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Part 12: Adaptation for motorcycles

Véhicules routiers — Sécurité fonctionnelle —

Partie 12: Adaptation aux motos

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Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms, definitions and abbreviated terms	2
4 Requirement for compliance	2
4.1 Purpose	2
4.2 General requirements	2
4.3 Interpretations of tables	3
4.4 ASIL-dependent requirements and recommendations	3
4.5 Adaptation for motorcycles	3
4.6 Adaptation for Trucks, Buses, Trailers and Semitrailers	3
5 Safety culture	4
5.1 Objective	4
5.2 Requirements and recommendations	4
6 Confirmation measures: types, independency and authority	4
6.1 Objective	4
6.2 Requirements and recommendations	5
7 Hazard analysis and risk assessment	8
7.1 Objective	8
7.2 General	8
7.3 Input to this clause	8
7.3.1 Prerequisites	8
7.3.2 Further supporting information	9
7.4 Requirements and recommendations	9
7.4.1 Initiation of the hazard analysis and risk assessment	9
7.4.2 Situation analysis and hazard identification	9
7.4.3 Classification of hazardous events	10
7.4.4 Determination of safety goals	13
7.4.5 Verification	13
7.5 Work products	14
8 Vehicle integration and testing	14
8.1 Objective	14
8.2 Requirements and recommendation	14
8.2.1 Vehicle integration	14
8.2.2 Test goals and test methods during vehicle testing	14
9 Safety Validation	16
9.1 Objective	16
9.2 General	16
9.3 Input to this clause	17
9.3.1 Prerequisites	17
9.3.2 Further supporting information	17
9.4 Requirements and recommendation	17
9.4.1 Safety validation environment	17
9.4.2 Planning of safety validation	17
9.4.3 Execution of safety validation	18
9.4.4 Evaluation	19
9.5 Work products	19
Annex A (informative) Overview of and workflow of adaptation of ISO 26262 for motorcycles	20
Annex B (informative) Hazard analysis and risk assessment for motorcycles	24

Annex C (informative) Example of controllability classification techniques	33
Bibliography	37

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC22/SC32 Electrical and electronic components and general system aspects.

A list of all parts in the ISO 26262- series can be found on the ISO website.

Introduction

ISO 26262 is the adaptation of IEC 61508 to address the sector specific needs of electrical and/or electronic (E/E) systems within road vehicles.

This adaptation applies to all activities during the safety lifecycle of safety-related systems comprised of electrical, electronic and software components.

Safety is one of the key issues in the development of road vehicles. Development and integration of automotive functionalities strengthen the need for functional safety and the need to provide evidence that functional safety objectives are satisfied.

With the trend of increasing technological complexity, software content and mechatronic implementation, among others there are increasing risks from systematic failures and random hardware failures, these being considered within the scope of functional safety. ISO 26262 includes guidance to mitigate these risks by providing appropriate requirements and processes.

To achieve functional safety, ISO 26262:

- a) provides a reference for the automotive safety lifecycle and supports the tailoring of the activities to be performed during the lifecycle phases, i.e. development, production, operation, service, and decommissioning;
- b) provides an automotive-specific risk-based approach to determine integrity levels [Automotive Safety Integrity Levels (ASIL)];
- c) uses ASILs to specify which of the requirements of ISO 26262 are applicable to avoid unreasonable residual risk;
- d) provides requirements for functional safety management, verification, validation and confirmation measures; and
- e) provides requirements for relations with suppliers.

ISO 26262 is concerned with functional safety of E/E systems that is achieved through safety measures including safety mechanisms. It also provides a framework within which safety-related systems based on other technologies (e.g. mechanical, hydraulic and pneumatic) can be considered.

The achievement of functional safety is influenced by the development process (including such activities as requirements specification, design, implementation, integration, verification, validation and configuration), the production and service processes and the management processes.

Safety is intertwined with common function-oriented and quality-oriented activities and work products. ISO 26262 addresses the safety-related aspects of these activities and work products.

[Figure 1](#) shows the overall structure of ISO 26262. ISO 26262 is based upon a V-model as a reference process model for the different phases of product development. Within the figure:

- the shaded “V”s represent the interconnection among ISO 26262-3, ISO 26262-4, ISO 26262-5, ISO 26262-6 and ISO 26262-7; for motorcycles ISO 26262-12, Clause 6 supplements ISO 26262-3 and [Clause 7](#), [8](#) and [9](#) supplements Part 4.
- the specific clauses are indicated in the following manner: “m-n”, where “m” represents the number of the particular part and “n” indicates the number of the clause within that part.

EXAMPLE “2-6” represents Clause 6 of ISO 26262-2.

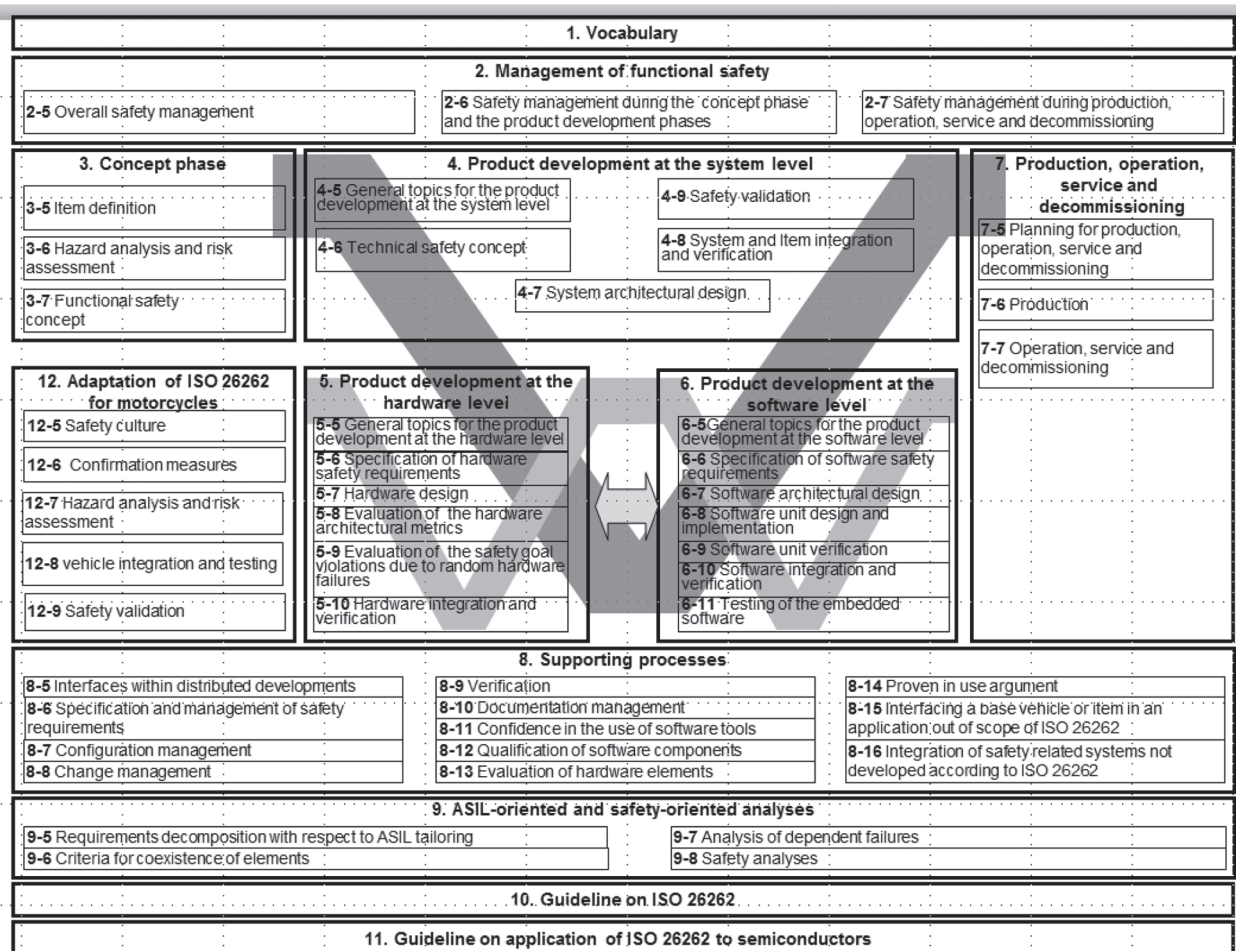


Figure 1 — Overview of ISO 26262

Road vehicles — Functional safety —

Part 12: Adaptation for motorcycles

1 Scope

ISO 26262 is intended to be applied to safety-related systems that include one or more electrical and/or electronic (E/E) systems and that are installed in series production road vehicles, excluding mopeds. ISO 26262 does not address unique E/E systems in special vehicles such as E/E systems designed for drivers with disabilities.

NOTE Other dedicated application-specific safety standards exist and may complement ISO 26262 or vice versa.

Systems and their components released for production, or systems and their components already under development prior to the publication date of this edition of ISO 26262, are exempted from the scope of this edition. For further development or alterations based on systems and their components released for production prior to the publication of this edition of ISO 26262, only the modifications will be developed in accordance with this edition of ISO 26262. This edition of ISO 26262 addresses integration of existing systems not developed according to this edition of ISO 26262 and systems developed according to this edition of ISO 26262 by tailoring the safety lifecycle.

ISO 26262 addresses possible hazards caused by malfunctioning behaviour of safety-related E/E systems, including interaction of these systems. It does not address hazards related to electric shock, fire, smoke, heat, radiation, toxicity, flammability, reactivity, corrosion, release of energy and similar hazards, unless directly caused by malfunctioning behaviour of safety-related E/E systems.

ISO 26262 does not address the nominal performance of E/E systems, even if functional performance standards exist for these systems (e.g. active and passive safety systems, brake systems, adaptive cruise control).

ISO 26262 describes a framework for functional safety to assist the development of safety-related E/E systems. This framework is intended to be used to integrate functional safety activities into a company-specific development framework. Some requirements have a clear technical focus to implement functional safety into a product; others address the development process and can therefore be seen as process requirements in order to demonstrate the capability of an organization with respect to functional safety.

