

Automation systems and integration — Assessment on convergence of informatization and industrialization for industrial enterprises — Part 2: Maturity model and evaluation methodology

CD stage

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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.

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The committee responsible for this document is Technical Committee ISO/TC 184, [*Automation systems and integration*], Subcommittee SC 5, [*Interoperability, integration, and architectures for enterprise systems and automation applications*].

A list of all parts in the ISO 22549 series can be found on the ISO website.

1 Introduction

2 Convergence of informatization and industrialization (CII) refers to a process that integrates information
3 technology into industrial production. The purpose of convergence is to promote development of
4 industry in a higher value-added direction through wide application of information and restructuring of
5 traditional industry.

6 CII will promote production and resource allocation in a more comprehensive and dynamic as well as
7 optimal way.

8 This document and its related parts serve as a framework and normalization guide for enterprises to
9 promote the convergence of information technology, its research and development, into the processes of
10 production and operations management.

11 The purposes of this document include, but not limited to, providing industrial enterprises guidance for:

- 12 – assessing the current situation of CII
13 – finding weakness within the CII
14 – identifying ways to improve CII

15 The intended users of this document can be grouped into the following categories:

- 16 – unaffected third-party assessor, e.g. a consulting company or government department, which
17 conducts a convergence of informatization and industrialization assessment;
18 – responsible organization, e.g. production management department, quality management
19 department, inventory management department, etc., which sponsor an assessment of itself or a
20 subordinate organization;
21 – other industrial sector enterprises.

24 **Automation systems and integration — Assessment on**
 25 **convergence of informatization and industrialization for**
 26 **industrial enterprises — Part 2: Maturity model and evaluation**
 27 **methodology**

28 **1 Scope**

29 This document defines maturity model and evaluation methodology on convergence of informatization
 30 and industrialization in industrial enterprises. The scope of this document includes the followings:

- 31 – Maturity model definition;
 32 – Principles of evaluation questionnaires; and
 33 – Guidance for maturity evaluation method

34 **2 Normative references**

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

38 ISO 22549-1, *Assessment on convergence of informatization and industrialization for industrial enterprises*
 39 — *Part 1: Framework and reference model*

40 **3 Terms and definitions**

41 For the purposes of this document, the terms and definitions given in ISO 22549-1 and the following apply.

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

- 43 — ISO Online browsing platform: available at <http://www.iso.org/obp>
 44 — IEC Electropedia: available at <http://www.electropedia.org/>

45 **3.1**

46 **maturity model**

47 classification scheme for measuring the effect of policies, procedures, training and control that results in
 48 the capability to execute efficient operations based on information technologies

49 **3.2**

50 **maturity level indicator**

51 **maturity level**

52 identified extent of measured effect within maturity model (3.1)

53 Note 1 to entry: The extent of measured effect is divided into segments, referred to as levels, of increasing
 54 competence to achieve enterprise objectives.

55 **3.3**

56 **evaluation questionnaire**

57 list of questions used to evaluate and determine the maturity level (3.2)

58 **3.4**

59 **maturity evaluation**

60 method for determining the maturity level (3.2) of an industrial enterprise using responses to evaluation
61 questionnaire (3.3)

62 **4 Symbols (and abbreviated terms)**

63 ACII assessment on convergence of informatization and industrialization

64 BOM bill of material

65 CAD computer aided design

66 CPS cyber-physical system

67 E-BOM engineering BOM

68 ECO engineering change order

69 EDI electronic data interchange

70 EHS environment, safety and health

71 ERP enterprise resource planning

72 IoT Internet of Things

73 IT information technology

74 KPI key performance indicator

75 MSDS material safety data sheets

76 MES manufacturing execution system

77 PLM product lifecycle management

78 SCM supply chain management

79 SPC statistical process control

80 WIP work in process

81 5 Maturity model

82 The maturity model shall consist of maturity levels where each level consists of a maturity level indicator,
 83 descriptive name, and characteristics relevant to the desired assessment information as shown in Table
 84 1. These characteristics guide domain aspect relevant evaluation questions for which simple yes or no
 85 answers are appropriate.

86 **Table 1 – Maturity model definition**

Maturity level indicator	Descriptive name	Characteristics
Level 0	Unidentified	<ul style="list-style-type: none"> – Little or no systematic documentation available
Level 1	Identified	<ul style="list-style-type: none"> – Tracking and traceability of materials, data and etc. – Registration and management of data using information collection devices and systems
Level 2	Measured	<ul style="list-style-type: none"> – Real time data acquisition of materials, machinery, process and human roles, and data integration – Measurement, aggregation, classification and management of data using information collection devices and systems – Synchronous history of data for the same time, same lot and same product
Level 3	Analysed	<ul style="list-style-type: none"> – Data analysis and optimized decision making using aggregated data
Level 4	Optimized	<ul style="list-style-type: none"> – Automation of processes according to optimized decision making throughout the intra-enterprise and/or the inter-enterprises
Level 5	Customized	<ul style="list-style-type: none"> – Self-diagnosis and self-healing through cyber-physical system (CPS), Internet of Things (IoT), artificial intelligence (AI), etc. – Flexible production of customized products through autonomous control

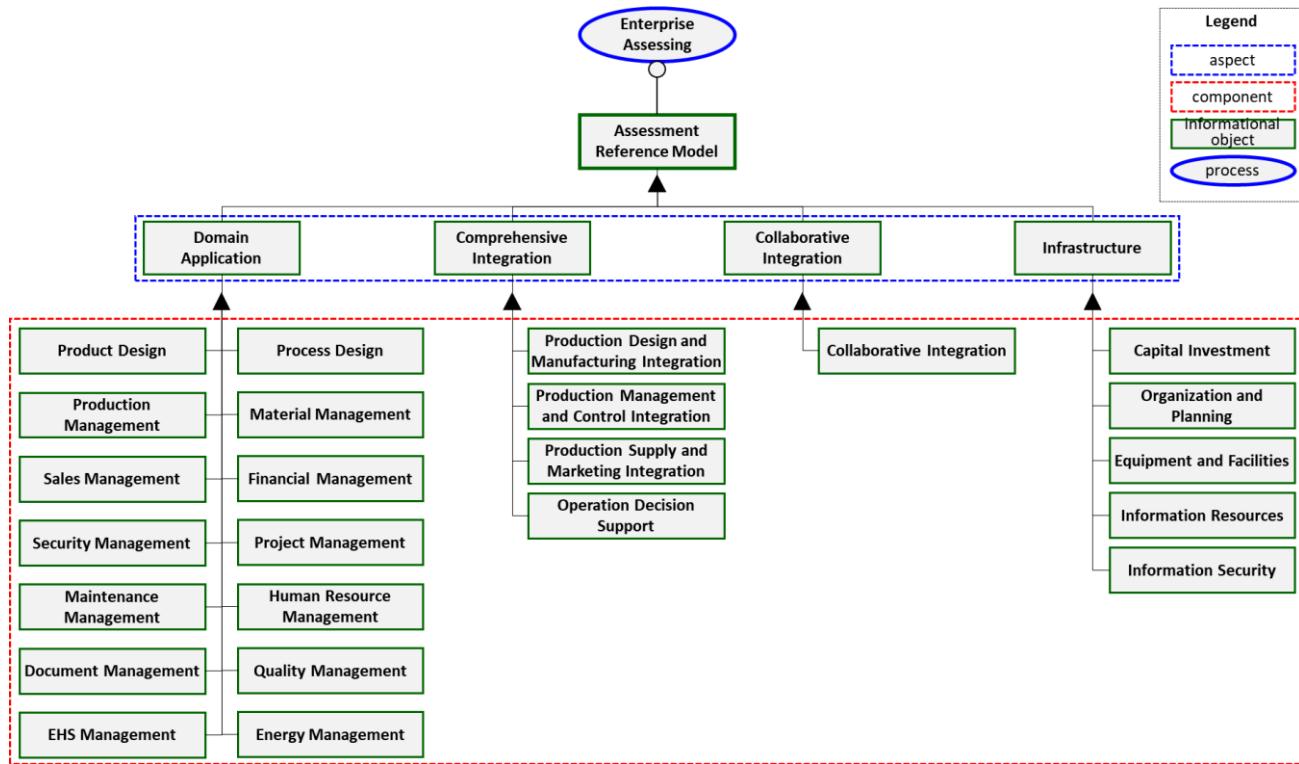
87
 88 NOTE Because maturity level 0 is the same for every questionnaire table, level 0 is not included in the
 89 separate tables.

90
 91 Assessment of maturity level is done by evaluating assessment on convergence of informatization and
 92 industrialization (ACII) reference model components based on the answers to the evaluation questions.

93 6 Principles of evaluation questionnaires for ACII reference model components

94 6.1 General

95 Figure 1 presents assessment reference model defined in ISO 22549-1. Four aspects are grouped by blue-dotted line and twenty-four subordinate components to four aspects are grouped by red-dotted line.



97 **Figure 1 – Assessment reference model (aspect and its subordinate component)**

98 In general, each ACII reference model component consists of one or more activities, for example, product
99 design requires commodity planning, design automation, bill of material (BOM)/parts management,
100 engineering change management, etc. For ACII, each ACII reference model component has to be evaluated
101 in the level of its activities, and each activity has a set of questions to answer for each maturity level.
102 Question answers shall be "YES" or "NO."

103 Table 2 shows the structure of questions for evaluation.

104 **Table 2 – Structure of question for maturity evaluation**

Activity	Question	Maturity level indicator
Activity name	Questions for maturity level 1.	1
	Questions for maturity level 2.	2
	Questions for maturity level 3.	3
	Questions for maturity level 4.	4
	Questions for maturity level 5.	5

105

- 106 – **Activity:**
107 activity of ACII reference model component.

109 This document specifies a number of activities to be evaluated for each ACII reference model
110 component.

- 111 - **Question:**
112 questions to assess maturity level satisfaction, and the answer shall be “yes” or “no”.
113 If a maturity level has multiple questions, answer shall be all “yes” to proceed to the next maturity
114 level questions by applying guidance for maturity evaluation method given in clause 7.
115 Annex A gives examples of a whole set of questions for all ACII reference model components.
- 116 - **Maturity level indicator:**
117 maturity level used for maturity evaluation.

