



**International
Standard**

ISO 21423

**Robotics — Industrial mobile
robots — Communications and
interoperability**

*Robotique — Robots mobiles industriels — Communications et
interopérabilité*

**First edition
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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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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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 299, *Robotics*.

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

As industrial mobile robots are increasingly used in industrial environments, there is a growing need for industrial mobile robots (IMRs) from single or multiple vendors to operate in the same area, regardless of vendor or model. Navigation and safety-related aspects of IMRs and IMR fleet(s) are not covered in this document. This document can enable different fleets to work more effectively, by sharing information about the location, speed, direction, condition(s), availability and other characteristics of the IMRs, and by requesting actions. The communication protocols in this document can also enable IMRs and IMR fleets to exchange data with other equipment and systems, e.g. alarm systems, lifts and doors.

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Robotics — Industrial mobile robots — Communications and interoperability

1 Scope

To facilitate interoperability in a shared industrial environment, this document specifies the requirements for communication between two or more of the following:

- industrial mobile robot (IMR);
- IMR fleet manager (IMRFM);
- other machines, equipment, and applications in the shared industrial environment (e.g. machines tended by the IMRs; enterprise resource planning (ERP) tools; and building infrastructure such as lifts, alarm systems, automated doors).

For the purposes of this document, “industrial environment” describes a workplace where the people are working-age adults and the public is restricted from access or not reasonably expected to be present. Further, “industrial” pertains to the production of goods and related services (e.g. manufacturing, laboratory, pharmaceutical, warehousing, distribution, logistics and other workplaces).

The following applications are excluded from the scope of this document: entertainment, consumer, military, medical and use on public roads.

This document is not safety-related; there are no safety requirements. Navigation requirements 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 8373, *Robotics — Vocabulary*

ISO 8601-1, *Date and time — Representations for information interchange — Part 1: Basic rules*

ISO/IEC 9834-8, *Information technology — Procedures for the operation of object identifier registration authorities — Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*

ISO 16100-1, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 1: Framework*

ISO/IEC 20922, *Information technology — Message Queuing Telemetry Transport (MQTT) v3.1.1*

ISO/IEC 21778, *Information technology — The JSON data interchange syntax*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8373, ISO 16100-1 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 Terms and definitions

3.1.1

industrial mobile robot

IMR

mobile platform capable of navigating and operating through an *industrial environment* (3.1.12) to reach a specified location or cover a specified area, together with any integrated *attachments* (3.1.2)

Note 1 to entry: Navigation of the IMR can be autonomous or guided.

3.1.2

attachment

component, mechanism or equipment to be integrated with a mobile platform

3.1.3

fleet

industrial mobile robot fleet

IMRF

one or more *IMRs* (3.1.1) that are collectively managed

3.1.4

fleet manager

industrial mobile robot fleet manager

IMRFM

software that monitors and directs one or more *IMRF(s)* (3.1.3)

Note 1 to entry: Fleet manager functions can include monitoring statuses or *poses* (3.1.9), or both, of *IMRs* (3.1.1), coordinating actions, order management, data synchronization, charging, idle parking and traffic management.

3.1.5

industrial mobile robot origin point

IMR origin point

point within an *IMR* (3.1.1) that is designated as the (0,0,0) coordinate

Note 1 to entry: The IMR origin point is usually selected by the manufacturer of the IMR and used by the IMR to report its position.

3.1.6

industrial mobile robot footprint point

IMR footprint point

coordinate measured in meters relative to the *IMR origin point* (3.1.5)

Note 1 to entry: The IMR footprint point is positive *x* when measured from IMR origin point in direction of front of vehicle (north bound), positive *y* when measured to the left of the *IMR* (3.1.1) when front of IMR is pointing upwards.

3.1.7

industrial mobile robot footprint

IMR footprint

two-dimensional projection of the physical volume of the *IMR* (3.1.1) and its payload(s), onto the travel surface, described as a polygon in the coordinate frame that defines the outer boundaries of the physical volume of the IMR and its payload(s) relative to the *IMR origin point* (3.1.5)

Note 1 to entry: The IMR footprint can change dynamically, e.g. due to the motion of an *attachment* (3.1.2).

