



DPC: 25/30477451 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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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.

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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 Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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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.	



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ISO/DIS 21423

Robotics — Industrial mobile robots — Communications and interoperability

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CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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).

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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.

80 Introduction

81 As mobile robots become increasingly available and effective for use in industrial settings, there is a
82 growing need for industrial mobile robots (IMRs) from single or multiple vendors to operate in the same
83 area. Each IMR fleet (IMRF) manages its own safety and navigation functionality, independent of this
84 standard. However, communication protocols can allow IMRFs from different vendors to work more
85 effectively, to share information about the location, speed, direction, condition(s), tasking / availability
86 and other performance characteristics in a warehouse or factory floor. The communication protocols in
87 this document enable the IMRFs to exchange data with building infrastructure equipment and systems,
88 such as alarm systems, lifts, and doors.

89 The following definitions apply in understanding how to implement an ISO International Standard:

- 90 — "shall" indicates a requirement;
- 91 — "should" indicates a recommendation;
- 92 — "may" is used to indicate that something is permitted; and
- 93 — "can" is used to indicate that something is possible, for example, that an organization or individual is
94 able to do something.

95 Notes are informative. Notes provide explanations or examples; they are not intended to be exhaustive.

96

Robotics — Industrial mobile robots — Communications and interoperability

1 Scope

To facilitate interoperability in a shared operating environment, this document specifies the communication requirements between any of the following, or any combination and/or number thereof:

- IMR;
- IMR fleet manager (IMRFM); and/or
- other machines, equipment, and applications in the working environment (e.g., machines tended by the IMRs; enterprise resource planning (ERP) tool; building infrastructure such as lifts, alarm systems, automated gates).

For the purposes of this document, “industrial” 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 and environments, including but not limited to manufacturing, laboratory, pharmaceutical, warehousing, distribution, logistics, and other workplaces not conventionally considered “industrial.”

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.

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.

ANSI/RIA R15.08-1:2020, *Industrial Mobile Robots — Safety Requirements — Part 1: Requirements for the Industrial Mobile Robot*

IETF RFC 6455, December 2011, *The WebSocket Protocol*

ISO 8373:2021, *Robotics — Vocabulary*

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

ISO/IEC 9834-8:2014, *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/IEC 11578:1996, *Information technology — Open Systems Interconnection — Remote Procedure Call (RPC)*

ISO 16100-1:2009, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in [ANSI/RIA R15.08-1:2020](#), [ISO 8373:2021](#), [ISO 16100-1:2009](#), and the following apply.

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

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

138 3.1 Terms and definitions

139 3.1.1

140 IMR origin point

141 arbitrarily selected point within an IMR that is designated as the (0,0,0) coordinate

142 3.1.2

143 IMR footprint point

144 coordinate measured in meters relative to the IMR origin point (positive x when measured from IMR
145 origin point in direction of front of vehicle [north bound], positive y when measured to the left of the
146 vehicle when front of vehicle is pointing upwards)

147 3.1.3

148 IMR footprint

149 two-dimensional projection of the IMR (x,y,0) onto the travel surface, described as a polygon in the
150 coordinate frame that defines the outer boundaries of the IMR's working space relative to the IMR origin
151 point

152 Note 1 to entry: The IMR footprint can change dynamically. For example, a robotic manipulator or arm attached to
153 a mobile platform can change the footprint of the IMR.

