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BSI Standards Publication

Automation systems and integration — Assessment on convergence of informatization and industrialization for industrial enterprises

Part 2: Maturity model and evaluation methodology

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National foreword

This British Standard is the UK implementation of ISO 22549-2:2020.

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Automation systems and integration — Assessment on convergence of informatization and industrialization for industrial enterprises —

Part 2: Maturity model and evaluation methodology

Systèmes d'automatisation et d'intégration — Évaluation de la convergence de l'informatisation et de l'industrialisation pour les entreprises industrielles —

Partie 2: Modèle de maturité et méthodologie d'évaluation

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Foreword

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

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 05, *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.

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

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Introduction

Convergence of informatization and industrialization (CII) refers to a process that integrates information technology into industrial production. The purpose of convergence is to improve productivity and resource allocation by digital transformation.

This improvement consists of:

— increasing the integration of production and resource allocation (internally and with each other);

— making production and resource allocation more dynamic and responsive to external changes;

— optimizing production and resource allocation.

The purposes of this document include is to provide industrial enterprises guidance for:

— assessing the current situation of CII

— finding weakness within the CII

— identifying ways to improve CII

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

— independent third-party, e.g. a consulting company or government department, that assesses the maturity of CII;

— organization in charge of production management department, quality management department, inventory management department, etc., which sponsors an assessment of itself or a subordinate organization;

— any other enterprises who have interest in digital transformation.

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Automation systems and integration — Assessment on convergence of informatization and industrialization for industrial enterprises —

Part 2:
Maturity model and evaluation methodology

1 Scope

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

— maturity model definition;

— principles of evaluation questionnaires; and

— guidance for a maturity evaluation method.

2 Normative references

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

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

3 Terms and definitions

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

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

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

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

3.1
maturity model
set of information that indicate the maturity of CII, its descriptive name and characteristics

3.2
maturity level indicator
maturity level
identified extent of measured effect within the *maturity model* (3.1)

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

3.3
evaluation questionnaire
list of questions used to evaluate and determine the *maturity level* (3.2)

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3.4
maturity evaluation
method for determining the *maturity level* (3.2) of an industrial enterprise using responses to the *evaluation questionnaire* (3.3)

4 Abbreviated terms

ACII	assessment on convergence of informatization and industrialization
BOM	bill of material
CAD	computer aided design
E-BOM	engineering BOM
ECO	engineering change order
EHS	environment, safety and health
ERP	enterprise resource planning
IT	information technology
M-BOM	manufacturing BOM
MES	manufacturing execution system
PLM	product lifecycle management
SPC	statistical process control
WIP	work in process

5 Maturity model

The maturity model consists of maturity levels where each level consists of a maturity level indicator, descriptive name, and characteristics relevant to the desired assessment information as shown in Table 1. These characteristics guide to create questions to evaluate maturity levels, which are given in Annex as examples.

Table 1 — Maturity model definition

Maturity level indicator	Descriptive name	Characteristics
Level 0	Unidentified	Little or no systematic documentation available
Level 1	Identified	Tracking and traceability of materials, data and etc.
		Registration and management of data using information collection devices and systems
Level 2	Measured	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	Data analysis based on aggregated data for support of decision making

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Table 1 *(continued)*

Maturity level indicator	Descriptive name	Characteristics
Level 4	Optimized	Optimized automation of processes throughout the intra-enterprise and/or the inter-enterprises
Level 5	Autonomous	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

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

Each maturity level is inclusive of the lower maturity levels (see Figure 1), such that the higher maturity level also includes all the characteristics of the lower levels.

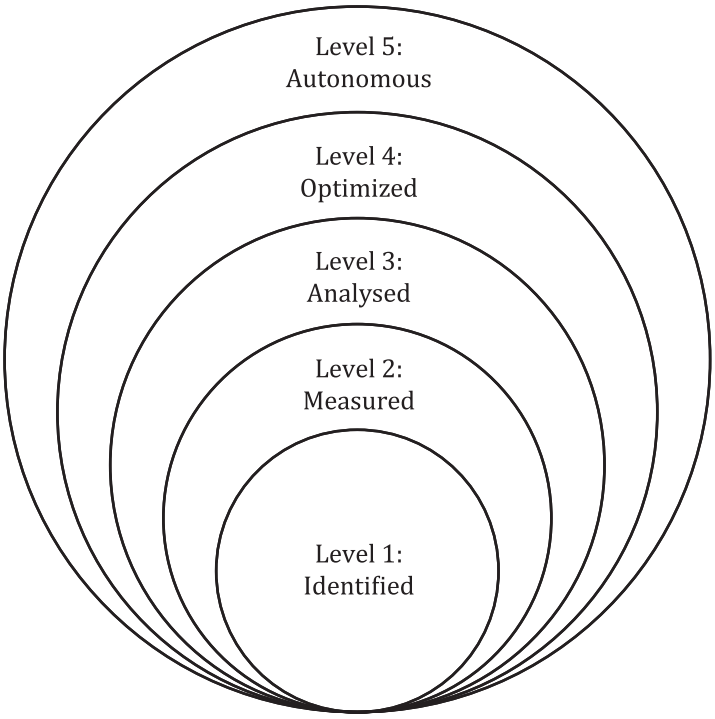

Figure 1 — Maturity level (inclusive)