Note 2 to entry: Often, IMR "forward" motion is in the positive *x* axis (+*x*) direction, but this can vary depending on the IMR type.

Note 3 to entry: The IMR footprint lists points in clockwise order. It is not necessary to repeat the first coordinate point to close the polygon, because the last point in the footprint is matched with the first. See [Figure 1](#).

EXAMPLE The footprint depicted in [Figure 1](#) is: [(8, 0), (6, -4), (-2, -4), (-2, 4), (6, 4)].

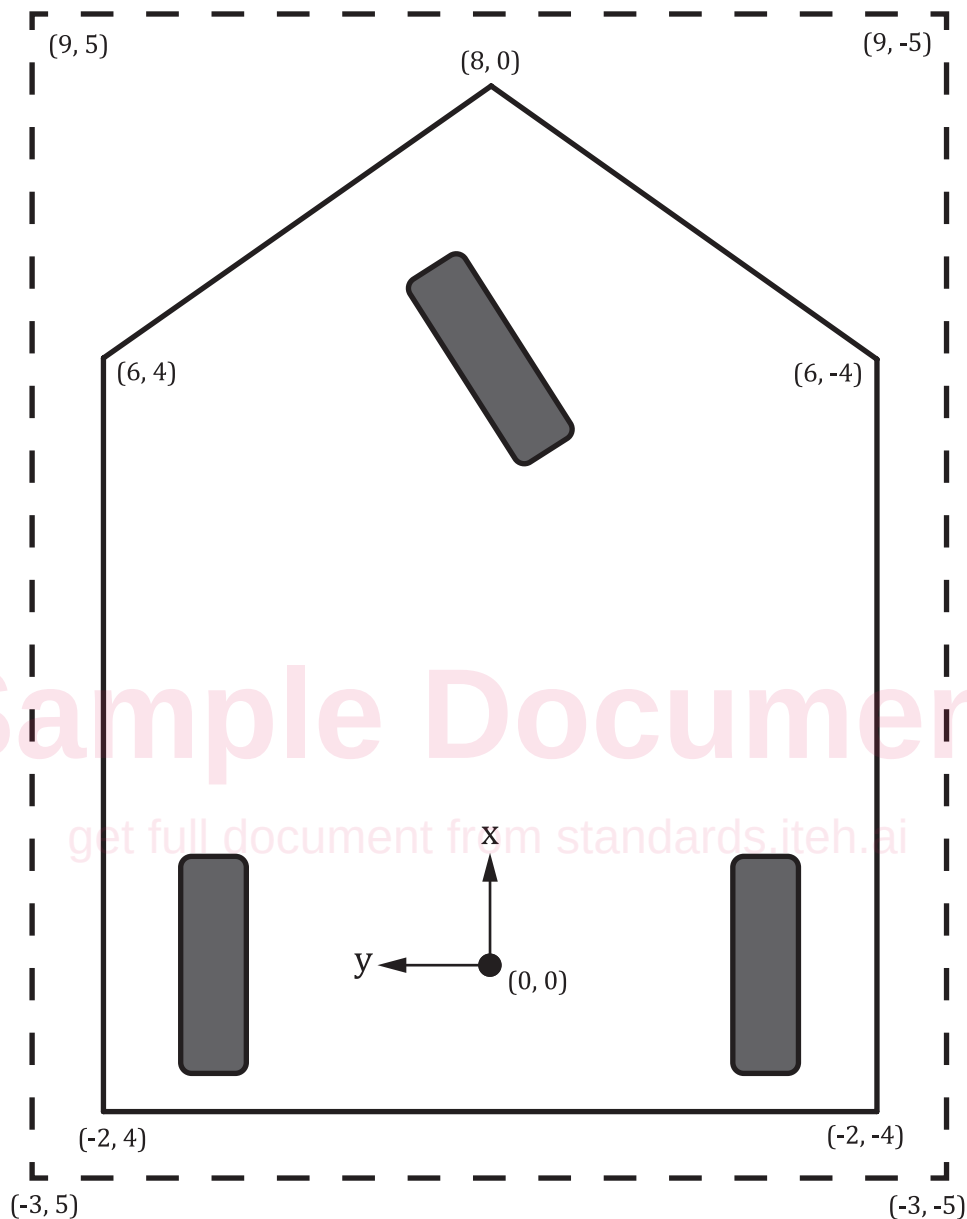


Figure 1 — Example of an IMR origin point (0,0) within an IMR footprint and IMR working area, top view

3.1.8 industrial mobile robot working area

IMR working area

two-dimensional polygon encompassing the *IMR footprint* ([3.1.7](#)) to allow the *IMR* ([3.1.1](#)) to work and navigate

Note 1 to entry: The IMR working area is reported in the same manner as the IMR footprint.