This part of ISO 26262 specifies the requirements for adaptation for motorcycles, including the following:

- safety management during the concept phase and the product development,
- hazard analysis and risk assessment,
- vehicle integration and testing, and
- Safety validation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 26262-1:2018, *Road vehicles — Functional safety — Part 1: Vocabulary*

ISO 26262-2:2018, *Road vehicles — Functional safety — Part 2: Management of functional safety*

ISO 26262-3:2018, *Road vehicles — Functional safety — Part 3: Concept phase*

ISO 26262-4:2018, *Road vehicles — Functional safety — Part 4: Product development at the system level*

ISO 26262-5:2018, *Road vehicles — Functional safety — Part 5: Product development at the hardware level*

ISO 26262-6:2018, *Road vehicles — Functional safety — Part 6: Product development at the software level*

ISO 26262-8:2018, *Road vehicles — Functional safety — Part 8: Supporting processes*

ISO 26262-9:2018, *Road vehicles — Functional safety — Part 9: Automotive Safety Integrity Level (ASIL)-oriented and safety-oriented analyses*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 26262-1:2018 apply.

4 Requirement for compliance

4.1 Purpose

This clause describes how:

- a) to achieve compliance with ISO 26262;
- b) to interpret the tables used in ISO 26262; and
- c) to interpret the applicability of each clause, depending on the relevant ASIL(s).

4.2 General requirements

When claiming compliance with ISO 26262, each requirement shall be met, unless one of the following applies:

- a) tailoring of the safety activities in accordance with ISO 26262-2 has been performed that shows that the requirement does not apply, or
- b) a rationale is available that the non-compliance is acceptable and the rationale has been assessed in accordance with ISO 26262-2, for example as part of the functional safety assessment.

Informative content, including notes and examples, is only for guidance in understanding, or for clarification of the associated requirement, and shall not be interpreted as a requirement itself or as complete or exhaustive.

The results of safety activities are given as work products. “Prerequisites” are information which shall be available as work products of a previous phase. Given that certain requirements of a clause are ASIL-dependent or may be tailored, certain work products may not be needed as prerequisites.

“Further supporting information” is information that can be considered, but which in some cases is not required by ISO 26262 as a work product of a previous phase and which may be made available by external sources that are different from the persons or organizations responsible for the functional safety activities.

4.3 Interpretations of tables

Tables are normative or informative depending on their context. The different methods listed in a table contribute to the level of confidence in achieving compliance with the corresponding requirement. Each method in a table is either

- a) a consecutive entry (marked by a sequence number in the leftmost column, e.g. 1, 2, 3), or
- b) an alternative entry (marked by a number followed by a letter in the leftmost column, e.g. 2a, 2b, 2c).

For consecutive entries, all listed highly recommended and recommended methods in accordance with the ASIL apply. It is allowed to substitute a highly recommended or recommended method by other one(s) not listed in the table, but a rationale shall be given that these comply with the corresponding requirement. A recommended method may be omitted, but a rationale why this method is omitted shall be given.

For alternative entries, an appropriate combination of methods shall be applied in accordance with the ASIL indicated, independent of whether they are listed in the table or not. If methods are listed with different degrees of recommendation for an ASIL, the methods with the higher recommendation should be preferred. A rationale shall be given that the selected combination of methods or even a selected single method complies with the corresponding requirement.

NOTE A rationale based on the methods listed in the table is sufficient. However, this does not imply a bias for or against methods not listed in the table.

For each method, the degree of recommendation to use the corresponding method depends on the ASIL and is categorized as follows:

- “++” indicates that the method is highly recommended for the identified ASIL;
- “+” indicates that the method is recommended for the identified ASIL;
- “o” indicates that the method has no recommendation for or against its usage for the identified ASIL.

4.4 ASIL-dependent requirements and recommendations

The requirements or recommendations of each subclause shall be met for ASIL A, B, C and D, if not stated otherwise. These requirements and recommendations refer to the ASIL of the safety goal. If ASIL decomposition has been performed at an earlier stage of development, in accordance with ISO 26262-9:2018, Clause 5, the ASIL resulting from the decomposition shall be met.

If an ASIL is given in parentheses in ISO 26262, the corresponding subclause shall be considered as a recommendation rather than a requirement for this ASIL. This has no link with the parenthesis notation related to ASIL decomposition.

4.5 Adaptation for motorcycles

For items or elements for which requirements of ISO 26262-12 are applicable, the requirements of ISO 26262-12 supersede the corresponding requirements in other Parts.

4.6 Adaptation for Trucks, Buses, Trailers and Semitrailers

Content that is intended to be unique for Trucks, Buses, Trailers and Semitrailers (T&B) is indicated as such.

5 Safety culture

5.1 Objective

This clause provides a tailoring of ISO 26262-2:2018, Clause 5.4.2 for motorcycles.

5.2 Requirements and recommendations

5.2.1 The organization shall create, foster, and sustain a safety culture that supports and encourages the effective achievement of functional safety for motorcycles.

NOTE See [Annex B](#).

5.2.2 The organization shall institute, execute and maintain organization-specific rules and processes to achieve and maintain functional safety and to comply with the requirements of ISO 26262.

NOTE Such organization-specific rules and processes can include the creation and maintenance of generic plans, e.g. a generic safety plan, or generic process descriptions.

5.2.3 The organization shall institute and maintain effective communication channels between functional safety and other disciplines that are related to functional safety, if applicable.

EXAMPLE 1 Communication channels between functional safety and non-E/E related safety such as mechanical safety.

EXAMPLE 2 Communication channels between functional safety and dependability.

5.2.4 During the execution of the safety lifecycle, the organization shall perform the required functional safety activities, including the production and management of the associated documentation in accordance with ISO 26262-8:2018, Clause 10.

5.2.5 The organization shall provide the resources required for the achievement of functional safety.

NOTE Resources include human resources, tools, databases, and templates.

5.2.6 The organization shall institute, execute and maintain a continuous improvement process, based on:

- learning from the experiences gained during the execution of the safety lifecycle of other items, including field experience; and
- derived improvements for application on subsequent items.

5.2.7 The organization shall ensure that the persons responsible for achieving or maintaining functional safety, or for performing or supporting the safety activities, are given sufficient authority to fulfil their responsibilities.

6 Confirmation measures: types, independency and authority

6.1 Objective

The objective of this clause is to define the independency requirements of confirmation measures associated with ASIL.

6.2 Requirements and recommendations

6.2.1 A confirmation review of the impact analysis in accordance with ISO 26262:2018, 6.4.3.4 to 6.4.3.7 shall be performed.

6.2.2 A confirmation review of the hazard analysis and risk assessment in accordance with [Clause 6](#) and a review of the corresponding safety goals shall be performed in accordance with [Table 1](#) and ISO 26262-2:2018, Table 2, considering each hazardous event, including those rated QM or not having an ASIL e.g. due to S0, C0 and E0 evaluations.

6.2.3 The functional safety of the item shall be judged, in accordance with ISO 26262-2:2018, 6.4.3.9 g), based on:

- a) confirmation reviews to judge whether the key work products, i.e. those included in [Table 1](#), provide sufficient and convincing evidence of their contribution to the achievement of functional safety, considering the corresponding objectives and requirements of ISO 26262, in accordance with [Table 1](#) and ISO 26262-2:2018, Table 2;
- b) one or more functional safety audits to evaluate the implementation of the processes against the definitions of the activities referenced or specified in the safety plan, in accordance with [Table 1](#), ISO 26262-2:2018, Table 2 and ISO 26262-2:2018, 6.4.8; and
- c) a functional safety assessment to judge the achieved functional safety of the item, or of the contribution to the achievement of functional safety by the developed elements, in accordance with [Table 1](#), ISO 26262-2:2018, Table 2 and ISO 26262-2:2018, 6.4.9.

NOTE 1 A judgement stated in a confirmation review of a work product, or in the functional safety assessment, that sufficient contribution to functional safety has been achieved, within the scope of that work product, is sufficient to accept the provided rationale for one or more deviations from the requirements of ISO 26262, with respect to this work product, in accordance with ISO 26262-2:2018, Clause 4.

NOTE 2 The aim of the independence is to ensure an objective viewpoint and to avoid conflict of interest. The use of the term independence in this part of ISO 26262 relates to organizational independence.

NOTE 3 The confirmation reviews are performed for those work products that are specified in [Table 1](#) and required by the safety plan.

NOTE 4 A confirmation review can be based on performing a judgement of whether the corresponding ISO 26262 objectives are achieved. In order to increase confidence in the achievement of the review objectives, the reviewer checks the correctness, completeness, consistency, adequacy and contents of the work product against the corresponding requirements of ISO 26262.

NOTE 5 The aim of each confirmation measure is given in ISO 26262-2, Annex C.

NOTE 6 [Table 1](#) includes the confirmation measures. An overview of the verification reviews is given in ISO 26262-2:2018, Annex D.

NOTE 7 A report that is a result of a confirmation measure includes the name and revision number of the work products or process documents analysed (see ISO 26262-8:2018, Clause 10).

NOTE 8 If the item changes subsequent to the completion of confirmation measures, then the pertinent confirmation measures will be repeated or supplemented (see ISO 26262-8:2018, 8.4.5.2).

NOTE 9 Confirmation measures such as confirmation reviews and functional safety audits can be merged and combined with the functional safety assessment to support the handling of comparable variants of an item.

