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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 21815-5

Earth-moving machinery — Collision warning and avoidance — Part 5: Risk area and risk level for other forms of motion

ICS: 53.100

ISO/TC 127/SC 2

Secretariat: **ANSI**

Voting begins on:
2025-06-06

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2025-08-29

This document is circulated as received from the committee secretariat.

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Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Performance requirements	2
4.1 General requirements	2
4.2 Collision risk levels	3
4.2.1 Multiple objects	3
4.3 Collision Risk Area	4
4.4 Calculating CxS Distance	5
4.5 Collision warning and collision avoidance action	5
4.6 Collision warning system	5
4.7 Collision avoidance system	5
5 Articulation	5
5.1 General	5
5.2 Calculation of the size of the collision risk area, or CxS distance	5
5.3 Collision risk levels – stationary intended object – simple solution	6
5.3.1 General	6
5.3.2 Collision risk level – not applicable (NA)	7
5.3.3 Collision risk level 1	8
5.3.4 Collision risk level 2	9
5.3.5 Collision risk level 3	9
5.3.6 Collision risk level 4	10
5.3.7 Collision risk level 5	10
5.4 Collision risk levels – moving intended object – simple solution	11
5.4.1 General	11
5.4.2 Collision risk level – not applicable (NA)	12
5.4.3 Collision risk level 1	13
5.4.4 Collision risk level 2	14
5.4.5 Collision risk level 3	14
5.4.6 Collision risk level 4	15
5.4.7 Collision risk level 5	16
5.5 Collision risk levels – stationary intended object	17
5.5.1 General	17
5.5.2 Collision risk level – not applicable (NA)	18
5.5.3 Collision risk level 1	19
5.5.4 Collision risk level 2	21
5.5.5 Collision risk level 3	22
5.5.6 Collision risk level 4	23
5.5.7 Collision risk level 5	24
5.6 Collision risk levels – moving intended object	25
5.6.1 General	25
5.6.2 Collision risk level – not applicable (NA)	27
5.6.3 Collision risk level 1	27
5.6.4 Collision risk level 2	28
5.6.5 Collision risk level 3	29
5.6.6 Collision risk level 4	30
5.6.7 Collision risk level 5	31
6 Four-wheel steering	31
6.1 Calculation of size of the collision risk area, or CxS distance	31
6.2 Collision risk levels	31
6.2.1 General	31

6.2.2	Four-wheel steering – Circle Steer	32
6.2.3	Four-wheel steering – Crab Steering	32
6.2.4	Crab steering – Motor graders	33
6.2.5	Collision risk levels	33
7	Towed trailer	35
7.1	Calculation of the size of the collision risk area, or CxS distance	35
7.2	Collision risk levels	36
7.2.1	General	36
7.2.2	Collision risk levels - Fixed axle trailers	37
7.2.3	Collision risk levels - Following axle trailers	37
8	Differential speed, skid and counter rotate steering	37
8.1	Calculation of the size of the collision risk area, or CxS distance	37
8.2	Determining collision risk levels – Differential speed, skid and counter rotate steering	38
8.2.1	General	38
8.2.2	Forward or reverse travel	38
8.2.3	Differential speed, same direction turning	38
8.2.4	Skid turning	39
8.2.5	Counter rotation turning	40
8.2.6	Differential speed, differential direction turning	40
8.2.7	Speed relationships	41
8.2.8	Collision risk levels	42
9	Telescopic movement	46
9.1	Calculation of the size of the collision risk area, or CxS distance	46
9.2	Determining collision risk levels – Telescopic movement (Extension/ Retraction).	47
9.2.1	General	47
10	Vertical (Height / Depth) movement	51
10.1	Calculation of the size of the collision risk area, or CxS distance	51
10.2	Determining collision risk levels – Vertical movement (Height /depth).	51
10.2.1	General	51
10.2.2	Collision risk levels – Height limit	52
10.2.3	Collision risk levels – Height	52
11	Information for Use	57
11.1	General	57
11.2	Operator's Manual	57
	Annex A (informative) Additional considerations for multi axis movements	59
	Bibliography	60

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 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery* Subcommittee SC 2, *Safety, ergonomics and general requirements*

A list of all parts in the ISO 21815 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The increasing use of detection systems and avoidance technology has been supporting operators to safely operate machines in the field of mining and construction.

At the same time, there are demands to set standards for machines and systems detecting, alerting and intervening to mitigate collision risk. This document addresses collision risk areas and collision risk levels for machines utilizing detection systems and avoidance technology in the area of earth-moving machinery for types of motion not specifically covered in ISO 21815 Parts 3 and 4. In particular this document addresses:

- articulation motion
- four-wheel steering motion
- towed trailer motion
- differential speed, skid turning, counter rotation motion
- telescopic motion that increases the length, the width, or the height of the machine
- vertical (height / depth) motion

This document is a type-C standard as stated in ISO 12100.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

- machine manufacturers (small, medium, and large enterprises);
- health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

- machine users/employers (small, medium, and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e. g. for maintenance (small, medium, and large enterprises);
- providers of collision warning and avoidance technology;
- system integrators.