118

119 **6.2 Activity of ACII reference model component for evaluation**120 **6.2.1 Infrastructure aspect assessment**121 **6.2.1.1 Capital investment**

122 Capital investment should be evaluated in terms of construction of automation and informatization,
 123 operation and maintenance of the information system.

124 **Table 3 – Activity of capital investment for evaluation**

Activity	Description
Capital Investment	Investment to the IT equipments and systems

125

126 **6.2.1.2 Organization and planning**

127 Organization and planning should be evaluated in terms of team of personnel, establishment of the
 128 organization, authority and defining of strategy related to the field of automation and informatization.

129 **Table 4 – Activity of organization and planning for evaluation**

Activity	Description
Organization and Planning	Team, organization, authority and strategy for automation and informatization

130

131 **6.2.1.3 Equipment and facilities management**

132 Equipment and facilities management should be evaluated in terms of management of information
 133 equipments and facilities, industrial equipments and facilities.

134 **Table 5 – Activity of equipment and facilities management for evaluation**

Activity	Description
Equipment and Facilities Management	Management of IT equipments and facilities Management of industrial equipments and facilities

135

136 **6.2.1.4 Information resources management**

137 Information resources management should be evaluated in terms of construction of the information
 138 resources.

139 **Table 6 – Activity of information resources management for evaluation**

Activity	Description
Information Resources Management	Collection, standardization, accumulation, integration, analysis, and management of information resources

140

141 **6.2.1.5 Information security management**

142 Information security management should be evaluated in terms of protection of information security
 143 such as.

144 **Table 7 – Activity of information security management for evaluation**

Activity	Description
Computer and Network Security Management	Implementation of protection of computer and networking security
System and Application Security Management	Implementation of protection of system security, application security and construction of the prevention mechanism

145

146 **6.2.2 Domain application aspect assessment**

147 **6.2.2.1 Product design**

148 Product design should be evaluated in terms of digitalized model of the product, digital examination,
 149 comprehensive design and optimization, and intelligent design of a product.

150 **Table 8 – Activity of production design for evaluation**

Activity	Description
Environment Analysis	Use of IT systems and applications for environment analysis
Commodity Planning	Use of IT systems and applications supporting commodity planning
Design Automation	Use of designing software systems and smart connected technology for design
BOM/Parts Management	Use of BOM/Part management systems
Engineering Change Management	Use of engineering change management systems
Prototyping	Use of IT systems and applications for prototyping and its validation
Advance Quality Management ¹	Use of IT systems and applications for advance quality management.

151

152 **6.2.2.2 Process design**

153 Process design should be evaluated in terms of design of process flow or planning, analysis of dynamic
 154 simulation, process control and parameter optimization and integrated process design.

¹ Advance quality management is different from quality management that the latter is applied to the mass product while the former is applied before the mass product, e.g., prototyping.

155

Table 9 – Activity of process design for evaluation

Activity	Description
Process Design	Use of IT systems and applications for supporting design of process flow or planning, analysis of dynamic simulation, process control and parameter optimization and integrated process design

156

157 **6.2.2.3 Production management**

158 Production management should be evaluated in terms of production planning and scheduling, production
 159 management, material requirement planning, distribution management, and outsource planning and
 160 management.

161

Table 10 – Activity of production management for evaluation

Activity	Description
Master Production Scheduling	Use of IT systems and applications for scheduling master production, and optimization and customization
Work in Process (WIP) Management	Use of IT systems and applications for managing work-in-process
Monitoring and Control	Use of IT systems and applications for monitoring and controlling production
Process Control	Use of IT systems and applications for automatic process control, and optimization and customization
Process Analysis and Enhancement	Use of IT systems and applications for process analysis and enhancement

162

163 **6.2.2.4 Materials management**

164 Material management should be evaluated in terms of purchasing, inbound logistics, and management of
 165 suppliers in the materials management of product as well as the e-commerce purchasing.

166

Table 11 – Activity of materials management for evaluation

Activity	Description
Material Order	Use of IT systems and applications for integrated material order with master production schedule, BOM and inventory status, etc
Material Receipt	Use of IT systems and applications for management of received material
Warehouse Management	Use of IT systems and applications for managing warehouse and optimization
Weighing Management	Use of IT systems and applications for weighing management, and automatic calibration

Material Release and Process Input	Use of IT systems and applications for material release and process input, and integration with production control system
------------------------------------	---

167

168 6.2.2.5 Sales management

169 Sales management should be evaluated in terms of management of sales, management of the inventory
 170 of finished products, logistics distribution, after-sales services and management of suppliers in the sales
 171 management of the product as well as the e-commerce sale.

172

Table 12 – Activity of sales management for evaluation

Activity	Description
Demand Forecasting	Use of IT systems and applications for supporting integrated demand forecasting with other system such as enterprise resource planning (ERP), manufacturing execution system (MES), product lifecycle management (PLM) and supply chain management (SCM), and its analysis
Delivery to Promise	Use of IT systems and applications for delivery promise in conjunction with production plan
Order Management	Use of IT systems and applications for managing order and strategic decision making based on contract information and cost information
Shipment Management	Use of IT systems and applications for supporting shipment management and its optimization

173

174 6.2.2.6 Financial management

175 Financial management should be evaluated in terms of accounting management, capital management,
 176 accounting statement and analysis, cost management and financial budgeting management.

177

Table 13 – Activity of financial management for evaluation

Activity	Description
Budget Management	Use of IT systems and applications for budget management and its optimization
Accounting Management	Use of IT systems and applications for accounting management and its optimization

178

179 6.2.2.7 Security management

180 Security management should be evaluated in terms of information technology construction and
 181 application of security management, emergency response for the forecast and early warning about major
 182 sources of hazard.

183

Table 14 – Activity of security management for evaluation

Activity	Description
Physical Protection and Regulation Management	Use of IT systems and applications for physical protection and regulation management
Risk Management	Use of IT systems and applications for risk management
Infringement Response Management	Use of IT systems and applications for infringement response management

184

6.2.2.8 Project management

186 Project management should be evaluated in terms of research and manufacturing of product, project planning, project design, etc.

187

Table 15 – Activity of project management for evaluation

Activity	Description
Project Management	Use of IT systems and applications for project management including analysis of project performance and prediction of future plans

189

6.2.2.9 Maintenance management

190 Maintenance management should be evaluated in terms of management of the equipment maintenance using IT.

191

Table 16 – Activity of maintenance management for evaluation

Activity	Description
Equipment Maintenance	Use of IT systems and applications for supporting equipment maintenance including monitoring, preventive maintenance, automatic update of facilities, etc
Jigs and Tools Management	Use of IT systems and applications for managing jigs and tools for support of locating and customizing design of jigs and tool
Spare Parts Management	Use of IT systems and applications for managing spare parts supporting locating, lifetime management and guaranteeing safety stock of spare parts
Mould Management	Use of IT systems and applications for mould management providing monitoring, locating and lifetime management, etc

192

6.2.2.10 Human resource management

193 Human resource management should be evaluated in terms of management of human resource planning and recruiting, training and development of the human resources, emoluments, benefits, achievement and employee relationship.

199

Table 17 – Activity of human resource management for evaluation

Activity	Description
Human Information Management	Use of IT systems and applications for promotion, and supporting of collaboration of personnel, etc
Payroll Management	Use of IT systems and applications for payroll management
Performance Management	Use of IT systems and applications for managing the performance of personnel
Competency Management	Use of IT systems and applications for competency management such as qualification evaluation and training, etc
Recruiting Management	Use of IT systems and applications for supporting recruit and its management

200

201 6.2.2.11 Document management

202 Document management should be evaluated in terms of management of the documents collected from
 203 the enterprise.

204

Table 18 – Activity of document management for evaluation

Activity	Description
Document Management	Use of IT systems and applications for managing the documents

205

206 6.2.2.12 Quality management

207 Quality management should be evaluated in terms of assurance of proper product quality.

208

Table 19 – Activity of quality management for evaluation

Activity	Description
Inspection and Quality Analysis	Use of IT systems and applications to support inspection and quality analysis
Experiment Management	Use of IT systems and applications to manage experiment such as experimental data management and experimental data association with the real time in-house system

209

210 6.2.2.13 Environment, Health and Safety (EHS) management

211 EHS management should be evaluated in terms of providing healthy, safe and sustainable manufacturing
 212 environments.

213

Table 20 – Activity of EHS management for evaluation

Activity	Description

Environment Management	Use of IT systems and applications to manage environment information and control environmental risks, etc
Health Management	Use of IT systems and applications to manage employees' health data
Safety Management	Use of IT systems and applications to support safety management

214

215 **6.2.2.14 Energy management**

216 Energy management should be evaluated in terms of assuring low energy consumption.

217 **Table 21 – Activity of energy management for evaluation**

Activity	Description
Energy-Saving Management	Use of IT systems and applications to manage energy consumption

218

219 **6.2.3 Comprehensive integration aspect assessment**220 **6.2.3.1 Product design and manufacturing integration**221 Product design and manufacturing integration should be evaluated in terms of the bidirectional flow of
222 information between research and design, and manufacturing of product, such as data definition, data
223 exchange and management of product specification.224 **Table 22 – Activity of product design and manufacturing integration for evaluation**

Activity	Description
Exchange of Process Information between Design and Production	Use of IT systems and applications to exchange and integrate information between design process and production process
Exchange of Material Information between Design and Production	Use of IT systems and applications to exchange and integration information of material between design process and production process

225

226 **6.2.3.2 Production management and control integration**227 Production management and control integration should be evaluated in terms of the integration between
228 operation management, manufacturing execution of the plant and process control of the manufacturing
229 enterprises.230 **Table 23 – Activity of production management and control integration for evaluation**

Activity	Description
Routing Management and Dispatching	Use of IT systems and applications to support routing management and dispatching

Recipe Management	Use of IT systems and applications to manage recipe supporting item-specific process or facility control
Resource Allocation	Use of IT systems and applications to allocate manufacturing resources and its optimization

231

232 **6.2.3.3 Production, supply and marketing integration**

233 Production, supply and marketing integration should be evaluated in terms of the integration of
 234 production, supply and marketing such as production according to the order, optimization of production
 235 arrangement and dynamic scheduling, integrated operation of the supply chains and the traceability on
 236 the entire process of product quality.

