights are not informed about the presence of the platoon. As a consequence, the traffic light timing is not adapted to avoid traffic lights to turn yellow/red while the platoon is passing. The platoon will brake the traffic rule (more trucks will circulate than the allowed ones).	S0 - No collision with other vehicles E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general.	-
Dry road - Approaching a traffic light on highway Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_08]	The intelligent traffic lights are not informed about the presence of the platoon. As a consequence, the traffic light timing is not adapted to avoid traffic lights to turn yellow/red while the platoon is passing. The platoon will brake the traffic rule (more trucks will circulate than the allowed ones).	S0 - No collision with other vehicles E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3 C0 - Controllable in general.	-
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_09]	The intelligent traffic lights are not informed about the presence of the platoon. As a consequence, the traffic light timing is not adapted to avoid traffic lights to turn yellow/red while the platoon is passing. This might lead the intelligent traffic lights to turn green, yellow or red in any moment. Potential split of the platoon and risk of collision	S3 - Potential fatal injuries for the pedestrians E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C0 - Controllable in general. All the other vehicles can see the stopped truck and apply brake and steering to avoid collision. The pedestrians if attentive can look at the trucks and wait their stop before crossing the road	-

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE03_10]	The intelligent traffic lights are not informed about the presence of the platoon. As a consequence, the traffic light timing is not adapted to avoid traffic lights to turn yellow/red while the platoon is passing. This might lead the intelligent traffic lights to turn green, yellow or red in any moment. Potential split of the platoon and risk of collision	S3 - Potential fatal injuries for the pedestrians E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C0 - Controllable in general. All the other vehicles can see the stopped truck and apply brake and steering to avoid collision. The pedestrians if attentive can look at the trucks and wait their stop before crossing the road	-

Risk Assessment of Hazard PAF_H04 Incorrect intention to cross communicated to the relevant infrastructures

NOTE: *The worst case scenario here is that the traffic lights are not adapted to facilitate the platoon.*

In the specific, two cases are possible:

1. *Lights are controlled when the platoon is not passing – no safety risk.*
2. *Lights are not controlled when the platoon is passing – same risks as the hazard 03 (Platoon's intention to cross not communicated to the relevant infrastructure). So, the same exact cases and results can be used.*

Based on this, a risk assessment for the hazard 04 is not necessary.

Risk Assessment of Hazard PAF_H05 - Loss of deceleration by following trucks

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_01]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Potential multiple-vehicle collisions at high speed and potential injuries for the occupants of the trucks and for the other road users.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Uncontrollable. The following truck is driverless (ref[PAF_A08]),so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	D
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_02]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Potential multiple-vehicle collisions at high speed and potential injuries for the occupants of the trucks and for the other road users.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time) C3 - Uncontrollable. The following truck is driverless (ref[PAF_A08]),so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	D

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE05_03]	The platoon is expected to reduce the truck speed while taking an offramp, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at medium speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Potential multiple-vehicle collisions at medium speed.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	A
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE05_04]	The platoon is expected to reduce the truck speed while taking an offramp, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at medium speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07])***. Potential multiple-vehicle collisions at medium speed.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, **as per VDA 702 Situation Catalogue** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so no manual corrective manoeuvres are possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	C
Dry road - Junctions Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE05_05]	The platoon is expected to reduce the truck speed when approaching a junction, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** It is assumed that the platoon intention to cross the platoon is communicated to the infrastructure. Therefore, no collision is assumed with other traffic participants. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C3 - Uncontrollable. The following truck is driverless	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
		(ref[PAF_A08]), so no manual corrective manoeuvres are possible.	
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE05_06]	The platooning is approaching the toll gates area, and an intervention of the platooning function is expected to reduce the truck speed and stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** It is assumed that the platoon intention to cross the platoon is communicated to the infrastructure. Therefore, no collision is assumed with other traffic participants. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), as per VDA 702 Situation Catalogue. C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so no manual corrective manoeuvres are possible.	A

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE05_07]	The platooning is approaching the toll gates area, and an intervention of the platooning function is expected to reduce the truck speed and stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** It is assumed that the platoon intention to cross the platoon is communicated to the infrastructure. Therefore, no collision is assumed with other traffic participants. E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, so medium probability (<1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so no manual corrective manoeuvres are possible.	B
Dry road - Driving in tunnel High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_08]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Accidents in tunnels are usually more dangerous than in the open air. In case of explosion or fire events, these may cause considerable damage and hazardous substances cannot be removed quickly. Additionally, smoke can cause poor visibility and lack of oxygen may occur.	S3 - Potential fire event and impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so corrective manoeuvres to avoid an impact are not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).**Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving in tunnel High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_09]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Accidents in tunnels are usually more dangerous than in the open air. In case of explosion or fire events, these may cause considerable damage and hazardous substances cannot be removed quickly. Additionally, smoke can cause poor visibility and lack of oxygen may occur.	S3 - Potential fire event and impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so corrective manoeuvres to avoid an impact are not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	C
Dry road - Cut-in High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_10]	The platoon is expected to reduce the truck speed and keep a safe distance with the in-front vehicle, but it doesn't happen. The following truck can have a rear-end collision with the forward vehicle at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the in-front vehicle cannot foresee and avoid that impact.	B

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Cut-in High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE05_11]	The platoon is expected to reduce the truck speed and keep a safe distance with the in-front vehicle, but it doesn't happen. The following truck can have a rear-end collision with the forward vehicle at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the in-front vehicle cannot foresee and avoid that impact.	D
Dry road - Approaching a traffic light on highway Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE05_12]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** The traffic lights on highway usually aims to control the traffic (e.g before tunnels or bridges). Vehicle in the opposite direction may come. Potential collision with those oncoming vehicles.	S3 - Potential front collision at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the oncoming vehicles cannot foresee and avoid that impact.	B
Dry road - Approaching a traffic light on highway Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE05_13]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** The traffic lights on highway usually aims to control the traffic (e.g before tunnels or bridges). Vehicle in the opposite direction may come. Potential collision with those oncoming vehicles.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3. C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the oncoming vehicles cannot foresee and avoid that impact.	C

Situation & [Hazardous Event ID]	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE05_14]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible.	B
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE05_15]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a deceleration to avoid an impact is not possible.	C

Risk Assessment of Hazard PAF_H06 - Excessive deceleration by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Wet road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_01]	In a braking situation, the following truck decelerates more than the necessary. On the wet roads the available grip is lower, for this reason braking excessively could place the truck into a skid situation during few moments. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per Table B.2, ISO 26262-3.** C0 - Controllable in general. The trailing truck is informed about the deceleration, so it can command braking as weel.	-
Wet road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_02]	In a braking situation, the following truck decelerates more than the necessary. On the wet roads the available grip is lower, for this reason braking excessively could place the truck into a skid situation during few moments. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on frequency, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per Table B.3, ISO 26262-3.** C0 - Controllable in general. The trailing truck is informed about the deceleration, so it can command braking as weel.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Low friction surface (snow/ice) - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_03]	In a braking situation, the following truck decelerates excessively. On the snowy/icy road the available grip is very low, for this reason an excessive deceleration can cause the wheels lock and place the truck into a skid situation, causing an unintended lateral movement of the truck. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C1 - Simply controllable. The ABS/ESC systems are active and they can intervene to prevent the wheels lock and provide the needed correction in case of oversteer/understeer events **(ref[PAF_EM06]).**	QM
Low friction surface (snow/ice) - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_04]	In a braking situation, the following truck decelerates excessively. On the snowy/icy road the available grip is very low, for this reason an excessive deceleration can place the truck into a skid situation, causing an unintended lateral movement of the truck. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on frequency, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per Table B.3, ISO 26262-3.** C1 - Simply controllable. The ABS/ESC systems are active and they can intervene to prevent the wheels lock and provide the needed correction in case of oversteer/understeer events **(ref[PAF_EM06]).**	QM
Driving at darkness without road visible - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_05]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue** C1 - Simply controllable at high speed without road visible (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Since this is a true braking situation, the following drive	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
		can notice the brake lights and the truck braking and react appropriately.	
Low visibility Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE06_06]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at low speed between the trailing truck and the following vehicle.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per VDA 702 Situation Catalogue** C1 - Simply controllable at low speed without low visibility (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** In case of low visibility the drivers usually keep a greater distance from the in-front vehicles. The following driver will notice the brake lights and the truck braking and react appropriately.	QM
Low visibility Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE06_07]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at low speed between the trailing truck and the following vehicle.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time), **as per VDA 702 Situation Catalogue** C1 - Simply controllable at low speed without low visibility (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** In case of low visibility the drivers usually keep a greater distance from the in-front vehicles. The following driver will notice the brake lights and the truck braking and react appropriately.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Low visibility - Highway Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE06_08]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per VDA 702 Situation Catalogue** C1 - Simply controllable at medium speed with low visibility (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** In case of low visibility the drivers usually keep a greater distance from the in-front vehicles. Since this is a true braking situation, the following vehicles will notice the truck braking and react appropriately.	QM
Low visibility - Highway Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE06_09]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E2, **as per VDA 702 Situation Catalogue** C1 - Simply controllable at medium speed with low visibility (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** In case of low visibility the drivers usually keep a greater distance from the in-front vehicles. Since this is a true braking situation, the following vehicles will notice the truck braking and react appropriately.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Other vehicle behind driving with normal distance - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_10]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Since this is a true braking situation, the following vehicles will notice the truck braking and react appropriately.	-
Other vehicle behind driving with normal distance - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE06_11]	In a braking situation, the following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Since this is a true braking situation, the following vehicles will notice the truck braking and react appropriately.	-