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations, or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

This document addresses requirements for detecting, alerting and intervention in mitigating collision risk.

There are currently two existing standards in the field: ISO 16001:2017 Earth-moving machinery – Object detection systems and visibility aids – Performance requirements and tests, and ISO 17757:2017 Earth-moving machinery – Autonomous machinery system safety. These standards provide guidance for visibility aids and object detection system and for autonomous and semi-autonomous machines, however, there is currently no standard that describes collision risk awareness, warning signals and collision avoidance actions of manually operated machinery when there is a risk of collision.

Earth-moving machinery — Collision warning and avoidance —

Part 5: Risk area and risk level for other forms of motion

1 Scope

This document defines requirements for collision warning systems (CWS) and collision avoidance systems (CAS) that address types of motion not specifically covered in ISO 21815 Parts 3 and 4 for:

- earth-moving machinery as defined in ISO 6165,
- mobile underground mining machinery as defined in ISO 19296,
- rock drill rigs as defined in ISO 18758-1, and
- road construction machinery as defined in ISO 22242.

[Clauses 5, 6, 7, and 8](#) do not consider machine height beyond that of height in travel position as established by the machine manufacturer.

The requirements for forward / reverse motion are stated in ISO 21815-3:2023 and for swing/rotation motion in ISO 21815-4:20XX.

This document covers:

- collision warning and avoidance for articulation motion by speed reduction, stopping, or motion inhibit,

NOTE Steering the machine whilst in forward/reverse motion is not considered as articulation motion.

- collision warning and avoidance for four-wheel steering motion by speed reduction, stopping, or motion inhibit,
- collision warning and avoidance for motion of towed trailers in reverse by speed reduction, stopping, or motion inhibit,
- collision warning and avoidance for differential speed, skid turning, counter rotation motion by speed reduction, stopping, or motion inhibit,
- collision warning and avoidance for telescopic extension/ retraction motions by speed reduction, stopping, or motion inhibit, and
- collision warning and avoidance for vertical motions i.e. height or depth by speed reduction, stopping, or motion inhibit.

This document does not cover avoidance by automatic manoeuvring (e.g. steering) away from the intended object.

The system described in this document is intended to assist the operator of the machine. The responsibility for safe operation of the machine remains with the machine operator.

This document is not applicable to collision warning and collision avoidance systems installed or manufactured before the date of its publication.

Machines that are double articulated are excluded from the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6750-1:2019, *Earth-moving machinery — Operator's manual — Part 1: Contents and format*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 21815-1, *Earth-moving machinery — Collision warning and avoidance — Part 1: General requirements*

ISO 21815-3:2023, *Earth-moving machinery — Collision warning and avoidance — Part 3: Risk area and risk level for forward/reverse motion*

ISO 21815-4:20xx, *Earth-moving machinery – Collision Warning and Avoidance – Part 4: Risk area and risk level swing/rotation motion*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010, ISO 21815-1:2021, ISO 21815-3:2023 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 articulation point

instant centre of rotation of two machine sections established by the mechanical coupling device joining those two sections

Note 1 to entry: The articulation point is between two parts of one machine (e.g. front frame and rear frame of a wheeled loader), or between two machines (e.g. machine towing a trailer).

[SOURCE: ISO 8855:2011 4.5, modified vehicle units to machine sections, shorter definition, changed note to entry]

4 Performance requirements

4.1 General requirements

Machinery shall conform with the safety requirements and/or protective/risk reduction measures of [clause 4](#). In addition, the machine shall be designed according to the principles of ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document.

Collision warning (CWS) systems, collision avoidance systems (CAS) or both (CxS) shall comply with the requirements of ISO 21815-1, ISO 21815-3 and ISO 21815-4, in as far as those are not modified or added to by the requirements in this document.

The CxS shall assign a collision risk level (CRL) upon detection of each intended object within the detection zone or collision risk area and communicate the proper CxS action. The collision risk level is based on

analysis of the current motion of the machine or a machine part, the location and movement of the intended object and the possibility of a collision.

NOTE The CxS will need to re-evaluate the risk level at a frequency high enough to address the relative movement of the machine and intended objects.

The detection zone of the CxS device (CxD) should be the same or larger than the collision risk area. However, due to limits of the system, the detection zone may be smaller than the collision risk area. Some CxS products could have the detection zone projecting from the base machine whilst others could have the detection zone projecting from the work equipment or a towed trailer. In all cases the limits of the system and the selection of detection zone according to the application shall be described in the information for use as a system limitation.

ISO 21815-3:2023 Annex B shall be used to provide information on the limitations of use of the CxS.

4.2 Collision risk levels

For general descriptions of the collision risk levels, refer to ISO 21815-3.