Table 1 — Required confirmation measures, including the required level of independency

Confirmation measures	Degree of independency ^a				Scope
	QM	ASIL A	ASIL B	ASIL C	
Confirmation review of the hazard analysis and risk assessment of the item (see Clause 6 , ISO 26262-3:2018, Clause 5, and if applicable, ISO 26262-8:2018, Clause 5) Independence with regard to those generating the work product	I2	I2	I2	I2	The scope of this review shall include the correctness of the determined ASILs, and quality management (QM) ratings of the identified hazardous events for the item, and a review of the safety goals
Confirmation review of the safety plan (see ISO 26262-2:2018, 6.5.1) Independence with regard to those generating the work product	—	—	I1	I2	Applies to the highest ASIL among the safety goals of the item
Confirmation review of the item integration and testing plan (see ISO 26262-4) Independence with regard to those generating the work product	—	I0	I1	I2	Applies to the highest ASIL among the safety goals of the item
Confirmation review of the validation plan (see ISO 26262-4) Independence with regard to those generating the work product	—	I0	I1	I2	Applies to the highest ASIL among the safety goals of the item
Confirmation review of the safety analyses (see ISO 26262-9:2018, Clause 8) Independence with regard to those generating the work product	—	I1	I1	I2	Applies to the highest ASIL among the safety goals of the item
Confirmation review of the Functional Safety Concept (see ISO 26262-3:2018, Clause 8) supported by the results of the safety analyses (see ISO 26262-9:2018, Clause 8). Independence with regard to those generating the work product.	—	I1	I1	I2	Applies to the highest ASIL among the safety goals of the item.
Confirmation review of the Technical Safety Requirements Specification (see ISO 26262-4:2018, Clause 6), supported by the results of the safety analyses (see ISO 26262-9:2018, Clause 8). Independence with regard to those generating the work product.	—	I1	I1	I2	Applies to the highest ASIL among the safety goals of the item.
<p>^a The notations are defined as follows. The indicated levels of independency are intended to represent minimum requirements:</p> <p>— —: no requirement and no recommendation for or against regarding this confirmation measure;</p> <p>— I0: the confirmation measure should be performed; however, if the confirmation measure is performed, it shall be performed by a different person;</p> <p>— I1: the confirmation measure shall be performed, by a different person;</p> <p>— I2: the confirmation measure shall be performed, by a person from a different team, i.e. not reporting to the same direct superior.</p> <p>— I3: the confirmation measure shall be performed, by a person from a different department or organization, i.e. independent from the department responsible for the considered work product(s) regarding management, resources and release authority</p> <p>^b A software tool development is outside the item's safety lifecycle whereas the qualification of such a tool is an activity of the safety lifecycle.</p>					

Table 1 (continued)

Confirmation measures	Degree of independency ^a				Scope
	QM	ASIL A	ASIL B	ASIL C	
Confirmation review of the software tool qualification report ^b (see ISO 26262-8:2018, Clause 11) Independence with regard to the persons performing the qualification of the software tool	—	—	I0	I1	Applies to the highest ASIL of the requirements that can be violated by the use of the tool.
Confirmation review of the proven in use arguments (analysis, data and credit), of the candidates (see ISO 26262-8:2018, Clause 14) Independence with regard to the author of the argument	—	I0	I1	I2	Applies to the ASIL of the safety goal or requirement related to the considered behaviour, or function, of the candidate
Confirmation review of the completeness of the safety case (see ISO 26262-2:2018, 6.5.3) Independence with regard to the authors of the safety case	—	I0	I1	I2	Applies to the highest ASIL among the safety goals of the item
Functional safety audit in accordance with ISO 26262-2:2018, 6.4.8 independence with regard to the developers of the item and project management	—	I0	I0	I2	Applies to the highest ASIL among the safety goals of the item
Functional safety assessment in accordance with ISO 26262-2:2018, 6.4.9 independence with regard to the developers of the item and project management	—	I0	I0	I2	Applies to the highest ASIL among the safety goals of the item
<p>a The notations are defined as follows. The indicated levels of independency are intended to represent minimum requirements:</p> <p>— —: no requirement and no recommendation for or against regarding this confirmation measure;</p> <p>— I0: the confirmation measure should be performed; however, if the confirmation measure is performed, it shall be performed by a different person;</p> <p>— I1: the confirmation measure shall be performed, by a different person;</p> <p>— I2: the confirmation measure shall be performed, by a person from a different team, i.e. not reporting to the same direct superior.</p> <p>— I3: the confirmation measure shall be performed, by a person from a different department or organization, i.e. independent from the department responsible for the considered work product(s) regarding management, resources and release authority</p> <p>b A software tool development is outside the item's safety lifecycle whereas the qualification of such a tool is an activity of the safety lifecycle.</p>					

6.2.4 The persons who carry out a confirmation measure shall have access to, and shall be supported by, the persons and organizational entities that carry out safety activities during the item development.

6.2.5 In accordance with 6.2.4, one or more assistants may be appointed to support the performance of a confirmation review in accordance with ISO 26262-2:2018, 5.4.3. Such persons may lack independence from the developers of the corresponding item, elements or work products, but their independence shall be at least I1, as defined in Table 1, and the reviewer shall appraise their input to ensure an unbiased opinion is given.

NOTE As the confirmation reviews are performed in order to support the functional safety assessment, this appointment and appraisal can also be evaluated in the functional safety assessment.

6.2.6 The persons who carry out a confirmation measure shall have access to the relevant information and tools.

6.2.7 A confirmation review and a verification review may be combined, provided the review is performed with sufficient independence in accordance with [Table 1](#).

7 Hazard analysis and risk assessment

7.1 Objective

The objectives of the hazard analysis and risk assessment are:

- a) to identify and to categorise the hazardous events caused by malfunctioning behaviour of the item; and
- b) to formulate the safety goals related to the prevention or mitigation of the hazardous events, in order to avoid unreasonable risk.

The objective of this clause is to specify the necessary requirements that need to be complied with in order to perform a motorcycle specific hazard analysis and risk assessment.

7.2 General

Due to the fact that the dynamic behaviour of motorcycles differs greatly from that of other vehicles within the scope of ISO 26262, and that controllability of motorcycle specific hazardous events could place more emphasis on the rider, it is recognised that the method of performing risk assessment requires a degree of tailoring to best suit motorcycle specific hazardous events.

Hazard analysis, risk assessment and Motorcycle Safety Integrity Level (MSIL) determination are used to determine the safety goals for the item to avoid unreasonable risk. For this, the item is evaluated with regard to its potential hazardous events. Safety goals and their assigned MSIL are determined by a systematic evaluation of hazardous events. The MSIL is determined by considering the estimate of the impact factors, i.e. severity, probability of exposure and controllability. The hazard analysis and risk assessment is based on the item's functional behaviour; therefore, the detailed design of the item does not need to be known.

NOTE The worldwide established level of technology ("state-of-the-art") in the motorcycle industry suggests that ASIL requirements are not appropriate for motorcycles. Specifically, in the motorcycle industry, a greater proportion of the overall rider safety is generally apportioned to complementary measures (for example, riding rules, training/qualification of riders, personal protective equipment, e.g. helmets and infrastructure features) to reduce potential injury or mitigate hazards. This is addressed through the alignment between ASIL and MSIL. MSIL is the output of hazard analysis and risk assessment. This is then apportioned between the risk reduction mechanisms and measures assigned to systems using ASIL and the risk reduction taken care of by external measures and/or other technologies [which are outside the scope of ISO 26262]. It is acknowledged that product development processes and technical solutions within the motorcycle industry are inhomogeneous with those of the automobile industry; therefore, the difference between MSIL and ASIL has been made to accommodate worldwide capability.

7.3 Input to this clause

7.3.1 Prerequisites

The following information shall be available:

- item definition in accordance with ISO 26262-3:2018, 5.5.1.

7.3.2 Further supporting information

The following information can be considered:

- impact analysis, if applicable (see ISO 26262-3:2018, 6.5.1);
- relevant information on other items (from an external source).

7.4 Requirements and recommendations

7.4.1 Initiation of the hazard analysis and risk assessment

7.4.1.1 The hazard analysis and risk assessment shall be based on the item definition.

7.4.1.2 The item without internal safety mechanisms shall be evaluated during the hazard analysis and risk assessment, i.e. safety mechanisms intended to be implemented or that have already been implemented in predecessor items shall not be considered in the hazard analysis and risk assessment.

NOTE 1 In the evaluation of an item, available and independent external measures can be beneficial.

NOTE 2 Safety mechanisms of the item that are intended to be implemented or that have already been implemented are incorporated as part of the functional safety concept.

7.4.2 Situation analysis and hazard identification

7.4.2.1 The operational situations and operating modes in which an item's malfunctioning behaviour will result in a hazardous event shall be described, both for cases when the vehicle is correctly used and when it is incorrectly used in a foreseeable way.

NOTE An operational situation addresses the conditions within which the item is expected to behave in a safe manner.

EXAMPLE 1 A normal motorcycle is not expected to travel on unimproved or unpaved surfaces at high speed.

EXAMPLE 2 A normal motorcycle is not expected to be used for road race, motocross or trial events.

7.4.2.2 The hazards shall be determined systematically based on the malfunctioning behavior of the item by using adequate techniques.

NOTE Techniques such as FMEA, HAZOP etc. are suitable systematic techniques for the extraction of hazards at the item level. These can be supported by brainstorming, checklists, quality history, and field studies where possible.

7.4.2.3 Hazards caused by malfunctioning behaviour of items shall be defined at vehicle level.

NOTE 1 In general, each hazard will have a variety of potential causes related to the item's implementation but they do not need to be considered in the hazard analysis and risk assessment for the definition of the conditions or behaviour, which result from a functional behaviour of the item.

NOTE 2 Only hazards associated with the item itself can be considered, every other system (external measure) is presumed to be functioning correctly provided it is sufficiently independent.

7.4.2.4 If there are hazards identified in this clause that are outside of the scope of ISO 26262 (see [Clause 1](#)), then these hazards shall be addressed according to organization specific procedures.

NOTE As these hazards are outside the scope of ISO 26262, this standard does not provide guidance for ASIL compliance of these hazards. Such hazards are classified according to the procedures of the applicable safety discipline.

7.4.2.5 Relevant hazardous events shall be determined.

NOTE If failures at an item level induce the loss of several functions of the item, then the situation analysis and hazard identification considers the resulting hazardous events from the combined malfunctional behaviour of the item or vehicle.

EXAMPLE Failure of the vehicle electrical power supply system can cause the simultaneous loss of a number of functions including “engine torque” and “forward illumination”.

7.4.2.6 The consequences of hazardous events shall be identified.

7.4.2.7 It shall be ensured that the chosen level of detail of the list of operational situations does not lead to an inappropriate lowering of the MSIL.

NOTE A very detailed list of operational situations (see 7.4.2.1) for one hazard, with regard to the vehicle state, road conditions and environmental conditions, can lead to a fine granularity of situations for the classification of hazardous events. This can make it easier to rate controllability and severity. However, a larger number of different operational situations can lead to a consequential reduction of the respective classes of exposure, and thus to an inappropriate lowering of the MSIL.

7.4.3 Classification of hazardous events

7.4.3.1 All hazardous events identified in 7.4.2 shall be classified, except those that are outside the scope of ISO 26262.

NOTE If classification of a given hazard with respect to severity (S), probability of exposure (E) or controllability (C) is difficult to make, it is classified conservatively, i.e. whenever there is a reasonable doubt, a higher S, E or C classification is chosen.

7.4.3.2 The severity of potential harm shall be estimated based on a defined rationale for each hazardous event. The severity shall be assigned to one of the severity classes S0, S1, S2 or S3 in accordance with Table 2.

