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

Part 1: Framework and reference model

ICS: 25.040.01

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

This document was prepared by 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.

Introduction

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

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

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

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

- for assessing the current situation of CII,
- for finding weakness within the CII,
- for identifying ways to improve CII.

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

- Unaffected third party assessor, e.g. a consulting company or government department, which conducts a convergence of informatization and industrialization assessment;
- Responsible organization, e.g. production management department, quality management department, inventory management department, etc., which sponsor an assessment of itself or a subordinate organization;
- Other industrial sector enterprises.

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

Part 1: Framework and reference model

1 Scope

This part of the standard defines the basic principles for an assessment concerning the convergence of informatization and industrialization in industrial enterprises. The scope of this part of the standard includes the following:

- Assessment framework definitions;
- Assessment reference model definitions;
- Assessment reference model components.

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 15704, *Industrial automation systems — Requirements for enterprise-reference architectures and methodologies*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1 **industrialization**

procedure of increasing productivity using sequential task allocation to automated or semi-automated methods, or to individuals

3.2 **informatization**

procedure of generating information from data within a given context using computing and communication technologies

3.3 **Convergence of informatization and industrialization (CII)**

integrating information technology into industrial production, which promotes the development of industry towards a higher value-added direction through wide application of information and restructuring of traditional industry

3.4

domain application

application of information technology in a single business activity that has a well-defined and identifiable boundary of responsibility and authority for subordinate activities

3.5

Level 4

functions involved in the business-related activities needed to manage a manufacturing organization

[SOURCE: IEC 62264-1:2013, 3.1.16]

3.6

Level 3

functions involved in managing the work flows to produce the desired end-products

Level 2

functions involved in monitoring and controlling of the physical process

[SOURCE: IEC 62264-1:2013, 3.1.17]

3.7

enterprise domain

domain that includes all the activities in Level 4 and information that flows to and from Level 3

[SOURCE: IEC 62264-1:2013, 3.1.11]

3.8

business activity

partially ordered set of enterprise activities on level 3 and level 4 of functional hierarchy defined in IEC 62264

3.9

comprehensive integration

the process of linking together functional applications within an enterprise

3.10

collaborative integration

the process of linking together functional applications between different enterprises

3.11

reference model

an abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication

Note 1 to entry: A reference model can represent the component parts of any consistent idea, from business functions to system components, as long as it represents a complete set. This frame of reference can then be used to communicate ideas clearly among members of the same community.

3.12

assessment objective

statement, provided as part of the assessment input, which defines the reasons for performing the assessment

[SOURCE: ISO/IEC 33001:2015, 3.2.6]

3.13

assessment expert team

one or more professional individuals who jointly perform an assessment process

[SOURCE: ISO/IEC 33001:2015, 3.2.10, modified – the word “professional” has been added before individuals.]

3.14

assessment framework

schema for use in characterizing an industrial enterprise quality characteristic of an implemented industrial enterprise