237 **Table 24 – Activity of production, supply and marketing integration for evaluation**

Activity	Description
Logistics Management	Use of IT systems and applications to support real time logistics information management
Sales Management	Use of IT systems and applications to manage sales information and integrate it with production system

238

239 **6.2.3.4 Operation decision support**

240 Operation decision support should be evaluated in terms of the analysis of business information,
 241 knowledge mining and accumulation, business decision of the enterprises, building of the credibility of
 242 enterprises and risk management and control.

243 **Table 25 – Activity of operation decision support for evaluation**

Activity	Description
Decision Support System Management	Use of IT systems and applications to support decision making based on the real time analysis of company operation

244

245 **6.2.4 Collaborative integration aspect assessment**

246 Collaborative integration should be evaluated in terms of the convergence of information, resources,
 247 businesses and marketing between different enterprises.

248 **Table 26 – Activity of collaborative integration for evaluation**

Activity	Description
Planned-Order Collaboration (Partner's perspective)	Use of IT systems and applications to support planned-order collaboration from partner's perspective, such as support of cooperation to guarantee delivery commitment based on customer's production plan in conjunction with all the customers' system

Procurement Collaboration (Customer's perspective)	Use of IT systems and applications to support procurement collaboration from customer's perspective such as checking the production status, process status, and logistics status of partner company in real time and manage the risks
Production Collaboration (Partner's perspective)	Use of IT systems and applications to support production collaboration from partner's perspective such as providing the customer with statistical process control (SPC) data acquired from the machinery and processes in real time
Development Collaboration	Use of IT systems and applications to support development collaboration such as sharing and verifying the development information in stages and carrying out mass production approval

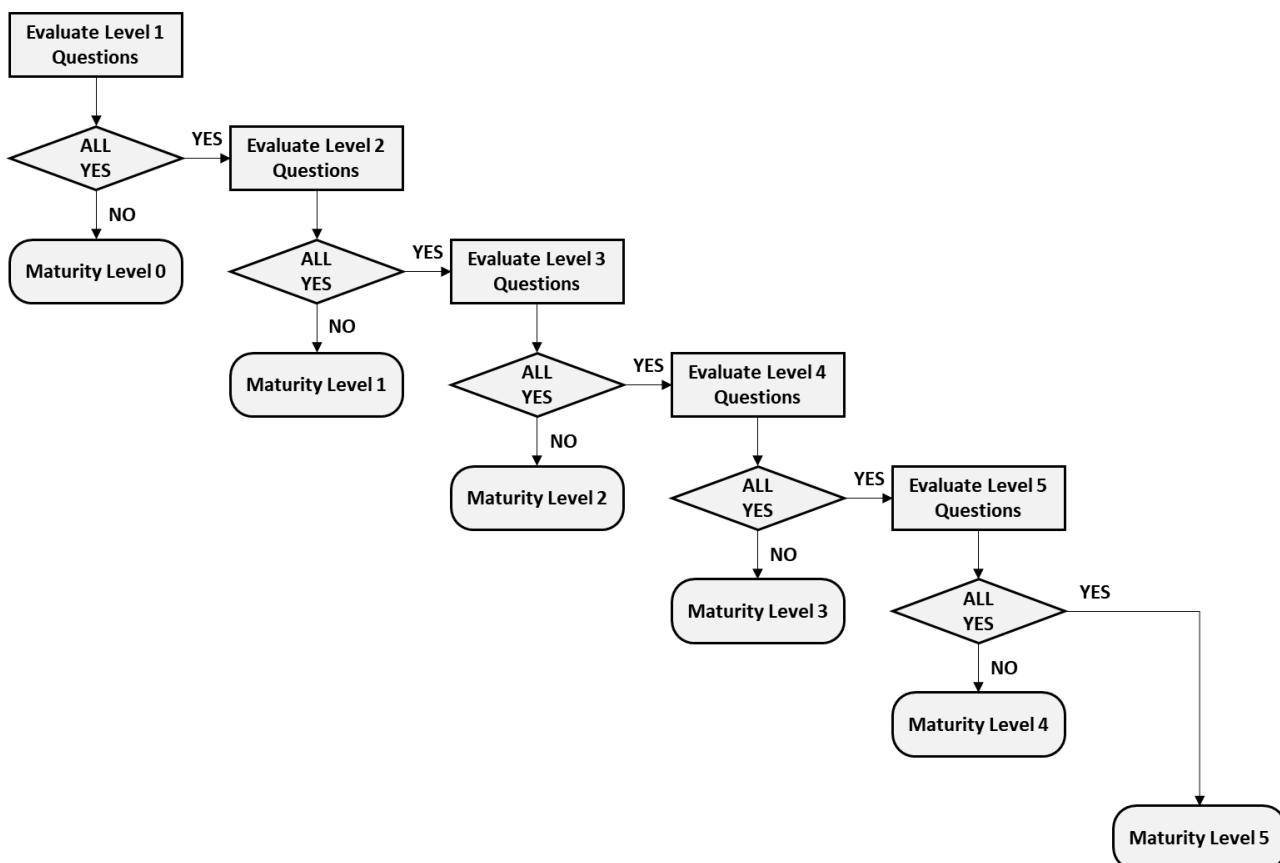
249

250 7 Guidance for maturity evaluation method

251 Maturity evaluation is conducted by assessing the maturity of each activity of each component. The
 252 principle of assessment is to guide enterprises to assess the current situation of CII, to find the weakness,
 253 and to identify ways to improve CII.

254 The basic rule for assessment is that maturity evaluation is conducted on the activities of ACII reference
 255 model components resulting maturity level of the activities. This does not derive any overall maturity
 256 level of each ACII reference model component, overall maturity level of four aspects and finally overall
 257 maturity level of an enterprise either.

258 However, it might be necessary to use a mechanism for averaging maturity level or weighing the
 259 importance of each activity to overall assessment. It is dependent on the situation of the enterprise
 260 conducting assessment, therefore this document does not define that kind of mechanism.



262 **Figure 2 – Maturity level evaluation method**

263 A maturity evaluation method is illustrated in Figure 2 and is to start at the Level 1 questions.

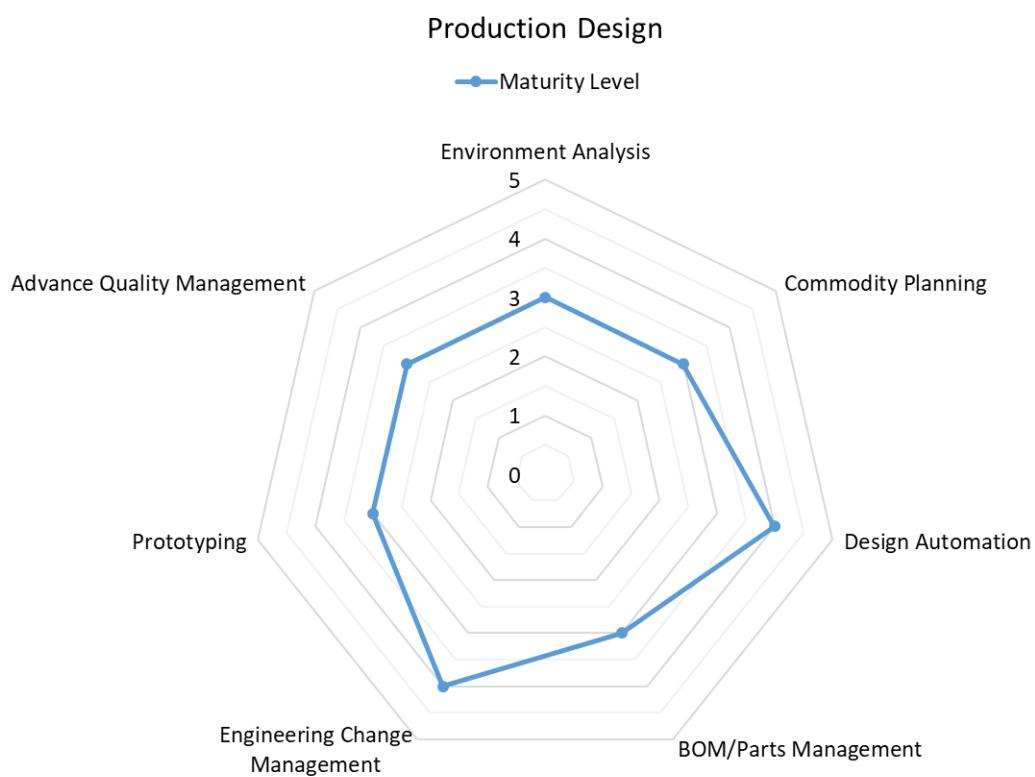
- 264 1) If all answers of the level 1 questions are YES,
 265 – then proceed to the level 2 questions
 266 – otherwise, maturity is level 0
- 267 2) If all answers of the level 2 questions are YES,
 268 – then proceed to the level 3 questions
 269 – otherwise, maturity is level 1

270 3) If all answers of the level 3 questions are YES,
 271 – then proceed to the level 4 questions
 272 – otherwise, maturity is level 2

273 4) If all answers of the level 4 questions are YES,
 274 – then proceed to the level 5 questions
 275 – otherwise, maturity is level 3

276 5) If all answers of the level 5 questions are YES,
 277 – then maturity level is 5
 278 – otherwise, maturity is level 4