The collision risk levels are based on the relationship of the machine to the intended object as per ISO 21815-3. However, any resultant CxS action is dependent upon the machine kinematics, the intended object and the motion being described within this part of ISO 21815. Generically, the CxS actions for this document are as shown in [Table 1](#) for stationary and moving intended objects:

Table 1 — collision Comparison of collision Risk Levels

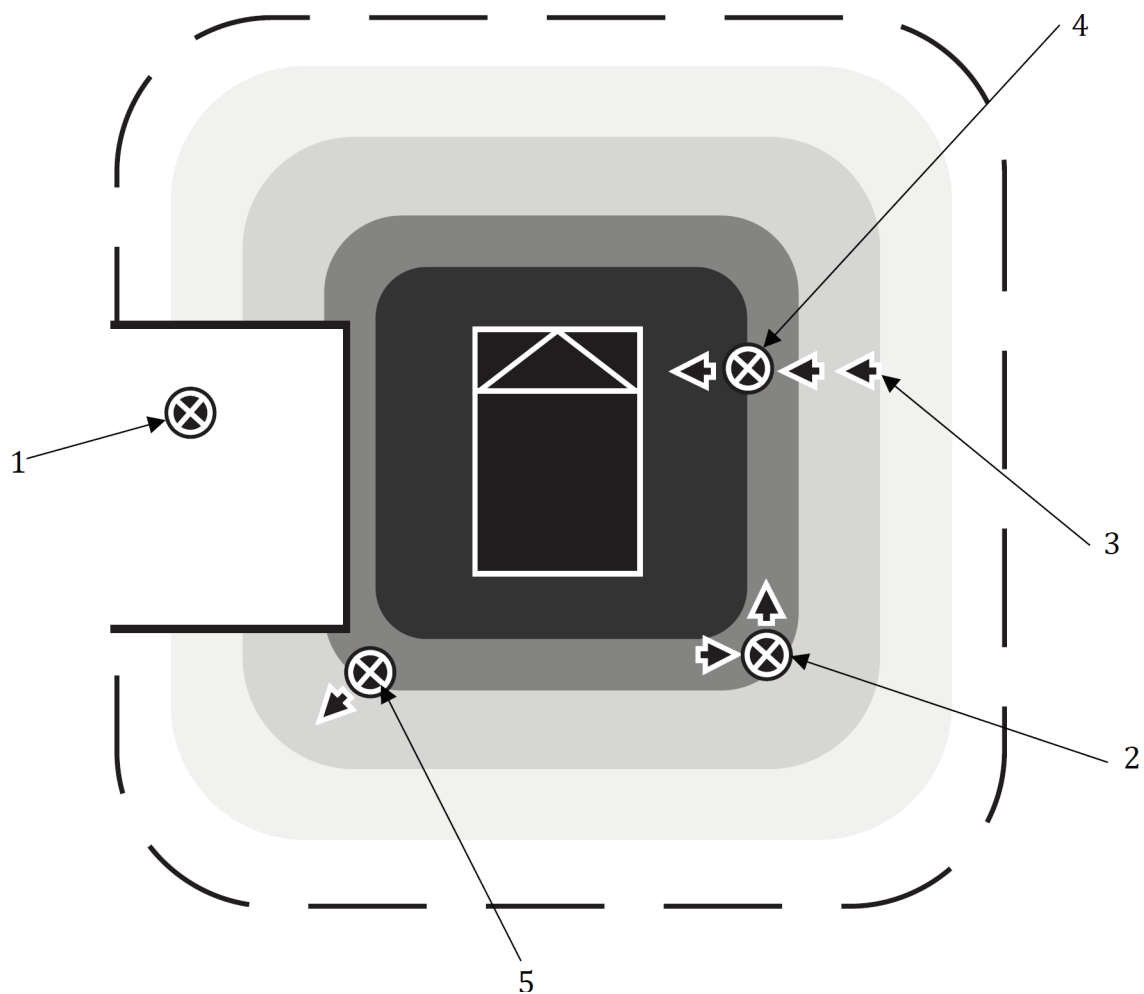
Collision Risk Level	Existence of an intended object	Possible Risk of Collision	Required CxS action
NA	No	No	No
1	Yes	No	No
2	Yes	Yes	No
3	Yes	Yes	CWS (warning), CAS (CSM, SDM)
4	Yes	Yes	CAS (ESM, TIC)
5	Yes	Yes	CAS (TIC)
NOTE 1 SDM is slow down of motion. NOTE 2 CSM is controlled stop of motion. NOTE 3 ESM is emergency stop of motion. NOTE 4 TIC is take-off inhibition NOTE 5 The required action(s) selected are dependent on the system.			

4.2.1 Multiple objects

Where multiple objects that need be evaluated simultaneously as shown in [Figure 1](#) are present, the CxS should analyse each object in the collision risk area, assign an appropriate collision risk level to each intended object and take the respective CxS action. The CxS can additionally track the object trajectory to determine the projected path of the intended objects.

This concept can be applied to all the ranges or combinations of machine motion as described in this document.

The system integrator shall describe the limitations of concurrent collision risk levels and the maximum number of intended objects that can be evaluated concurrently in the information for use. [Figure 1](#) shows an example of multiple intended objects.