4 Symbols (and abbreviated terms)

CII Convergence of informatization and industrialization

ACII Assessment on convergence of informatization and industrialization

OPM Object-Process Methodology

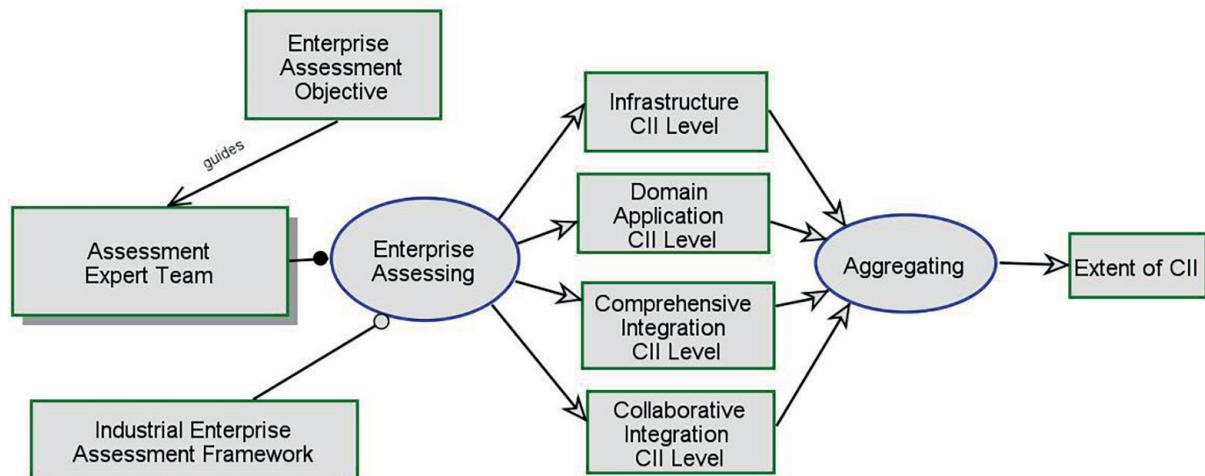
5 Overview of Assessment

5.1 General

The assessed objects of a CII assessment include enterprise manufacturing activities, enterprise business activities and enterprise infrastructure. Manufacturing activities are associated with manufacturing operations management. Business activities are considered to be a partially ordered set of enterprise activities that execute to achieve some desired end-result in pursuit of a given objective of an enterprise or part of an enterprise distinct from manufacturing.

For assessment of CII, data shall be acquired from Level 2, Level 3 and Level 4 to answer questionnaires. However, this document covers enterprise activities beyond Level 4 that are not directly related to manufacturing.

5.2 Enterprise assessing system



NOTE [Figure 1](#) uses the graphical notation of ISO 19450 Object-process methodology.

Figure 1 — Enterprise assessing system

[Figure 1](#) depicts the architecture of the enterprise assessing system, and describes the relationship of Enterprise Assessing process with its input and output objects which aggregate into Extent of CII using the Aggregating process.

Assessment Expert Team enables Enterprise Assessing, which requires Industrial Enterprise Assessment Framework.

Enterprise Assessment Objective guides Assessment Expert Team.

Enterprise Assessment Objective includes:

- 1) to assessment of the current situation of CII,
- 2) identification of weakness within the CII,
- 3) identification of ways to improve CII.

The extent of CII shall be assessed in terms of infrastructure aspect, domain application aspect, comprehensive integration aspect and collaborative integration aspect within that enterprise by the Enterprise Assessing process. Enterprise Assessing process results are the Infrastructure CII Level, Domain Application CII Level, Comprehensive Integration CII Level and Collaborative Integration CII Level which aggregate into Extent of CII.

5.3 Industrial enterprise assessment framework

Industrial Enterprise Assessment Framework consists of Evaluation Questionnaires, Maturity Model, and Assessment Reference Model. Assessment Reference Model supports Evaluation Questionnaires and Maturity Model, as shown in [Figure 2](#).