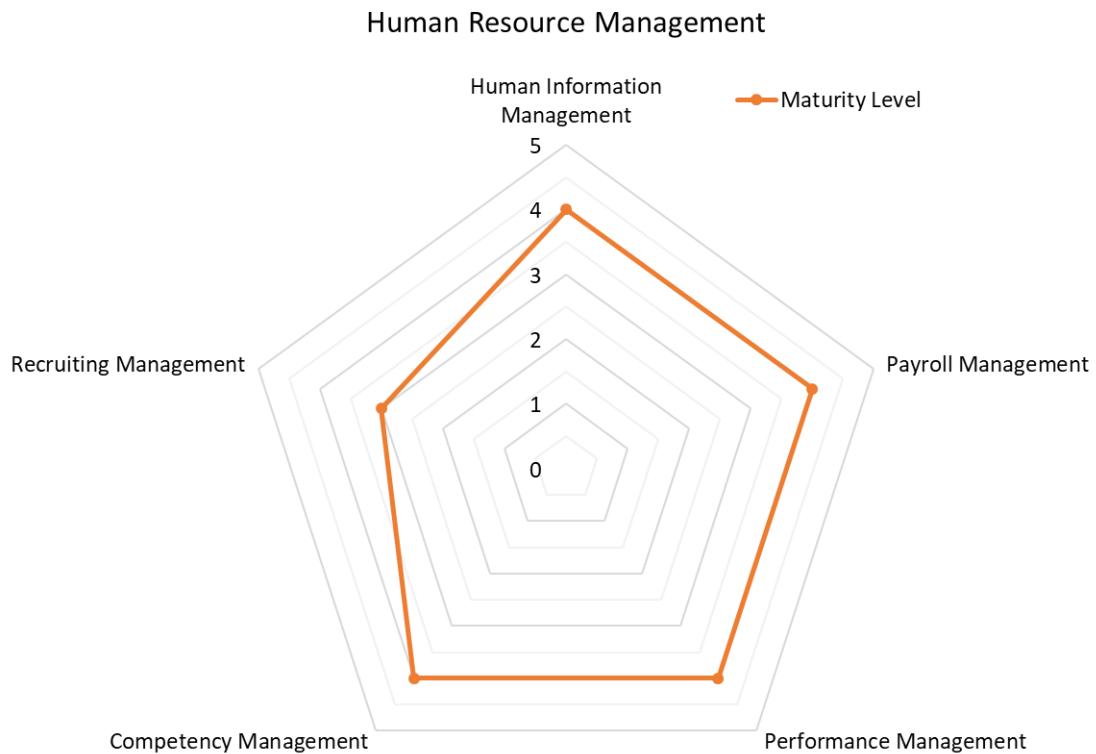
279 As described above, the principle of assessment is to guide an enterprise to assess the current situation
 280 of CII, to find the weakness, and to identify ways to improve CII. Therefore, it may be beneficial to visualize
 281 the result of evaluation. The use of spider charts is an appropriate means of displaying the relative
 282 maturity without mathematically manipulating the evaluation result.



283

284 **Figure 3 – EXAMPLE: Maturity evaluation on activities of production design component –**
 285 **strength**

286 Figure 3 illustrates an example of maturity evaluation result with a spider chart. In Figure 3, it has
 287 relatively high level of maturity in engineering change management and design automation. On the other
 288 hand, Figure 4 illustrated an example of relatively low level of maturity. Through this evaluation and
 289 visualizing the result, an assessing enterprise can easily find the weakness, and identify ways of
 290 improvement.



291

292
293

294

Figure 4 – EXAMPLE: Maturity evaluation on activities of production design component – weakness

295
296
297
298
299**Annex A**
(informative)**Examples of evaluation questionnaires for ACII reference model components**300 **A.1 Infrastructure aspect assessment**301 **A.1.1 Capital investment**

302 For evaluation of capital investment, questions in Table A.1 can be answered.

303 **Table A.1 – Questions for assessment of capital investment**

Activity	Questions	Maturity level indicator
Capital Investment	– Do you invest in IT equipments?	1
	– Do you register the invested IT equipments to the systems?	
	– Do you make an IT investment plan?	2
	– Do you carry out maturity level 1 according to the plan?	
	– Do you have a system to provide IT investment plan automatically?	3
	– Do you have a system to help investing IT equipments, for example, optimal time and prices?	4
	– Do you have a system to help investing IT equipments, for example, recommending necessary IT equipments?	5

304

305 **A.1.2 Organization and planning**

306 For evaluation of organization and planning, questions in Table A.2 can be answered.

307

Table A.2 – Questions for assessment of organization and planning

Activity	Questions	Maturity level indicator
Organization and Planning	- Do you allocate and register personnel when IT job occurs?	1
	- Do you establish IT job standards?	2
	- Do you allocate and register personnel according to the standards?	
	- Do you establish IT job standards with review and approval?	3
	- Do you establish a human resource growth roadmap with review and approval?	
	- Do you place personnel according to the standards and the roadmap?	
	- Do you circulate personnel according to the standards and the roadmap?	
	- Do you train personnel according to the standards and the roadmap?	
	- Do you evaluate the result of maturity level 3?	4
	- Do you continuously improve the IT job standards?	5
	- Do you continuously improve the human resource growth roadmap?	
	- Do you continuously improve the placement of personnel?	
	- Do you continuously improve the circulation of personnel?	
	- Do you continuously improve the training of personnel?	

308

A.1.3 Equipment and facilities

310 For evaluation of equipment and facilities, questions in Table A.3 can be answered.

311

Table A.3 – Questions for assessment of equipment and facilities

Activity	Questions	Maturity level indicator
Equipment and Facilities	- Do you have the documented processes in place to register IT HW and IT SW in an equipment master registry?	1
	- Do you make an inspection plan?	2
	- Do you execute the inspection plan?	
	- Do you review the inspection plan?	3
	- Do you approve the inspection plan?	
	- Do you execute the inspection plan?	

	<ul style="list-style-type: none"> - Do you make a conservation plan? - Do you execute the conservation plan? - Do you evaluate IT H/W, IS S/W and related equipments? 	4
	<ul style="list-style-type: none"> - Do you periodically improve including upgrade IT H/W, IT S/W and related equipments? 	5

312

A.1.4 Information resources

314 For evaluation of information resources, questions in Table A.4 can be answered.

315

Table A.4 – Questions for assessment of information resources

Activity	Questions	Maturity level indicator
Information Resources	<ul style="list-style-type: none"> - Do you collect the necessary data from unit system, online, etc., for business use? 	1
	<ul style="list-style-type: none"> - Do you standardize the collected data according to business rules to guarantee data quality for business use? 	2
	<ul style="list-style-type: none"> - Do you accumulate the standardized data on both an event-by-event basis and time-driven basis for business use? 	3
	<ul style="list-style-type: none"> - Do you integrate the accumulate data with systems, e.g., source data (unit system) -> wrapper -> mediated schema (virtual database)? 	4
	<ul style="list-style-type: none"> - Do you provide useful information, present conclusions, and build and use decision support systems through inspecting, organizing, transforming, and modeling enterprise data? 	5

316

A.1.5 Information security

318 For evaluation of information security, questions in Table A.5 can be answered.

319

Table A.5 – Questions for assessment of information resources

Activity	Questions	Maturity level indicator
Computer and network security	<ul style="list-style-type: none"> - Do you manage the list of assets such as network, major asset list, configuration diagram, IP status? 	1
	<ul style="list-style-type: none"> - Do you use access control according to services, user groups, information asset importance? 	2
	<ul style="list-style-type: none"> - Do you have an intrusion prevention system according to services, user groups, information asset importance? 	

	<ul style="list-style-type: none"> - Do you conduct periodic inspections using server vulnerability analysis tools or security systems? - Do you operate anti-malware solutions mainly for business PCs? 	
	<ul style="list-style-type: none"> - Do you separate the network area logically? - Do you use access control using intrusion blocking system and VPN system? - Do you monitor the operation status of your wireless network and internal network assets? - Do you operate a vulnerability check tool or system? - Do you operate a malicious code prevention solution in important information systems? - Do you operate an automatic patching solution in important information systems? 	3
	<ul style="list-style-type: none"> - Do you use access control using mobile network access control? - Do you operate a blocking system such as unauthorized wireless network? - Do you manage server vulnerability patch automation tool? 	4
	<ul style="list-style-type: none"> - Do you operate an anomalous symptom monitoring system to detect abnormal conditions such as network connection of illegal terminals that occur during network operation? - Do you test the patches for system availability before automatic patching server vulnerabilities? - Do you operate a system to establish security measures in conjunction with analysis of anomalies by malicious code? 	5
System and application security	<ul style="list-style-type: none"> - Do you set a password for a personal computer? 	1
	<ul style="list-style-type: none"> - Do you have management systems for server, application, user account and access rights of the data base? 	2
	<ul style="list-style-type: none"> - Do you operate a unit security solution such as password program mainly for personal business PC? 	
	<ul style="list-style-type: none"> - Do you monitor operating status of information system related assets such as hardware, operating system, commercial software package, etc? - Do you use cryptographic programs such as DB encryption systems to protect important data? 	3
	<ul style="list-style-type: none"> - Do you have an associated system enforcing authentication other than password authentication separately? - Do you have an associated system monitoring the server, applications, and any anomalies that occur during database operation? 	4

	<ul style="list-style-type: none"> - Do you use automated tools to manage information system assets such as hardware, operating system, commercial software packages, etc? - Do you measure the performance and security impact of asset changes? - Do you analyse the result of monitoring? - Do you apply the result of analysis to the establishment of the next security measures? 	5
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320