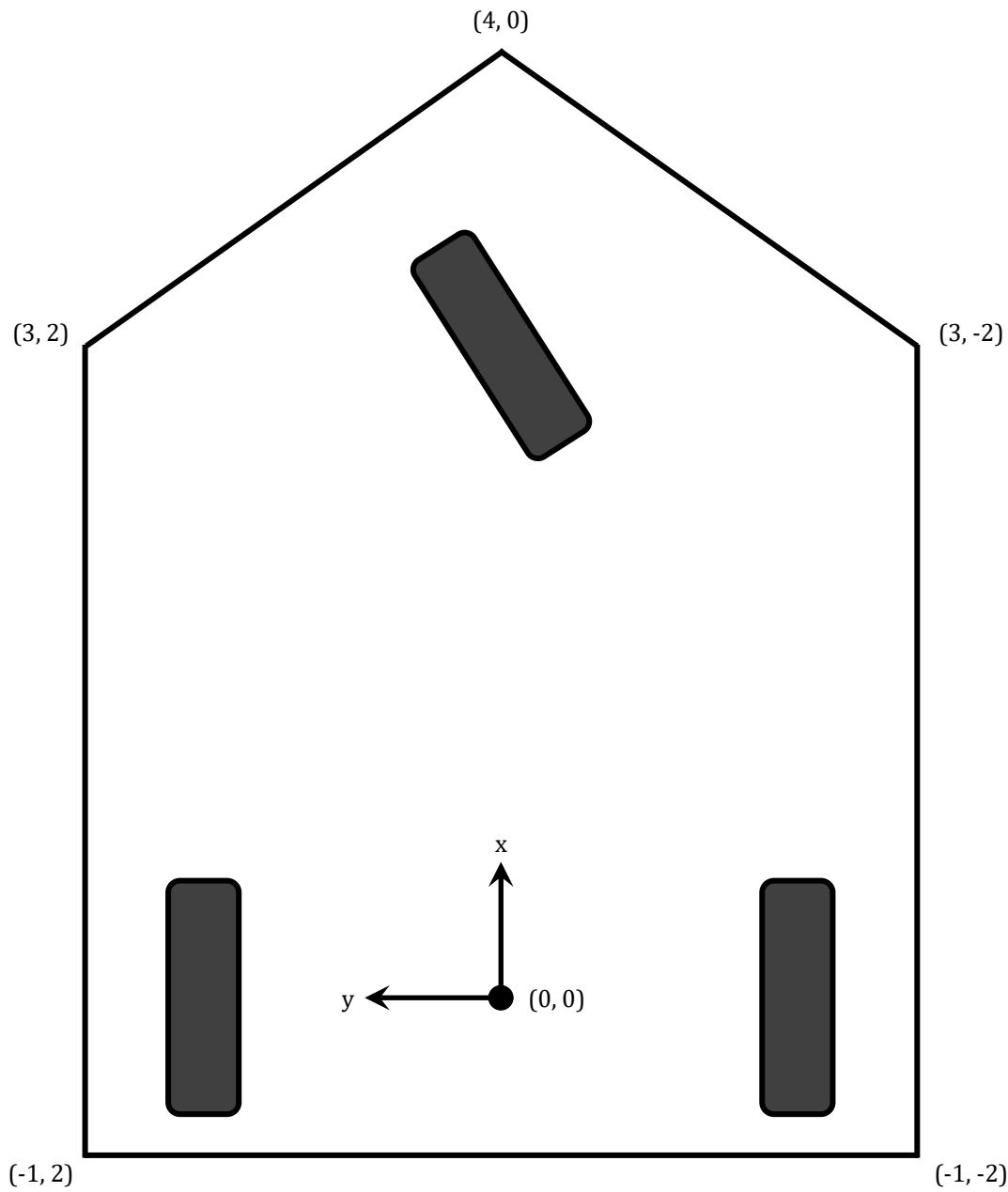
154 Note 2 to entry: Conventionally, IMR "forward" motion is in the positive X axis (+x) direction, but this might vary
155 depending on the IMR type.

156 Note 3 to entry: The IMR footprint lists points in clockwise order. There is no need to repeat the first coordinate
157 point to close the polygon, because the last point in the footprint is matched with the first. See Figure 1.

158 EXAMPLE The footprint for the IMR depicted in Figure 1 would be: [(-1, 2), (3, 2), (4, 0), (3, -2), (-1, -2)].

159

160



161

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

162

3.1.3.1

163

working space

164

space representing the IMR and any attachments; volume used to manage traffic during path planning

165

[SOURCE: ANSI/RIA R15.08-1:2020, Clause 3.24.6, modified; modified by replacing “avoid obstacles” with “manage traffic”.]