3.1.9

pose

combination of position and orientation in space

[SOURCE: ISO 8373:2021, 5.5, modified — Note 1 to entry and Note 2 to entry have been deleted.]

3.1.10

odometry

combination of *pose* (3.1.9), linear velocity and angular velocity

3.1.11

docking

process of reaching or connecting or both reaching and connecting to another object

Note 1 to entry: "Another object" can include, e.g. transfer points, charging stations, other *industrial mobile robots* (3.1.1).

3.1.12

industrial environment

workplace where the public is restricted from access or not reasonably expected to be present

3.1.13

enterprise resource planning

ERP

planning function that includes inventory transaction, cost accounting, order fulfilment and resource tracking

Note 1 to entry: The planning methodology uses material requirements planning and master production schedule to calculate requirements for materials and to make recommendations to release replenishment orders when due dates and need dates are not in phase.

Note 2 to entry: An alternative definition of enterprise resources planning can be found in ISO 15531-1.

[SOURCE: ISO 16100-1:2009, 3.11]

3.1.14

common coordinate system

CCS

coordinate system used to communicate locations

Note 1 to entry: The common coordinate system is defined in the Euclidean space (x,y,z) .

3.1.15

common coordinate system origin point

CCS origin point

arbitrarily selected point within a facility that is designated as the (0,0,0) coordinate in the *common coordinate system (CCS)* (3.1.14)

Note 1 to entry: The CCS origin point is a property of the facility or *industrial environment* (3.1.12) in which *industrial mobile robots (IMRs)* (3.1.1) or *IMR fleets* (3.1.3) operate, e.g. a point on a wall, column or floor.

Note 2 to entry: The CCS follows the right-hand rule convention.

Note 3 to entry: All locational data shared is a position relative to the CCS origin point, which is stated in meters (m).

3.1.16

reference point

coordinate that is relative to the *common coordinate system (CCS) origin point* (3.1.15) which can be used as a reference for all *industrial mobile robots (IMRs)* (3.1.1) or *IMR fleet managers (IMRFMs)* (3.1.4) to establish a transformation from their individual maps to the CCS (3.1.14)

EXAMPLE Centre or edges of *fiducials* (3.1.18), corners of the rooms.

Note 1 to entry: The CCS origin point can be considered a reference point.

Note 2 to entry: Coordinate transforms can be computed by the IMRFM to which the IMRs belong.

3.1.17

location point

industrial mobile robot origin point (3.1.5) relative to the *common coordinate system origin point* (3.1.15) at a moment in time

3.1.18

fiducial

physical marker or object to designate a *reference point* (3.1.16)

Note 1 to entry: A fiducial can be considered a landmark.

3.1.19

local trajectory

ordered list of *industrial mobile robot (IMR)* (3.1.1) *location points* (3.1.17) and timestamps that the IMR uses for navigation within the range of sensors

3.1.20

global path

geometric representation of the *industrial mobile robot (IMR)*'s (3.1.1) planned path that the IMR uses for navigation beyond the range of sensors

Note 1 to entry: This can be a set of interpolation points, e.g. non-uniform rational basis spline (NURBS). See [Annex A](#) for the JSON schema for NURBS.

3.1.21

global plan

ordered list of *industrial mobile robot* (3.1.1) *location points* (3.1.17) for future destinations with estimated times of arrival at each location point

Note 1 to entry: This is intended to be a short list of significant intermediate points (e.g. intersections, working locations) and not intended to be an extension of *local trajectory* (3.1.19).