Key

- 1 intended object (stationary)
- 2 intended object moving at the same speed and direction as machine movement (maintaining risk level)
- 3 intended object (previous movement, historical)
- 4 intended object moving towards machine (increasing risk level)
- 5 intended object moving away from machine movement (reducing risk)

Figure 1 — Multiple objects and Collision risk areas (Graphical interpretation)

4.3 Collision Risk Area

Sizing the collision risk area should be based on:

- the combination of the base machine and the maximum reach of the work equipment (e.g. boom, arm, working tool), or
- the combination of the base machine and a towed trailer

The collision risk area is determined by the physical kinematics (e.g. mode, speed, turning radius, angle, dimensions). The size of the collision risk area may be adjusted by knowing the real-time value of kinematics (e.g. mode, speed, turning angle).

Physical or virtual barriers may be utilized to adjust the collision risk area. The collision risk area may be adjusted by utilizing information regarding projected path, expected path, or their interactions.

The collision risk area shall be described in the information for use.

4.4 Calculating CxS Distance

A method appropriate for the type of motion the CxS has been designed for shall be selected according to the application. ISO 21815-3:2023 section 5 provides guidance on determining individual components of the CxS distance. Examples of calculations are provided in ISO 21815-3:2023 Annexes C and D and in ISO 21815-4 Annex C.

4.5 Collision warning and collision avoidance action

The CxS actions shall only occur for intended objects in the collision risk area.

NOTE There are several challenges (see ISO 21815-3:2023 Annex B) that can result in false positive detections (detecting objects that do not have a high risk of collision) or false negative detections – missing real risks. False positives could create alarm fatigue and result in operators ignoring real collision risks.

4.6 Collision warning system

For CWS requirements, ISO 21815-3:2023 section 4.6. shall apply.

4.7 Collision avoidance system

For CAS requirements, ISO 21815-3:2023 section 4.7. shall apply.

5 Articulation

5.1 General

Following the approach taken in ISO 21815 Part 3 to determine collision risk levels results in collision risk areas and CxS actions that systems currently available may not be capable of implementing. Two approaches are described. Using a simple form of current technology to determine collision risk levels is described in [clauses 5.3](#) and [5.4](#). The theoretical approach to determining collision risk levels is described in [clauses 5.5](#) and [5.6](#).

The system integrator may choose to take one or more of the approaches listed in [clauses 5.3](#) through to 6. It is not necessary to implement all these approaches.

5.2 Calculation of the size of the collision risk area, or CxS distance.

The CxS distance should be enough to cover the full range of articulation motion that the base machine could move through with no forward/reverse motion actively occurring. Configurations of the base machine fitted with attachments should cover the full range of motion of the base machine and attachment. Where detection zone is less than the full range of articulation motion, it shall be stated as limitations of use in the information for use. Applicable base machine and attachment configurations shall be listed in the information for use.

The system integrator may limit the number of recommended attachments and machine configurations that the CxS is suitable for. These shall be stated as limitations of use in the information for use.

For articulation motion there are multiple levels of risk, however not all risk levels NA to 5 as described in ISO 21815-3 can be applicable to all types of machines.

For some machines static articulation (articulation without travel movement) is difficult or impossible; this may be taken into consideration when assigning the collision risk level.

The degree of articulation varies from machine to machine. For some machines the collision risk area for the front frame will overlap the collision risk area for the rear frame, for other machines articulation is limited leaving space between front and rear frames when fully articulated.

The diagrams in [clauses 5.3](#) to [5.6](#) show the articulation point remaining stationary during articulation. This is not true for all machines, for some machines the articulation point will move in the opposite direction to the front and rear frames. For simplicity and clarity, diagrams for CRL's 1 to 5 show the machine articulating to the right. In reality the machine can articulate in either direction.

The diagrams in [clauses 5.3](#) to [5.6](#) illustrate both front and rear frames of the machine articulating.