166

167

3.1.3.2

168

IMR pose

169

combination of position and orientation in space

170

[SOURCE: ISO 8373:2021, Clause 5.5, modified; modified by deletion of Notes.]

171	3.1.4
172	docking
173	process of reaching and/or connecting to another object in order to perform an intended task
174	Note 1 to entry: "Another object" could include, e.g., transfer points, charging stations, other IMRs.
175	3.1.5
176	industrial environment
177	workplace where the public is restricted from access or not reasonably expected to be present
178	3.1.6
179	industrial mobile robot (IMR)
180	mobile platform capable of navigating and operating through an industrial environment to reach a
181	specified location
182	Note 1 to entry: Navigation of the IMR can be autonomous or guided.
183	3.1.6.1
184	attachment
185	component, mechanism, or manipulator to be integrated with a mobile platform that functions with the
186	additional vehicle dynamics defined by the IMR's function
187	[SOURCE: ANSI/RIA R15.08-1:2020, Clause 3.1, modified; modified by removing references to "IMR
188	Types A, B, and C".]
189	3.1.7
190	industrial mobile robot fleet (IMRF)
191	one or more IMRs that are collectively managed
192	3.1.8
193	IMR fleet manager (IMRFM)
194	software that monitors and directs one or more IMRF(s)
195	Note 1 to entry: IMRFM functions can include monitoring statuses and/or poses of IMRs, coordinating actions, order
196	management, data synchronization, charging, idle parking, and traffic management.
197	3.1.9
198	enterprise resource planning (ERP)
199	planning function that includes inventory transaction, cost accounting, order fulfilment and resource
200	tracking
201	Note 1 to entry: The planning methodology uses material requirements planning and master production schedule
202	to calculate requirements for materials and to make recommendations to release replenishment orders when due
203	dates and need dates are not in phase.
204	Note 2 to entry: An alternative definition of enterprise resources planning can be found in ISO 15531-1.
205	[SOURCE: ISO 16100-1:2009, Clause 3.11.]
206	3.1.10
207	common coordinate system (CCS)
208	coordinate system used by IMR(s) and/or related system(s) to communicate locations
209	Note 1 to entry: The common coordinate system is defined in the Euclidean space (x,y,z).
210	3.1.11
211	common coordinate system origin point
212	CCS origin point
213	arbitrarily selected point within a facility that is designated as the (0,0,0) coordinate in the common
214	coordinate system

215 Note 1 to entry: The CCS origin point is a property of the facility or environment in which IMRs or IMRFs operate,
216 such as a wall, column, or point on the floor.

217 Note 2 to entry: The common coordinate system follows the right-hand rule convention.

218 3.1.12

219 reference point

220 coordinate that is relative to the origin of the common coordinate system, and used as a reference for all
221 IMRs or IMRFMs to include in their individual maps

222 EXAMPLES Center or edges of fiducial, corners of the rooms.

223 Note 1 to entry: All locational data shared is a position relative to the CCS origin point, which is stated in meters.

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

225 3.1.13

226 location point

227 IMR origin point relative to the common coordinate system at any moment in time

228 3.1.14

229 fiducial

230 physical marker or object to designate a reference point

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

232 3.1.15

233 local trajectory

234 ordered list of IMR location points and timestamps that the IMR uses for immediate navigation within the
235 range of sensors

236 3.1.16

237 global path

238 geometric representation of the IMR's path that the IMR uses for future navigation in the environment
239 beyond the range of sensors

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

242 3.1.17

243 global plan

244 ordered list of IMR location points for future destinations with estimated times of arrival at each location
245 point

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

248 3.2 Abbreviations

Term	Abbreviation
Common Coordinate System	CCS
Enterprise Resource Planning	ERP
Industrial Mobile Robot	IMR
Industrial Mobile Robot Fleet	IMRF
Industrial Mobile Robot Fleet Manager	IMRFM
Internet Engineering Task Force	IETF

Term	Abbreviation
JavaScript Object Notation	JSON
Last Will and Testament	LWT
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
Request For Comments	RFC
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). Three reference points per CCS, one of which may be the CCS origin point, shall be identified to establish a CCS for different IMRs or IMRFMs operating in the same facility. These points are assumed to be on a horizontal plane, and in accordance with 4.2. Ramps or other 3-dimensional data shall be projected down into a horizontal plane.