Risk Assessment of Hazard PAF_H07 - Insufficient deceleration by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE07_01]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Fatal injuries due to a potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),**so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Difficult for them to perform corrective manoeuvres and avoid collision.	D
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE07_02]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Fatal injuries due to a potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time). C3 - Difficult to control. The following truck is driverless (ref[PAF_A08]),so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). Difficult for them to perform corrective manoeuvres and avoid collision.	D
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE07_03]	The platoon is expected to reduce the truck speed while taking an offramp, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at low relative speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE07_04]	The platoon is expected to reduce the truck speed while taking an offramp, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at low relative speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, **as per VDA 702 Situation Catalogue** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	C
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE07_05]	The platoon is approaching the toll gates area, and an intervention of the platooning function is expected to reduce the truck speed, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at very low relative speed. Potential injuries for the occupants of the following truck.	S1 - Potential impact at very low relative speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE07_06]	The platoon is approaching the toll gates area, and an intervention of the platooning function is expected to reduce the truck speed, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at very low relative speed. Potential injuries for the occupants of the following truck.	S1 - Potential impact at very low relative speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, so medium probability (<1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	A
Dry road - Driving in tunnel High speed (>80 km/h) Platooning driving mode [PAF_HE07_07]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Accidents in tunnels are usually more dangerous than in the open air. In case of explosion or fire events, these may cause considerable damage and hazardous substances cannot be removed quickly. Additionally, smoke can cause poor visibility and lack of oxygen may occur.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per VDA 702 Situation Catalogue.** Since the driving situation considered is "being in a tunnel and requiring to brake", the exposure may be lower. Exposure reduced to the lower value (E1) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving in tunnel High speed (>80 km/h) Platooning driving mode [PAF_HE07_08]	The platoon is expected to reduce the truck speed or to stop it in order to avoid collision, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** Accidents in tunnels are usually more dangerous than in the open air. In case of explosion or fire events, these may cause considerable damage and hazardous substances cannot be removed quickly. Additionally, smoke can cause poor visibility and lack of oxygen may occur.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** Since the driving situation considered is "being in a tunnel and requiring to brake", the exposure may be lower. Exposure reduced to the lower value (E2) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** Very difficult also for the other road users to perform an evasive manoeuvre and avoid an impact.	B
Dry road - Cut-in High speed (>80 km/h) Platooning driving mode [PAF_HE07_09]	The platoon is expected to reduce the truck speed and keep a safe distance with the in-front vehicle, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward vehicle at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Potential fatal injuries for the road users.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the in-front vehicle cannot foresee and avoid that impact.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Cut-in High speed (>80 km/h) Platooning driving mode [PAF_HE07_10]	The platoon is expected to reduce the truck speed and keep a safe distance with the in-front vehicle, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward vehicle at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Potential fatal injuries for the road users.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The driver of the in-front vehicle cannot foresee and avoid that impact.	D
Dry road - Approaching a traffic light on highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE07_11]	The platoon is expected to reduce the truck speed and to stop it, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** The traffic lights on highway usually aims to control the traffic (e.g before tunnels or bridges). Vehicle in the opposite direction may come. Potential collision with those oncoming vehicles.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The drivers of the oncoming vehicles in the opposite direction cannot foresee and avoid the collision.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a traffic light on highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE07_12]	The platoon is expected to reduce the truck speed and to stop it, but the following truck decelerates less than the required. The following truck can have a rear-end collision with the forward truck at medium relative speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail ***(ref[PAF_A07]).*** The traffic lights on highway usually aims to control the traffic (e.g before tunnels or bridges). Vehicle in the opposite direction may come. Potential collision with those oncoming vehicles.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3 C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The drivers of the oncoming vehicles in the opposite direction cannot foresee and avoid the collision.	C
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE07_13]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low relative speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	B
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10 km/h, <=80 km/h) Platooning driving mode [PAF_HE07_14]	The platoon is expected to reduce the truck speed and to stop it, but it doesn't happen. The following truck can have a rear-end collision with the forward truck at low relative speed. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre to avoid an impact is not possible.	C

Risk Assessment of Hazard PAF_H08 - Unintended deceleration by the following truck

Note - *Exposure based on frequency is not required for cases of uninteded deceleration of the truck because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Wet road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_01]	The following truck decelerates unexpectedly. On the wet roads the available grip is lower, for this reason braking can place the truck into a skid situation during few moments. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The platooning function cannot perform corrective manoeuvre **(ref[PAF_A11])**. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights, he should perform an evasive manoeuvre to avoid collision.	C

Low friction surface (snow/ice) - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_02]	The following truck decelerates unexpectedly. On the snowy/icy road the available grip is very low, for this reason an unintended deceleration can cause the wheels to lock and place the truck into a skid situation, causing an unintended lateral movement of the truck. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The ABS/ESC systems are active and they can intervene to prevent the wheels to lock and provide the needed correction in case of oversteer/understeer events **(ref[PAF_EM06])**. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**.The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights and react by braking or steering to avoid collision, he should perform an evasive manoeuvre and maintain che controllability of the vehicle on the snowy/icy road.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Driving at darkness without road visible - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_03]	The following truck decelerates unexpectedly. This can cause an unexpetcted deceleration of the platoon (in case of unintended deceleration by the following truck) or an unintended deceleration of the trailing truck only. In both cases, the following vehicles does not expect such deceleration. Possible collision at high speed between the trailing truck and the following vehicle.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights and react by braking or steering, he should perform an evasive manoeuvre to avoid collision.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Low visibility - Highway Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE08_04]	The following truck decelerates unexpectedly. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at low speed between the trailing truck and the following vehicle.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time),**as per VDA 702 Situation Catalogue** C1 - Simply controllable at low speed (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following vehicle's driver will usually keep a greater distance from the in-front vehicles in case of low visibility, and they observe the deceleration of the forward vehicle and the brake lights so they can react by braking or steering to avoid collision.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Low visibility - Highway Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE08_05]	The following truck decelerates excessively. This can cause an excessive deceleration of the platoon (in case of excessive deceleration by the following truck) or an excessive deceleration of the trailing truck only. In both cases, the following vehicles does not expect such amount of deceleration. Possible collision at medium speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time),**as per VDA 702 Situation Catalogue** C2 - Normally controllable (90% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicles will notice the truck braking and react appropriately.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE08_06]	The following truck decelerates unexpectedly. An unxepcted deceleration of the platoon or of the trailing truck only forces the following vehicle to decelerate to avoid a rear-end collision. Possible rear-end collision at low speed	S0 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1,***are S2. Intelligent traffic lights are presents ***(ref[PAF_A10])*** and they can regulate the access within the roundabout, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). In case of following vehicles present, the drivers can apply brake and steer if needed to avoid collision.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Onramp/offramp Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE08_07]	Taking an onramp, the following truck decelerates unexpectedly. This can cause an unintended deceleration of the platoon (in case of unintended deceleration by the following truck) or an unintended deceleration of the trailing truck only. In both cases, the following vehicles does not expect such deceleration. Possible rear-end collision at medium speed between the trailing truck and the following vehicle.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C2 - Normally controllable. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect a deceleration, but he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights and react by braking or steering to avoid collision.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Other vehicle behind driving with normal distance - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_08]	The following truck decelerates unexpectedly forcing the following vehicle to react (brake/steer) quickly to avoid collision. Possible collision at medium/high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights and react by braking or steering, he should perform an evasive manoeuvre to avoid collision.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Being overtaken - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_09]	The platoon is being overtaken. Just before the following vehicle changes lane to perform the overtaking manoeuvre, the trailing truck decelerates unexpectedly, forcing the following vehicle to react (brake/steer) quickly to avoid collision. Possible collision at medium/high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C3 - Difficult to control and avoid a collision. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The driver of the following vehicle is aware about the deceleration of the forward vehicle because of the brake lights, but he does not expect a deceleration. Difficult to perform an evasive manoeuvre and avoid an impact at high speed.	C
Cruising with vehicles following closely - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_10]	The truck decelerates unexpectedly forcing the following vehicle to react (brake/steer) quickly to avoid collision. Possible collision at medium/high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability. C3 - Difficult to control and avoid a collision. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The driver of the following vehicle is aware about the deceleration of the forward vehicle because of the brake lights, but he does not expect a deceleration. Difficult to perform an evasive manoeuvre and avoid an impact at high speed.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE08_11]	The following truck decelerates unexpectedly forcing the following vehicle to react (brake/steer) quickly to avoid collision. Possible collision at medium/high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The platooning function cannot perform corrective manoeuvre **(ref[PAF_A11]).** It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The following vehicle's driver does not expect a deceleration. Even if he's keeping a safe distance and he can observe the deceleration of the forward vehicle and the brake lights, he should perform an evasive manoeuvre to avoid collision.	D