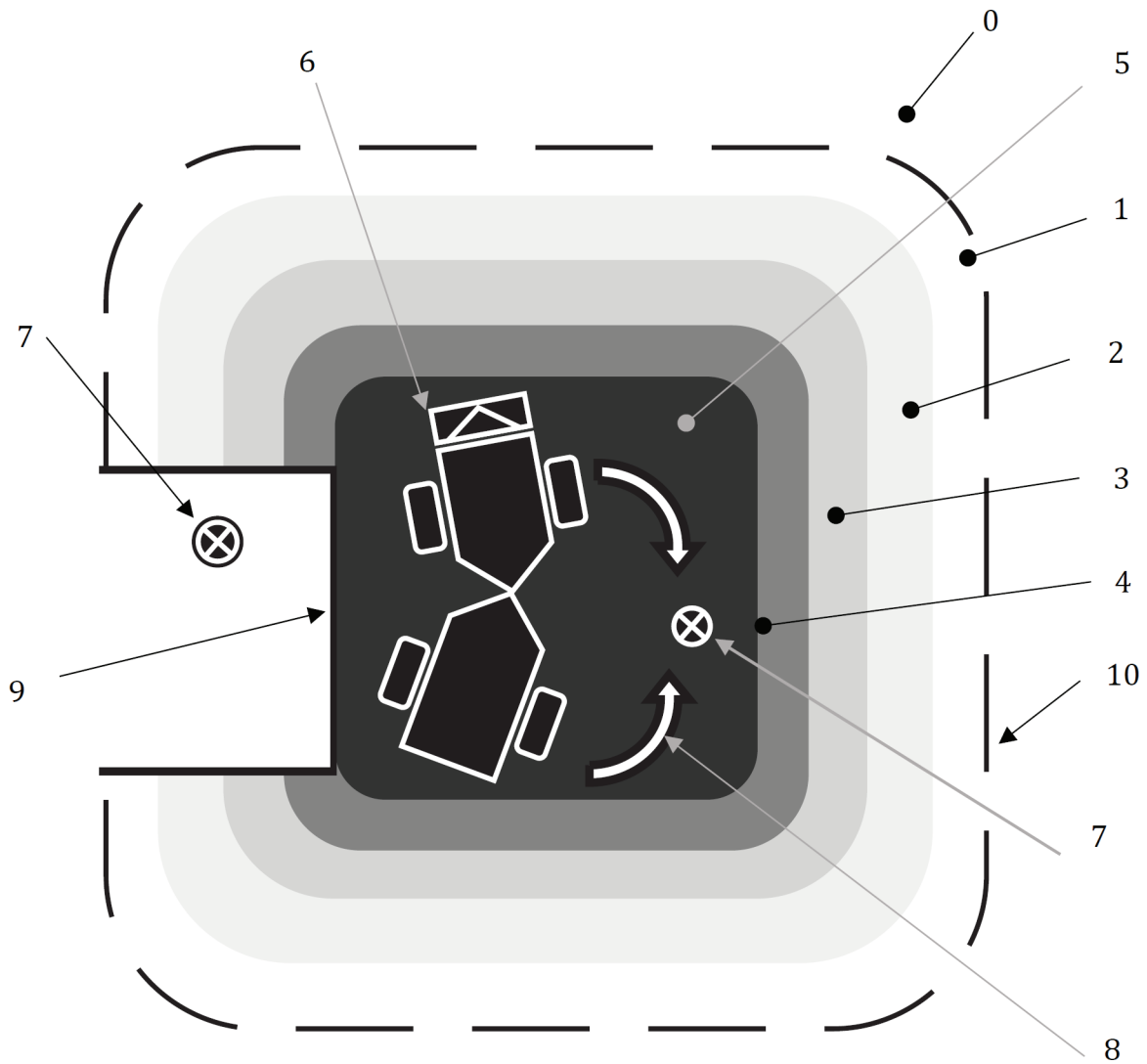
NOTE When one end of the machine is restrained e.g. bucket dug into a pile or carrying a heavy load, only the unladen end of the machine can articulate or movement can be possible

5.3 Collision risk levels – stationary intended object – simple solution

5.3.1 General

This clause describes a simple solution for articulation. It may apply to systems currently available that are not capable of implementing the CRL's and CxS actions described in [clauses 5.5](#) and [5.6](#).

The diagrams in [clauses 5.3.1](#) to [5.3.7](#) are for illustration purposes only.



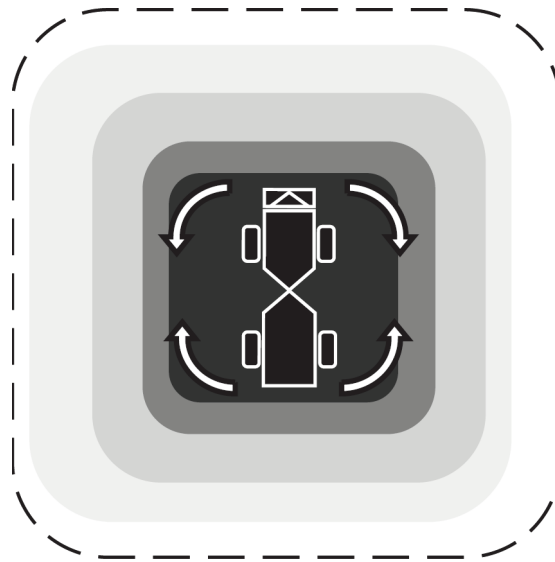
Key

- 0 area where no CRL exists
- 1 area where CRL 1 exists
- 2 area where CRL 2 exists
- 3 area where CRL 3 exists
- 4 area where CRL 4 exists
- 5 area where CRL 5 exists
- 6 typical machine
- 7 intended object (stationary)
- 8 movement of machine
- 9 barrier (e.g. berm, wall)
- 10 limit of detection

Figure 2 — Collision risk level stationary intended object

5.3.2 Collision risk level - not applicable (NA)

The CxS determines there is no risk of a collision as there is no intended object as shown in [Figure 3](#). The CRL is defined as (NA).