CCS enables independent and individual coordinate systems of IMRs to transform their individual coordinates into a unified coordinate system. This is achieved by connecting individual coordinate systems through reference points (e.g., fiducials), allowing them to function as a common coordinate system. If necessary, coordinate transformations can be applied to each individual coordinate system based on the designated CCS origin to ensure consistency across the system.

The map used by IMRFM or IMR shall include at least three reference points or two reference points and the CCS origin point within their own coordinate systems. When multiple maps are used within a facility, all maps using the CCS shall use a consistent UUID for each reference point.

NOTE 1 By knowing these reference points and/or CCS origin point, the IMRs or IMRFM(s) can transform back and forth among multiple coordinate systems.

NOTE 2 The independent and individual coordinate system of a IMR refers to the local coordinate system that the IMR uses within its local map.

NOTE 3 To integrate independent and individual coordinate systems of IMRs into a unified CCS, it can be useful to identify as many reference points (e.g., fiducials) as possible.

4.2 Common coordinate system (CCS)

A CCS shall be defined by the following fields as shown in Table 1:

273

Table 1 — Common Coordinate System (CCS) Fields

Field name	Type	Description	Required, Recommended, or Optional?
id	string	A universally unique identifier (UUID), compliant with ISO/IEC 9834-8:2014, that defines this CCS. This is the identifier when referencing this CCS.	Required
name	string	A user-friendly label for display purposes.	Required
ReferencePointIds	List<(Reference Point ids)>	A list of at least three reference points, of which one could be the CCS origin point; measured in meters (m). NOTE Reference points should be spaced out over the area being used by the IMRs to reduce the effects of measurement errors.	Required

274

275 4.3 Reference points

276 A reference point shall be defined by the following fields as shown in Table 2:

277

Table 2 — Reference Point Fields

Field name	Type	Description	Required, Recommended, or Optional?
id	string	A universally unique identifier (UUID) that defines this reference point. This is the identifier when internally referencing this point.	Required
name	string	A user-friendly label for display purposes. NOTE The name should not be used for referencing purposes.	Required
x	float32	The x is 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 is the y-coordinate of the position of the reference point relative to the CCS origin point, measured in meters (m).	Required
NOTE A CCS can have more than one reference point in addition to the CCS origin point.			

278

4.4 Location points

A location point shall be defined by the following fields as shown in Table 3:

Table 3 — Location Point Fields

Field name	Type	Description	Required, Recommended, or Optional?
CCS id	string	A universally unique identifier (UUID) that defines the CCS within which the location point is referenced. This is the identifier when internally referencing this CCS.	Required
x	float32	The x is 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 is 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 is the z-coordinate of the position of the IMR's location point relative to the CCS origin point, measured in meters (m). NOTE This is not an absolute height, but reference to the ground of the referenced CCS, measured in meters. If this is omitted, it is assumed that the vehicle is on the ground. A negative value indicates a location below the ground plane.	Required

5 Industrial mobile robot identity and capability

5.1 General

The IMR, or IMRFM on behalf of IMR(s) it manages, shall provide the following IMR identity and capability information upon start-up to other IMRs, IMRFMs, and related systems, in accordance with Table 4 below.

When the IMR does not have any means to detect or report a change to IMR footprint or IMR height, the IMR shall send the maximum value at startup.

When the IMR does not have any means to detect a height change, or function “reporting a height dynamically” is not implemented within the IMR control system, the IMR shall send its maximum height at startup.