NOTE 1 The risk assessment of hazardous events focuses on the harm to each person potentially at risk – including the rider or the passengers of the vehicle causing the hazardous event, and other persons potentially at risk such as cyclists, pedestrians or occupants of other vehicles. The description of the Abbreviated Injury Scale (AIS) can be used for characterising the severity and can be found in Annex B, along with informative examples of different types of severity and accidents. Where available, motorcycle appropriate accident databases can be used to provide a basis for determining severity levels.

NOTE 2 The severity class can be based on a combination of injuries for a person, and this can lead to a higher evaluation of the severity than would result from just looking at a single injury.

NOTE 3 The estimate considers reasonable sequences of events for the situation being evaluated. **NOTE 4** The severity determination is based on a representative sample of individuals for the target markets.

NOTE 5 Standard protective equipment (e.g. helmet, protective jacket, gloves and boots) as prescribed in the vehicle user manual is assumed to be in use.

Table 2 — Classes of severity

	Class			
	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

7.4.3.3 There are operational situations that result in harm (e.g. an accident). A subsequent malfunctioning behaviour of an item in such an operational situation may increase the resulting harm. In

this case the classification of the severity shall be limited to the difference between the severity caused by the initial operational situation (e.g. the accident) and the malfunctioning behaviour of the item.

EXAMPLE If an accident occurs which is not caused by the malfunctioning behaviour of an item, the resulting harm from the accident is not considered for the classification of the severity.

7.4.3.4 The severity class S0 may be assigned if the hazard analysis determines that the consequences of a malfunctioning behaviour of the item are clearly limited to material damage and do not involve harm to persons. If a hazard is assigned to severity class S0, no MSIL assignment is required.

7.4.3.5 The probability of exposure of each operational situation shall be estimated based on a defined rationale for each hazardous event. The probability of exposure shall be assigned to one of the probability classes, E0, E1, E2, E3 and E4, in accordance with [Table 3](#).

NOTE 1 For classes E1 to E4, the difference in probability from one E class to the next is an order of magnitude.

NOTE 2 The exposure determination is based on a representative sample of operational situations for the target markets.

NOTE 3 For details and examples related to the probability of exposure see [Annex B](#).

Table 3 — Classes of probability of exposure regarding operational situations

	Class				
	E0	E1	E2	E3	E4
Description	incredible	Very low probability	Low probability	Medium probability	High probability

7.4.3.6 The number of vehicles equipped with the item shall not be considered when estimating the probability of exposure.

NOTE The evaluation of the probability of exposure is performed assuming each vehicle is equipped with the item. This means that the argument “the probability of exposure can be reduced, because the item is not present in every vehicle (as only some vehicles are equipped with the item)” is not valid.

7.4.3.7 Class E0 may be used for those situations that are suggested during hazard analysis and risk assessment, but which are considered incredible and therefore not evaluated. A rationale shall be recorded for the exclusion of these situations. If a hazard is assigned to exposure class E0, no MSIL assignment is required.

EXAMPLE E0 can be used in the case of “force majeure” risk (see [B.3](#)).

7.4.3.8 The controllability of each hazardous event, by the person(s) potentially at risk, shall be estimated based on a defined rationale for each hazardous event. The controllability shall be assigned to one of the controllability classes C0, C1, C2 and C3 in accordance with [Table 4](#).

NOTE 1 The evaluation of the controllability is an estimate of the probability that the person(s) potentially at risk are able to gain sufficient control of the hazardous event, such that they are able to avoid the specific harm. For this purpose, the parameter C is used, with the classes C0, C1, C2 and C3, to classify the potential of avoiding harm. Some examples, which serve as an interpretation of these classes, are listed in [Table B.4](#). Estimates can be made using either experimental or analytical procedures.

NOTE 2 For motorcycles, it is assumed that the rider is in an appropriate condition to ride (e.g. he/she is not tired), has the appropriate riding training (he/she has a rider's licence), understands the operational characteristics of the motorcycle in use and is complying with all applicable legal regulations, including due care requirements to avoid risks to other traffic participants.

NOTE 3 Where the hazardous event is not related to the control of the vehicle direction and speed, e.g. potential limb entrapment in moving parts, the controllability can be an estimate of the probability that the person at risk is able to remove themselves, or to be removed by others from the hazardous situation. When considering controllability, note that the person at risk might not be familiar with the operation of the item.

NOTE 4 When controllability involves the actions of multiple traffic participants, the controllability assessment can be based on the controllability of the vehicle with the malfunctioning item, and the likely action of other participants.

NOTE 5 For motorcycle hazardous events, the evaluation of controllability levels is described in [Annex C](#).

Table 4 — Classes of controllability

	Class			
	C0	C1	C2	C3
Description	Controllable in general	Simply controllable	Normally controllable	Difficult to control or uncontrollable

7.4.3.9 Class C0 is used for hazards addressing the unavailability of the item if they do not affect the safe operation of the vehicle (e.g. some driver assistance systems) or if an accident can be avoided by “normal” riders reaction like slight braking adjustments or steering inputs. If a hazard is assigned to the controllability class C0, no MSIL assignment is required.

EXAMPLE A dedicated regulation is the certification of a vehicle system with a precise definition of forces or acceleration values in the case of a failure.

7.4.3.10 An MSIL shall be determined for each hazardous event using the parameters “severity”, “probability of exposure” and “controllability” in accordance with [Table 5](#).

NOTE Four MSILs are defined: MSIL A, MSIL B, MSIL C and MSIL D, where MSIL A is the lowest safety integrity level and MSIL D the highest safety integrity level.

Table 5 — MSIL determination

Severity class	Probability class	Controllability class		
		C1	C2	C3
S1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
S2	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	A	B	C
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

7.4.3.11 The conversion of MSIL to ASIL shall be performed in accordance with [Table 6](#), prior to the definition of the safety goals, so that applicable ISO 26262 requirements can be adopted.

NOTE 1 In addition to these three ASILs, the class QM (quality management) denotes no requirement to comply with ISO 26262. Nevertheless, the corresponding hazardous event can have safety-related consequences and safety requirements can be formulated in this case. Note that additional safety requirements for an item can result from other activities, regulations or company internal rules that are not directly related to ISO 26262 and that will be satisfied by the company’s processes. The classification QM indicates that these processes are expected to provide sufficient evidence of compliance to the safety-related requirements for the safety case.

NOTE 2 It is important that MSIL is converted to ASIL so that the most appropriate degree of rigour is used in avoiding unreasonable residual risk associated with malfunctioning E/E items or elements used in motorcycle applications.

NOTE 3 The indicated ASIL levels, determined from MSIL levels are intended to represent minimum requirements.

Table 6 — Conversion of MSIL to ASIL

MSIL	ASIL
QM	QM
A	QM
B	A
C	B
D	C

7.4.4 Determination of safety goals

7.4.4.1 A safety goal shall be determined for each hazardous event with an ASIL, converted from MSIL. If similar safety goals are determined, these may be combined into one safety goal.

NOTE Safety goals are top-level safety requirements for the item. They lead to the functional safety requirements needed to avoid an unreasonable risk for each hazardous event. Safety goals are not expressed in terms of technological solutions, but in terms of functional objectives.

7.4.4.2 The ASIL, converted from MSIL, shall be assigned to the corresponding safety goal. If similar safety goals are combined into a single one, as described in [7.4.4.1](#), the highest ASIL shall be assigned to the combined safety goal.

NOTE If combined safety goals refer to the same hazard in different situations, then the resulting ASIL of the safety goal is the highest one of the considered safety goals of every situation.

7.4.4.3 The safety goals together with their attributes (ASIL) shall be specified in accordance with ISO 26262-8:2018, Clause 6.

NOTE The safety goal can include features such as the fault tolerant time interval on vehicle level, or physical characteristics (e.g. a maximum level of unwanted acceleration) if they were relevant to the MSIL determination.

7.4.4.4 Technical assumptions used for, or resulting from the hazard analysis and risk assessment which are relevant for ASIL classification shall be identified. These assumptions shall be validated in accordance with [Clause 9](#) for the integrated item (including hazardous event classified QM or with no MSIL assignment).

7.4.5 Verification

7.4.5.1 The hazard analysis and risk assessment including the safety goals shall be verified in accordance with ISO 26262-8:2018, Clause 9, to provide evidence for their:

- a) completeness with regard to situations analyses and hazard identification;
- b) compliance with the item definition;
- c) consistency with related hazard analyses and risk assessments;
- d) completeness of the coverage of the hazardous events;
- e) consistency of the assigned MSILs with the corresponding hazardous events; and

f) consistency of MSIL-ASIL conversion.

7.5 Work products

7.5.1 Hazard analysis and risk assessment report resulting from the requirements of [7.4.1](#) to [7.4.4](#).

7.5.2 Verification review report of the hazard analysis and risk assessment resulting from the requirement of [7.4.5](#).

8 Vehicle integration and testing

8.1 Objective

This clause provides a tailoring of ISO 26262-4:2018, Clause 8.4.4 for motorcycles.

The vehicle integration is the integration of the item with other systems within a vehicle and with the vehicle itself.

8.2 Requirements and recommendation

8.2.1 Vehicle integration

8.2.1.1 The item shall be integrated into the vehicle and the vehicle integration tests shall be carried out.

NOTE If the subject of development is a complete vehicle function implemented by the item(s), this has to be subject of testing at the vehicle integration and testing phase.

8.2.1.2 The verification of the interface specification of the item with the in-vehicle communication network and the in-vehicle power supply network shall be performed.

8.2.2 Test goals and test methods during vehicle testing

8.2.2.1 To detect systematic faults during vehicle integration, the test goals, resulting from the requirements 8.4.2.2 to 8.4.2.6, shall be addressed by the application of adequate test methods as given in the corresponding tables.

NOTE Depending on the function implemented, its complexity, or the distributed nature of the item, it can be reasonable to move test methods to other integration sub-phases with adequate rationale.

8.2.2.2 The correct implementation of the functional safety requirements at the vehicle level shall be demonstrated where feasible using test methods given in [Table 7](#).

Table 7 — Correct implementation of the functional safety requirements at the vehicle level

Methods		ASIL			
		A	B	C	D
1a	Requirement-based test ^a	++	++	++	++
1b	Fault injection test ^b	++	++	++	++
1c	Long-term test ^c	++	++	++	++
1d	User test under real-life conditions ^{c,d}	++	++	++	++
^a A requirements-based test denotes a test against functional and non-functional requirements. ^b A fault injection test uses special means to introduce faults into the item. This can be done within the item via a special test interface or specially prepared elements or communication devices. The method is often used to improve the test coverage of the safety requirements, because during normal operation safety mechanisms are not invoked. ^c A long-term test and a user test under real-life conditions are similar to tests derived from field experience but use a larger sample size, normal users as testers, and are not bound to prior specified test scenarios, but performed under real-life conditions during everyday life. These test can have limitations if necessary to ensure the safety of the testers, e.g. with additional safety measures or disabled actuators. Long-term tests can be infeasible for motorcycles. ^d User tests can be infeasible for motorcycles.					

8.2.2.3 This requirement applies to ASIL (A), (B), C, and D, in accordance with 4.4: the correct functional performance, failure mode coverage, accuracy and timing of the safety mechanisms at the vehicle level shall be demonstrated using test methods given in Table 8.

Table 8 — Correct functional performance, accuracy, and timing of safety mechanisms at the vehicle level

Methods		ASIL			
		A	B	C	D
1a	Performance test ^a	+	+	++	++
1b	Long-term test ^b	+	+	++	++
1c	User test under real-life conditions ^{b,c}	+	+	++	++
^a A performance test can verify the performance (e.g. fault tolerant time intervals and vehicle controllability in the presence of faults) of the safety mechanisms concerning the item. ^b A long-term test and a user test under real-life conditions are similar to tests derived from field experience but use a larger sample size, normal users as testers, and are not bound to prior specified test scenarios, but performed under real-life conditions during everyday life. These test can have limitations if necessary to ensure the safety of the testers, e.g. with additional safety measures or disabled actuators. Long-term tests can be infeasible for motorcycles. ^c User tests can be infeasible for motorcycles.					

8.2.2.4 This requirement applies to ASIL (A), (B), C, and D, in accordance with 4.4: the consistency and correctness of the implementation of the internal and external interfaces at the vehicle level shall be demonstrated using test methods given in Table 9.

NOTE Internal and external means internal and external to the vehicle - internal: between item's; external: between item and vehicle environment.

Table 9 — Consistent and correct implementation of internal and external interfaces at the vehicle level

Methods		ASIL			
		A	B	C	D
1a	Test of internal interfaces	0	+	++	++
1b	Test of external interfaces ^a	0	+	++	++
1c	Test of interaction/communication ^b	0	+	++	++
^a An interface test at the vehicle level tests the interfaces of the vehicle systems for compatibility. This can be done statically by validating value ranges, ratings, or geometries, as well as dynamically during operation of the whole vehicle.					
^b A communication and interaction test includes tests of the communication between the systems of the vehicle during runtime against functional and non-functional requirements.					

8.2.2.5 This requirement applies to ASIL (A), (B), C, and D, in accordance with 4.4: the level of robustness at the vehicle level shall be demonstrated using test methods given in Table 10.

Table 10 — Level of robustness at the vehicle level

Methods		ASIL			
		A	B	C	D
1a	Resource usage test ^a	0	+	++	++
1b	Stress test ^b	0	+	++	++
1c	Test for interference resistance and robustness under certain environmental conditions ^c	0	+	++	++
1d	Long-term test ^d	0	+	++	++
^a At the item level, resource usage testing is usually performed in dynamic environments (e.g. lab cars or prototypes). Issues to test include item internal resources, power consumption, or limited resources of other vehicle systems.					
^b A stress test verifies the correct operation of the vehicle under high operational loads or high demands from the environment. Therefore, tests under high loads on the vehicle or with extreme user inputs or requests from other systems, as well as tests with extreme temperatures, humidity, or mechanical shocks, can be applied.					
^c A test for interference resistance and robustness, under certain environmental conditions, is a special case of stress testing. This includes EMC and ESD tests (e.g. see References[4] and [7]).					
^d A long-term test and a user test under real-life conditions are similar to tests derived from field experience but use a larger sample size, normal users as testers, and are not bound to prior specified test scenarios, but performed under real-life conditions during everyday life. Long-term tests can be infeasible for motorcycles.					

9 Safety Validation

9.1 Objective

This clause provides a tailoring of ISO 26262-4:2018, Clause 9 for motorcycles.

The objectives of this clause are:

- a) to provide evidence of compliance with the safety goals and that the safety concepts are appropriate for the functional safety of the item; and
- b) to provide evidence that the safety goals are correct, adequate and achieved at the vehicle level.

9.2 General

The purpose of the preceding verification activities (e.g. design verification, safety analyses, hardware, software, and item integration and testing) is to provide evidence that the results of each particular activity comply with the specified requirements.

The safety validation of the integrated item in representative vehicle(s) aims to provide evidence of appropriateness for the intended use and aims to confirm the adequacy of the safety measures for a class or set of vehicles. Safety validation does cover assurance, that the safety goals are sufficient and have been achieved, based on examination and tests.

9.3 Input to this clause

9.3.1 Prerequisites

The following information shall be available:

- hazard analysis and risk assessment report in accordance with [7.5.1](#);
- safety goals in accordance with [7.5.2](#); and
- functional safety concept in accordance with ISO 26262-3:2011, 7.5.1.

9.3.2 Further supporting information

The following information can be considered:

- technical safety concept (see ISO 26262-4:2018, 7.5.1);
- functional concept (from external source);
- safety analysis reports (see ISO 26262-4:2018, 7.5.6).

9.4 Requirements and recommendation

9.4.1 Safety validation environment

9.4.1.1 The safety goals shall be validated for the item considered in a representative context at vehicle level.

NOTE This integrated item includes, where applicable, system, software, hardware, elements of other technologies, and external measures.

9.4.1.2 For the definition of a representative context a set of representative vehicles those base vehicle types and vehicle configurations shall be considered that have been identified as relevant in the hazard analysis and risk assessment (see [Clause 7](#)).

9.4.1.3 The safety goals shall be validated considering the variances in operation with impact on technical characteristics that have been considered in the hazard analysis and risk assessment.

9.4.2 Planning of safety validation

9.4.2.1 The safety validation plan shall be refined, including:

- a) the configuration of the item subjected to safety validation including its calibration data in accordance with ISO 26262-6:2018, Annex C;

NOTE If a complete validation of each item configuration is not feasible, then a reasonable subset can be selected.

- b) the specification of safety validation procedures, test cases, riding manoeuvres, and acceptance criteria;
- c) the equipment and the required environmental conditions.

9.4.3 Execution of safety validation

9.4.3.1 If testing is used for safety validation, then the same requirements as provided for verification testing (see ISO 26262-8:2018, 9.4.2 and 9.4.3), may be applied.

9.4.3.2 The correct implementation of adequate safety goals by the item shall be validated at the vehicle level by evaluating the following:

- a) the controllability;

NOTE Controllability can be validated using operating scenarios, including intended use and foreseeable misuse.

- b) the effectiveness of safety measures for controlling random and systematic failures;
- c) the effectiveness of the external measures;
- d) the effectiveness of the elements of other technologies;
- e) technical assumption with influence on the MSIL in the hazard analysis and risk assessment (see [7.4.4.4](#)).

EXAMPLE An intended mechanical element was limiting the risk for malfunctioning E/E elements but a change during the development was done on the mechanical side with a potential higher risk for malfunctioning E/E elements.

9.4.3.3 This requirement applies to ASILs (B), C, and D of the safety goal: the validation of the metrics for random hardware failures shall be carried out at the item level (see ISO 26262-3:2018, Clause 5) for:

- a) the evaluation of safety goal violations due to random hardware failures as identified in ISO 26262-5:2018, Clause 9, against the target values as defined by requirement ISO 26262-4:2018, 7.4.4.4; and
- b) the evaluation of the hardware architectural metrics in accordance with the assessment criteria of ISO 26262-5:2018, Clause 8, against the target values as defined by requirement ISO 26262-4:2018, 7.4.4.2.

NOTE Quantitative evaluation for elements of the item level is defined in ISO 26262-5:2018, Clause 9. The item may be evaluated qualitatively in case other technologies are involved in it.

9.4.3.4 This requirement applies to ASILs (B), (C) and D of the safety goal: the validation of the metrics for random hardware failures shall be carried out at the item level for the evaluation of the hardware architectural metrics in accordance with the assessment criteria of ISO 26262-5:2018, Clause 8, against target values as defined by requirements ISO 26262-4:2018, 7.4.4.3.

9.4.3.5 The safety validation at the vehicle level, based on the safety goals, the functional safety requirements, and the intended use, shall be executed as planned using the following:

- a) the safety validation procedures and test cases for each safety goal including detailed pass/fail criteria;
- b) the scope of application. This may include issues such as configuration, environmental conditions, riding situations, operational use cases, etc.

NOTE Operational use cases can be created to help focus the safety validation at the vehicle level.

9.4.3.6 An appropriate set of the following methods shall be applied:

- a) repeatable tests with specified test procedures, test cases, and pass/fail criteria;

EXAMPLE 1 Positive tests of functions and safety requirements, black box testing, simulation, tests under boundary conditions, fault injection, durability tests, stress tests, highly accelerated life testing (HALT), simulation of external influences.

b) analyses;

EXAMPLE 2 FMEA, FTA, ETA, simulation.

c) long-term tests, such as vehicle driving schedules and captured test fleets;

d) user tests under real-life conditions, panel or blind tests, expert panels; and

e) reviews.

9.4.4 Evaluation

9.4.4.1 The results of the safety validation shall be evaluated to provide evidence that the implemented safety goals achieve an adequate level of functional safety for the item.

9.5 Work products

9.5.1 Safety validation specification including safety validation environment description resulting from requirement [9.4.3](#).

9.5.2 Safety validation report resulting from requirements [9.4.3](#) and [9.4.4](#).

Annex A **(informative)**

Overview of and workflow of adaptation of ISO 26262 for motorcycles

A.1 General

This annex gives the over view of and work flow for motorcycles to implement ISO 26262-2, ISO 26262-3 and ISO 26262-4.

A.2 Overview of and workflow of management of functional safety

[Table A.1](#) provides an overview of objectives, prerequisites and work products of management of functional safety for motorcycles.

Table A.1 — Overview of Functional safety management

Clause	Objectives	Prerequisites	Work products
ISO 26262-2:2018, Clause 5 Overall safety management 5 in this Part of ISO 26262 Safety culture	<p>The intent of this clause is to ensure the organizations that are involved in the execution of the safety lifecycle, i.e. responsible for the safety lifecycle or performing safety activities in the safety lifecycle, achieve the following objectives:</p> <p>a) a safety culture that supports and encourages the effective achievement of functional safety;</p> <p>b) a competence management to ensure that the level of competence of the involved persons is commensurate with their responsibilities;</p> <p>c) a quality management to support functional safety; and</p> <p>d) adequate organization-specific rules and processes for functional safety.</p> <p>This clause serves as a prerequisite to the activities in the ISO 26262 safety lifecycle.</p>	None	<p>ISO 26262-2:2018, 5.5.1 Organization-specific rules and processes for functional safety.</p> <p>ISO 26262-2:2018, 5.5.2 Evidence of competence.</p> <p>ISO 26262-2:2018, 5.5.3 Evidence of quality management.</p>
6, in this Part of ISO 26262 Safety management during the concept phase and the product development 6 in this Part of ISO 26262 Confirmation measures	<p>The intent of this clause is to ensure the safety management, during the concept phase and the development phases in the safety lifecycle (see Figure 1 and ISO 26262-2:2018, Figure 2), of the organizations involved in the safety life cycle achieves the following objectives:</p> <p>a) the definition of the safety management roles and responsibilities;</p> <p>b) the adequate planning of the functional safety activities;</p> <p>c) the coordination of the execution of the safety activities in accordance with the safety plan;</p> <p>d) the creation of a comprehensible safety case in order to provide an argument for the achievement of functional safety;</p> <p>e) a correct progression of the safety life cycle; and</p> <p>f) the definition and execution of the confirmation measures.</p>	<p>Organization specific rules and processes for functional safety (see ISO 26262-2:2018, 5.5.1)</p> <p>Evidence of competence (see ISO 26262-2:2018, 5.5.2)</p> <p>Evidence of quality management (see ISO 26262-2:2018, 5.5.3)</p> <p>Impact analysis, if applicable (see 7.5.1)</p>	<p>ISO 26262-2:2018, 6.5.1 Safety plan.</p> <p>ISO 26262-2:2018, 6.5.2 Project plan (refined).</p> <p>ISO 26262-2:2018, 6.5.3 Safety case.</p> <p>ISO 26262-2:2018, 6.5.4 Functional safety assessment plan.</p> <p>ISO 26262-2:2018, 6.5.5 Confirmation measure reports.</p>
ISO 26262-2:2018, Clause 7 Safety management after the item's release for production	<p>The objective of this clause is to ensure the safety activities after the item's release for production achieve the following objective: definition of the responsibilities of the organizations and persons responsible for functional safety after the item's release for production. This relates to the general activities for ensuring the required functional safety of the item during the lifecycle subphases after the release for production.</p>	Evidence of quality management (see ISO 26262-2:2018, 5.5.3).	ISO 26262-2:2018, 7.5.1 Evidence of field monitoring.

A.3 Overview of and workflow of concept phase

[Table A.2](#) provides an overview of objectives, prerequisites and work products of concept phase for motorcycles.

Table A.2 — Overview of concept phase

Clause	Objectives	Prerequisites	Work products
ISO 26262-3:2018, Clause 5 Item definition	The objectives of this clause are a. to define and describe the item, its dependencies on, and interaction with, the environment and other items, and b. to support an adequate understanding of the item so that the activities in subsequent phases can be performed.	None	ISO 26262-3:2018, 5.5.1 Item definition
7, in this Part of ISO 26262 Hazard analysis and risk assessment	The objectives of the hazard analysis and risk assessment are a. to identify and to categorise the hazards caused by malfunctioning behaviour of the item, and b. to formulate the safety goals related to the prevention or mitigation of the hazardous events, in order to avoid unreasonable risk.	Item definition (see ISO 26262-3:2018, 5.5.1)	7.5.1 in this Part of ISO 26262 Hazard analysis and risk assessment report 7.5.2 in this Part of ISO 26262 Verification review report of the hazard analysis and risk assessment
ISO 26262-3:2018, Clause 7 Functional safety concept	The objectives of this clause are a. to derive the functional safety requirements from the safety goals, and b. to allocate the functional safety requirements to the preliminary architectural elements of the item, or to external measures	Item definition (see ISO 26262-3:2018, 5.5.1) Hazard analysis and risk assessment report (see 7.5.1 in this Part of ISO 26262)	ISO 26262-3:2018, 7.5.1 Functional safety concept ISO 26262-3:2018, 7.5.2 Verification report of the functional safety concept

A.4 Overview of and workflow of product development of system level

[Table A.3](#) provides an overview of objectives, prerequisites and work products of product development at system level for motorcycles.

Table A.3 — Overview of and workflow of product development at the system level for motorcycles

Clause	Objectives	Prerequisites	Work products
ISO 26262-4:2018, Clause 6 Specification of the technical safety requirements	<p>The objectives of this clause are:</p> <p>a) to specify the technical safety requirements. The technical safety requirements specification specifies the technical implementation of the functional safety concept at the respective hierarchical level, considering both the functional concept and the preliminary architectural assumptions; and</p> <p>b) to verify that the technical safety requirements comply with the functional safety requirements.</p>	Functional safety concept;	<p>ISO 26262-4:2018, 6.5.1 Technical safety concept</p> <p>ISO 26262-4:2018, 6.5.2 System verification report</p>
ISO 26262-4:2018, Clause 7 System design	<p>The objectives of this clause are:</p> <p>a) to develop a system architectural design and a technical safety concept that satisfies both the safety requirements and the non-safety-related requirements;</p> <p>b) to describe the concept to achieve Functional Safety for the system;</p> <p>c) to analyse the system architectural design in order to prevent systematic design faults and to derive the necessary safety-related special characteristics for production and service; and</p> <p>d) to verify that the system architectural design and the safety concept are suitable to satisfy the system requirements according to their respective ASIL.</p>	<p>Technical safety requirements specification;</p> <p>Preliminary architectural assumptions;</p>	<p>ISO 26262-4:2018, 7.5.1 Technical safety concept (refined)</p> <p>ISO 26262-4:2018, 7.5.2 System design specification</p> <p>ISO 26262-4:2018, 7.5.3 Hardware-software interface specification (HSI)</p> <p>ISO 26262-4:2018, 7.5.4 Specification of requirements for production, operation, service and decommissioning</p> <p>ISO 26262-4:2018, 7.5.5 System verification report (refined)</p> <p>ISO 26262-4:2018, 7.5.6 Safety analysis reports resulting</p>
ISO 26262-4:2018, 8 Item integration and testing 8 in this Part of ISO 26262 Vehicle integration and testing	<p>The objectives of this clause are:</p> <p>a) to test compliance with each safety requirement in accordance with its specification and ASIL classification; and</p> <p>b) to verify that the “System design” covering the safety requirements are correctly implemented by the entire item.</p>	<p>Safety goals from the hazard analysis and risk assessment report;</p> <p>Functional safety concept;</p> <p>Technical safety concept System design specification;</p> <p>Hardware-software interface specification (HSI);</p>	<p>ISO 26262-4:2018, 8.5.1 Integration verification specification</p> <p>ISO 26262-4:2018, 8.5.2 Integration verification report</p>
9, in this Part of ISO 26262 Safety validation	<p>The objectives of this clause are:</p> <p>a) to provide evidence of compliance with the safety goals and that the safety concepts are appropriate for the functional safety of the item; and</p> <p>b) to provide evidence that the safety goals are adequate and achieved at the vehicle level.</p>	<p>Hazard analysis and risk assessment report;</p> <p>Safety goals;</p> <p>Functional safety concept;</p>	<p>9.5.1, in this Part of ISO 26262 Safety validation specification</p> <p>9.5.2, in this Part of ISO 26262 Safety validation report</p>

Annex B (informative)

Hazard analysis and risk assessment for motorcycles

B.1 General

This annex gives a general explanation of the hazard analysis and risk assessment. The examples in [Clause B.2](#) (severity), [B.3](#) (probability of exposure), and A.B (controllability) are for information only and are not exhaustive.

For this analytical approach a risk (R) can be described as a function (F), with the frequency of occurrence (f) of a hazardous event, the ability to avoid specific harm or damage through timely reactions of the persons involved, that is controllability (C), and the potential severity (S) of the resulting harm or damage:

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

The frequency of occurrence f is, in turn, influenced by several factors. One factor to consider is how frequently and for how long individuals find themselves in a situation where the aforementioned hazardous event can occur. In ISO 26262 this is simplified to be a measure of the probability of the riding scenario taking place in which the hazardous event can occur (exposure: E). Another factor is the failure rate of the item that could lead to the hazardous event (failure rate: λ). The failure rate is characterised by hazardous hardware random failures and systematic faults that remained in the system:

$$f = E \times \lambda$$

Hazard analysis and risk assessment is concerned with setting requirements for the item such that unreasonable risk is avoided.

The MSILs that result from the hazard analysis and risk assessment determine the minimum set of requirements on the item, in order to control or reduce the probability of random hardware failures, and to avoid systematic faults. 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 three steps:

- a) Situation analysis and hazard identification (see 6.4.2): 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 requires a clear definition of the item, its functionality and its boundaries. It is based on the item's behaviour; therefore, the detailed design of the item does not necessarily need to be known.

EXAMPLE Factors to be considered for situation analysis and hazard identification can include:

- vehicle usage scenarios, for example high speed and urban operation, parking and off-road;
 - environmental conditions, for example road surface friction, side winds;
 - reasonably foreseeable rider use and misuse;
 - interaction between operational systems.
- b) Classification of hazardous events (see 6.4.3): The hazard classification scheme 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

particular riding situation, while the probability of exposure is determined by the corresponding situation. The controllability rates how easy or difficult it is for the rider or other road traffic participant 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.

- c) MSIL determination (see 6.4.3): determining the required motorcycle safety integrity level.

B.2 Examples of severity

B.2.1 General

The potential injuries as a result of a hazard are evaluated for the rider, passengers and people around the vehicle, or to individuals in surrounding vehicles to determine the severity class for a given hazard. From this evaluation, the corresponding severity class is then determined for example as shown in [Table B.1](#).

[Table B.1](#) presents examples of consequences which can occur for a given hazard, and the corresponding severity class for each consequence.

Because of the complexity of accidents and the many possible variations of accident situations, the examples provided in [Table B.1](#) represent only an approximate estimate of accident effects. They represent expected values based on previous accident analyses. Therefore, no generally valid conclusions can be derived from these individual descriptions.

Accident statistics can be used to determine the distribution of injuries that can be expected to occur in different types of accidents.

In [Table B.1](#), AIS represents a categorisation of injury classes, but only for single injuries. Instead of AIS, other categorisations such as Maximum AIS (MAIS) and Injury Severity Score (ISS) can be used.

The use of a specific injury scale depends on the state of medical research at the time the analysis is performed. Therefore, the appropriateness of the different injury scales, such as AIS, ISS, and NISS, can vary over time (see References[1],[2],[3]).

Table B.1 — Examples of severity classification

	Class of Severity			
	S0	S1	S2	S3
Description	No injuries	Light and moderate injuries	Severe injuries, possibly life-threatening, survival probable	Life-threatening injuries (survival uncertain) or fatal injuries
Reference for single injuries (from AIS scale)	AIS 0 and less than 10% probability of AIS 1-6 Damage that cannot be classified safety-related	more than 10% probability of AIS 1-6 (and not S2 or S3)	more than 10% probability of AIS 3-6 (and not S3)	more than 10% probability of AIS 5-6
Informative examples	Falling alone/loss of balance. Collision with road-side infrastructure/stationary vehicle at walking speed. Rear collision (passenger car into rear of motorcycle) with differential speed equivalent to typical walking speed.	Collision with road-side infrastructure/stationary vehicle at typical urban vehicle speeds. Impact with pedestrian/cyclist at typical walking speed. Low side fall at typical urban/main road vehicle speeds with no subsequent impact. High side fall at typical urban road vehicle speeds with no subsequent impact. Side collision (passenger car into side of motorcycle) at typical walking speed. Rear collision (passenger car into rear of motorcycle) with differential speed equivalent to typical urban vehicle speed. Front collision into an oncoming passenger car with differential speed equivalent to typical walking speed.	Collision with road-side infrastructure/stationary vehicle at typical main road vehicle speeds. Impact with pedestrian/cyclist at typical urban vehicle speeds. Low side fall at typical highway vehicle speeds with no subsequent impact. High side fall at typical main road/highway vehicle speeds with no subsequent impact. Side collision (passenger car into side of motorcycle) at typical urban vehicle speed. Rear collision (passenger car into rear of motorcycle) with differential speed equivalent to typical main road vehicle speed. Front collision into an oncoming passenger car with differential speed equivalent to typical urban vehicle speed.	Collision with road-side infrastructure/stationary vehicle at typical highway vehicle speeds. Impact with pedestrian/cyclist at typical main road vehicle speeds. Side collision (passenger car into side of motorcycle) at typical main road vehicle speed. Rear collision (passenger car into rear of motorcycle) with differential speed equivalent to typical highway vehicle speed. Front collision into an oncoming passenger car with differential speed equivalent to typical main road/highway vehicle speed.

B.2.2 Description of the AIS stages

To describe the severity, the AIS classification is used. The AIS represents a classification of the severity of injuries and is issued by the Association for the Advancement of Automotive Medicine (AAAM) (see References[1]). The guidelines were created to enable an international comparison of severity. The scale is divided into seven classes:

- AIS 0: no injuries;
- AIS 1: light injuries such as skin-deep wounds, muscle pains, whiplash, etc.;

- AIS 2: moderate injuries such as deep flesh wounds, concussion with up to 15 minutes of unconsciousness, uncomplicated long bone fractures, uncomplicated rib fractures, etc.;
- AIS 3: 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.;
- AIS 4: severe injuries (life-threatening, survival probable) such as concussion with or without skull fractures with up to 12 hours of unconsciousness, paradoxical breathing;
- AIS 5: 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;
- AIS 6: 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.

B.3 Examples and explanations of the probability of exposure

An estimation of the probability of exposure requires the evaluation of the scenarios in which the relevant environmental factors that contribute to the occurrence of the hazard are present. The scenarios to be evaluated include a wide range of riding or operating situations.

These evaluations result in the designation of the hazard scenarios into one of five probability of exposure classifications, given the nomenclature E0 (lowest exposure level), E1, E2, E3 and E4 (highest exposure level).

The first of these, E0, is assigned to situations which, although identified during a hazard and risk analysis, are considered to be unusual or incredible. Subsequent evaluation of the hazards associated exclusively with these E0 scenarios can be excluded from further analysis.

EXAMPLE Typical examples of E0 include the following:

- a) a very unusual, or infeasible, co-occurrence of circumstances, e.g. vehicle involved in an incident which includes an aeroplane landing on a highway;
- b) natural disasters, e.g. earthquake, hurricane, forest fire.

The remaining E1, E2, E3 and E4 levels are assigned for situations that can become hazardous depending on either the duration of a situation (temporal overlap) or the frequency of occurrence of a situation.

NOTE 1 The classification can depend on, for example, geographical location or type of use (see 6.4.3.4).

In the first case, where the exposure is ranked based on the duration of a situation, the probability of exposure can be estimated by the proportion of time (of being in the considered situation) compared to total operating time (ignition on). In special cases the total operating time can be the vehicle life-time (including ignition off). [Table B.2](#) gives examples of these durational situations classifications and the typical exposure rankings.

NOTE 2 A hazard can be related to the duration of a given scenario (e.g. the average time spent negotiating traffic intersections), while another hazard can be related to the frequency of this same scenario (e.g. the rate of repetition with which a vehicle negotiates traffic intersections).

Alternately, some exposure estimations can be determined more appropriately by using the frequency of occurrence of a related riding situation. In these circumstances, pre-existing system faults lead to the hazardous event within a short interval after the situation occurs. Examples of these riding situations and typical exposure rankings are given in [Table B.3](#).

A riding situation can have both duration and a frequency, such as riding in a parking lot. In this case, the examples in [Table B.2](#) and [B.3](#) might not lead to the same exposure category, so the most appropriate exposure rank is selected for the analysis of the considered riding scenario.

Table B.2 — Classes of probability of exposure regarding duration in operational situations

	Class of probability of exposure in operational situations			
	E1	E2	E3	E4
Description	Very low probability	Low probability	Medium probability	High probability
Duration (% of average operating time)	Not specified	<1%	1%-10%	>10%
Informative Examples (Event)	Large lean angle In the process of jump/bump starting bike Engine starting Using side stand (up or down) Emergency braking (immediate danger is present) Riding across rail or tram tracks Negotiating lost cargo or obstacle in lane of travel (public road) Shifting transmission gears	Intermediate lean angle Refuelling Performing a hill-start Using directional indicators Pulling out of an intersection Performing an overtaking manoeuvre Pulling away from a stand-still Braking Normal cornering In a tunnel Feet down motorcycle balancing and manoeuvring	Small lean angle Passing (other vehicles) Accelerating Decelerating Engine idling, motorcycle on stand Stopped at traffic light or intersection	Slight lean angle or less Cruising EV bike plug-in recharging Parked (incl. bike on centre/side stand)

Table B.3 — Classes of probability of exposure regarding frequency in operational situations

		Class of probability of exposure in operational situations			
		E1	E2	E3	E4
Description		Very low probability	Low probability	Medium probability	High probability
Frequency of Situation		Occur less often than once a year for the great majority of riders	Occur a few times a year for the great majority of riders	Occur once a month or more often for an average riders	Occur during almost every ride on average
	Road layout	Off-road/ uncategorised roads	Mountain roads Cobbled roads (pave) Roundabout	Motorway/Highway (incl. divided)	Secondary road Urban road

Table B.3 (continued)

		Class of probability of exposure in operational situations			
		E1	E2	E3	E4
In-formative Examples	Road surface/ riding conditions	Snow and ice on road	Riding on low friction (leaves, loose stones, oil, diesel, mud) Riding in heavy rain Unexpected side-winds Uneven road surfaces Fog	Riding in rain/mist Wet roads Riding across rail or tram tracks Speed humps/speed reduction corrugations	—
	Environment/ infrastructure	Lost cargo or obstacle in lane of travel (public road)	In a tunnel	Traffic congestion In a fuel station forecourt Unlit roads at night (riding in the dark)	—
	Bike stationary state	In the process of jump/ bump starting bike	In repair garage	Refuelling	Engine starting Using side stand (up/down) Parked (incl. bike on centre/ side stand) Feet down motorcycle balancing and manoeuvring Engine idling, motorcycle on stand Stopped at traffic light or intersection
	Manoeuvre	Large lean angle Intentional front wheel lift (wheelie) Intentional rear wheel lift (stoppie)	Intermediate lean angle Urgent braking (potential for danger) Overtaking (low performance motorcycle) Manoeuvring through several stationary or moving cars Evasive manoeuvre, deviating from desired path Executing a curve at high lateral acceleration Minor front wheel lift Minor rear wheel lift	Small lean angle Performing a hill-start	Slight lean angle or less Using directional indicators Pulling out of an intersection Passing other vehicles Overtaking Pulling away from a stand-still Accelerating Braking Decelerating Cruising Normal cornering EV bike plug-in recharging Shifting transmission gears

If the time period in which a failure remains latent is comparable to the time period before the hazardous event can be expected to take place, then the estimation of the probability of exposure considers that time period. Typically this will concern devices that are expected to act on demand, e.g. airbags.

In this case, the probability of exposure is estimated by $\sigma \times T$ where; σ is the rate of occurrence of the hazardous event and T is the duration that the failure is not perceived (possibly up to the lifetime of the vehicle). This approximation $\sigma \times T$ is valid when this resulting product is small.

NOTE 3 With regard to the duration of the considered failure, the hazard analysis and risk assessment does not consider safety mechanisms that are part of the item (see 6.4.1.2).

B.4 Examples of controllability (chances to avoid harm)

The determination of the controllability class, for a given hazard, requires an estimation of the probability that the representative rider will be able to retain or regain control of a vehicle if a given hazard were to occur.

This probability estimation involves the consideration of the likelihood that representative rider will be able to retain or regain control of the vehicle if the hazard were to occur, or that individuals in the vicinity or the situation will contribute to the avoidance of the hazard by their actions. This consideration is based on evaluation of the control actions necessary by the individuals involved in the hazard scenario to retain or regain control of the situation, as well as the representative riding behaviours of the rider involved (which can be related to the target market, individuals' age, skill level, riding experience, cultural background, etc.).

NOTE 1 Controllability estimations can be influenced by a number of factors including the cultural background of the analyst, the target market for the vehicle, or rider profiles for the target market.

To aid in these evaluations, [Table B.4](#) provides examples of riding situations in which a malfunction is introduced, and the assumptions about the corresponding control behaviours that would avoid harm. These situations are mapped to the controllability rankings, clarifying the 90% and 99% breakpoints levels for judging participant controllability.

NOTE 2 The controllability classification examples provided in [Table B.4](#) are assumed to be based on a mid-sized motorcycle intended for road use. The informative examples provided will be reviewed with respect to the type and performance of motorcycle under consideration.