321 A.2 Domain application aspect assessment

322 A.2.1 Product design

323 For evaluation of product design, questions in Table A.6 can be answered.

324

Table A.6 – Questions for assessment of product design

Activity	Questions	Maturity level indicator
Environment Analysis	<ul style="list-style-type: none"> - Do you register information for product planning to the system, for example, markets, customers, and competitors? 	1
	<ul style="list-style-type: none"> - Do you manually analyse the collected information? - Do you register the result to the system? 	2
	<ul style="list-style-type: none"> - Do you analyse the collected information using specialized analysis tools, e.g., statistical analysis, etc? 	3
	<ul style="list-style-type: none"> - Do you have a system that supports internal step-by-step process and reflects them in decision making based on the results of the environmental analysis? 	4
	<ul style="list-style-type: none"> - Do you have a system that shares the latest product roadmaps and the latest technology roadmaps, and maintains the relationship between the two roadmaps? 	5
Commodity Planning	<ul style="list-style-type: none"> - Do you register the requirements collected for product planning in the system? 	1
	<ul style="list-style-type: none"> - Do you manage the collected requirements of product development systematically by a system? 	2
	<ul style="list-style-type: none"> - Do you manage the requirements to be applied to the functions of actual products using specific techniques such as quality function deployment (QFD)? 	3
	<ul style="list-style-type: none"> - Do you use the system to simulate and technically review (feasibility studies) the product development including product design, development feasibility of parts, functional arrangements, etc., and ease-of-use? 	4
	<ul style="list-style-type: none"> - Do you have a system in which entire related parts of enterprise join and discuss for the feasibility studies, 	

	planning, and decision making of product development?	
	- Do you plan a product considering not only ideas inside your company but also ideas outside your company, i.e., Open Innovation?	5
Design Automation	- Do you design with 2D computer aided design (CAD)?	1
	- Do you design with 3D CAD?	2
	- Do you analyse and validate with computer aided engineering (CAE)?	3
	- Do you design automatically with optimization solutions as one of following? <ul style="list-style-type: none"> - Model based Parametric design (template design: automatic generation of model by inputting product characteristics) - Engineering based Parametric design (optimal design with input of formula and analysis result) - Integrated parametric design (design considering subsequent processes such as production, logistics, and customer service for warranty, etc.). 	4
	- Do you design a product by using smart connected technology such as IoT, augmented reality (AR)/ virtual reality (VR)?	5
	- Do you upload the engineering-BOM (E-BOM) to the system?	1
	- Do you integrate the E-BOM with 3D CAD? - Do you generate the E-BOM automatically?	2
BOM/Parts Management	- Do you generate the manufacturing BOM (M-BOM) automatically in PLM?	3
	- Do you manage the software configuration in PLM?	
	- Do you configure the BOM according to the purpose of use such as procurement, process cost, production, and customer service for warranty, etc.?	4
	- Do you improve business through preliminary simulation using the BOM data according to the purpose of use?	5
	- Do you register the engineering change order (ECO) files in the system?	
	- Do you manage the ECO files in the system systematically?	
	- Do you make the ECO using systems? - Do you track changes and improvements of the ECO?	2
Engineering Change Management	- Do you execute the engineering change request (ECR) using systems?	3
	- Do you manage the ECR in conjunction with the ECO?	

	<ul style="list-style-type: none"> - Do you distribute the ECO to the post-process department (other system) systematically, e.g., ERP, MES, etc.? 	4
	<ul style="list-style-type: none"> - Do you have a system that can systematically collect relevant department opinion and support decision making for impact analysis of engineering changes and deployment management? 	5
Prototyping	<ul style="list-style-type: none"> - Do you register the results of prototyping in the system and manage them? 	1
	<ul style="list-style-type: none"> - Do you maintain the BOM or material management system for prototyping? 	2
	<ul style="list-style-type: none"> - Do you support digital test, quality prediction, and reliability prediction using digital mock-up (DMU) and digital pre-assembly (DPA)? 	3
	<ul style="list-style-type: none"> - Do you have a systematic virtual assessment (validation) process? 	4
	<ul style="list-style-type: none"> - Do you perform a virtual assessment to determine design specifications for each step? 	
	<ul style="list-style-type: none"> - Do you make overall workflow control? 	5
	<ul style="list-style-type: none"> - Do you make integrated design by integration with the digital factory (virtual factory)? 	
Advance Quality Management²	<ul style="list-style-type: none"> - Do you register the pre-quality data at the development stage in the system? 	1
	<ul style="list-style-type: none"> - Do you manage the registered pre-quality data? 	
	<ul style="list-style-type: none"> - Do you have a history management system for quality issues and perform pre-quality verification for each stage of development? 	2
	<ul style="list-style-type: none"> - Do you have the definite assessment criteria for achievement including product characteristic, reliability, stability, mass production, and etc., per product development type and grade? 	3
	<ul style="list-style-type: none"> - Do you have a process for approval of mass production? 	
	<ul style="list-style-type: none"> - Do you share approval specification for mass production through the system for use as a standard of company quality control such as import inspection, shipment inspection and service quality control? 	
	<ul style="list-style-type: none"> - Do you prevent the recurrence of the same issue by using a preventive management system such as failure modes and effects analysis (FMEA) during product development? 	4
	<ul style="list-style-type: none"> - Do you have a system to track quality issues? 	

² Advance quality management is different from quality management that the latter is applied to the mass product while the former is applied before the mass product, e.g., prototyping.

	<ul style="list-style-type: none"> - Do you have the development quality management systems such as advanced product quality planning (APQP) and design for manufacturing (DFM)? - Do you assess the quality management system by regular and occasional audits? - Do you update the quality management system continuously by evaluating the compliance with international standards through an independent agency? 	5
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325

326 A.2.2 Process design

327 For evaluation of process design, questions in Table A.7 can be answered.

328 **Table A.7 – Questions for assessment of process design**

Activity	Questions	Maturity level indicator
Process Design	- Do you register library data or process design data in the system?	1
	- Do you design the process, production-line, and plant lay-out using classical tool such as CAD?	2
	- Do you have a system to change the process design according to the engineering change of product?	3
	- Do you design and validate process, production-line and plant lay-out using digital manufacturing solutions?	4
	- Do you monitor the operation of the process and the equipment using IoT, and change the process and the lay-out if necessary?	5

329

330 A.2.3 Production management

331 For evaluation of production management, questions in Table A.8 can be answered.

332 **Table A.8 – Questions for assessment of production management**

Activity	Questions	Maturity level indicator
Master Production Scheduling	- Do you register planned production quantities into the system?	1
	- Do you register planned production quantities, production facilities, processes, and work groups into the system?	2
	- Do you make a production plan by systems?	3
	- Do you analyse the load of the production plan?	

	<ul style="list-style-type: none"> - Do you have advanced planning and scheduling (APS)? 	4
	<ul style="list-style-type: none"> - Do you analyse what-if and make alternatives in real time? 	5
WIP Management	<ul style="list-style-type: none"> - Do you identify and quantify process-specific WIP using identification code? 	1
	<ul style="list-style-type: none"> - Do you identify process-specific WIP and production history information using identification code? 	2
	<ul style="list-style-type: none"> - Do you manage the yield of process-specific WIP using identification code? 	3
	<ul style="list-style-type: none"> - Do you check the location of WIP and the post-process schedule in real time? 	4
	<ul style="list-style-type: none"> - Do you have automatic system to input WIP into the process? 	5
Monitoring and Control	<ul style="list-style-type: none"> - Do you automatically store the actual production in order units and production lots? 	1
	<ul style="list-style-type: none"> - Do you automatically store the corresponding equipments, processes, and worker data in order units and production lots? 	2
	<ul style="list-style-type: none"> - Do you analyse the cause using the system if there is a difference relative to the plan? 	3
	<ul style="list-style-type: none"> - Do you re-establish resource allocation and dispatching in real time based on the result of the cause analysis of the difference? 	4
	<ul style="list-style-type: none"> - Do you use CPS for monitoring and control? 	5
Process Control	<ul style="list-style-type: none"> - Do you collect process information, i.e., start and end of work, through data collection devices, which supports lot-tracking of the major processes? 	1
	<ul style="list-style-type: none"> - Do you automatically collect process information from equipment or process transfer equipment, for example, bogies, pallets, forklifts, wagons, etc.? 	2
	<ul style="list-style-type: none"> - Do you automatically aggregate major process operating information and analyse it in real time? 	3
	<ul style="list-style-type: none"> - Do you automatically control the process? 	4
	<ul style="list-style-type: none"> - Do you have a flexible production system supported by automatic work change and work preparation considering the surrounding environment? 	5
Process Analysis and Enhancement	<ul style="list-style-type: none"> - Do you register data collected from facilities and processes? 	1
	<ul style="list-style-type: none"> - Do you semi-automatically collect data using barcode, RFID, etc., from equipment and processes? 	2
	<ul style="list-style-type: none"> - Do you automatically aggregate the collected data? 	
	<ul style="list-style-type: none"> - Do you automatically collect data from equipment and processes through data collection devices? 	3

	<ul style="list-style-type: none"> - Do you analyse the collected data in real time using the system? - Do you automatically detect process anomalies such as material shortage, equipment abnormality, and quality abnormality? - Do you automatically generate alarm or stop production line? 	
	<ul style="list-style-type: none"> - Do you automatically detect process anomalies such as equipment abnormality and quality abnormality? - Do you automatically control processes? - Do you provide operation guide in real time using detected information? 	4
	<ul style="list-style-type: none"> - Do you automatically control the operating conditions for operation normalization? 	5

333

334 A.2.4 Materials management

335 For evaluation of material management and inventory management, questions in Table A.9 can be
336 answered.

337 **Table A.9 – Questions for assessment of material management and inventory management**

Activity	Questions	Maturity level indicator
Material Order	<ul style="list-style-type: none"> - Do you register and manage the order data in the system? 	1
	<ul style="list-style-type: none"> - Do you have an inventory management module? 	2
	<ul style="list-style-type: none"> - Do you manage safety inventory? 	
	<ul style="list-style-type: none"> - Do you manage reorder points in case of scarcity? 	
	<ul style="list-style-type: none"> - Do you automatically order the material? 	3
	<ul style="list-style-type: none"> - Do you use BOM as product units to calculate the material requirements and the shortage quantities? 	4
	<ul style="list-style-type: none"> - Do you plan monthly, weekly, or daily procurement in conjunction with information such as master production schedule (MPS), BOM and inventory status? - Do you make purchase order (PO) and delivery order (DO) based on the procurement plan, or do you have vendor management inventory (VMI)? 	5
Material Receipt	<ul style="list-style-type: none"> - Do you register the material information when receiving the material? 	1
	<ul style="list-style-type: none"> - Do you register material information with the data collection device when receiving the material? 	2
	<ul style="list-style-type: none"> - Do you automatically collect data on materials, worker, and time on material receipt in the systems? 	3