Table 4 — IMR Identity and Capability Information

Field name	Type	Description	Required, Recommended, or Optional?
id	string	The universally unique identifier (UUID) that defines this IMR	Required
manufacturerName	string	The company name of the manufacturer of the IMR	Required
imrModel	string	The model of the IMR	Required
imrSerialNumber	string	Serial number of the IMR	Required
imrFootprint	array of tuples	An array of coordinates denoting the IMR footprint in accordance with 3.1.3, in meters (m)	Required
imrHeight	float32	The maximum height of the IMR's working space, in meters (m)	Required
timestamp	YYYY-MM-DDThh:mm:ss,fffZ	Timestamp format in accordance with ISO 8601, as shown: YYYY-MM-DDThh:mm:ss,fffZ	Required
softwareVersions	list of tuples	The current version of software in use by the IMR, provided as a list of tuples with component and version (one or more could be used)	Required
imrCapabilities	string	The capabilities of the IMR	Required
priority	unsigned integer	Value used to determine the priority of actions and resolving conflicts; zero (0) is the highest priority	Recommended
ratedSpeed	float32	The IMR's rated speed, measured in m/s	Recommended
supportedChargerType	string	The type(s) of charger which can be used by the IMR	Recommended
supportVendorName	string	The company name of the vendor that supplies technical support for the IMR NOTE This could be the manufacturer of the IMR, or a different company.	Recommended
supportVendorContactInformation	string	The contact information for the vendor that supplies technical support for the IMR	Recommended
visualThumbnailImage	SVG	A visual thumbnail image of the IMR	Recommended
imrDocumentation	string	A link to where more detailed IMR documentation can be obtained	Optional

Field name	Type	Description	Required, Recommended, or Optional?
payloadTypes	array of strings	The types of payload the IMR can handle	Optional
ratedLoad	float32	The IMR's rated load, measured in kg	Optional
batteryType	string	The type of battery used by the IMR	Optional
NOTE Means to detect footprint changes are IMR-specific and are not part of this standard.			

6 Industrial mobile robot location and status

6.1 General

IMR location and status information shall be provided to other IMRs, IMRFMs, and related systems, in accordance with Clauses 6.2, 6.3, and 6.4, to facilitate interoperability by allowing all entities receiving the information to know the location of the IMR, and information about its operating mode and state.

NOTE 1 Information regarding current location and operating mode and state facilitates, e.g., location visualization, intersection control, and traffic management. Additional non-mandatory information facilitates interoperability by allowing all entities receiving the information to know, e.g., current speed and direction, and future forecast locations of the IMRs. This additional non-mandatory information further facilitates interoperability by allowing for additional traffic management.

The message containing this information shall be sent when the information described in Clause 6.2 changes. The minimum and maximum frequency shall be set. See Annex B for sample message formats.

NOTE 2 Information about IMR location and status is likely to be updated with greater frequency than is information about IMR identity and capability.

6.1.1 Availability, operating mode, and operating state

The availability shall be reported according to the JSON schema in Annex A. The list of capabilities below shall be reported:

- The IMR can provide location and other status updates (e.g., battery state of charge, velocity);
- The IMR can provide intention information (e.g., local path, global path, forecast pose);
- The IMR can respond to *requests*; see Annex C for more information on *request* messages.

In the case where the status message containing this information is not received, it can be assumed that all of the three bullet points described above are false. Once the status messages start being delivered again, the three bullet points above shall be evaluated again based on the information in that message.

The operating mode and state shall be reported as an array of strings that provide a list of all presently active operating mode and states of the IMR. The list may be empty if the IMR is not in any one of these states. State strings are ordered in the list according to the IMR implied priority with the operating mode first, following by the highest priority operating state. The list may be expanded. The mode and state names as described in Table 5 below shall be used when applicable. Defining or redefining new strings shall only occur if it is for a purpose not listed in Table 5.

IMRs and/or IMRFMs shall communicate applicable operating modes and states as specified in Table 5.