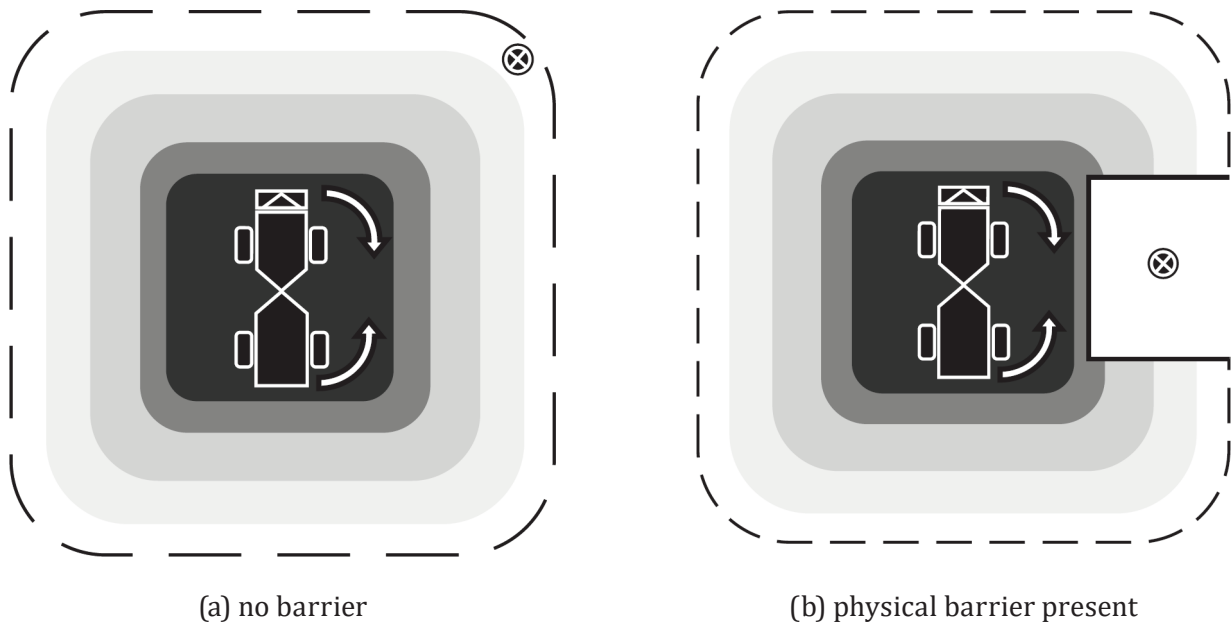
Key

See [Figure 2](#) key.

Figure 3 — Collision risk level NA

5.3.3 Collision risk level 1

The risk of collision is not possible based on machine movement direction and the location of the intended object as shown in [Figure 4](#).



Key

See [Figure 2](#) key.

Figure 4 — Collision risk level 1 based on location or on a physical barrier

[Figure 4\(b\)](#) illustrates a physical barrier, but the barrier is not required to be a valid example.

NOTE A simple solution is unlikely to recognise any barriers. A warning or avoidance action is likely to take place if there is an intended object behind a barrier in an area that would otherwise be a CRL zone.

5.3.4 Collision risk level 2

The risk of collision is possible, if machine movement is initiated or continues in the same state (e.g. relative speed, direction, etc.), but no action is needed as shown in [Figure 5](#).



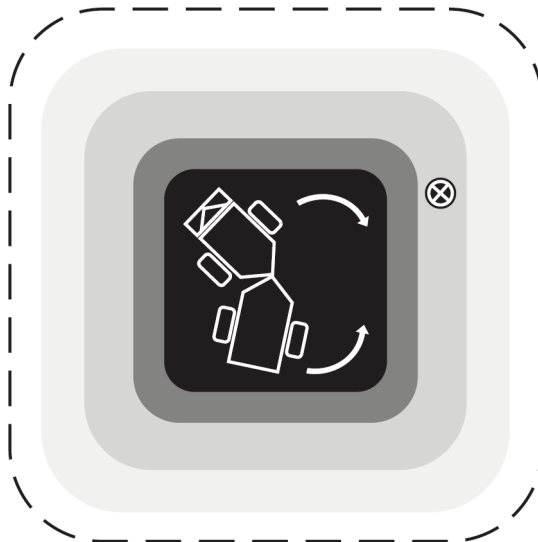
Key

See [Figure 2](#) key.

Figure 5 — Collision risk level 2

5.3.5 Collision risk level 3

The risk of collision is possible, if machine movement is initiated and continues in the same state (e.g. relative speed, direction, etc.), but the operator has time to take evasive action as shown in [Figure 6](#). The CWS issues a warning to the operator.



Key

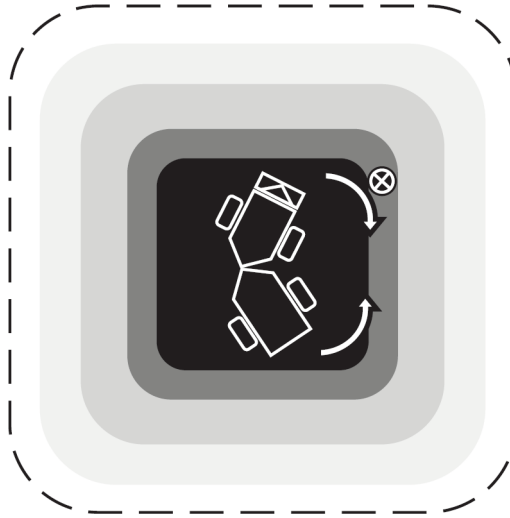
See [Figure 2](#) key.