	<ul style="list-style-type: none"> - Do you identify the location of material in real time in the system when receiving material? 	4
	<ul style="list-style-type: none"> - Do you automatically transfer the material to the system-specified goods receipt location by transfer equipment? 	5
Warehouse Management	<ul style="list-style-type: none"> - Do you manage the quantity of materials in physical and logical warehouses? 	1
	<ul style="list-style-type: none"> - Do you always monitor the properties of the material in the warehouse, such as its location and status? 	2
	<ul style="list-style-type: none"> - Do you operate process such as first-in-first-out (FIFO) and last-in-first-out (LIFO) to minimize material loss by system? 	3
	<ul style="list-style-type: none"> - Do you analyse data to optimize loading or aging? 	4
	<ul style="list-style-type: none"> - Do you automate the aging optimization by considering automatically identified material properties or loading optimization through material relocation? 	5
Weighing Management	<ul style="list-style-type: none"> - Do you register the material weighing data to the system when releasing the material? 	1
	<ul style="list-style-type: none"> - Do you automatically register weighing values when releasing the material? 	2
	<ul style="list-style-type: none"> - Do you monitor the weighing data by system in real time, and send alarm with problem messages by system when problems occur? 	3
	<ul style="list-style-type: none"> - Do you automatically control the weighing? 	4
	<ul style="list-style-type: none"> - Do you analyse the cause and calibrate automatically by system when problems occur? 	5
Material Release and Process Input	<ul style="list-style-type: none"> - Does the worker reflect the inventory quantity in the system after material dispensing and the process input? 	1
	<ul style="list-style-type: none"> - Do you automatically reflect the inventory quantity as soon as the materials are dispensed from warehouse? 	2
	<ul style="list-style-type: none"> - Do you automatically reflect process and WIP information immediately after the materials are dispensed from warehouse or put into the process? 	3
	<ul style="list-style-type: none"> - Do you determine the appropriateness of the destination using information such as scheduler? 	4
	<ul style="list-style-type: none"> - Do you issue alarm message in the event of an error in the destination? 	
	<ul style="list-style-type: none"> - Do you automate destination reflections and material dispatches according to the production control system? 	5

339 **A.2.5 Sales management**

340 For evaluation of sales management, questions in Table A.10 can be answered.

341 **Table A.10 – Questions for assessment of sales management**

Activity	Questions	Maturity level indicator
Demand Forecasting	– Do you register the demand history in the system and manage it?	1
	– Do you register the demand data in the system and forecast the demand with basic algorithms?	2
	– Do you forecast and analyse the demand using the system based on intelligent IT?	3
	– Do you collect and analyse the actual performance information required for the demand forecasting by linking with ERP, MES, PLM, and SCM?	4
	– Do you forecast and analyse the demand using the demand data based on intelligent IT?	
	– Do you forecast the demand through specialized algorithms and crowdsourcing?	5
	– Do you use the forecasted demand to develop new products?	
Delivery to Promise	– Do you accept customer's demand on delivery without checking information when receiving an order?	1
	– Do you accept the order after on-site checking the product inventory by information system when receiving an order?	2
	– Do you accept the order whether that can be delivered from the product inventory using the system when receiving an order?	3
	– Do you make conjunction of the production plans with the order and provide delivery information when receiving an order?	4
	– Do you flexibly respond to the change of order of parent company?	
	– Do you automatically establish production plan?	
	– Do you provide delivery information?	5
Order Management	– Do you register the estimated data and the order data in the system and track order history?	1
	– Do you use the system to manage production progress by order?	2
	– Do you manage contract information?	3
	– Do you analyse order fulfilment satisfaction?	
	– Do you periodically analyse contract information?	4

	<ul style="list-style-type: none"> - Do you provide information in comparison with product cost? 	
	<ul style="list-style-type: none"> - Do you provide strategic decision making information by comparing the information of the contract, cost information, and management index information? 	5
Shipment Management	<ul style="list-style-type: none"> - Do you process shipments using data collection devices? 	1
	<ul style="list-style-type: none"> - Do you make digital shipping instructions? 	
	<ul style="list-style-type: none"> - Do you keep track of product orders with stored data? 	
	<ul style="list-style-type: none"> - Do you automatically collect the shipment history using the system in conjunction with equipments and devices used in the shipping process? 	2
	<ul style="list-style-type: none"> - Do you automate shipments ordered by the system in conjunction with the shipping equipment for packaging, labelling, shipping, etc.? 	3
	<ul style="list-style-type: none"> - Do you automatically manage information about the distribution process of the shipped products, and use it for returning or collecting products? 	4
	<ul style="list-style-type: none"> - Do you provide optimal flow information by analysing routing information for manufacturing and distribution logistics? 	5

342

343 A.2.6 Financial management

344 For evaluation of financial management, questions in Table A.11 can be answered.

345

Table A.11 – Questions for assessment of financial management

Activity	Questions	Maturity level indicator
Budget Management	<ul style="list-style-type: none"> - Do you identify and manage the finance-oriented factory budget plan including the amount of production and sales using the systems? 	1
	<ul style="list-style-type: none"> - Do you measure and manage budget plans that reflect plant operation indicators such as quality, procurement, production, human resources, and informatization? 	2
	<ul style="list-style-type: none"> - Do you operate and informatize the factory by the budget plan? 	3
	<ul style="list-style-type: none"> - Do you periodically review the analysed results through the system? 	
	<ul style="list-style-type: none"> - Do you have the optimized factory budget information system to reflect the changing operating environment and share in a timely manner? 	4

	<ul style="list-style-type: none"> - Do you make it possible to collaborate in real time by integrating and managing budget information with other tasks and other systems? 	5
Accounting Management	<ul style="list-style-type: none"> - Do you register the basic accounting management such as basic document processing, bond, financial obligation, financing, and settlement of accounts? 	1
	<ul style="list-style-type: none"> - Do you automate statement analysis and cost management by linking purchasing, sales, bonds, and financial obligation with factory logistics information? 	2
	<ul style="list-style-type: none"> - Do you have depreciation analysis simulation capability, and make departmental budgets, and control and manage expenses according to the budget? 	3
	<ul style="list-style-type: none"> - Do you have total accounting management by the system, and collect and analyse data in real time? 	4
	<ul style="list-style-type: none"> - Do you make it possible to collaborate in real time by integrating and managing accounting information with other tasks and other systems? 	5

346

347 A.2.7 Security management

348 For evaluation of security management, questions in Table A.12 can be answered.

Table A.12 – Questions for assessment of security management

Activity	Questions	Maturity level indicator
Physical Protection and Regulation Management	<ul style="list-style-type: none"> - Do you establish information protection regulations? - Do you operate physical protection zones to protect information systems? 	1
	<ul style="list-style-type: none"> - Do you have access control to the physical protected area? - Do you have an information protection organization? 	2
	<ul style="list-style-type: none"> - Do you have import and export management system for equipments in the physical protected area operated by a department dedicated to information security? 	3
	<ul style="list-style-type: none"> - Do you operate the system for controlling the use of equipment, such as control of internal network use of portable storage media, in a physical protected area, and monitoring whether equipment in and out of the area is controlled? 	4
	<ul style="list-style-type: none"> - Do you evaluate the performance of the implementation of physical protection measures, such as control of equipment use in physical protection areas, whether or not the control systems 	5

	are being implemented, and reflect them in the next protection activities and measures?	
Risk Management	- Do you designate the person(s) who handles important information assets (information, systems, etc.) within the organization and clearly specify the roles/responsibilities?	1
	- Do you plan and implement on a regular basis information assets risk management?	2
	- Do you regularly check for technical risks by using inspection tools to check for vulnerabilities in information assets?	3
	<ul style="list-style-type: none"> - Using the information asset management system, <ul style="list-style-type: none"> - Do you systematically manage information assets? - Do you calculate the risk of information asset risk? - Do you establish a plan for implementation of information protection measures including processing strategies? - Do you have the security officer to report the results? 	4
	<ul style="list-style-type: none"> - Using the information asset management system, <ul style="list-style-type: none"> - Do you manage information asset status in real time? - Do you conduct internal audits on the appropriateness and implementation of the information security measures implementation plan for information assets risk? 	5
Infringement Response Management	- Do you create an information system operation log?	1
	- Do you operate a backup system for the information system operation log?	2
	- Do you check whether the information is infringing by checking the operation log in the important information system?	
	- Do you use operational log analysis tools to analyse operational logs such as user access logs?	3
	- Do you have a monitoring system that is used to detect the occurrence of an infringement accident or anomalous signatures from the central office to the enterprise along with the use of automated log analysis tools such as user log records?	4
	- Do you operate a system in conjunction with abnormal symptom detection and response systems to recognize and respond to intrusion attempts from outside in real time?	5

	<ul style="list-style-type: none"> - Do you operate it in conjunction with an external vulnerability providing system to periodically update information system vulnerability information? 	
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351 A.2.8 Project management

352 For evaluation of project management, questions in Table A.13 can be answered.

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Table A.13 – Questions for assessment of project management

Activity	Questions	Maturity level indicator
Project Management	<ul style="list-style-type: none"> - Do you manage the schedule and the output which are the minimum management targets of the project in the system? 	1
	<ul style="list-style-type: none"> - Do you maintain standard work breakdown structure (WBS) for each type and use required tasks, time period, and resources as basic data for planning? 	2
	<ul style="list-style-type: none"> - Do you manage development planning and goal management in the system? 	
	<ul style="list-style-type: none"> - Do you manage the project's critical path? 	3
	<ul style="list-style-type: none"> - Do you have a system that can manage all areas such as issues, resources, costs, and quality? 	
	<ul style="list-style-type: none"> - Do you have a system to retrieve all the information of the project in real time, and make decisions based on data in the system without manual report? 	4
	<ul style="list-style-type: none"> - Do you have a system to analyse project performance and use the results to predict future project plans? 	5

354

355 A.2.9 Maintenance management

356 For evaluation of maintenance management, questions in Table A.14 can be answered.

357

Table A.14 – Questions for assessment of maintenance management

Activity	Questions	Maturity level indicator
Equipment Maintenance	<ul style="list-style-type: none"> - Do you register inspection information by data acquisition device and manage the repair and inspection history? 	1
	<ul style="list-style-type: none"> - Do you operate on the master data on downtime? 	2
	<ul style="list-style-type: none"> - Do you collect the downtime details by data acquisition device? 	
	<ul style="list-style-type: none"> - Do you have overall equipment effectiveness (OEE) indicator as the result? 	