6.2 Required status data

6.2.1 General

The IMR or IMRFM shall be capable of sending the IMR's current operational state. The following information shall be provided:

- a) The IMR's UUID as reported in the Industrial Mobile Robot Identity and Capability message;
- b) Timestamp format in accordance with ISO 8601, as shown: YYYY-MM-DDThh:mm:ss,fffZ ;
- c) Current location, including CCS id, position relative to location point, location point (assumed origin, if not included); and
- d) Operating mode and operating state.

6.2.2 Operating state

The operating state shall be reported as an array of strings that provide a list of all presently active operating states of the IMR. The operating state list may be empty if the IMR is not in any one of these states. In Table 5, state strings are ordered in the list according to the priority with the highest priority operating state coming first in the list. The IMR shall follow this priority order when reporting its state. The list may be expanded. The state names as described in Table 1 shall be used when applicable. Defining or redefining new strings shall only occur if it is for a purpose not listed in Table 5.

IMRs and/or IMRFMs shall implement applicable operating states 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 the stop category operating states are required. 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:

Name of Operating State	Description	Either <code>MODE_AUTO</code> or <code>MODE_SEMIAUTO</code> State is Published
<code>STOP_CATEGORY_0</code> ^a	Uncontrolled stop by immediately removing power to the machine actuators (e.g., Emergency Stop)	Required
<code>STOP_CATEGORY_1</code> ^a	Controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved (e.g., Safety Stop)	Required
<code>STOP_CATEGORY_2</code> ^a	Controlled stop with power left available to the machine actuators	Required
<code>PAUSED</code>	IMR is paused temporarily, while retaining its objective	Optional
<code>WAIT_FOR_RESET</code>	IMR is waiting for a human intervention (e.g., reset) before it can operate	Optional
<code>MAPPING</code>	IMR is being driven to create a new map	Optional
<code>LOST</code>	IMR lost localization and does not know where it is in the environment	Required
<code>WAIT_FOR_ATTACHMENT</code>	Attachment on the IMR is active and can be moving; the IMR will not move	Optional
<code>WAIT_FOR_EVENT</code>	IMR is waiting for an external event or input	Optional

Name of Operating State	Description	Either MODE_AUTO or MODE_SEMIAUTO State is Published
BLOCKED	IMR is prevented from making progress along its current objective; includes deadlock situations	Optional
ATTACHMENT_ACTIVE	Attachment on the IMR is active	Optional
STOPPED	The IMR is stopped	Optional
DOCKING	IMR is docking with another object, e.g., a transfer point, charging station, or another IMR	Required
SLOWING	Decelerating ("braking")	Optional
ACCELERATING	Accelerating	Optional
LEFT_TURN	Approaching or in a left turn based on direction of travel	Optional
RIGHT_TURN	Approaching or in a right turn based on direction of travel	Optional
REVERSE	IMR is traveling mainly in its reverse direction (long-term reverse)	Optional
FORWARD	IMR is traveling mainly in its forward direction (long-term forward)	Optional
LINE_FOLLOWING	IMR is actively following a physical or virtual line, and is unable to leave it	Optional
CHARGING	IMR is charging and cannot move	Required
LOW_BATTERY	Battery low condition	Optional
IDLE	IMR is not currently engaged in an order, mission, task, or assignment	Required
PARKED	IMR is parked	Required
OFFLINE	IMR is offline	Optional
MODE_AUTO	Autonomous mode	
MODE_SEMIAUTO	Semi autonomous or Assisted Manual mode	
MODE_TELEOP	Teleoperation mode; mode that allows for direct control by a remote operator or a tele-operator	
MODE_MANUAL	Manual mode	
MODE_MAINTENANCE	Maintenance mode	
^a Stop Categories are defined in IEC 60204-1:2016+AMD1:2021 CSV.		

6.3 Recommended status data

The IMR or IMRFM should be capable of communicating following:

- Current linear velocity in meters/sec;
- Current angular velocity in radians/sec;
- Local path, which describes a trajectory;

d) Global path; and

e) Battery State of Charge (SoC) percentage.

6.4 Optional status data

The IMR or IMRFM may be capable of communicating the following:

— local trajectory;

— global path;

— global plan; and

— load percentage used.

NOTE This is a vendor-specific metric from 0%-100% that represents how much of the carrying capacity of their IMR is used. This can be any combination of volume, area, weight, or vendor-specific information for use.

7 Industrial Mobile Robot Fleet Manager identity and capability

7.1 General

The IMRFM shall provide the following IMRFM identity and capability information upon start-up to other IMRs, IMRFMs, and related systems in accordance with Table 6 below.

Table 6 — IMRFM Identity and Capability Information

Field name	Type	Description	Required, Recommended, or Optional?
id	string	The universally unique identifier (UUID) that defines this IMRFM	Required
manufacturerName	string	The company name of the manufacturer of the IMRFM	Required
timestamp	YYYY-MM-DDThh:mm:ss,fffZ	Timestamp format in accordance with ISO 8601, as shown: YYYY-MM-DDThh:mm:ss,fffZ	Required
softwareVersions	list of tuples	The current version of software in use by the IMRFM, provided as a list of tuples with component and version (one or more could be used)	Required
imrfmCapabilities	string	The capabilities of the IMRFM	Required
imrfmModel	string	The model of the IMRFM	Recommended
supportVendorName	string	The company name of the vendor that supplies technical support for the IMRFM NOTE This could be the manufacturer of the IMR, or a different company.	Recommended
supportVendorContactInformation	string	The contact information for the vendor that supplies technical support for the IMRFM	Recommended
imrfmDocumentation	string	A link to where more detailed IMRFM documentation can be obtained	Optional

8 Industrial mobile robot fleet manager status

8.1 General

IMRFM status information shall be provided to other IMRs, IMRFMs, and related systems, in accordance with Clause 8.2, to facilitate interoperability by allowing all entities receiving the information to know information about the IMRFM state.

The message containing this information shall be sent when the information described in Clause 8.2 changes. The minimum and maximum frequency shall be set. See Annex B for sample message formats.

NOTE Information about IMRFM status is likely to be updated with greater frequency than is information about IMRFM identity and capability.

8.2 Required status data

8.2.1 General

The IMRFM shall be capable of sending the IMRFM's current state. Status messages shall include:

- the IMRFM's UUID as reported in the Industrial Mobile Robot Fleet Manager Identity and Capability message;
- timestamp format in accordance with ISO 8601, as shown: YYYY-MM-DDThh:mm:ss,fffZ ; and
- state.

8.2.2 State

IMRFMs shall report its state from the list of available states in Table 7.

Table 7 — IMRFM state descriptions:

Name	Description
READY	Ready to send and receive messages
NOT_READY	Not ready to send or receive messages
OFFLINE	IMRFM not connected

9 Messaging protocol and message formats

9.1 General

A consistent messaging protocol and message format shall be provided to allow for easy and reliable integration. The messaging protocol should follow best practices related to cyber-security and authentication, in accordance with IEC 62443.

9.2 Messaging protocol

All messaging protocol shall be done over a standard communication protocol according to IETF as RFC 6455 in 2011.

NOTE At the time of publication, MQTT is the current option meeting this requirement.

9.3 Message format

Messaging shall utilize JSON in accordance with ISO/IEC 20922. See Annex A for the JSON schema for this document.

10 Request messages

10.1 General

The IMR or IMRFM shall be capable of sending and receiving *request* and *requestStatus* messages. Messages shall follow the format described in Annex B. IMRs or IMRFMs that can report their location shall be capable of sending and receiving the MOVE, pauseImr, resumeImr, and CANCEL messages as described in Annex B.

10.2 Concepts

The messages defined are JSON-encoded objects that are part of a messaging protocol used to enable the communications for interoperability.

At their most basic, the messages are used by a sender to request a receiver to perform an action or a sequence of actions. The messages are designed to be extensible by a vendor or integrator in order to extend longevity of the mechanism.