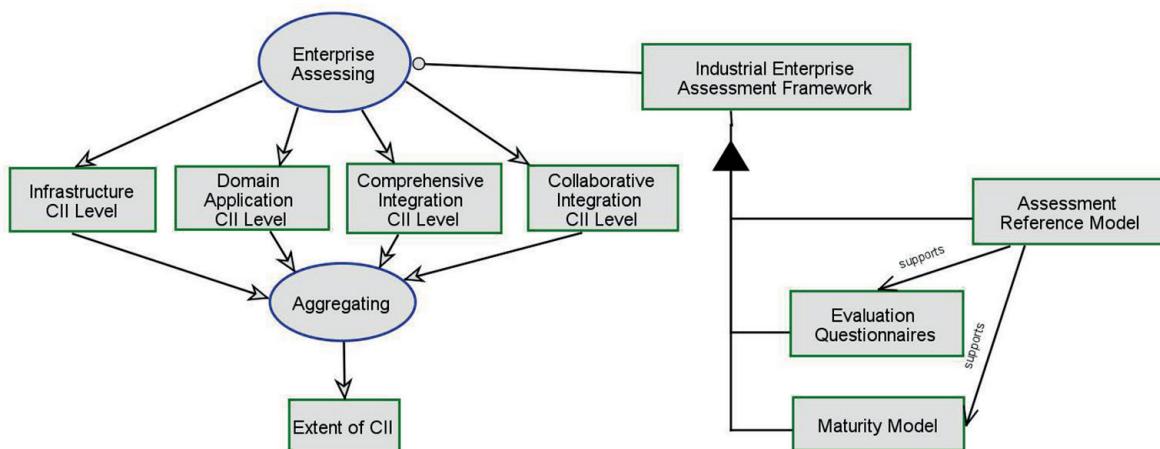


Figure 2 — Industrial Enterprise Assessment Framework

6 Assessment reference model definitions

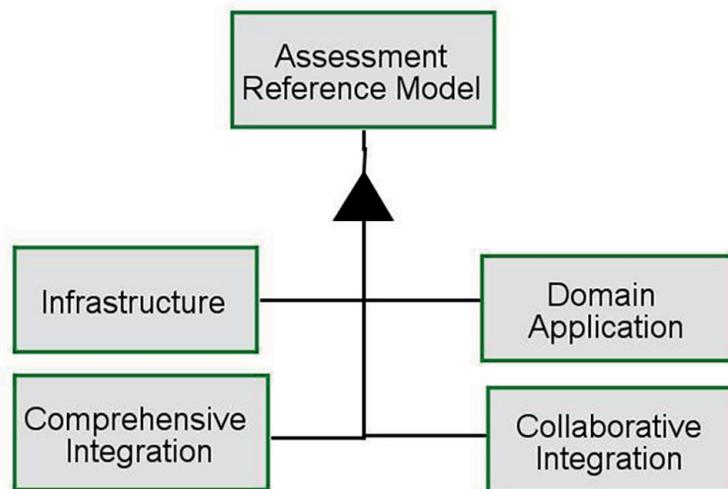


Figure 3 — Assessment Reference Model

Figure 3 depicts the structure of Assessment Reference Model and its constituents. The Enterprise Assessing process should refer to the following aspects:

- Infrastructure
- Domain Application
- Comprehensive Integration
- Collaborative Integration

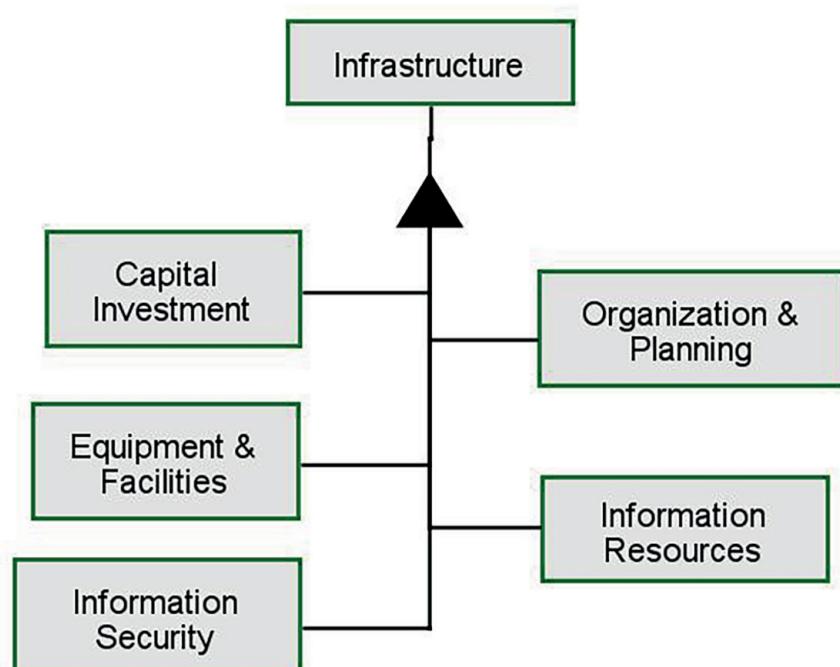


Figure 4 — Infrastructure aspect

The assessment on Infrastructure aspect should be made on the construction of the infrastructure and conditions related to CII.

Infrastructure consists of Capital Investment, Organization and Planning, Equipment and Facilities, Information Resources, and Information Security.