Risk Assessment of Hazard PAF_H09 - Loss of acceleration by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE09_01]	Unintended loss of propulsion for the following truck. The distance between the following truck and the leading truck can increase up to the disengagement of the platoon. The driverless trucks turn into "obstacles" for the following vehicles and impede a regular circulation on the highway. Possible rear-end collision at high speed	S3 - Potential impact, the trailing truck may be hit from behind by following vehicles at high speed. ***As per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C0 - Controllable in general. The trailing truck can perceive the loss of acceleration and decrease its speed. It is assumed that the vehicles around the platoon are manually driven (**ref[PAF_A09]**). The following vehicles can apply brake and steer to avoid collision or overtake the trucks.	-
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE09_02]	Unintended loss of propulsion for the following truck. Part of the platoon or the trailing truck only might be exposed in a vulnerable position in the road. Possible collision at low speed with following traffic.	S0 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1,*** are S2. Intelligent traffic lights are present ***(ref[PAF_A10])*** and they can regulate the access within the roundabout, allowing temporarily the access to the platoon only. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Even in case of vehicle nearby present, the vehicle's drivers can apply brake and steer to avoid collision.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Performing overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE09_03]	The following truck is overtaking and it loses propulsion unexpectedly. This might result in the overtake manoeuvre failing and in the disengament of the platoon, leaving the truck in a vulnerable position in the highway. Possible collision with following traffic.	S3 - Potential impact, truck may be hit from behind by following vehicles at high speed. ***As per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, **as per Table B.4, ISO 26262-3.** C2 - Normally controllable at high speed. The following truck is driverless (ref[PAF_A08]), so a corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). "The loss of propulsion is not expected by the following vehicle's driver. He/she might have to apply brakes to avoid collision while driving in the fast lane. He might also have difficulties in changing lane, depending on the traffic in the adjacent lanes.	QM

Risk Assessment of Hazard PAF_H10 - Excessive acceleration by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE10_01]	The platoon is expected to increase the speed of the following truck, but the acceleration is excessive. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Potential multiple-vehicle collisions at high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The nearby and following vehicles have limited time to react. The following vehicles shall apply the needed brake pressure/steering and perform a corrective manoeuvre to avoid a collision.	D
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE10_02]	The platoon is expected to increase the speed of the following truck, but the acceleration is excessive. The following truck can have a rear-end collision with the forward truck at high speed, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Potential multiple-vehicle collisions at high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C3 - Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The nearby and following vehicles have limited time to react. The following vehicles shall apply the needed brake pressure/steering and perform a corrective manoeuvre to avoid a collision.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Low friction surface (snow/ice) - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE10_03]	On icy and snowy roads, there is less traction between the tires and the road. An excessive acceleration can lead to to lose traction and to spin on the snow, losing control of the vehicle. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Difficult also for the nearby and following vehicles to perform an evasive manoeuvre.	B
Low friction surface (snow/ice) - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE10_04]	On icy and snowy roads, there is less traction between the tires and the road. An excessive acceleration can lead to to lose traction and to spin on the snow, losing control of the vehicle. Possible collision at high speed between the truck and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on frequency, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time), **as per Table B.3, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven (**ref[PAF_A09]**). Difficult also for the nearby and following vehicles to perform an evasive manoeuvre.	B
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE10_05]	The following accelerates more than needed. The following truck may have a collision with the forward truck. After the impact, the truck may invade another lane or go off the road, having a collision at low speed with other road users. Potential collisions with pedestrians or side impact with other vehicles at low speed.	S3 - Pedestrian/bycicle accident and side impact with low speed, ***as per [Ref 1] Part 3 - Table B.1*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE10_06]	The following accelerates more than needed. The following truck may have a collision with the forward truck. After the impact, the truck may invade another lane or go off the road, having a collision at low speed with other road users. Potential collisions with pedestrians or side impact with other vehicles at low speed.	S3 - Pedestrian/bycicle accident and side impact with low speed, ***as per [Ref 1] Part 3 - Table B.2*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.	D
Dry road - Onramp/offramp Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE10_07]	While taking an onramp, the following truck accelerates more than required. The following truck can have a rear-end collision with the forward truck, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Possible collision at medium or high speed between the trucks and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Difficult also for the following vehicles to perform an evasive manoeuvre and avoid an impact.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Onramp/offramp Medium speed (>50 km/h, <=80 km/h) Platooning driving mode [PAF_HE10_08]	While taking an onramp, the following truck accelerates more than required. The following truck can have a rear-end collision with the forward truck, and both vehicles can deviate from the intented path and move towards other lanes or the guard rail. Possible collision at medium or high speed between the trucks and other vehicles or stationary object (e.g. guard rail).	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E3, **as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). Difficult also for the following vehicles to perform an evasive manoeuvre and avoid an impact.	C
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE10_09]	While approaching a junction, the following truck accelerates more than required. The following truck can have a rear-end collision with the forward truck at low speed. After the impact, the truck may invade another lane or go off the road at low speed. Potential injuries for the occupants of the following truck and for the pedestrians.	S3 - Pedestrian accident E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE10_10]	While approaching a junction, the following truck accelerates more than required. The following truck can have a rear-end collision with the forward truck at low speed. After the impact, the truck may invade another lane or go off the road at low speed. Potential injuries for the occupants of the following truck and for the pedestrians.	S3 - Pedestrian accident E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C3 - Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre is not possible. The pedestrians have little time to detect the truck and move away.	D
Slow driving/start-up process Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE10_11]	Once engaged the platoon, the leading truck start to drive from the hub. The following truck starts following the leader, but it accelerates excessively. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following trucks.	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre is not possible.	QM
Slow driving/start-up process Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE10_12]	Once engaged the platoon, the leading truck start to drive from the hub. The following truck starts following the leader, but it accelerates excessively. The following truck can have a rear-end collision with the forward truck at low speed. Potential injuries for the occupants of the following trucks.	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre is not possible.	B

Risk Assessment of Hazard PAF_H11 Insufficient acceleration by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE11_01]	The speed of the following truck is lower than required. The distance between the following truck and the leading truck can increase up to the disengagement of the platoon. The driverless trucks turn into "obstacles" and impede a regular circulation on the highway	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C0 - Controllable in general. The driver of the leading truck can decelerate once realized that the following truck cannot accelerate more than a value. The trailing truck can perceive the loss of acceleration and decrease its speed. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The oncoming vehicles can apply brake and steer to avoid collision or overtake the trucks.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE11_02]	The speed of the following truck is lower than required. The distance between the following truck and the leading truck can increase up to the disengagement of the platoon. The driverless trucks turn into "obstacles" and impede a regular circulation on the highway	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time) C0 - Controllable in general. The driver of the leading truck can decelerate once realized that the following truck cannot accelerate more than a value. The trailing truck can perceive the loss of acceleration and decrease its speed. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The oncoming vehicles can apply brake and steer to avoid collision or overtake the trucks.	-
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE11_03]	The speed of the following truck is lower than required. Part of the platoon or the trailing truck only might be exposed in a vulnerable position in the road.	S0 - Potential impact at very low relative speed are S1, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** Intelligent traffic lights are present ***(ref[PAF_A10])*** and they can regulate the access within the roundabout, allowing temporarily the access from the platoon direction only. This can limit the presence of other vehicles only behind the platoon. No collision E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Even in case of vehicles nearby, they can apply brake and steer to avoid collision.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE11_04]	The speed of the following truck is lower than required. Part of the platoon or the trailing truck only might be exposed in a vulnerable position in the road.	S0 - Potential impact at very low relative speed are S1, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** Intelligent traffic lights are present ***(ref[PAF_A10])*** and they can regulate the access within the roundabout, allowing temporarily the access from the platoon direction only. This can limit the presence of other vehicles only behind the platoon. No collision E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Even in case of vehicles nearby, they can apply brake and steer to avoid collision.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Slow driving/start-up process Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE11_05]	Once the platoon is engaged, the leading truck start to drive from the hub. The following truck starts following the leader, but its acceleration is insufficient. This can lead to the loss of communication and disangement of the platoon, leaving the truck exposed in vulnerables positions (e.g. between hub and highway) without knowing the dynamic parameters.	S3 - Potential impact at medium speed with stationary objects or other road users E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. The driver of the leading truck can decelerate once realized that the following truck cannot accelerate more than a value. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Vehicles nearby can normally control the situation, braking/steering to avoid collision and overtaking the truck/platoon.	-
Slow driving/start-up process Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE11_06]	Once the platoon is engaged, the leading truck start to drive from the hub. The following truck starts following the leader, but its acceleration is insufficient. This can lead to the loss of communication and disangement of the platoon, leaving the truck exposed in vulnerables positions (e.g. between hub and highway) without knowing the dynamic parameters.	S3 - Potential impact at medium speed with stationary objects or other road users E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C0 - Controllable in general. The driver of the leading truck can decelerate once realized that the following truck cannot accelerate more than a value. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. Vehicles nearby can normally control the situation, braking/steering to avoid collision and overtaking the truck/platoon.	-

Risk Assessment of Hazard PAF_H12 - Unintended acceleration by the following truck

NOTE - *Exposure based on frequency is not required for unintended acceleration of the truck because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Stopped at a toll gate - Platoon stationary Platooning driving mode [PAF_HE12_01]	The following truck accelerates unexpectedly. Possible collision at very low speed between the following truck and the forward one. Potential injuries for the occupants of the following truck.	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (< 1% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a corrective manoeuvre is not possible.	QM
Stopped at the hub - Platoon stationary Platooning driving mode [PAF_HE12_02]	The following truck accelerates unexpectedly. People might be present in front of the following truck for some reasons (e.g. loading/unloading) and suffer an impact.	S3 - Potential fatal injuries for people in front of the following truck E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). Since the driving situation considered is "truck stopped at the hub and people present in front of it", the exposure may be lower. Exposure reduced to the lower value (E1) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a corrective manoeuvre is not possible.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Stopped at traffic lights - Platoon stationary Platooning driving mode [PAF_HE12_03]	The following truck accelerates unexpectedly. Possible collision at very low speed between the following truck and the forward one. Potential injuries for the occupants of the following truck.	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre is not possible.	QM
Stopped at parking lots - Platoon stationary Platooning driving mode [PAF_HE12_04]	The following truck accelerates unexpectedly. People might be present in front of the following truck for some reasons (e.g. loading/unloading, taking a walk, talking on the phone) and suffer an impact.	S3 - Potential fatal injuries for people in front of the following truck E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** Since the driving situation considered is "truck stopped at the hub and people present in front it", the exposure may be lower. Exposure reduced to the lower value (E1) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a corrective manoeuvre is not possible.	A
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE12_05]	The following truck accelerates unexpectedly. The vehicle might invade the opposite lane or go off the road. This might lead to a possible collision with other vehicles or stationary objects. Potential injuries for the occupants of the following truck.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a corrective manoeuvre is not possible.	B

Risk Assessment of Hazard PAF_H13 - Loss lateral motion by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE13_01]	The platoon is expected to steer the following truck, but it doesn't happen. The loss of steering may result in the following truck leaving its current lane and enter other lanes or the side of the road.	S3 - Potential fatal injuries due to impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]), but it is difficult to perform an evasive manoeuvre and avoid an impact at high speed.	D
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE13_02]	The platoon is expected to steer the following truck, but it doesn't happen. The loss of steering may result in the following truck leaving its current lane and enter other lanes or the side of the road.	S3 - Potential fatal injuries due to impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**), but it is difficult to perform an evasive manoeuvre and avoid an impact at high speed.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE13_03]	The platoon is expected to steer the following truck within a roundabout, but it doesn't happen. The loss of lateral displacement control can lead the following truck to move from the lane center to other lanes or the side road.	S3 - Pedestrian accident and side impact for other vehicles. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time)**, as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	C
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE13_04]	The platoon is expected to steer the following truck within a roundabout, but it doesn't happen. The loss of lateral displacement control can lead the following truck to move from the lane center to other lanes or the side road.	S3 - Pedestrian accident and side impact for other vehicles. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE13_05]	The platoon is expected to steer the following truck approaching a junction/intersection, but it doesn't happen. The loss of lateral displacement control can lead the following truck to move from the lane center to other lanes or the side road. The following truck might go off the road or have a collision with other vehicles, pedestrians and stationary objects (e.g. guard rail) at low speed.	S3 - Pedestrian accident and side impact for other vehicles. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the junction, but not prevent the presence of pedestrians. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C3 - Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	C
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE13_06]	The platoon is expected to steer the following truck approaching a junction/intersection, but it doesn't happen. The loss of lateral displacement control can lead the following truck to move from the lane center to other lanes or the side road. The following truck might go off the road or have a collision with other vehicles, pedestrians and stationary objects (e.g. guard rail) at low speed.	S3 - Pedestrian accident and side impact for other vehicles. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the junction, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Hub Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE13_07]	The platoon is expected to steer the following truck inside a hub, but it doesn't happen. The loss of lateral displacement control can lead to deviate from the intended path and have a collision with other vehicles present in the hub, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C2 - Simply controllable. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can notice that the vehicle is not steering and move quickly, avoiding the impact.	A
Hub Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE13_08]	The platoon is expected to steer the following truck inside a hub, but it doesn't happen. The loss of lateral displacement control can lead to deviate from the intended path and have a collision with other vehicles present in the hub, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4 C2 - Simply controllable. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can notice that the vehicle is not steering and move quickly, avoiding the impact.	C
Resting area/parking lots Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE13_09]	The platoon is expected to steer the following truck approaching a junction, but it doesn't happen. The loss of lateral displacement control can lead to deviate from the intended path and have a collision with other vehicles, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C2 - Simply controllable. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can notice that the vehicle is not steering and move quickly, avoiding the impact.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Resting area/parking lots Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE13_10]	The platoon is expected to steer the following truck approaching a junction, but it doesn't happen. The loss of lateral displacement control can lead to deviate from the intended path and have a collision with other vehicles, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C2 - Simply controllable. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can notice that the vehicle is not steering and move quickly, avoiding the impact.	C
Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode [PAF_HE13_11]	The following truck loses the lateral displacement control while changing lanes. Due to this, it might be exposed in a vulnerable position between two different lanes.	S3 - Potential fatal injuries due to impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The other road users have little time to react and perform an evasive manoeuvre.	C
Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode [PAF_HE13_12]	The following truck loses the lateral displacement control. Due to this, it cannot anymore change lane and follow the forward truck. This might lead to a split of the platoon.	S3 - Potential fatal injuries due to impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The other road users have little time to react and perform an evasive manoeuvre.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE13_13]	The following truck loses the lateral displacement control while executing a turn. The following truck might go off its own lane and have collision with other road users or the guard rail. Potential collisions also with oncoming vehicles.	S3 - Potential fatal injuries due to a front collision E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The oncoming vehicles have little time to react and to perform an evasive manoeuvre.	C
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE13_14]	The following truck cannot control its lateral displacement due to a pre-existing fault of the platooning function. The following truck might go off its own lane and have collision with other road users or the guard rail. Potential collisions also with oncoming vehicles	S3 - Potential fatal injuries due to impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per Table B.3, ISO 26262-3** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The oncoming vehicles have little time to react and to perform an evasive manoeuvre.	D