NOTE 3 [Table B.4](#) provides indications on possible hazards which can occur and to whom it is necessary to make reference when evaluating a specific item.

Table B.4 — Examples of possibly controllable hazardous events by the rider or by the persons potentially at risk

	Class of controllability			
	C0	C1	C2	C3
Description	Controllable in general	Simply Controllable	Normally Controllable	Difficult to Control or Uncontrollable
Riding Factors and Scenarios	Controllable in general	More than 99% of all riders or other traffic participants are usually able to avoid harm	Between 90% and 99% of all riders or other traffic participants are usually able to avoid harm	Less than 90% of all riders or other traffic participants are usually able, to avoid harm
Hazard	Operational situation (control actions by rider/persons potentially at risk)			
Loss of traction (loss of lateral and/or longitudinal tyre force)	while accelerating from a standstill (<i>de clutch, cancel acceleration</i>)	—	—	while accelerating during a banking manoeuvre (<i>cancel acceleration, counter steer, brake</i>)

Table B.4 (continued)

	Class of controllability			
	C0	C1	C2	C3
Undemanded acceleration (equivalent to wide open throttle)	—	—	in congested urban traffic (<i>apply brakes, declutch</i>)	—
Undemanded deceleration (equivalent to engine braking)	in congested urban traffic (riders can declutch, other vehicle users can apply brakes)	during a cornering manoeuvre (<i>riders can declutch</i>)	—	—
Undemanded (maximum) braking (not locked wheels)	—	in congested urban traffic (other vehicle users can apply brakes)	—	during a cornering manoeuvre (<i>counter steer, weight shift</i>)
Loss of tractive power	whilst cruising on a highway (<i>brake and steer to side of road</i>)	during an overtaking manoeuvre (brake and steer to cancel overtaking manoeuvre)	—	—
Undemanded rear wheel lock	—	when approaching a stop junction (<i>steer and apply front brake</i>)	—	—
Undemanded front wheel lock	—	—	—	when approaching a stop junction (<i>weight shift</i>) during a cornering manoeuvre (<i>steer, weight shift</i>)
substantially reduced braking capability	—	—	when approaching a group of pedestrians crossing (steer around pedestrian, down shift, sound horn, pedestrian can avoid motorcycle)	—
Rollaway	while on an incline (apply brake, accelerate)	—	—	—
Loss of forward illumination	—	whilst riding on an unlit rural road at night (slow down or stop if necessary, switch on alternative lighting if available, e.g. high beam)	—	—

Table B.4 (continued)

	Class of controllability			
	C0	C1	C2	C3
Loss of steering damping	—	on uneven road surfaces at highway speeds (<i>increase steering activity, reduce speed</i>)	—	—
Excessive steering damping	—	during an overtaking manoeuvre (<i>apply more steering force, reduce speed or stop</i>) while manoeuvring in a car park (<i>apply more steering force, reduce speed or stop</i>)	—	—
Unexpected pitching	—	when approaching a stop junction (<i>weight shift</i>) when accelerating from a standstill (<i>weight shift, reduce speed</i>)	—	—

Annex C

(informative)

Example of controllability classification techniques

C.1 General

This annex provides a general introduction to some recognised techniques that can be used to assist with the assignment of the controllability class for motorcycle specific hazardous events. This annex also introduces the concept of using a Controllability Classification Panel (CCP), which assigns controllability class considering the results of evaluation and the output from controllability evaluation techniques.

This annex does not provide guidance on how to select the controllability class for specific hazardous events but rather focuses on the available methodologies and techniques that can be used to assist with controllability evaluation.

C.2 Concept of controllability classification panel

The assignment of the controllability class can be performed by a CCP, which can have expertise in the areas of:

- evaluation of motorcycle controllability (performed by expert rider(s));
- motorcycle dynamics;
- electrical/electronic system;
- functional safety; or
- rider behaviour.

Motorcycle manufacturers and system suppliers can be allowed the flexibility to tailor the numbers and make-up of the CCP on a project by project basis. A suitable rationale can be provided for the CCP selected. Involved organisations can share the role of forming a CCP as part of any functional safety planning activity in the safety lifecycle. During the concept phase, it is allowable for the CCP to perform evaluations of the controllability classification for particular hazardous events, provided a rationale supports the selection.

Evaluations by the CCP can be based on a common understanding of classifications for severity, exposure and controllability during the hazard analysis and risk assessment, the results from previous safety validation tests, previous safety analyses, the functional safety objectives and available documentation, as well as an understanding of the representative riders' abilities and the intended use of the motorcycle. A single technique or an appropriate combination of the techniques described below, or others, can be used to confirm controllability evaluations during the hazard analysis and risk assessment.

C.3 Evaluating controllability of motorcycle hazardous events

The evaluation of controllability is an estimate of the probability, that if a hazardous event occurs, representative riders would be able to retain or regain control of the motorcycle, or other persons potentially at risk would be able to gain sufficient control of the hazardous event, such that they would be able to avoid specific harm. An evaluation can be accomplished experimentally or analytically.

Historically, automotive hazardous events have been assessed for controllability initially by evaluation based on the responses of the representative driver or other persons potentially at risk. This can involve, where allowable, groups of representative drivers to make an evaluation on the level of vehicle controllability when system malfunctions are introduced.

Since the dynamic behaviour of a motorcycle places far more emphasis on human interaction to ensure stability, intended trajectory and composure compared to passenger car dynamics, it is not always possible to evaluate controllability in the same way as the automotive industry. Furthermore, representative control behaviours of riders can differ substantially from those of passenger car drivers, therefore a motorcycle specific evaluation is necessary.

As such, one evaluation approach is to make an evaluation of controllability based on feedback from actual riders in order to understand how motorcycle stability, trajectory and composure can be influenced as a result of the rider's responses (e.g. by counter steering, throttling, braking and weight shifting). Therefore, one generally accepted method to evaluate controllability of motorcycle hazardous events is to use expert riders to make a judgement on how a representative rider would have coped with a specific hazardous event. Expert riders have the experience and skill to handle some fairly extreme hazardous events. Use of expert riders can however be subject to appropriate controls to ensure his/her safety.

C.4 Expert riders

This annex does not require that expert riders be certified to any particular standard or hold a particular type of advanced riding licence, but rather recommends that vehicle manufacturers, test organisations and/or suppliers select expert riders based on their own internal procedures, which places the safety of the expert rider as the highest priority and calls for adequate risk reduction controls to be in place to minimise the risk of harm to the expert rider(s). Company procedures can include guidance on how to select expert riders. The following informative examples can be used for expert rider selection criteria:

- experience in motorcycle riding for several years in all target group relevant situations and environmental conditions;
- knowledge of using company specific standardised classification of controllability;
- experienced in accomplishing evaluations;
- capability to translate the test results to representative riders;
- technical ability to discuss the test and the results in terms of technical background;
- participation on company specific rider training courses; or
- holds an official statement as expert rider by the company.

C.5 Controllability evaluation techniques

The assignment of the controllability class, made by the CCP, can be made using an appropriate combination of common evaluation techniques such as for example through a group of representative or expert riders, using riding simulators or mathematical modelling techniques. If there are situations where the safety of the expert rider cannot be assured, the highest controllability class would be assigned (i.e. where a particular manoeuvre is considered uncontrollable even by an expert rider). No particular controllability evaluation technique is preferred and no specific recommendation is made as to which techniques can be used. The following techniques can be considered:

a) Evaluation by a group of representative riders

This remains a common method used within the automotive industry, and there can be examples where the risk is acceptably low for this type of evaluation to be useful, i.e. where hazardous events do not

affect stability, intended trajectory and composure of the motorcycle (e.g. electronically controlled grip heaters).

b) Evaluation by expert riders

It is a commonly adopted technique to use evaluations by expert riders. Expert riders can make a judgement on how a representative rider would have coped with a particular hazardous event. It can be useful to use more than one expert rider to evaluate controllability (see [C.6](#)).

c) Evaluation using riding simulators

This approach could use typical riders and a riding simulator capable of providing a sufficiently realistic representation of the motorcycle dynamic control properties and riding environment when subject to a system malfunction situation. Note that the word “simulator” in this context implies the use of a human rider controlling a physical, electro-mechanical dynamic representation of a motorcycle using handlebars, throttle, brakes, etc. The simulator can have suitable control feel characteristics and appropriate perceptual displays. The function of the simulator can be tailored for the purposes of the controllability evaluation.

d) Evaluation using mathematical modelling and simulation techniques

This computer simulation method uses mathematical models of the motorcycle dynamics and rider/controller. Note that the word “simulation” in this context implies a software representation of both the motorcycle and rider/controller and their dynamic interaction.

C.6 Evaluating Controllability

Evaluation of representative riders’ controllability classification can be done on the basis of:

- vehicle response and performance as shown, for example, in [Table C.1](#);
- awareness as shown, for example, in [Table C.2](#); or
- control behaviour as shown, for example, in [Table C.3](#).

Table C.1 — Vehicle response and performance

More controllable		Less controllable	
There is no change in vehicle response and performance	There is a slight change in vehicle response and performance	There is a moderate change in vehicle response and performance	There is a substantial change in vehicle response and performance

Table C.2 — Awareness

More controllable		Less controllable	
The hazard and resulting vehicle response is imperceptible ^a or has no effect on the operation of the vehicle. (e.g. Sound volume of radio)	The hazard and resulting vehicle response is perceptible but does not alarm the rider.	The hazard and resulting vehicle response is perceptible and can alarm the rider.	The hazard and resulting vehicle response is perceptible and can substantially alarm the rider.
	The timing of the rider’s control actions can have a small effect.	The timing of the rider’s control actions is important, but not critical.	The timing of the rider’s control actions is critical.
^a e.g. for small relative motion between vehicles, a rider may not be able to distinguish between deceleration of a nearby vehicle or acceleration of his own.			

Table C.3 — Control behaviour

More controllable		Less controllable	
It is not necessary for the rider to change his/her control behaviour. ^a	Normal compensatory control actions ^b are adequate for the rider to maintain control of the vehicle.	The rider can need to adapt his/her control behaviour beyond normal compensatory control actions to maintain control of the vehicle.	Extraordinary skill and or unusually high control force effort is necessary to maintain control of the vehicle.
^a This may include, for example, controls necessary to maintain a constant following distance to a leading vehicle, whose speed may be expected to vary. ^b Normal compensatory control actions means a range of operating force, effort or other control action needed to control a motorcycle subjected to typical disturbances, such as wind gusts, rough road surfaces etc.			

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