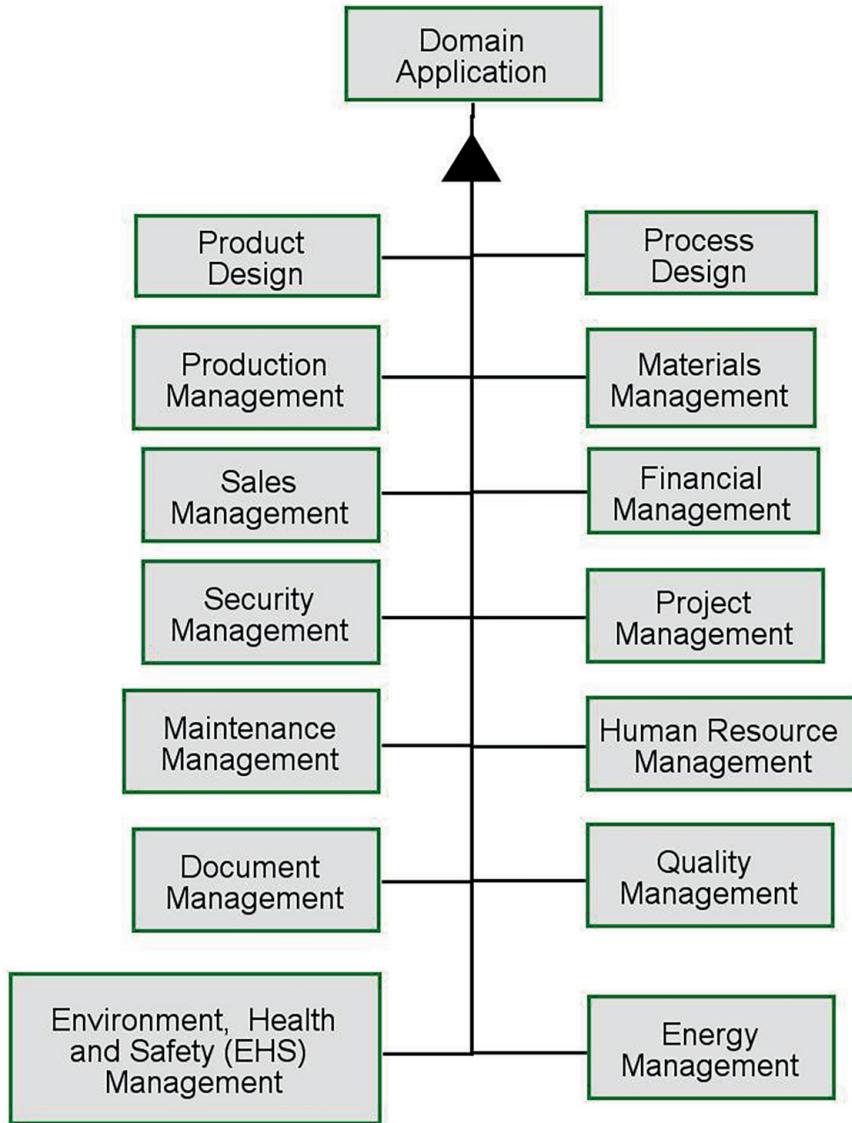


Figure 5 — Domain Application aspect

The assessment on Domain Application aspect should be made on the application of information technology in a single business activity that has a well-defined and identifiable boundary of responsibility and authority for subordinate activities.

Domain Application consists of Product Design, Process Design, Production Management, Materials Management, Sales Management, Financial Management, Security Management, Project Management, Maintenance Management, Human Resource management, Document Management, Quality Management, Environment, Health and Safety (EHS) Management, and Energy Management.

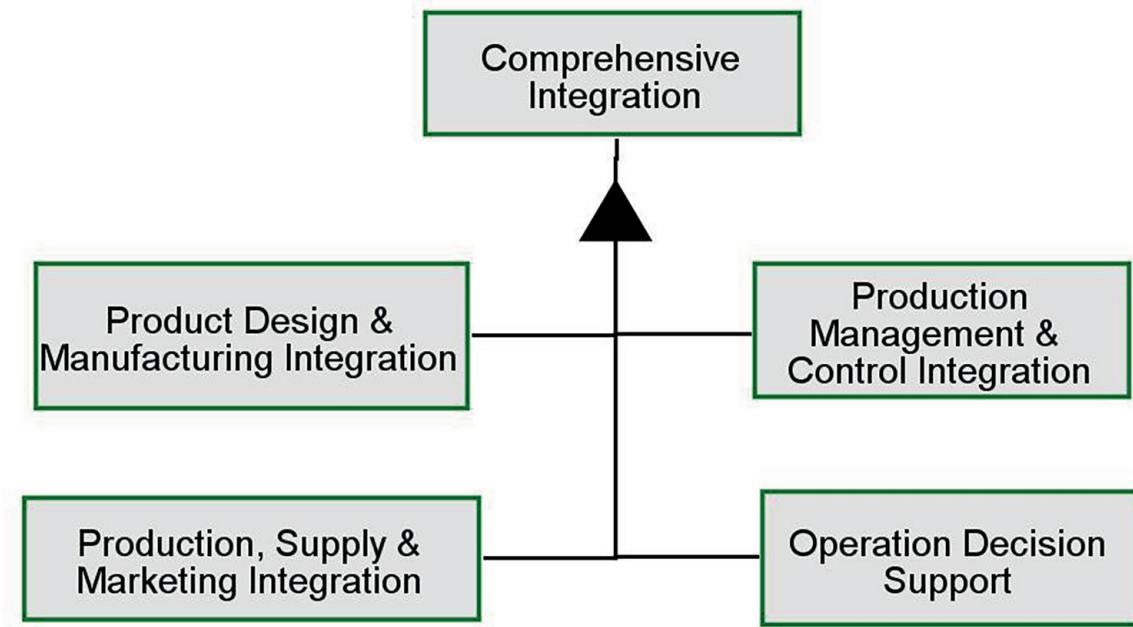


Figure 6 — Comprehensive Integration aspect

The assessment on Comprehensive Integration aspect should be made on the process of linking together functional applications within an enterprise.

Comprehensive Integration consists of Product Design and Manufacturing Integration, Production Management and Control Integration, Production Supply and Marketing Integration, and Operation Decision Support.

The assessment on Collaborative Integration aspect should be made on the process of linking together functional applications between different enterprises.

7 Assessment reference model components

7.1 Infrastructure aspect

7.1.1 Capital investment

The assessment of CII should examine the application of information technology for: capital investment such as the investment in construction of automation and informatization, the investment in the operation and maintenance of the information system, the investment in the R&D.

7.1.2 Organization and planning

The assessment of CII for organization and planning should examine team of personnel, establishment of the organization, authority and defining of strategy related to the field of automation and informatization.

7.1.3 Equipment and facilities

The assessment of CII for equipment and facilities should examine information equipment and facilities, industrial equipment and facilities related to the informatization.

7.1.4 Information resources

The assessment of CII should examine the application of information technology for: construction of the information resources such as collection, standardization, accumulation, integration, analysis, and management of information resources.

7.1.5 Information security

The assessment of CII should examine the application of information technology for: protection of information security such as implementation of protection of the information security, computer and networking security, information resources security and disaster preparedness, system security, security management and construction of the prevention mechanism.

7.2 Domain application aspect

7.2.1 Product design

The assessment of CII should examine the application of information technology for: product design and design processing such as digitalized model of the product, digital examination, comprehensive design and optimization, and intelligent design of a product.

7.2.2 Process design

The assessment of CII should examine the application of information technology for: process design and process execution such as design of process flow or planning, analysis of dynamic simulation, process control and parameter optimization and integrated process design.

7.2.3 Production management

The assessment of CII should examine the application of information technology for: production activities such as production planning and scheduling, production management, material requirement planning, distribution management, and outsource planning and management.

7.2.4 Materials management

The assessment of CII should examine the application of information technology for: materials management such as management of purchasing, inbound logistics, and management of suppliers in the materials management of product as well as the e-commerce purchasing.

7.2.5 Sales management

The assessment of CII should examine the application of information technology for: sales management such as 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.

7.2.6 Financial management

The assessment of CII should examine the application of information technology for: financial management such as accounting management, capital management, accounting statement and analysis, cost management and financial budgeting management.

7.2.7 Security management

The assessment of CII should examine the application of information technology for: security management such as information technology construction and application of security management, emergency response for the forecast and early warning about major sources of hazard.

7.2.8 Project management

The assessment of CII should examine the application of information technology for: project management such as research and manufacturing of product and engineering construction emphasizing

- the business scope and application of the informationalized management of both project planning and authorization,
- the business scope and contents of the informationalized management of project design, planning and budgeting, and
- the business scope and contents of the informationalized management of project implementation.

7.2.9 Maintenance management

The assessment of CII should examine the application of information technology for: maintenance management such as informationalized management of the equipment maintenance.

7.2.10 Human resource management

The assessment of CII should examine the application of information technology for: human resource management such as management of human resource planning and recruiting, training and development of the human resources, emoluments, benefits, achievement and employee relationship.

7.2.11 Document management

The assessment of CII should examine the application of information technology for: document management of the documents collected from the enterprise to be assessed.

7.2.12 Quality management

The assessment of CII should examine the application of information technology for: quality management to assure proper product quality.

7.2.13 Environment, Health and Safety (EHS) management

The assessment of CII should examine the application of information technology for: providing healthy, safe and sustainable manufacturing environments.

7.2.14 Energy management

The assessment of CII should examine the application of information technology for: assuring low energy consumption.

7.3 Comprehensive integration aspect

7.3.1 Product design and manufacturing integration

The assessment of CII for product design and manufacturing integration should examine the bidirectional flow of information between research and design, and manufacturing of product, such as data definition, data exchange and management of product specification.

7.3.2 Production management and control integration

The assessment of CII for production management and control integration should examine the integration between operation management, manufacturing execution of the plant and process control of the manufacturing enterprises.

7.3.3 Production, supply and marketing integration

The assessment of CII for production, supply and marketing integration should examine the integration of production, supply and marketing such as production according to the order, optimization of production arrangement and dynamic scheduling, integrated operation of the supply chains and the traceability on the entire process of product quality.

7.3.4 Operation decision support

The assessment of CII for operation decision support should examine the analysis of business information, knowledge mining and accumulation, business decision of the enterprises, building of the credibility of enterprises and risk management and control.

7.4 Collaborative integration aspect

The assessment of CII for collaborative integration aspect should examine the convergence of information, resources, businesses and marketing between different enterprises.

Annex A (informative)

Convention for using ISO 19450

This document utilizes object process methodology (OPM) to describe enterprise assessing system and industrial enterprise assessment framework. OPM is a compact conceptual approach, language, and methodology for modelling and knowledge representation of automation systems and their interoperation. OPM is also a formal yet intuitive paradigm for systems design, engineering, development, life cycle support, communication, and evolution. OPM notation supports the conceptual modelling of systems. Its holistic approach can describe the functional, structural and behavioral aspects of a system. Table B.1 defines the OPM notations used in this document.

Table A.1 — OPM notation used in this document

Symbol	name	Definition
	Informatical object	An object is an item that exists or can exist once constructed, physically or informatically. Associations among objects shall constitute the object structure of the system being modelled, i.e., the static, structural aspect of the system.
	Physical object	Physical object is an item that exists or can exist once constructed, physically. Associations among objects shall constitute the object structure of the system being modelled, i.e., the static, structural aspect of the system.
	Process	A process is an item that expresses the behavioural, dynamic system aspect: how processes transform objects in the system and how the system functions to provide benefit. Processes complement objects by providing the dynamic, procedural aspect of the system.
	Aggregation-participation relation link	The fundamental structural relation Aggregation-Participation is a source item that aggregates one or more other participant items, the destination items, into a meaningful whole.
	Unidirectional tagged structural link	A unidirectional tagged structural link shall have a user-defined semantics regarding the nature of the relation from one thing to the other thing. A meaningful tag, in the form of a textual phrase, shall express the nature of the structural relation between the connecting objects or connecting processes.
	Agent link	Agent is a human or a group of humans who enables the occurrence of the process to which it is linked but is not transformed by that process.
	Instrument link	Instrument is an inanimate object that enables the occurrence of the process to which it is linked but is not transformed by that process.
	Result link	A result link shall be a transforming link specifying that the linked process creates (generates, yields) the linked object, which is the resulted.
	Consumption link	A consumption link shall be a transforming link specifying that the linked process consumes (destroys, eliminates) the linked object.

Annex B (informative)

Functional hierarchy defined in IEC 62264

IEC 62264 is referenced to explain the scope of CII in terms of functional hierarchy of manufacturing systems. IEC 62264 defines functional hierarchically as follows, see Figure C.1.

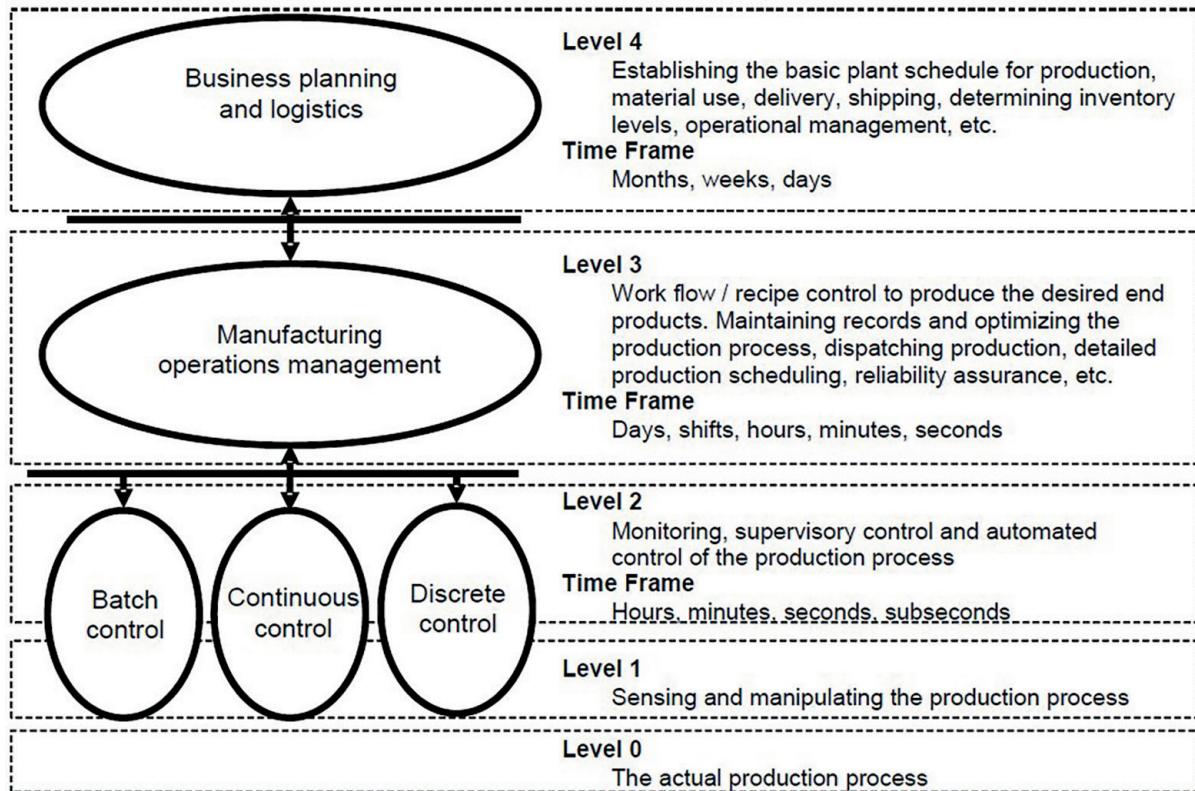


Figure B.1 — Functional hierarchy (Figure 3 of IEC 62264-1)

- Level 0 defines the actual physical processes.
- Level 1 defines the activities involved in sensing and manipulating the physical processes. Level 1 typically operates on time frames of seconds and faster.
- