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## Robotics — Modularity for service robots —

### Part 1: General requirements

ICS: 25.040.30

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87 **Foreword**

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90 carried out through ISO technical committees. Each member body interested in a subject for which a  
91 technical committee has been established has the right to be represented on that committee.  
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93 the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all  
94 matters of electrotechnical standardization.

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

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102 on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

103 Any trade name used in this document is information given for the convenience of users and does not  
104 constitute an endorsement.

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

109 This document was prepared by Technical Committee ISO/TC 299, *Robotics*.

## 110 Introduction

111 This International Standard has been developed to cope with the rapidly evolving service robotics  
112 sector. At present this robotics market covers many small and niche sectors for which it is difficult to  
113 develop the specific and wide-ranging components needed. The market sizes and applications are  
114 expected to grow significantly, and the number and range of their functions are also increasing. To  
115 enable wide-spread and interoperable development of service robots, a common approach for building  
116 service robots is needed. This Standard lays out such common requirements.

117 On one side, the manufacturer-dependent architectural approaches currently adopted for designing  
118 service robots makes design and development difficult and substitution and reuse of modules in  
119 upgrading robot products is virtually impossible. On the other side, the research community has  
120 developed a vast knowledge base in robot modular design and continues to develop new methods for  
121 realising modular approaches, but none have the widespread appeal needed to make significant impact.  
122 In these conditions, it is not feasible for the service robotics sector to produce the quality products  
123 needed at the prices demanded by the markets and new approaches are urgently needed to help the  
124 markets evolve to meet the global challenges.

125 An international standard on robot modularity and robot component interoperability focusing on main  
126 issues of safety, connectivity (from both hardware and software perspectives) and functionality is  
127 pivotal to change the service robotics landscape and speed up the development of the new service robot  
128 market sectors. The robot modularity issues in this international standard are classified into the issues  
129 related to basic and composite modules, basic modules with hardware and/or software aspects.  
130 Requirements and guidelines are formulated so that module-based design approaches can be realised  
131 allowing application specific service robots and robot systems meeting customer's requirements to be  
132 easily configured. The issues are classified into (a) safety and security, and (b) interoperability  
133 guidelines. In addition, the open modular approach realised should enable modules to be easily  
134 substituted by other modules having the same interface specifications but perhaps with enhanced  
135 functionalities as needed.

136 Safety requirements specified in existing safety standards (e.g. ISO 13482, ISO 10218-1, ISO 10218-2,  
137 ISO TS 15066) shall be applied on the system level as well as on the level of a single module. Security  
138 issues are also important when adopting an open modularity approaches and hence have been included  
139 in this standard (e.g. to align with emerging IEC TC44 and IEC TC65 security related work projects).

140 The standard contains design and functionality requirements for robot modules to ensure safe and  
141 secure operation of such modules and robots built from those modules. It presents design guidelines for  
142 building inter-operable robot modules to ensure effective connectivity and correct functionality in line  
143 with published standards (e.g. IEC 62443 series). This international standard does not specify the  
144 technical implementation of a modular framework. It is intended to provide the necessary guidelines to  
145 framework designers, to define a modular framework according to their needs. In view of this, the  
146 International Standard, uses the following verbal forms:

- 147 — “shall” indicates a requirement;
- 148 — “should” indicates a recommendation;
- 149 — “may” indicates a permission;
- 150 — “can” indicates a possibility or a capability.

151 The safety guidelines at the module level of this International Standard are formulated to ensure  
152 compliance with the C-type standards for robot system safety.

153 Future editions and parts of this family of International Standards are intended to include more specific  
154 requirements on particular types of robot modules, e.g., basic and composite modules with hardware  
155 and/or software aspects, and for particular types of service robots, e.g., mobile servant robots, physical  
156 assistant robots, person carrier robots, and service robots in professional environments.

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159 **Title (Robotics — Modularity for service robots — Part 1: General**  
160 **requirements)**

161 **1 Scope**

162 This International Standard presents guidelines on the specification of modular frameworks, on open  
163 modular design and on the integration of modules for realising service robots in various environments,  
164 including personal and professional sectors.

165 The document is targeted at the following user groups:

- 166 • modular service robot framework designers who shall be enabled to specify performant  
167 frameworks in an unambiguous way
- 168 • module manufacturers who are then able to supply end users or robot integrators as customers
- 169 • integrators who are then able to choose applicable modules for building a modular system

170 This International Standard includes guidelines on how to apply existing safety and security standards  
171 to service robot modules.

172 This International Standard is not a safety standard.

173 This standard does not apply to robots which are not service robots, although the modularity principles  
174 established in this standard can be utilized for these other robots.

175 **2 Normative references**

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

180 ISO 8373: 2012, Robots and robotic devices – Vocabulary

181 ISO 9409-1:2004, Manipulating industrial robots – Mechanical interfaces – Part 1: Plates

182 ISO 9409-2:2002, Manipulating industrial robots – Mechanical interfaces – Part 2: Shafts

183 ISO 10218-1, Robots and robotic devices — Safety requirements for industrial robots— Part 1: Robots

184 ISO 10218-2, Robots and robotic devices — Safety requirements for industrial robots— Part 2: Robot  
185 systems and integration

186 ISO 10303 (all parts), Industrial automation systems and integration — Product data representation  
187 and exchange

188 ISO 11593:1996, Manipulating industrial robots – Automatic end-effector exchange systems –  
189 Vocabulary and presentation of characteristics

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

191 ISO 13482, Robots and robotic devices — Safety requirements for personal care robots

192 ISO 13849-1, Safety of machinery — Safety-related parts of control systems — Part 1: General  
193 principles for design

- 194 ISO TS 15066, Robots and robotic devices — Collaborative robots
- 195 ISO 19649: 2017, Mobile robots – Vocabulary
- 196 IEC 60204-1, Safety of machinery — Electrical equipment of machines — Part 1: General requirements
- 197 IEC 60529, Degrees of protection provided by enclosures (IP Code)
- 198 IEC/TR 60601-4.1, Medical electrical equipment – Part 4-1: Guidance and interpretation – Medical  
199 electrical equipment and medical electrical systems employing a degree of autonomy
- 200 IEC 61076-1:2006 Connectors for electronic equipment-Product requirements – Part 1: Generic  
201 specification
- 202 IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems –  
203 Parts 1 to 7
- 204 IEC 61784-3:2016 Industrial communication networks – Profiles –Part 3: Functional safety fieldbuses –  
205 General rules and profile definitions
- 206 IEC 61800-5-2, Adjustable speed electrical power drive systems – Part 5-2: Safety requirements –  
207 Functional
- 208 IEC 61984:2008 Connectors – Safety requirements and tests
- 209 IEC 62061, Safety of machinery – Functional safety of safety-related electrical, electronic and  
210 programmable electronic control systems
- 211 IEC 62280:2014 Railway applications – Communication, signalling and processing systems –Safety  
212 related communication in transmission systems
- 213 IEC/TR 62390, Common automation device – Profile guideline
- 214 IEC 62443 series of standards on Industrial communication networks - Network and system security
- 215 IEC/TR 63074 ED1: Security aspects related to functional safety of safety-related control systems.
- 216 ISO/IEC 7498-1, Information technology – Open systems interconnection – Basic reference model: The  
217 basic model
- 218 ISO/IEC/IEEE 15288 Systems and software engineering – System life cycle processes
- 219 ISO/IEC 27032:2012 Information technology – Security techniques – Guidelines for cybersecurity
- 220 ISO/IEC Guide 77-1:2008, Guide for specification of product properties and classes – Part 1:  
221 Fundamental benefits
- 222 ISO/IEC Guide 77-2:2008, Guide for specification of product properties and classes – Part 2: Technical  
223 principles and guidance
- 224 ISO/IEC Guide 77-3:2008, Guide for specification of product properties and classes – Part 3: Experience  
225 gained.
- 226 NIST SP 800-37 Rev. 1 Guide for Applying the Risk Management Framework to Federal Information  
227 Systems: a Security Life Cycle Approach
- 228 NIST SP 800-154 Guide to Data-Centric System Threat Modelling

229 NIST SP 800-160 vols 1 and 2 Systems Security Engineering Considerations for a Multidisciplinary  
230 Approach in the Engineering of Trustworthy Secure Systems.

### 231 **3 Terms and definitions**

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

233 — IEC Electropedia: available at <http://www.electropedia.org/>

234 — ISO Online browsing platform: available at <https://www.iso.org/obp>

235 For the purposes of this International Standard, the following terms and definitions apply.

#### 236 **3.1. General terms**

##### 237 **3.1.1.**

##### 238 **abstraction layer**

239 interface to the system that allows some or all of the capabilities of the system to be viewed in a  
240 different and generally more abstract manner.

241 Note to entry: An abstraction layer for a module is the same in the case where the system is the module

##### 242 **3.1.2.**

##### 243 **connector**

244 physical link that establishes connection between parts of the system

245 EXAMPLE: Communication, powering, mechanical linking.

##### 246 **3.1.3.**

##### 247 **control signals**

248 signals for altering the state of a receiving module or component in some way

249 Note to entry: Control signal does not transmit structured data like sensor readings (images, sound, etc.) or other  
250 data processed as part of the robots application.

##### 251 **3.1.4.**

##### 252 **software communication interface**

253 logical layer in communication with other parts of the system

##### 254 **3.1.5.**

##### 255 **electrical interface**

256 connectors and the electrical properties for transmitting power, analogue or digital signals

##### 257 **3.1.6.**

##### 258 **execution life cycle**

259 finite state machine defining all stages of execution of a part's function

##### 260 **3.1.7.**

##### 261 **error**

262 discrepancy between a computed, observed or measured value or condition, and the true, specified or  
263 theoretically correct value or condition

264 [SOURCE IEC 60050 International Electrotechnical Vocabulary 192-03-02]

##### 265 **3.1.8.**

##### 266 **failure**

267 loss of ability to perform as required

268 [SOURCE IEC 60050 International Electrotechnical Vocabulary 192-03-01]

269 **3.1.9.**

270 **fault**

271 inability to perform as required, due to an internal state

272 [SOURCE IEC 60050 International Electrotechnical Vocabulary 192-04-01]

273 **3.1.10.**

274 **function**

275 defined objective or characteristic action of a system or component or module

276 [SOURCE ISO/IEC/IEEE 24765 3.1206-5 (Modified)]

277 **3.1.11.**

278 **functional safety**

279 part of the overall safety relating to the equipment under control (EUC) and the EUC control system that  
280 depends on the correct functioning of the electrical, electronic and programmable electronic (E/E/PE)  
281 safety-related systems and other risk reduction measures

282 [SOURCE IEC 61508-4:2010, 3.1.12]

283 **3.1.12.**

284 **hardware abstraction layer (HAL)**

285 an abstraction layer for a component/module that contains hardware aspects, with the abstraction  
286 layer providing control of the component/module via a software interface.

287 Note to entry: The purpose of a HAL is usually so that different module implementations can be accessed through  
288 the same software interface

289 **3.1.13.**

290 **information model**

291 abstraction and representation of the entities in a managed environment, their properties, attributes  
292 and operations, and the way that they relate to each other.

293 Note to entry: The information model is independent of any specific repository, usage of software aspects,  
294 protocol, or platform.

295 **3.1.14.**

296 **software communication interface**

297 logical layer in communication with other parts of the system

298 **3.1.15.**

299 **security**

300 combination of confidentiality, integrity, and availability

301 [SOURCE ISO TR 17522:2015 3.19]

302 **3.2. Terms related to component**

303

304 **3.2.1.**

305 **component**

306 part of something that is discrete and identifiable with respect to combining with other parts to  
307 produce something larger

308 [SOURCE: ISO/IEC 24765]

309 Note 1 to entry: Component can be either software or hardware. Even a component that is mainly software or  
310 hardware can be referred to as a software or hardware component respectively.

311 Note 2 to entry: Component does not need to have any special properties regarding modularity.

312 Note 3 to entry: Component and module have been used interchangeably in general terms, but to avoid confusion  
313 the term module is used to refer to a component that meets the guidelines presented in this International  
314 Standard

315 Note 4 to entry: A module is a component, whereas a component does not need to be a module.

### 316 3.2.2.

#### 317 **software component**

318 component whose implementation consists of a computer programmed algorithm

### 319 3.2.3.

#### 320 **hardware component**

321 component whose implementation consists of physical elements and possibly any embedded software  
322 necessary for its operation

### 323 3.3. Terms related to module

324 Note to entry: Many terms defined in this subclause can also apply to components but for the purposes of this  
325 International Standard the definitions are formulated to apply to modules as presented in this standard.

#### 326 3.3.1.

#### 327 **composability**

328 ability to assemble modules logically and physically (without need for adaptation of the modules or  
329 additional interfacing work) using various combinations into new modules

330 Note to entry: While 'integration' generally implies significant effort, 'composition' generally implies limited to no  
331 effort

#### 332 3.3.2.

#### 333 **configuration**

334 arrangement of a modular service robot in terms of the number and type of modules used, the  
335 connections between those modules, and the settings for those modules, in order to achieve the desired  
336 functionality of the modular robot as a whole

337 Note 1 to entry: ISO 8373 also defines (joint) configuration but this is a different concept

338 Note 2 to entry: This term describes to result of some process, i.e. the state something is in. The process of  
339 creating such a state is covered by term 3.3.3

#### 340 3.3.3.

#### 341 **configuring**

342 setting the number of modules, type of modules, the connections between the modules, and the settings  
343 for the modules in order to achieve the desired functionality of a modular service robot as a whole

#### 344 3.3.4.

#### 345 **granularity**

346 degree to which a robot module can be broken down into separate modules

#### 347 3.3.5.

#### 348 **hardware aspects**

349 information regarding properties and functions necessary for a module and its physical interconnection  
350 and regarding the allowed range of physical properties of the operational environment