NOTE CAS can initiate interventional collision avoidance action e.g. slowdown or take-off inhibition.

Figure 6 — Collision risk level 3

5.3.6 Collision risk level 4

The risk of collision is possible, if machine movement is initiated and continues in the same state (e.g. relative speed, direction, etc.), but the CAS shall take interventional collision avoidance action as shown in [Figure 7](#).



Key

See [Figure 2](#) key.

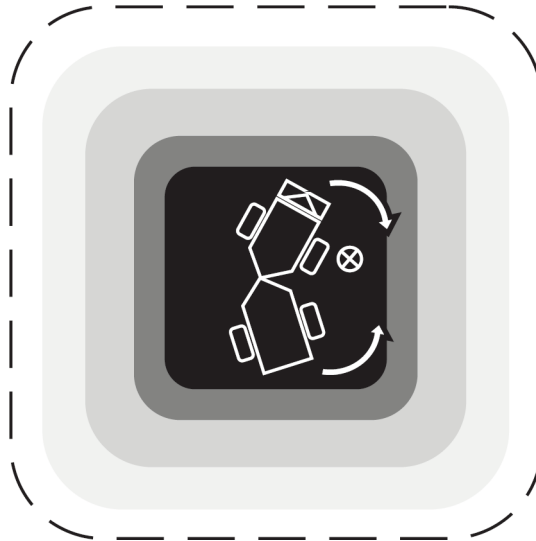
NOTE 1 The CWS informing the operator does not have time to avoid the intended object by only slow down of motion

NOTE 2 The CAS can react fast enough by applying interventional collision avoidance action (e.g. emergency stop or take-off inhibition).

Figure 7 — Collision risk level 4

5.3.7 Collision risk level 5

The risk of collision cannot be avoided, if machine movement is initiated and continues in the same state (e.g. relative speed, direction, etc.) as shown in [Figure 8](#). The CAS shall react by applying a TIC, i.e. inhibition of articulation.



Key

See [Figure 2](#) key.