Risk Assessment of Hazard PAF_H14 - Excessive lateral motion by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE14_01]	The following truck is driving at high speed on the highway and controlling its lateral displacement within the lane, but the correction is excessive. This might lead the following truck to move out from the lane. The other road users may suffer a side impact.	S3 - Side impact for other vehicles E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control at high speed. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE14_02]	The following truck is driving at high speed on the highway and controlling its lateral displacement within the lane, but the correction is excessive. This might lead the following truck to move out from the lane. The other road users may suffer a side impact.	S3 - Side impact for other vehicles E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time) C3 - Difficult to control at high speed. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.	D
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE14_03]	The following truck steers excessively within a roundabout. This might lead the following truck to invade another lane. The other road users may suffer a side impact. Possible collision also with pedestrians.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE14_04]	The following truck steers excessively within a roundabout. This might lead the following truck to invade another lane. The other road users may suffer a side impact. Possible collision also with pedestrians.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	D
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE14_05]	The following truck steers excessively approaching a junction/intersection. This might lead the following truck to go off the lane. The worst case can be a collision at low speed with other vehicles or pedestrians.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles to the junction, but not prevent the presence of pedestrians. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C3 - Difficult to control. The following truck is driverless (ref[PAF_A08]), so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE14_06]	The following truck steers excessively approaching a junction/intersection. This might lead the following truck to go off the lane. The worst case can be a collision at low speed with other vehicles or pedestrians.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles to the junction, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The pedestrians have very little time to detect the truck and move away.	D
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE14_07]	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).	S3 - Side impact for other vehicles E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time)**,as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform corrective manoeuvre at medium speed to avoid collision.	C
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE14_08]	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).	S3 - Side impact for other vehicles. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform corrective manoeuvre at medium speed to avoid collision.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode [PAF_HE14_09]	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).	S3 - Side impact for other vehicles E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time)**,as per VDA 702 Situation Catalogue** C3 - Difficult to control at high speed. Difficult for the road users to perform a corrective manoeuvre at high speed to avoid collision.	C
Dry road - Changing lanes High speed (>80km/h, <=90 km/h) Platooning driving mode [PAF_HE14_10]	The following truck steers excessively while changing lanes. This might lead the following truck to move faster to the target lane or to move towards another lane (not the target one).	S3 - Side impact for other vehicles E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per VDA 702 Situation Catalogue** C3 - Difficult to control at high speed. Difficult for the road users to perform a corrective manoeuvre at high speed to avoid collision.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE14_11]	The following truck steers excessively while executing a turn. This might lead the following truck to move towards the guard rail or to go off road, having a collision at low speed with stationary objects.	S2 - Potential injuries for the truck's occupants due to an impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** *E3* - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. The other road users have little time to perform a corrective manoeuvre to avoid collision.	B
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE14_12]	The following truck steers excessively while executing a turn. This might lead the following truck to move towards the guard rail or to go off road, having a collision at low speed with stationary objects.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per Table B.3, ISO 26262-3** C3 - Difficult to control. The following truck is driverless (**ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The other road users have little time to perform a corrective manoeuvre to avoid collision	C
Hub Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE14_13]	The platoon is expected to steer the following truck inside a hub, but the truck steers excessively. This can lead to deviate from the intended path and have a collision with other vehicles present in the hub, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C2 - Simply controllable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can move quickly, avoiding the impact.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Resting area/parking lots Very low speed (>0 km/h, <=10 km/h) Platooning driving mode [PAF_HE14_14]	The platoon is expected to steer the following truck inside a resting area, but the truck steers excessively. This can lead to deviate from the intended path and have a collision with other vehicles present in the resting area, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C2 - Simply controllable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People nearby, if attentive, can move quickly, avoiding the impact.	A

Risk Assessment of Hazard PAF_H15 - Insufficient lateral motion by the following truck

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE15_01]	The following truck is driving at high speed on the highway and controlling its lateral displacement to stay within the lane, but the lateral control is not sufficient. The following truck might go off its lane and move close to the other road users or the guard rail.	S3 - Potential collisions at high speed with other road users and potential injuries for the occupants, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.	D
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE15_02]	The following truck is driving at high speed on the highway and controlling its lateral displacement to stay within the lane, but the lateral control is not sufficient. The following might go so off its lane and move close to the other road users or the guard rail.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, so high probability (>10% of average operating time) C3 - Difficult to control. The following truck is driverless (**ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other road users to perform a corrective manoeuvre at high speed to avoid collision.	D

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE15_03]	The platoon is driving inside a roundabout and the following truck is expected to steer, but the provided lateral displacement is not sufficient. The following truck might go off its lane.	S3 - Pedestrian accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),as per VDA 702 Situation Catalogue. C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. The other vehicle's drivers if attentive can perform corrective manoeuvre if needed. The pedestrians if attentive can also wait for the complete stop of the truck before to cross the road.	B
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE15_04]	The platoon is driving inside a roundabout and the following truck is expected to steer, but the provided lateral displacement is not sufficient. The following truck might go off its lane.	S3 - Pedestrian accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles within the roundabout, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4**, as per VDA 702 Situation Catalogue.** C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The other vehicle's drivers if attentive can perform corrective manoeuvre if needed. The pedestrians if attentive can also wait for the complete stop of the truck before to cross the road.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_05]	The platoon is driving inside a junction and the following truck is expected to steer, but the provided lateral displacement is not sufficient. The following truck might go off its lane.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles to the junction, but not prevent the presence of pedestrians. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. The other vehicle's drivers if attentive can perform corrective manoeuvre if needed. The pedestrians if attentive can also wait for the complete stop of the truck before to cross the road.	B
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_06]	The platoon is driving inside a junction and the following truck is expected to steer, but the provided lateral displacement is not sufficient. The following truck might go off its lane.	S3 - Pedestrians accident. Intelligent traffic lights are present ***(ref[PAF_A10])*** and can regulate the access of other vehicles to the junction, but not prevent the presence of pedestrians. E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4. C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. The other vehicle's drivers if attentive can perform corrective manoeuvre if needed. The pedestrians if attentive can also wait for the complete stop of the truck before to cross the road.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving on construction site/rod works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_07]	The platoon is expected to steer, but the lateral displacement is not sufficient, so the following truck might deviate from the intended path and struck the construction workers.	S3 - Potential fatal injuries for the construction workers. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People in the construction area are working, so they are not attentive and they cannot move away.	B
Dry road - Driving on construction site/rod works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_08]	The platoon is expected to steer, but the lateral displacement is not sufficient, so the following truck might deviate from the intended path and struck the construction workers.	S3 - Potential fatal injuries for the construction workers. E2 - Based on frequency, if the fault occurs while in the mentioned situation, the exposure is E2, so medium probability (<1% of average operating time). C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People in the construction area are working, so they are not attentive and they cannot move away.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_09]	The platoon is expected to steer and change lane, but the lateral displacement is not sufficient. The following truck might be exposed in a vulnerable position between two different lanes, representing an obstacle for the other road users.	S3 - Potential collision at low speed with other road users, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. The other road users are usually attentive and can apply brake and steer to avoid potential collisions, as well as keep a safe distance.	A
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_10]	The platoon is expected to steer and change lane, but the lateral displacement is not sufficient. The following truck might be exposed in a vulnerable position between two different lanes, representing an obstacle for the other road users.	S2 - Potential collision at low speed with other road users, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4**, as per VDA 702 Situation Catalogue.** C2 - Normally controllable. The following truck is driverless (**ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. The other road users are usually attentive and can apply brake and steer to avoid potential collisions, as well as keep a safe distance.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_11]	The platoon is expected to turn, but the lateral displacement is not sufficient. The following truck might move towards another lane being exposed in a vulnerable position and representing an obstacle for the other road users. The worst case might be a potential collision with oncoming vehicles at low speed.	S3 - Fatal injuries due to a front collision. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The oncoming vehicle have very little time to apply brake and steer to avoid a collision.	C
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE15_12]	The platoon is expected to turn, but the lateral displacement is not sufficient. The following truck might move towards another lane being exposed in a vulnerable position and representing an obstacle for the other road users. The worst case might be a potential collision with oncoming vehicles at low speed.	S3 - Fatal injuries due to a front collision E4 - Based on frequency, if the pre-existing fault leads to a hazardous event when the mentioned driving situation occurs, the exposure is E4, **as per Table B.3, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]**), so a manual corrective manoeuvre to avoid an impact is not possible. The oncoming vehicle have very little time to apply brake and steer to avoid a collision.	D

Risk Assessment of Hazard PAF_H16 - Unintended lateral motion by the following truck

NOTE - *Exposure based on frequency is not required for cases of unintented lateral motion of vehicle because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE16_01]	The platooning function command an unexpected lateral displacement of the following truck. The following truck can move from the center of the lane to the right or to the left. This might lead to have collision with other road users or the guard rail at high speed.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other vehicles's drivers to perform a corrective manoeuvre at high speed to avoid collision.	D
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE16_02]	The platooning function command an unexpected lateral displacement while taking an onramp/offramp. The following truck moves from the center of the lane to the right or to the left. This can lead to have a collision with other vehicles or with the crashrail. The following vehicles might get involved in an accident. Potential injuries for the truck occupants and the following vehicles's drivers.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per Table B.2, ISO 26262-3.** C3 - Uncontrollable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Junctions Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE16_03]	The platooning function command an unexpected lateral displacement approaching a junction. The following truck moves from the center of the lane to the right or to the left. This might lead to have a collision with other vehicles or pedestrians.	S3 - Pedestrian accident and side impact for other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible.	C
Dry road - Toll gates Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE16_04]	The platooning function command an unexpected lateral displacement while approaching a toll gate. This can lead to have a collision with other vehicles or with the same tollboth. Possible collision with the people working nearby.	S3 - People accident. An intelligent tool infrasctructure is present ***(ref[PAF_A10])*** and they can regulate the access to a specific toll to the platoon only. In this way, no vehicles will be present in the immediate vacinity. But even in this case, the following might have a collision with the toll infrastructure and with the people nearby. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), **as per VDA 702 Situation Catalogue.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the people working nearby to move away and avoid an impact.	B
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE16_05]	The platooning function command an unexpected lateral displacement while driving in a construction/road works area. This can lead to have a collision with the construction structures and workers.	S3 - Potential fatal injuries for the construction workers. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3.** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People in the construction area are working, so they are not attentive and they cannot move away.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE16_06]	The platooning function command an unexpected lateral displacement while driving in a hub. This can lead to have a collision with other vehicles, stationary objects or people nearby at very low speed.	S3 - People accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The platoon is driving at very low speed, so the people nearby if attentive can react and move away from the platoon.	A
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE16_07]	The platooning function command an unexpected lateral displacement driving in a resting area/parking lot. This can lead to have a collision with other vehicles, stationary objects or people nearby at very low speed.	S3 - Pedestrian accident. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C2 - Normally controllable. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. The platoon is driving at very low speed, so the people nearby if attentive can react and move away from the platoon.	A
Dry road - Being overtaken High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE16_08]	The platooning function command an unexpected lateral displacement while it is being overtaken. This can lead to have a collision with the overtaking vehicle. Possible multiple-vehicle collision.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C3 - Difficult to control and avoid a collision. It is assumed that the following vehicle that perform the overtaking manoeuvre is manually driven **(ref[PAF_A09]).** The driver of the vehicle does not expect such lateral displacement from the truck. Difficult to perform an evasive manoeuvre and avoid an impact at high speed.	C

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE16_09]	The platooning function command an unexpected lateral displacement while the truck is overtaking. This can lead to have a collision with the guard rail or with the vehicle overtaken. Possible multiple-vehicle collision.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, **as per Table B.4, ISO 26262-3.** C3 - Difficult to control and avoid a collision. it is assumed that the undertaken vehicle is manually driven **(ref[PAF_A09])**. The driver of the vehicle does not expect such manoeuvre from the truck. Difficult to perform an evasive manoeuvre and avoid an impact at high speed.	A

Risk Assessment of Hazard PAF_H17 - Total loss of vehicle control

NOTE - *Exposure based on frequency is not required for cases of total loss of vehicle control because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE17_01]	The platooning function loses the control of acceleration, braking and steering of the following truck. This will result in the truck driving without any control, moving out of its lane and having a collision with other road users or stationary objects.	S3 - Potential impact at high speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** S3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. Difficult for the other vehicles's drivers to perform a corrective manoeuvre at high speed to avoid collision.	D
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE17_02]	The platooning function loses the control of acceleration, braking and steering of the following truck. This will result in the truck driving without any control, moving from the intended path towards another direction.	S3 - Pedestrian accident. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People nearby have very little time to move away and avoid a collision.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE17_03]	The platooning function loses the control of acceleration, braking and steering of the following truck. This will result in the truck driving without any control, moving from the intended path towards another direction.	S3 - Pedestrian accident E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08]),** so a manual corrective manoeuvre to avoid an impact is not possible. People nearby have very little time to move away and avoid a collision.	B
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE17_04]	The platooning function loses the control of acceleration, braking and steering of the following truck. This will result in the truck driving without any control, moving off the road.	S3 - Pedestrian accident E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People nearby have very little time to move away and avoid a collision.	C
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE17_05]	The platooning function loses the control of acceleration, braking and steering of the following truck while driving in a construction/road works are. This will result in the truck driving without any control and might lead to have a collision with the construction structures and workers.	S3 - Potential fatal injuries for the construction workers E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3** C3 - Difficult to control. The following truck is driverless **(ref[PAF_A08])**, so a manual corrective manoeuvre to avoid an impact is not possible. People in the construction area are working, so they are not attentive and they cannot move away.	B

Risk Assessment of Hazard PAF_H18 - Unexpected disengagement of the following truck from the platoon

***NOTE** - Exposure based on frequency is not required for cases of unexpected disengagement because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE18_01]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). On highway, this might leave the trucks in a vulnerable position.	S3 - Potential impact at high speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time), **as per Table B.2, ISO 26262-3.** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The following drivers does not expect such deceleration of the truck/platoon, but they are keeping a safe distance and can notice the deceleration of the platoon, so they have time to react appropriately applying brake and steering or overtaking to to avoid possible collisions.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE18_02]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). Within a roundabout/intersection, this might leave the trucks in a vulnerable position.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the roundabout/intersection, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access, allowing it temporarily only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The intelligent infrastructures prevents other vehicles from closely following the platoon inside the roundabout, so there is enough time to react safely. In case of following vehicles present, the drivers can apply brake and steer if needed.	-
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE18_03]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). Driving in an onramp, this might lead the truck to stop within the acceleration lane without taking the highway, leaving the trucks in a vulnerable position. In case of offramp, this might lead the following truck to stop in the deceleration lane, leaving the trucks in a vulnerable position.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), ***as per Table B.2, ISO 26262-3.*** C1 **-** Simply controllable (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]**). The following drivers are usually attentive and keep a safe distance, so they have time to react appropriately applying brake and steering to avoid possible collisions.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE18_04]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). Approaching a junction, this might leave the trucks in a vulnerable position.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the junction, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the junction, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C0 - Controllable in general. The intelligent infrastructure prevents other vehicles from entering the junction, so there is enough time to react safely. In case of following vehicles present, the drivers can apply brake and steer if needed.	-
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE18_05]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected the obstacles related to the construction site (ref[PAF_A13]). This can result in having stopped trucks in the construction zone.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** Following vehicles can collide with the trucks if not controlled. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3.** C0 - Controllable in general. In construction zones, following vehicle drivers are more attentive, so they can apply brake and steer if needed to avoid collision.	-
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE18_06]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE18_07]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE18_08]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). While changing lanes, this can be a risky manoeuvre if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time)**,as per VDA 702 Situation Catalogue.** C1 - Simply controllable at low speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE18_09]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path. While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to stop wherever it is. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing..	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue**. C2 - Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	B
Dry road - Performing overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE18_10]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). This might lead the trucks to remain in the fast lane once completed the overtaking manoeuvre, putting the trucks in a vulnerable situation.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, **as per Table B.4, ISO 26262-3.** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The nearby road users does not expect such manoeuvre of the truck while overtaking. They have little time to react and perform an evasive manoeuvre.	A

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE18_11]	The following truck are not part of the platoon anymore and cannot communicate with the other trucks. It can perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]).	S0 - Potential impact at low speed (S2) might happen with other vehicles within the junction, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the junction, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C0 - Controllable in general. The following truck can still detect the surrounding environment and react accordingly.	-

Risk Assessment of Hazard PAF_H19 - Disengagement request approval not communicated to the following truck's operator

NOTE - *Exposure based on frequency is not required for cases of disengagement request approval not communicated because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE19_01]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). Within a roundabout/intersection, this might leave the trucks in a vulnerable position.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the roundabout/intersection, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access, allowing it temporarily only from the platoon direction. In this case, no collision will happen with other vehicles. E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE19_02]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected the obstacles related to the construction site (ref[PAF_A13]). This can result in having stopped trucks in the construction zone.	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** Following vehicles can collide with the trucks if not controlled. C2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3.** C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE19_03]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE19_04]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE19_05]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). While changing lanes, this can be a risky manoeuvre if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue**. C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE19_06]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to go back to the previous road lane and stop. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-
Dry road - Performing overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE19_07]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). This might lead the trucks to remain in the fast lane once completed the overtaking manoeuvre, putting the trucks in a vulnerable situation.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, as per Table B.4, ISO 26262-3. C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE19_08]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]).	S0 - Potential impact at low speed (S2) might happen with other vehicles within the junction, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the junction, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time). C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE19_09]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]).	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time)**, as per Table B.2, ISO 26262-3.** C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Executing a turn Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE19_10]	The following trucks are not part of the platoon anymore but the following truck's operator is not informed about it. The following truck can still perceive information regarding the surrounding environment but it has not a path to follow. This will result in the truck stopping in its path (ref[PAF_A13]). Stopping in its path while turning can put the truck into a vulnerable situation. Possible collision at low speed with the following vehicle.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The driver of the following truck asked for a disengagement. It means that he is already attentive and he can notice the loss of autonomous control and take charge. The following vehicle's driver will usually observe the deceleration of the forward vehicle and the brake lights and react by braking or steering to avoid collision.	-

Risk Assessment of Hazard PAF_H20 - Engaged status informed to the following truck's operator before initiation of autonomous control

NOTE - *Exposure based on frequency is not required for cases of communication of engagement before than happened because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered. It is also assumed that the driver of the following truck will not ask for the engagement during complicated driving situations (e.g. while changing lanes, overtaking, driving in construction zone, etc..).*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Hub Very low speed (>0km/h, <=10 km/h) No platoon engaged [PAF_HE20_01]	The driver of a following truck is asking for being part of a platoon and he receives communication about the successful engagement before initiating autonomous control. This might result in the driver releasing controls before the autonomous function take charge.	S0 - No collision, so no injuries E2- Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. The driver is still attentive and he will notice that the truck is not driving autonomously, so he can easily react and take charge.	-
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) No platoon engaged [PAF_HE20_02]	The driver of a following truck is asking for being part of a platoon and he receives communication about the successful engagement before initiating autonomous control. This might result in the driver releasing controls before the autonomous function take charge.	S0 - No collision, so no injuries E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time) C0 - Controllable in general. The driver is still attentive and he will notice that the truck is not driving autonomously, so he can easily react and take charge.	-

Risk Assessment of Hazard PAF_H21 - Unexpected engagement of a platoon

NOTE - *Exposure based on frequency is not required for cases of unexpected engagement because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road- Stopped at the hub No platoon engaged [PAF_HE21_01]	A platoon is formed unexpectedly and as a consequence the following truck might start moving unexpectedly. People might be present working on the following trucks or loading/unloading cargo and experience a fall/impact due to the unexpected movement.	S3 - Potential injuries for people working on the following trucks or loading/unloading cargo E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). Since the driving situation considered is "truck stopped at the hub and people present in front of it", the exposure may be lower. Exposure reduced to the lower value (E1) C3 - People will be occupied working. They will not be expecting the truck to move and they might have no time to react and avoid injuries	A

Risk Assessment of Hazard PAF_H22 - Unexpected disengagement of the platoon by the lead truck

NOTE - *Exposure based on frequency is not required for cases of unexpected disengagement of the platoon because the consequences of this fault will be experienced immediately irrespective of the current operational situation (not a pre-existing fault). For this reason, only exposure by duration will be considered.*

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Highway High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE22_01]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in its path (ref[PAF_A13]). On highway, this might leave the trucks in a vulnerable position.	S3 - Potential impact at high speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** *E4 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E4, so high probability (>10% of average operating time),* ***as per Table B.2, ISO 26262-3.*** C0 - Controllable in general. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The following drivers does not expect such deceleration of the truck/platoon, but they are keeping a safe distance and can notice the deceleration of the platoon, so they have time to react appropriately applying brake and steering or overtaking to to avoid possible collisions.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Roundabout/intersections Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE22_02]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in its path (ref[PAF_A13]). Within a roundabout/intersection, this might leave the trucks in a vulnerable position.	S0 - Potential impact at low speed (S2) might happen with other vehicles within the roundabout/intersection, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access, allowing it temporarily only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time)**,as per VDA 702 Situation Catalogue.** C0 - Controllable in general. The intelligent infrastructures prevents other vehicles from closely following the platoon inside the roundabout, so there is enough time to react safely. In case of following vehicles present, the drivers can apply brake and steer if needed.	-
Dry road - Onramp/offramp Low speed (>10 km/h, <=50 km/h) Platooning driving mode [PAF_HE22_03]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in its path (ref[PAF_A13]). Driving in an onramp, this might lead the trucks to stop within the acceleration lane without taking the highway, leaving the trucks in a vulnerable position. In case of offramp, this might lead the following truck to stop in the deceleration lane, leaving the trucks in a vulnerable position.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time), as per Table B.2, ISO 26262-3. C1 - Simply controllable (99% or more of drivers are able to avoid harm). It is assumed that the vehicles around the platoon are manually driven (ref[PAF_A09]). The following drivers are usually attentive and keep a safe distance, so they have time to react appropriately applying brake and steering to avoid possible collisions.	QM

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Driving on construction site/road works Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE22_04]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in its path. This can result in having stopped trucks in the construction zone (ref[PAF_A13]).	S2 - Potential impact at low speed, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** Following vehicles can collide with the trucks if not controlled. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time),**as per Table B.4, ISO 26262-3.** C0 - Controllable in general. In construction zones, following vehicle drivers are more attentive, so they can apply brake and steer if needed to avoid collision.	-
Dry road - Hub Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE22_05]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-
Dry road - Resting areas/parking lots Very low speed (>0km/h, <=10 km/h) Platooning driving mode [PAF_HE22_06]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in its path. This will result in the trucks stopping in its path once detected other road users or stationary object (ref[PAF_A13]).	S1 - Potential impact at very low speed, ***as per [Ref 1] Part 3 - Table B.1 very low speed front/rear collision S1.*** A collision at very low speed might happen if the trucks are stopped in the middle of the driving lanes. E2 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E2, so low probability (<1% of average operating time). C0 - Controllable in general. Other vehicles are driving slowly and the driver are attentive, so they can easily react.	-

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Changing lanes Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE22_07]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path (ref[PAF_A13]). While changing lanes, this can be a risky manoeuvre if the trucks were moving to another lane to undertake other vehicles or due to a roadway narrowing.	S2 - Potential impact at low speed with the following vehicles, ***as per [Ref 1] Part 3 - Table B.1 low speed front/rear collision S2.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue.** S1 - Simply controllable at low speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	QM
Dry road - Changing lanes Medium speed (>50km/h, <=80 km/h) Platooning driving mode [PAF_HE22_08]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path (ref[PAF_A13]). While changing lanes, since the truck has the goal to move within its lanes, this might lead the truck to stop wherever it is. This can be a risky manoeuvre, if the truck was moving to another lane to undertake other vehicles or due to a roadway narrowing.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time),**as per VDA 702 Situation Catalogue** C2 - Normally controllable at medium speed. The following truck can still detect the surrounding environment and react accordingly. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09])**. The following vehicle's driver does not expect such manoeuvre, but it is assumed that they are keeping a safe distance so that they can apply brake and steer to avoid collision.	B

Situation	Comments / Possible Effects	Severity (S)/Exposure(E)/Controllability(C) - Rationale	ASIL
Dry road - Performing overtaking manoeuvre High speed (>80 km/h, <=90 km/h) Platooning driving mode [PAF_HE22_09]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path (ref[PAF_A13]). This might lead the truck to remain in the fast lane once completed the overtaking manoeuvre, putting the truck in a vulnerable situation.	S3 - Potential impact at medium speed, ***as per [Ref 1] Part 3 - Table B.1 medium speed front/rear collision S3.*** E1 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E1, so very low probability, **as per Table B.4, ISO 26262-3.** C3 - Difficult to control. It is assumed that the vehicles around the platoon are manually driven **(ref[PAF_A09]).** The nearby road users does not expect such manoeuvre of the truck while overtaking. They have little time to react and perform an evasive manoeuvre.	A
Dry road - Approaching a junction/intersections with intelligent traffic lights Low speed (>10km/h, <=50 km/h) Platooning driving mode [PAF_HE22_10]	The platoon is unexpectedly disengaged and the following trucks are not part of a platoon anymore. They will start driving based on the perceived information regarding the surrounding environment but they will not have information regarding the path to follow. This will result in the trucks stopping in their path (ref[PAF_A13]).	S0 - Potential impact at low speed (S2) might happen with other vehicles within the junction, but ITS are presents ***(ref[PAF_A10])*** and they can regulate the access to the junction, allowing temporarily the access only from the platoon direction. In this case, no collision will happen with other vehicles. E3 - Based on duration, if the fault occurs while in the mentioned situation, the exposure is E3, so medium probability (from 1% to 10% of average operating time) C0 - Controllable in general. The following truck can still detect the surrounding environment and react accordingly.	-

APPENDIX C – GLOSSARY

Term	Definition
Convoy	A truck platoon may be defined as trucks that travel together in convoy formation at a fixed gap distance typically less than 1 second apart up to 0.3 seconds. The vehicles closely follow each other using wireless vehicle-to-vehicle (V2V) communication and advanced driver assistance systems
Cut-in	A lane change manoeuvre performed by vehicles from the adjacent lane to the ego vehicle's lane, at a distance close enough (i.e., shorter than desired inter vehicle distance) relative to the ego vehicle.
Cut-out	A lane change manoeuvre performed by vehicles from the ego lane to the adjacent lane.
Cut-through	A lane change manoeuvre performed by vehicles from the adjacent lane (e.g. left lane) to ego vehicle's lane, followed by a lane change manoeuvre to the other adjacent lane (e.g. right lane).
Ego Vehicle	The vehicle from which the perspective is considered.
Emergency brake	Brake action with an acceleration of <-4 m/s2
Event	An event marks the time instant at which a transition of a state occurs, such that before and after an event, the system is in a different mode.
Following truck	Each truck that is following behind a member of the platoon, being every truck except the leading and the trailing truck, when the system is in platoon mode.
Leading truck	The first truck of a truck platoon
Legal Safe Gap	Minimum allowed elapsed time/distance to be maintained by a standalone truck while driving according to Member States regulation (it could be 2 seconds, 50 meters or not present)
Manoeuvre ("activity")	A particular (dynamic) behaviour which a system can perform (from a driver or other road user perspective) and that is different from standing still, is being considered a manoeuvre.
ODD (operational design domain)	The ODD should describe the specific conditions under which a given automation function is intended to function. The ODD is the definition of where (such as what roadway types and speeds) and when (under what conditions,

Term	Definition
	such as day/night, weather limits, etc.) an automation function is designed to operate.
Operational layer	The operational layer involves the vehicle actuator control (e.g. accelerating/braking, steering), the execution of the aforementioned manoeuvres, and the control of the individual vehicles in the platoon to automatically perform the platooning task. Here, the main control task is to regulate the inter-vehicle distance or velocity and, depending on the Platooning Level, the lateral position relative to the lane or to the preceding vehicle. Key performance requirements for this layer are vehicle following behaviour and (longitudinal and lateral) string stability of the platoon, where the latter is a necessary requirement to achieve a stable traffic flow and to achieve scalability with respect to platoon length, and the short-range wireless inter-vehicle communication is the key enabling technology.
Platoon	A group of two or more automated cooperative vehicles in line, maintaining a close distance, typically such a distance to reduce fuel consumption by air drag, to increase traffic safety by use of additional ADAS-technology, and to improve traffic throughput because vehicles are driving closer together and take up less space on the road.
Platoon Automation Levels	In analogy with the SAE automation levels subsequent platoon automation levels will incorporate an increasing set of automation functionalities, up to and including full vehicle automation in a multi-brand platoon in real traffic for the highest Platooning Automation Level. The definition of “platooning levels of automation” will comprise elements like e.g. the minimum time gap between the vehicles, whether there is lateral automation available, driving speed range, operational areas like motorways, etc. Three different levels are anticipated; called A, B and C.
Platoon candidate	A truck who intends to engage the platoon either from the front or the back of the platoon.
Platoon cohesion	Platoon cohesion refers to how well the members of the platoon remain within steady state conditions in various scenario conditions (e.g. slopes, speed changes).
Platoon disengaging	The ego-vehicle decides to disengage from the platoon itself or is requested by another member of the platoon to do so. When conditions are met the ego-vehicle starts to increase the gap between the trucks to a safe non-platooning gap. The disengaging is completed when the gap is large enough (e.g. time gap of 1.5 seconds, which is depends on the operational safety based on vehicle dynamics and human reaction times is given). A.k.a. leave platoon

Term	Definition
Platoon dissolve	All trucks are disengaging the platoon at the same time. A.k.a. decoupling, a.k.a. disassemble.
Platoon engaging	Using wireless communication (V2V), the Platoon Candidate sends an engaging request. When conditions are met the system starts to decrease the time gap between the trucks to the platooning time gap. A.k.a. join platoon
Platoon formation	Platoon formation is the process before platoon engaging in which it is determined if and in what format (e.g. composition) trucks can/should become part of a new / existing platoon. Platoon formation can be done on the fly, scheduled or a mixture of both. Platoon candidates may receive instructions during platoon formation (e.g. to adapt their velocity, to park at a certain location) to allow the start of the engaging procedure of the platoon.
Platoon split	The platoon is split in 2 new platoons who themselves continue as standalone entities.
Requirements	Description of system properties. Details of how the requirements shall be implemented at system level
Scenario	A scenario is a quantitative description of the ego vehicle, its activities and/or goals, its static environment, and its dynamic environment. From the perspective of the ego vehicle, a scenario contains all relevant events. Scenario is a combination of a manoeuvre (“activity”), ODD and events
Service layer	The service layer represents the platform on which logistical operations and new initiatives can operate.
Specifications	A group of two or more vehicles driving together in the same direction, not necessarily at short inter-vehicle distances and not necessarily using advanced driver assistance systems
Steady state	In systems theory, a system or a process is in a steady state if the variables (called state variables) which define the behaviour of the system or the process are unchanging in time. In the context of platooning this means that the relative velocity and gap between trucks is unchanging within tolerances from the system parameters.
Strategic layer	The strategic layer is responsible for the high-level decision-making regarding the scheduling of platoons based on vehicle compatibility and Platooning Level, optimisation with respect to fuel consumption, travel times, destination, and impact on highway traffic flow and infrastructure, employing cooperative ITS cloud-based solutions. In addition, the routing of vehicles to allow for platoon forming is included in this layer. The strategic layer is implemented in a

Term	Definition
	centralised fashion in so-called traffic control centres. Long-range wireless communication by existing cellular technology is used between a traffic control centre and vehicles/platoons and their drivers.
Tactical layer	The tactical layer coordinates the actual platoon forming (both from the tail of the platoon and through merging in the platoon) and platoon dissolution. In addition, this layer ensures platoon cohesion on hilly roads, and sets the desired platoon velocity, inter-vehicle distances (e.g. to prevent damaging bridges) and lateral offsets to mitigate road wear. This is implemented through the execution of an interaction protocol using the short-range wireless inter-vehicle communication (i.e. V2X). In fact, the interaction protocol is implemented by message sequences, initiating the manoeuvres that are necessary to form a platoon, to merge into it, or to dissolve it, also taking into account scheduling requirements due to vehicle compatibility.
Target Time Gap	Elapsed time to cover the inter vehicle distance by a truck indicated in seconds, agreed by all the Platoon members; it represents the minimum distance in seconds allowed inside the Platoon.
Time gap	Elapsed time to cover the inter vehicle distance by a truck indicated in seconds.
Trailing truck	The last truck of a truck platoon
Truck Platoon	Description of system properties. Details of how the requirements shall be implemented at system level
Use case	Use-cases describe how a system shall respond under various conditions to interactions from the user of the system or surroundings, e.g. other traffic participants or road conditions. The user is called actor on the system, and is often but not always a human being. In addition, the use-case describes the response of the system towards other traffic participants or environmental conditions. The use-cases are described as a sequence of actions, and the system shall behave according to the specified use-cases. The use-case often represents a desired behaviour or outcome. In the ensemble context a use case is an extension of scenario which add more information regarding specific internal system interactions, specific interactions with the actors (e.g. driver, I2V) and will add different flows (normal & alternative e.g. successful and failed in relation to activation of the system / system elements).

Acronyms and abbreviations

Acronym / Abbreviation	Meaning
ACC	Adaptive Cruise Control
ADAS	Advanced driver assistance system
AEB	Autonomous Emergency Braking (System, AEBS)
ASIL	Automotive Safety Integrity Level
ASN.1	Abstract Syntax Notation One
BTP	Basic Transport Protocol
C-ACC	Cooperative Adaptive Cruise Control
C-ITS	Cooperative ITS
CA	Cooperative Awareness
CAD	Connected Automated Driving
CAM	Cooperative Awareness Message
CCH	Control Channel
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DITL	Driver-In-the-Loop
DOOTL	Driver-Out-Of-the Loop
DSRC	Dedicated Short-Range Communications
ETSI	European Telecommunications Standards Institute
EU	European Union
FCW	Forward Collision Warning
FLC	Forward Looking Camera
FSC	Functional Safety Concept
GN	GeoNetworking
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface

Acronym / Abbreviation	Meaning
HARA	Hazard Analysis and Risk Assessment
HIL	Hardware-in-the-Loop
HMI	Human Machine Interface
HW	Hardware
I/O	Input/Output
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITL	In-The_Loop
ITS	Intelligent Transport System
IVI	Infrastructure to Vehicle Information message
LDWS	Lane Departure Warning System
LKA	Lane Keeping Assist
LCA	Lane Centring Assist
LRR	Long Range Radar
LSG	Legal Safe Gap
MAP	MapData message
MIO	Most Important Object
MRR	Mid Range Radar
OS	Operating system
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OOTL	Out-Of The-Loop
PAEB	Platooning Autonomous Emergency Braking
PMC	Platooning Mode Control
QM	Quality Management
RSU	Road Side Unit
SA	Situation Awareness

Acronym / Abbreviation	Meaning
SAE	SAE International, formerly the Society of Automotive Engineers
SCH	Service Channel
SDO	Standard Developing Organisations
SIL	Software-in-the-Loop
SPAT	Signal Phase and Timing message
SRR	Short Range Radar
SW	Software
TC	Technical Committee
TOR	Take-Over Request
TOT	Take-Over Time
TTG	Target Time Gap
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to any (where x equals either vehicle or infrastructure)
VDA	Verband der Automobilindustrie (German Association of the Automotive Industry)
WIFI	Wireless Fidelity
WLAN	Wireless Local Area Network
WP	Work Package