	<ul style="list-style-type: none"> - Do you automatically aggregate downtime data and perform preventive maintenance based on the collected data and manage the maintenance history? 	3
	<ul style="list-style-type: none"> - Do you monitor the condition of the facility by real time monitoring? - Do you use the information to manage the parts life and preventive maintenance plan to maintain the equipment? 	4
	<ul style="list-style-type: none"> - Do you automatically update the facility information? - Does the facility diagnose by itself to forecast the downtime? 	5
Jigs and Tools Management	<ul style="list-style-type: none"> - Do you manage the jigs and tools information in the system? 	1
	<ul style="list-style-type: none"> - Do you manage the stock of jigs and tools by identification technologies such bar code and RFID as well as key-in? 	2
	<ul style="list-style-type: none"> - Do you have the master data of jigs and tools, and analyse the history of use of jigs and tools? 	3
	<ul style="list-style-type: none"> - Do you manage the location information through identifiers of jigs and tools, and location map? 	4
	<ul style="list-style-type: none"> - Do you provide Big Data of the design area for customized design of jigs and tools? 	5
Spare Parts Management	<ul style="list-style-type: none"> - Do you have the information of spare parts in the system? 	1
	<ul style="list-style-type: none"> - Do you manage the stock of spare parts identification technologies such bar code and RFID as well as key-in? 	
	<ul style="list-style-type: none"> - Do you have the master data of spare parts? - Do you manage the life span through history management of usage? 	2
	<ul style="list-style-type: none"> - Do you automatically calculate the periodic required amount based on the life span information of spare parts? 	3
	<ul style="list-style-type: none"> - Do you manage the location information through identifiers of spare parts, and location map? 	4
	<ul style="list-style-type: none"> - Do you make automatic ordering in conjunction with partner companies to secure safety stock of spare parts? 	5
Mould Management	<ul style="list-style-type: none"> - Do you manage the stock of mould by identification technologies such bar code and RFID as well as key-in, including management of outsourcing order? 	1
	<ul style="list-style-type: none"> - Do you have the master data of moulds? - Do you manage the history including the repair and modification history in the system? 	2

	<ul style="list-style-type: none"> - Do you automatically monitor the status of moulds, e.g., temperature, pressure, etc., by using various sensors combined with communication? 	3
	<ul style="list-style-type: none"> - Do you automatically identify and locate the moulds using identification technologies? - Do you automatically calculate the mould ratio mould shot and put it into the system? 	4
	<ul style="list-style-type: none"> - Do you predict the life of the moulds by aggregating operation information associated with the operation status of the equipment in real time? - Do you automatically compile the number of repair workers and manage the history of quality of moulds in the beginning, the middle, and the finish of work? 	5

358

359 A.2.10 Human resource management

360 For evaluation of human resource management, questions in Table A.15 can be answered.

361 **Table A.15 – Questions for assessment of human resource management**

Activity	Questions	Maturity level indicator
Human Information Management	<ul style="list-style-type: none"> - Do you identify and manage personnel recruitment cards such as personal recruitment, human resource (HR) master, issuance, training, and benefits? 	1
	<ul style="list-style-type: none"> - Do you automatically manage time and attendance using the access card system? 	2
	<ul style="list-style-type: none"> - Do you automatically analyse and adjust yearly, special promotion and reorganization based on automatically collected time and attendance information and personnel evaluation information? 	3
	<ul style="list-style-type: none"> - Do you have a system for personnel management providing real time data collection and analysis? 	4
	<ul style="list-style-type: none"> - Do you have real time collaboration based on personnel information management in conjunction with other tasks and other systems? 	5
Payroll Management	<ul style="list-style-type: none"> - Do you register and manage the master data of payroll management by using system? 	1
	<ul style="list-style-type: none"> - Do you register the payroll table by grades, individual national pension, medical insurance, and employment insurance management information in the system, and manage it simply? 	2
	<ul style="list-style-type: none"> - Do you automatically manage labour costs information including individual salary, bonus, retrospective, and year-end settlement information by support of accounting system? 	3

	<ul style="list-style-type: none"> - Do you have a system for payroll management supporting real time data collection and analysis? 	4
	<ul style="list-style-type: none"> - Do you have real time collaboration based on payroll management in conjunction with other tasks and other systems? 	5
Performance Management	<ul style="list-style-type: none"> - Do you register and manage the master data of worker's performance management by using system? 	1
	<ul style="list-style-type: none"> - Do you register performance information in the system according to basic personal evaluation criteria such as key performance indicator (KPI) and evaluation period, and simply identify and manage it? 	2
	<ul style="list-style-type: none"> - Do you routinely measure and manage individual competency and performance? 	3
	<ul style="list-style-type: none"> - Do you automatically analyse and manage KPIs by department and individual? 	4
	<ul style="list-style-type: none"> - Do you have real time collaboration based on training management in conjunction with other tasks and other systems? 	5
Competency Management	<ul style="list-style-type: none"> - Do you register and manage the master data of worker's competency management by using system? 	1
	<ul style="list-style-type: none"> - Do you have incomplete eligibility management, and register and manage the education plan information on the minimum duties and safety in the system? 	2
	<ul style="list-style-type: none"> - Do you make employee competency development modeling, and manage eligibility, and establish job-oriented training programs? 	3
	<ul style="list-style-type: none"> - Do you conduct periodic employee competency and qualification evaluations, and operate training programs focused on competency and eligibility? 	4
	<ul style="list-style-type: none"> - Do you integrate employee competency and eligibility management with self-directed learning through work? 	5
	<ul style="list-style-type: none"> - Do you automatically plan and operate employees' career development using the system? 	
Recruiting Management	<ul style="list-style-type: none"> - Do you register and manage the master data of recruiting management by using system? 	1
	<ul style="list-style-type: none"> - Do you manage recruiting documents and examination documents in the system? 	2
	<ul style="list-style-type: none"> - Do you have a work system appropriate for recruiting? 	3
	<ul style="list-style-type: none"> - Do you operate on-line system for job application support and examination? 	
	<ul style="list-style-type: none"> - Do you have a system for recruiting tasks providing various statistical functions for efficient operation of staffs and budget? 	4

	<ul style="list-style-type: none"> - Do you have real time collaboration based on recruiting management information in conjunction with other tasks and other systems? 	5
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A.2.11 Document management

364 For evaluation of document management, questions in Table A.16 can be answered.

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Table A.16 – Questions for assessment of document management

Activity	Questions	Maturity level indicator
Document Management	- Do you register and manage major technical documents or materials such as technical specifications in the system?	1
	- Do you define the essential technical documents and register them in the system on a guarantee of effectiveness and up-to-date?	2
	- Do you have document security and rating management?	3
	- Do you manage various know-how as well as technical documents and other materials as assets of the company?	4
	- Do you accumulate data and do Big Data analysis?	5

366

A.2.12 Quality management

368 For evaluation of quality management, questions in Table A.17 can be answered.

369

Table A.17 – Questions for assessment of quality management

Activity	Questions	Maturity level indicator
Inspection and Quality Analysis	- Do you define and register product-specific inspection and measurement items?	1
	- Do you determine the abnormality after measurement and inspection and input the resultant data?	2
	- Do you have a system to support automatic entering measurement and inspection data?	3
	- Do you have a system to trace the history, in which inspection information and measurement information are operated independently?	
	- Do you support product re-development and process re-development by data base of quality defect analysis, or do you change the process operating	4

	conditions in real time immediately after the quality defect is detected?	
	<ul style="list-style-type: none"> - Do you have knowledge of quality abnormality and change of process and facility operation conditions? - Based on this knowledge, do you predict quality in real time and change process operation conditions in real time? 	5
Experiment Management	- Do you define and register experiment items per product?	1
	- Do you enter experiment results data?	2
	- Do you automatically enter the experimental data into the system, and trace it?	3
	- Do you support product re-development and process re-development by data base of quality defect analysis?	4
	- Do you make the experimental data associated with the real time in-house system?	5

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371 **A.2.13 Environment, Health and Safety (EHS) management**

372 For evaluation of EHS management, questions in Table A.18 can be answered.

373 **Table A.18 – Questions for assessment of EHS management**

Activity	Questionnaire	Maturity level indicator
Environment Management	- Do you manually register and manage records of climate information, hazardous facilities information and hazardous material information in the system?	1
	- Do you automatically register and manage records of climate information, hazardous facilities information and hazardous material information in the system?	2
	<ul style="list-style-type: none"> - Do you register and manage climate information in real time using information systems? - Do you conduct safety monitoring on harmful facilities and harmful substances? 	3
	<ul style="list-style-type: none"> - Do you use environmental management data to conduct safety surveillance analysis of hazardous installations and hazardous substances? - Do you use environmental management data to identify environmental risks? 	4
	- Do you use environmental management data to evaluate and control environmental risks?	5
	- Do you collect and manage employees' health data?	1