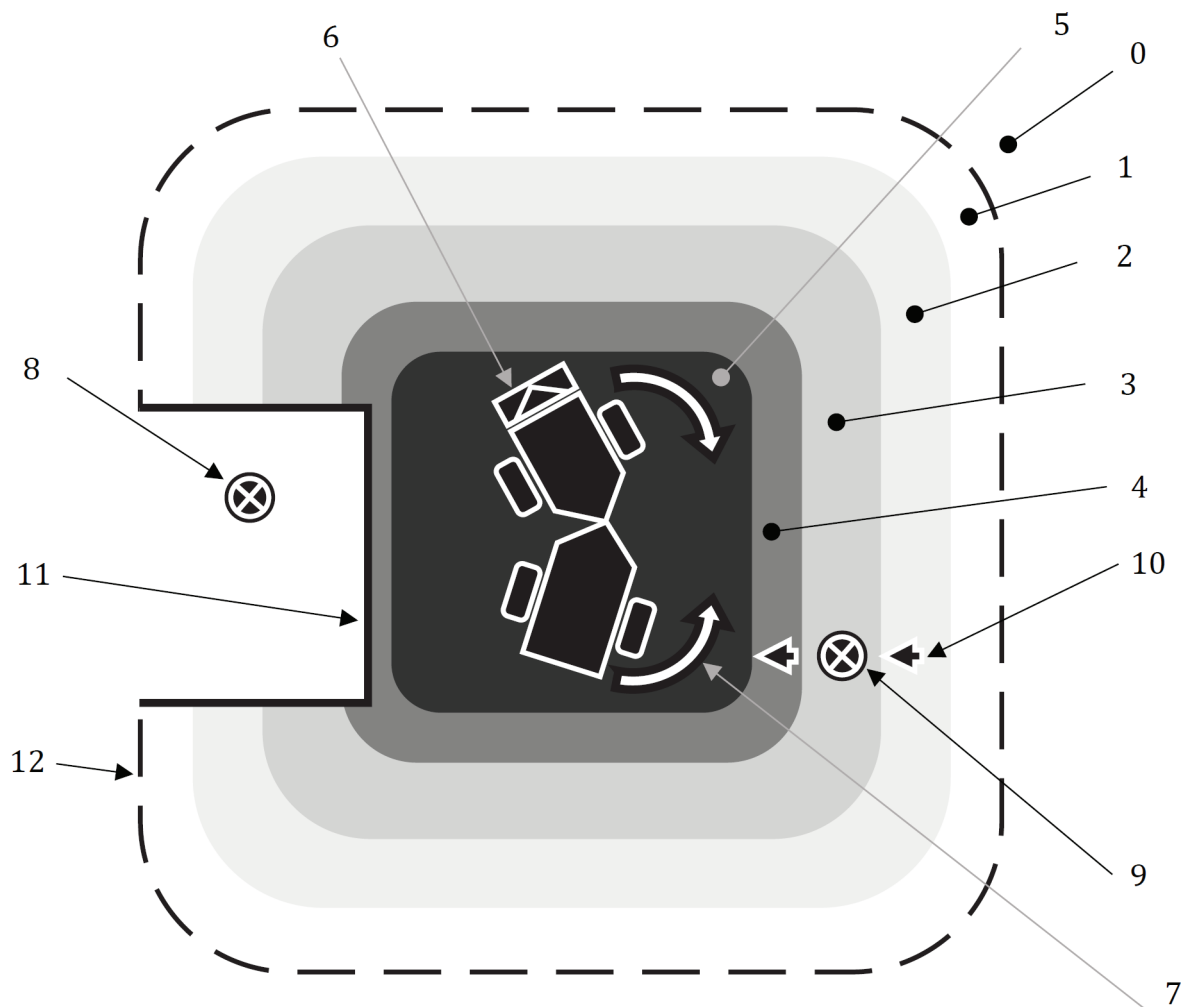
Figure 8 — Collision risk level 5

5.4 Collision risk levels – moving intended object – simple solution

5.4.1 General

This clause describes a simple solution for articulation. It may apply to systems currently available that are not capable of implementing the CRL's and CxS actions described in [clause 5.6](#).

The diagrams in [clauses 5.4.1](#) to [5.4.7](#) are for illustration purposes only.



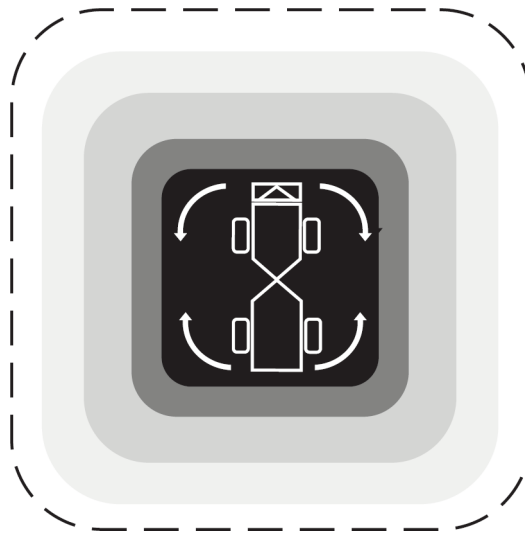
Key

- 0 area where no CRL exists
- 1 area where CRL 1 exists
- 2 area where CRL 2 exists
- 3 area where CRL 3 exists
- 4 area where CRL 4 exists
- 5 area where CRL 5 exists
- 6 typical machine
- 7 movement of machine (anticipated)
- 8 intended object (Stationary)
- 9 intended object (Moving)
- 10 previous or historical movement of intended object
- 11 barrier (e.g. berm, wall)
- 12 limit of detection

Figure 9 — Collision risk level moving object (graphical interpretation)

5.4.2 Collision risk level – not applicable (NA)

The CxS determines there is no risk of a collision as there is no intended object as shown in [Figure 10](#). The CRL is defined as (NA).



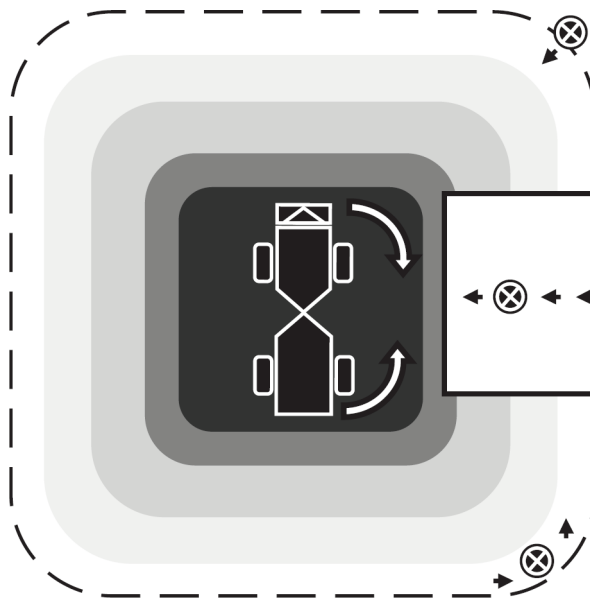
Key

See [Figure 9](#) key.

Figure 10 — Collision risk level NA

5.4.3 Collision risk level 1

The risk of collision is not possible based on movement of both the machine and the intended object as shown in [Figure 11](#).



Key

See [Figure 9](#) key.

Figure 11 — Collision risk level 1

[Figure 11](#) illustrates a physical barrier, which can be located anywhere in relation to the machine, but it is not required to be a valid example.

NOTE Some simple solutions are unlikely to recognise any barriers. A warning or avoidance action is likely to take place if there is an intended object behind a barrier in an area that would otherwise be a CRL zone.