3.2 Abbreviated terms

Term	Abbreviated term
common coordinate system	CCS
enterprise resource planning	ERP
industrial mobile robot	IMR
industrial mobile robot fleet	IMRF
industrial mobile robot fleet manager	IMRFM
JavaScript Object Notation	JSON
light detection and ranging	LIDAR
message queuing telemetry transport	MQTT
non-uniform rational basis spline	NURBS
original equipment manufacturer	OEM
ping request	PINGREQ
quality of service	QoS
scalable vector graphics	SVG
state of charge	SoC
transmission control protocol	TCP
universally unique identifier	UUID

4 Common coordinate system (CCS)

4.1 General

All industrial mobile robot fleets (IMRFs) operating in the same physical space (e.g. floor, mezzanine, building) shall use the same common coordinate system (CCS). At least three reference points per CCS, one of which can be the CCS origin point, shall be identified to establish a CCS for different IMRs or IMRFMs operating in the same facility. These reference points shall be:

- on a horizontal plane, with three-dimensional data (e.g. ramps) projected down into the horizontal plane;
- measured in meters (m);
- spaced out over the area being used, as far as is practicable, to reduce the effects of measurement errors.

NOTE 1 CCS enables transformation of independent and individual coordinate systems into a common coordinate system. See [Annex D](#) for an explanation of how to implement this, with examples.

The local map(s) used by each IMRFM or IMR shall include points that correspond to at least three reference points. When multiple maps are used, all maps shall use the same universally unique identifier (UUID) for each reference point. All UUIDs shall conform with ISO/IEC 9834-8.

NOTE 2 By knowing these reference points, maps can be transformed back and forth among multiple coordinate systems.

4.2 CCS fields

A CCS shall have the following fields as shown in [Table 1](#).

Table 1 — Common Coordinate System (CCS) fields

Field name	Type	Description	Required, recommended or optional?
id	string	A string representation of a universally unique identifier (UUID) that defines this CCS. This is the identifier when referencing this CCS.	Required
name	string	A label for display purposes, which should not be used for referencing purposes.	Required
referencePointIds	array of strings	A list of at least three reference point IDs, that are spaced out over the area being used to reduce the effects of measurement errors.	Required

4.3 Reference point fields

Reference points shall have the following fields as shown in [Table 2](#).

Table 2 — Reference point fields

Field name	Type	Description	Required, recommended or optional?
id	string	A string representation of a universally unique identifier (UUID) that defines this reference point. This is the identifier for referencing this point.	Required
name	string	A label for display purposes, which should not be used for referencing purposes.	Required
x	float32	The x-coordinate of the position of the reference point relative to the CCS origin point, measured in meters (m).	Required
y	float32	The y-coordinate of the position of the reference point relative to the CCS origin point, measured in meters (m).	Required

4.4 Location point fields

Location points shall have the following fields as shown in [Table 3](#). The field name “z” shall be relative to ground of the referenced CCS, where a negative value is a location below the ground plane.

Table 3 — Location point fields

Field name	Type	Description	Required, recommended or optional?
ccsId	string	A string representation of a universally unique identifier (UUID) that defines the CCS within which the location point is referenced. This is the identifier used when internally referencing this CCS.	Required
x	float32	The x-coordinate of the position of the IMR's location point relative to the CCS origin point, measured in meters (m).	Required
y	float32	The y-coordinate of the position of the IMR's location point relative to the CCS origin point, measured in meters (m).	Required
z	float32	The z-coordinate of the position of the IMR's location point relative to the CCS origin point, measured in meters (m), where a negative value is a location below the CCS origin point.	Required

5 Industrial mobile robot identity and capability

Upon start-up or change, the IMR information stated in this document shall be provided in accordance with [Table 4](#). In the context of this document, the following shall apply:

- "Required" information shall be provided;
- "Recommended" information should be provided;
- "Optional" information may be provided.

The maximum value shall be communicated if the IMR does not have the means to detect or report a change to IMR footprint, IMR working area, height, speed or payload.