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

6 Principles of evaluation questionnaires for ACII reference model components

6.1 General

Figure 2 presents assessment reference model defined in ISO 22549-1. Four aspects are grouped by the blue-dotted line which twenty-four subordinate components to four aspects are grouped by the red-dotted line.

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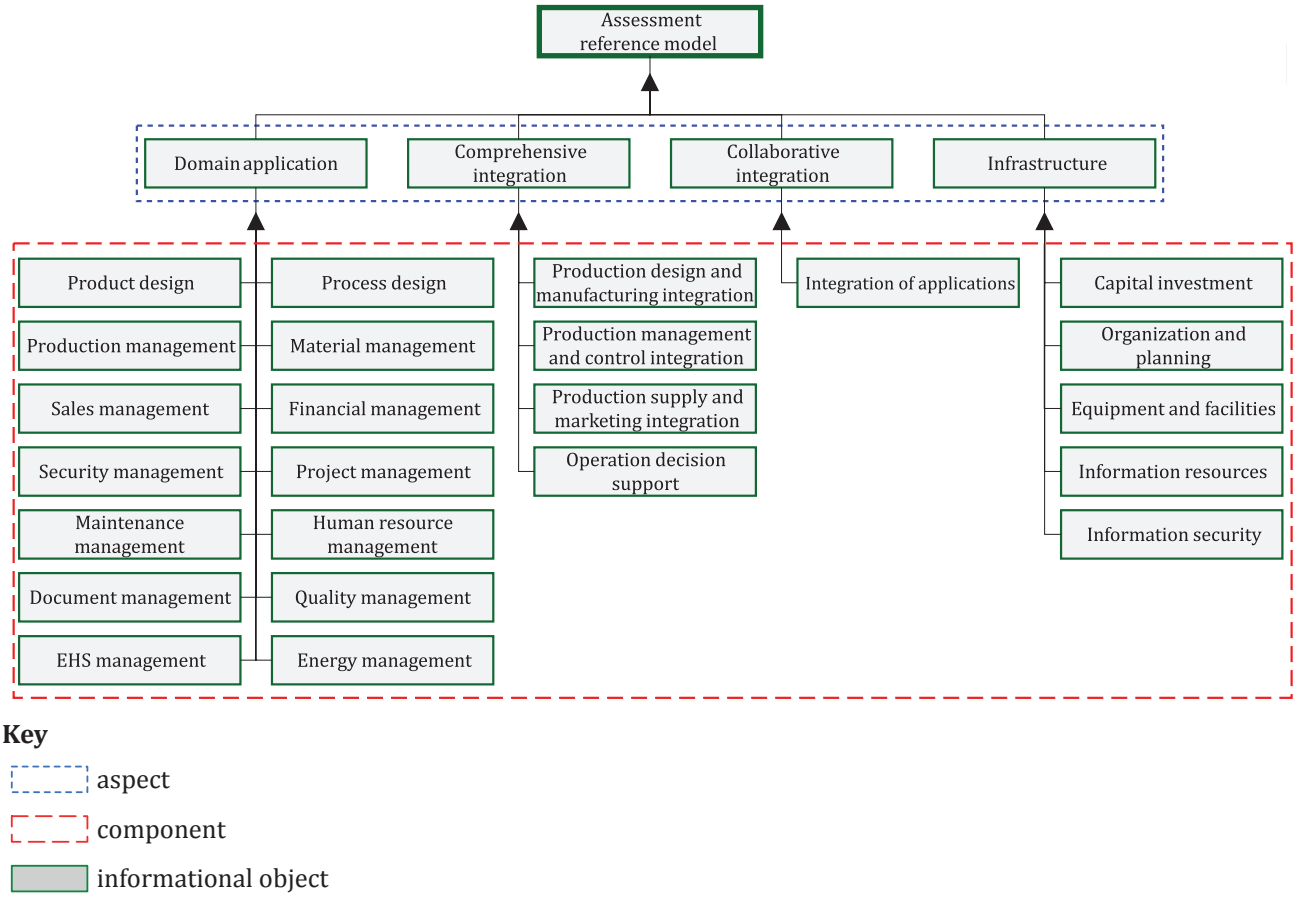

Figure 2 — Assessment reference model (aspect and its subordinate component)

In general, each ACII reference model component consists of one or more activities, for example, product design requires commodity planning, design automation, bill of material (BOM)/Parts management, engineering change management, etc.

For ACII, each ACII reference model component has to be evaluated in the level of its activities, and each activity has a set of questions to answer for each maturity level. Question answers shall be “YES” or “NO.”

Evaluation of maturity level using questionnaires is well-known and a common way, since it is easy to make answers to the given questions and evaluate the maturity level based on the answers.

Table 2 shows the structure of questions for evaluation.

Table 2 — Structure of question for maturity evaluation

Activity	Question	Maturity level indicator
Activity name 1	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

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Table 2 *(continued)*

Activity	Question	Maturity level indicator
Activity name 2	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
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
Activity name N	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

— **Activity**:

Activity of ACII reference model component.

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

— **Question**:

Questions to assess maturity level satisfaction, and the answer shall be “YES” or “NO”.

All questions in all activities in a given level need to be evaluated and all must be “YES” to proceed to the next level questions by applying guidance for maturity evaluation method given in 7.

Annex A gives examples of a whole set of questions for all ACII reference model components.

— **Maturity level indicator**:

Maturity level used for maturity evaluation.

6.2 Activity of ACII reference model component for evaluation

6.2.1 Infrastructure aspect assessment

6.2.1.1 Capital investment

Capital investment should be evaluated in terms of construction of automation and informatization, operation and maintenance of the information system as shown in Table 3.

Table 3 — Activity of capital investment for evaluation

Activity	Description
Capital investment	Investment to the IT equipment and systems

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6.2.1.2 Organization and planning

Organization and planning should be evaluated in terms of team of personnel, establishment of the organization, authority and defining of strategy related to the field of automation and informatization as shown in Table 4.

Table 4 — Activity of organization and planning for evaluation

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

6.2.1.3 Equipment and facilities management

Equipment and facilities management should be evaluated in terms of management of information equipment and facilities, industrial equipment and facilities as shown in Table 5.

Table 5 — Activity of equipment and facilities management for evaluation

Activity	Description
Equipment and facilities management	Management of information and industrial equipment and facilities

6.2.1.4 Information resources management

Information resources management should be evaluated in terms of construction of the information resources as shown in Table 6.

Table 6 — Activity of information resources management for evaluation

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

6.2.1.5 Information security management

Information security management should be evaluated in terms of protection of information security as shown in Table 7.

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

6.2.2 Domain application aspect assessment

6.2.2.1 Product design

Product design should be evaluated in terms of digitalized model of the product, digital examination, comprehensive design and optimization, and intelligent design of a product as shown in Table 8.

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Table 8 — Activity of product design for evaluation

Activity	Description
Design environment analysis	Analysis of IT environment for product design to collect and analyse product design information
Product planning	Process of identifying and articulating market requirements that define a product's feature set such as creation of a product idea, price, distribution and promotion, etc
Design automation	Use of designing software systems and smart connected technology for design such as computer aided design (CAD), computer aided engineering (CAE), augmented reality and virtual reality
BOM/parts management	Management of both engineering BOM (E-BOM) and manufacturing BOM (M-BOM) using IT systems
Engineering change management	Management of both engineering change order (ECO) and engineering change request (ECR) using IT systems
Prototyping	Use of IT systems and applications for prototyping and its validation
Advance quality management	Quality management of product in prototyping stage

6.2.2.2 Process design

Process design should be evaluated in terms of design of process flow or planning, analysis of dynamic simulation, process control and parameter optimization and integrated process design as shown in Table 9.

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

6.2.2.3 Production management

Production management should be evaluated in terms of production planning and scheduling, production management, material requirement planning, distribution management, and outsource planning and management as shown in Table 10.

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

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6.2.2.4 Materials management

Material management should be evaluated in terms of purchasing, inbound logistics, and management of suppliers in the materials management of product as well as the e-commerce purchasing as shown in Table 11.

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

6.2.2.5 Sales management

Sales management should be evaluated in terms of management of sales, management of the inventory of finished products, logistics distribution, after-sales services and management of suppliers in the sales management of the product as well as the e-commerce sale as shown in Table 12.

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

6.2.2.6 Financial management

Financial management should be evaluated in terms of accounting management, capital management, accounting statement and analysis, cost management and financial budgeting management as shown in Table 13.

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

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