Health Management	- Do you perform basic analysis such as analysing trends of health of employees?	2
	- Do you monitor departmental and individual productivity using the health data of employees?	3
	- Do you use the health data of employees for work placement, overtime, etc.?	
	- Do you use the result of analysis on the health data of employees in daily work?	4
	- Do you analyse and navigate important health data, such as orthopedic and atypical, in a well-managed structure?	5
	- Do you use the analysed health data for mission-critical activities such as treatment?	
Safety Management	- Do you register information on the safety of workers, hazardous facilities, hazardous materials information, and material safety data sheets (MSDS) in the system for records management?	1
	- Do you automatically record and manage records of personnel safety, hazardous facilities, hazardous materials information, and MSDS in the system?	2
	- Do you use information systems to monitor safety for workers, real time risk facilities, and hazardous materials?	3
	- Do you use safety monitoring data to identify safety hazards for worker safety, hazardous facilities, and hazardous materials using safety management data?	4
	- Do you use safety management data to identify, assess, and control safety hazards using safety monitoring analysis of worker safety, hazardous facilities, and hazardous materials?	5

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375 A.2.14 Energy management

376 For evaluation of energy management, questions in Table A.19 can be answered.

377

Table A.19 – Questions for assessment of energy management

Activity	Questions	Maturity level indicator
Energy-Saving Management	- Do you measure the external supply energy such as electricity, gas, heat, steam, etc?	1
	- Do you measure the internally generated energy such as self-generation, renewal, and ESS?	
	- Do you generate an alarm when the threshold, i.e., peak value, and abnormality occurs?	
	- Do you measure external data such as external temperature, humidity, etc., for each major process	2

	(more than 10%), energy use equipment (more than 5% use)? – Do you measure the energy use of the entire plant? – Do you collect production data for factories, process lines and major production facilities?	
	– Do you analyse energy efficiency and energy unit level such as plant, process line, major facility? – Do you establish production plans and schedules for load levelling? – Do you monitor indicators, goals, and achievements of enterprise, organizations, and boundaries?	3
	– Do you control plant, process line, and facility by optimization algorithm in conjunction with production and demand forecast?	4
	– Do you set up an energy supply optimization plan considering internal energy production capacity, external energy supply sources, and demand forecasts? – Do you have comprehensive control?	5

378

379 A.3 Comprehensive integration aspect assessment

380 A.3.1 Product design and manufacturing integration

381 For evaluation of product design and manufacturing integration, questions in Table A.20 can be answered.

382 **Table A.20 – Questions for assessment of product design and manufacturing integration**

Activity	Questions	Maturity level indicator
Exchange of Process Information between Design and Production	– Do you download design information such as drawings, BOM and engineering change from the PLM system, and deliver it as a file?	1
	– Do you deliver design information in conjunction with the PLM system and digital manufacturing for use in process and construction review?	2
	– Do you deliver the method information in conjunction with digital manufacturing and the MES system for use on production?	3
	– Do you reflect the status of production site to engineering change by integration of the PLM system, digital manufacturing, and the MES systems?	4
	– Do you use the latest information technology, such as Big Data, to analyse the status of production site, and reflect it in the development of new products?	5

Exchange of Material Information between Design and Production	- Do you download E-BOM and engineering change information from the PLM system, and deliver it as a file?	1
	- Do you deliver the E-BOM and engineering change information in conjunction with the PLM system and the ERP system?	2
	- Do you send ECO with reference to material information by integration of the PLM system and the ERP system?	3
	- Do you manage the appropriate time for application of new parts by leading ECO to break point notice (BPN)- break point confirmation (BPC) procedures?	4
	- Do you determine and share the material handling such as compatibility, inventory handling, application time, etc., by the systems when engineering change occurs?	5

383

384 A.3.2 Production management and control integration

385 For evaluation of production management and control integration, questions in Table A.21 can be
 386 answered.

387 **Table A.21 – Questions for assessment of production management and control integration**

Activity	Questions	Maturity level indicator
Routing Management and Dispatching	- Do you register routing information including such as item, facility and process sequence?	1
	- Do you register routing information including standard time such as setup time and production time?	2
	- Do you make a routing in batch in conjunction with the production plan and the production status of the site?	3
	- Do you make a routing based on the schedule in real time?	4
	- When an abnormality occurs, do you make a new route in real time in conjunction with the production plan and the production status of the site?	5
Recipe Management	- Do you manage standard operation procedure (SOP) with databases?	1
	- Do you manage recipes of item-specific process or facility control program by synchronizing with the operating point?	2

	<ul style="list-style-type: none"> - Do you have recipes of the item-specific process or facility control program completed in the process development stage in the system storage? - Does the program call it and control during the operation? 	3
	<ul style="list-style-type: none"> - Do you have recipes of the item-specific process or facility control program in the system? - Are they automatically updated to the optimal recipes? 	4
	<ul style="list-style-type: none"> - Do you automatically apply the recipes of the item-specific process or facility control program before the start of the work? - Are the recipes automatically changed according to the schedule when the work is changed? 	5
Resource Allocation	<ul style="list-style-type: none"> - Do you allocate lines, processes, or facilities without conjunction with the production plan, and register them in the system? 	1
	<ul style="list-style-type: none"> - Do you make a schedule in conjunction with production plan? - Do you periodically allocate lines, processes, or facilities? - Do you register them in the system? 	2
	<ul style="list-style-type: none"> - Do you automatically allocate lines, processes, and facilities periodically in conjunction with the production plan and the production status on the site? 	3
	<ul style="list-style-type: none"> - Do you modify the lot in conjunction with the schedule and production status on the site? - Do automatically allocate lines, processes and facilities and production order adjustment? 	4
	<ul style="list-style-type: none"> - Do you automatically allocate lines, processes and facilities, and automatically adjust production order in conjunction with schedule, the production status of the site, the quality and facility forecast information? 	5

388

389 A.3.3 Production, supply and marketing integration

390 For evaluation of production, supply and marketing integration, questions in Table A.22 can be answered.

391 **Table A.22 – Questions for assessment of production, supply and marketing integration**

Activity	Questions	Maturity level indicator
Logistics Management	<ul style="list-style-type: none"> - Do you find production and product information in the logistics system? 	1

	<ul style="list-style-type: none"> - Do you find production schedule information in the logistics system? 	2
	<ul style="list-style-type: none"> - Do you find production information in real time in the logistics system? 	3
	<ul style="list-style-type: none"> - Do you reflect the logistics information to the production system? 	4
	<ul style="list-style-type: none"> - Do you reflect the logistics information to the production system in real time? 	5
Sales Management	<ul style="list-style-type: none"> - Do you find production and product information in the sales system? 	1
	<ul style="list-style-type: none"> - Do you find production schedule information in the sales system? 	2
	<ul style="list-style-type: none"> - Do you find production information in real time in the sales system? 	3
	<ul style="list-style-type: none"> - Do you reflect the sales information to the production system? 	4
	<ul style="list-style-type: none"> - Do you reflect the sales information to the production system in real time? 	5

392

393 A.3.4 Operation decision support

394 For evaluation of operation decision support, questions in Table A.23 can be answered.

395 **Table A.23 – Questions for assessment of operation decision support**

Activity	Questions	Maturity level indicator
Decision Support System Management	<ul style="list-style-type: none"> - Do you manually register company's operating information in the system that supports decision making? 	1
	<ul style="list-style-type: none"> - Do you automatically collect KPI information about operations and use them for monitoring and decision making? 	2
	<ul style="list-style-type: none"> - Do you automatically collect periodic analysis of company operation and correspondence information, and use them in the system to support decision making? 	3
	<ul style="list-style-type: none"> - Do you automatically collect real time analysis of company operation and response information? 	4
	<ul style="list-style-type: none"> - Do you use the collected real time analysis and response information to support decision making? 	
	<ul style="list-style-type: none"> - Do you automatically collect what-if analysis and response information? 	5
	<ul style="list-style-type: none"> - Do you use the collected what-if analysis and response information to support decision making? 	

396

397 **A.4 Collaborative integration aspect assessment**

398 For evaluation of collaborative integration, questions in Table A.24 can be answered.

399 **Table A.24 – Questions for assessment of collaborative integration**

Activity	Questions	Maturity level indicator
Planned-Order Collaboration (Partner's perspective)	– Do you use customer's system to inquire and check customers' production plans?	1
	– Do you receive and respond to the planned order (PO) and the delivery order (DO) in conjunction with customer's system for cooperation?	2
	– Do you have cooperation that guarantees delivery commitment based on customer's production plan in conjunction with all the customers' system?	3
	– Do you have an international standard electronic data interchange (EDI) system that can deal with all parent companies?	4
	– Do you make a delivery commitment to the parent company?	
	– Do you make a delivery commitment to the parent company according to the real time required schedule?	5
Procurement Collaboration (Customer's perspective)	– Do you provide ordering information and confirmed production plans?	1
	– Do you receive confirmation information including subcontracting information?	
	– Do you receive partner's production results and quality data?	2
	– Do you trace the quality history of the product?	
	– Do you support the various collaborative methods, for example, Internet, 1:1 specific communication system, EDI, etc., with partner's system?	3
	– Do you receive SPC data?	
	– Do you analyse the received SPC data in real time?	
	– Do you check the production status, process status, and logistics status of partner company in real time ?	4
	– Do you manage the risks?	
	– Are you able to adjust the deadline by the system when an abnormal situation occurs?	
Production Collaboration	– Do you use crowdsourcing?	5
	– Do you provide the customer with the production progress by the system?	1

(Partner's perspective)	- Do you provide the customer with the quality data?	2
	- Do you provide the customer with SPC data acquired from the machinery and processes in real time?	3
	- Do you forecast the risks other than SPC such as material shortages, equipment and process abnormalities, natural disasters, etc?	4
	- Do you inform the customer immediately of the forecasted risks?	
	- Do you share the controlled situation for the risks in real time with the customer?	5
Development Collaboration	- Do you register and share collaboration information including schedule?	1
	- Does a client periodically approve the development by partner companies, and is this history managed by the system?	2
	- Do you share and verify the development information in stages and carry out mass production approval?	3
	- Do you manage developments with one project or one process?	4
	- Do you reflect issue when it occurs?	5

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Bibliography

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