Table 4 — IMR identity and capability Information

Field name (parent)	Child field name (if any)	Type	Description	Required, recommended or optional?
id		string	A string representation of the IMR's universally unique identifier (UUID)	Required
timestamp		YYYY-MM-DDThh:mm:ss.fffZ	The timestamp of the message when this identity and capability is valid, in accordance with ISO 8601-1	Required
entityType		string	An entity is the sender or receiver of JSON messages defined in this document. For an IMR the value of this field shall be IMR	Required
manufacturerName		string	The company name of the IMR manufacturer	Required
iso21423Version		string	ISO 21423 protocol version used by this IMR, starting with version 1.0	Optional
capabilities		Capabilities object	The capabilities of the IMR according to B.5.2.3 ; see Table A.3	Required
details		{		Required
	imrModel	string	The IMR model	Required
	imrSerialNumber	string	IMR serial number	Required
	imrFootprint	array of Point objects	An array of coordinates of the IMR footprint points in meters (m); see Table A.1	Required
	imrWorkingArea	array of Point objects	An array of coordinates of the IMR working area, in meters (m); see Table A.1	Required
	imrHeight	float32	The maximum height of the working space, in meters (m)	Required
	softwareVersions	array of Software-Version objects	The current version of software, provided as an array of tuples with component and version; see Table A.2	Required
	priority	uint32	IMR priority for resolving conflicts, where zero (0) is the highest priority	Recommended
	ratedSpeed	float32	The IMR's rated speed in the primary direction of travel, measured in m/s	Recommended
	supportedChargerTypes	array of strings	The type(s) of charger which can be used by the IMR	Recommended
	supportVendor-Name	string	The company name of the technical support supplier NOTE This can be the manufacturer of the IMR, or a different company	Recommended
	SupportVendor-ContactInformation object	string	The contact information for the technical support supplier, see Table A.4	Recommended
	visualThumbnail-Image	string(base64)	A visual thumbnail image of the IMR, as a base64-encoded SVG	Recommended
	ratedLoad	float32	The IMR's rated load, expressed as mass (kg), corresponding to the maximum load under standard gravitational acceleration	Recommended
	supportURL	string	URL to support web user interface	Optional
	imrDocumentation	string	A link to more detailed IMR documentation	Optional

Table 4 (continued)

Field name (parent)	Child field name (if any)	Type	Description	Required, recommended or optional?
	payloadTypes	array of strings	The types of payload the IMR can handle	Optional
	batteryType	string	The type of battery used by the IMR	Optional
	additionalProperties	array of AdditionalProperty objects	Additional properties of the IMR as appropriate for specific IMR types and applications see Table A.12	Optional
		}		

6 Industrial mobile robot location and status

6.1 General

IMR location and status information shall be published in accordance with [6.3](#).

NOTE This information regarding current location and operating mode and state can facilitate location visualization, traffic management and more.

6.2 Operating mode and operating state

The operating mode and operating state shall be reported as an array of strings that provide the active operating mode and a list of all current states of the IMR. The list can be empty if the IMR is not in any of these states. State strings are ordered in the list according to the IMR implied priority with the operating mode first, followed by the highest priority operating state. The mode and state names as described in [Table 5](#) shall be used. The list can be expanded by defining or redefining new strings only if it is for a purpose not listed in [Table 5](#).

The applicable operating states shall be communicated as specified in [Table 5](#).

If the state MODE_MANUAL, MODE_TELEOP or MODE_MAINTENANCE is active, and any or all of STOP_CATEGORY_0, STOP_CATEGORY_1 and STOP_CATEGORY_2 are present, then communication of the stop category operating states shall be provided. If the active state is either MODE_AUTO or MODE_SEMIAUTO, then the following states are optional or required as stated in [Table 5](#).

Table 5 — Operating state descriptions and requirements when in autonomous or semiautonomous mode

Name of operating state	Description	Required, recommended or optional, if presently active
STOP_CATEGORY_0 ^a	Uncontrolled stop by immediately removing power to the machine actuators	Required
STOP_CATEGORY_1 ^a	Controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved	Required
STOP_CATEGORY_2 ^a	Controlled stop with power left available to the machine actuators	Required
PAUSED	IMR is paused temporarily, while retaining its objective	Recommended
WAIT_FOR_RESET	IMR is waiting for a human intervention (e.g. reset) before it can operate	Optional
MAPPING	IMR is creating a new map	Optional
LOST	IMR lost localization and does not know where it is	Required

^a Stop categories are defined in IEC 60204-1.