The interaction between the sender of the *request* and the receiver is:

- Sender issues a *request* message to an identified receiver.
- After receiving the *request*, the receiver responds with a *requestStatus* message upon any state change for that *request*.
- The changes of the state are dependent on the content of the *request*.

When the *request* is complete, the last *requestStatus* message will indicate the message is CANCELED, SUCCEEDED, or ABORTED.

10.3 Requirements and assumptions

The receiver of a *request* shall acknowledge the *request* and send progress status updates. Status updates shall be sent if and only if state changes. This means that status updates shall not be sent periodically. To accomplish this, the messaging layer through which the messages are sent shall offer a non-interruptible delivery quality of service.

Annex A (normative)

JSON Schema

A.1 JSON Schema

The JSON Schema found in this Annex shall be used to communicate IMR identity and capability (Clause 5), IMR location and status (Clause 6), IMRFM identity and capability (Clause 7), and IMRFM status (Clause 8).

A.1.1 Top Level

```
{
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "$id": "http://iso24123.org/schemas/v1.json",
  "title": "ISO 24123 JSON Schema v1 - Entity Information",
  "description": "This schema provides all JSON objects describing the data than an
entity may publish to report its identification, capabilities and state",
  "type": "object",
  "properties": {
    "timestamp": {
      "type": "string",
      "format": "date-time",
      "title": "Timestamp",
      "description": "Timestamp format in accordance with ISO8601 (YYYY-MM-DDThh:mm:ss,fffZ)",
      "examples": [
        "2025-04-08T10:00:00Z"
      ]
    },
    "locationPoint": {
      "type": "object",
      "title": "Location Point",
      "description": "Point relative to the common coordinate system at any moment
in time",
      "required": [
        "ccsId",
        "x",
        "y",
        "z"
      ],
      "properties": {
        "ccsId": {
          "type": "string",
          "format": "uuid",
          "title": "The CCS within which the location is defined"
        },
        "x": {
          "type": "number",
          "title": "X coordinate",
          "description": "X coordinate relative to the CCS origin point;
measured in meters (m)"
        },
        "y": {
          "type": "number",
          "title": "Y coordinate",
```

```

480         "description": "Y coordinate relative to the CCS origin point;
481 measured in meters (m)"
482     },
483     "z": {
484         "type": "number",
485         "title": "Z coordinate",
486         "description": "Z coordinate relative to the CCS origin point;
487 measured in meters (m)"
488     }
489 },
490 {
491     "localTrajectory": {
492         "title": "Local Trajectory",
493         "description": "Ordered list of IMR location points and timestamps the IMR
494 uses for immediate navigation within the range of sensors",
495         "type": "object",
496         "properties": {
497             "timestamp": {
498                 "$ref": "#/properties/timestamp"
499             },
500             "localTrajectory": {
501                 "$ref": "#/$defs/locationPointStampedArray"
502             }
503         },
504         "required": [
505             "timestamp",
506             "localTrajectory"
507         ]
508     },
509     "globalPlan": {
510         "title": "Global Plan",
511         "description": "Ordered list of IMR location points for future destinations
512 with estimated times of arrival at each location point",
513         "type": "object",
514         "properties": {
515             "timestamp": {
516                 "$ref": "#/properties/timestamp"
517             },
518             "globalPlan": {
519                 "$ref": "#/$defs/locationPointStampedArray"
520             }
521         },
522         "required": [
523             "timestamp",
524             "globalPlan"
525         ]
526     },
527     "globalPath": {
528         "title": "Global path as a NURBS Curve",
529         "description": "Geometric representation of the IMR's path the IMR uses for
530 future navigation in the environment beyond the range of sensors",
531         "type": "object",
532         "properties": {
533             "timestamp": {
534                 "$ref": "#/properties/timestamp"
535             },
536             "globalPath": {
537                 "$ref": "#/$defs/nurbsCurve"
538             }
539         },

```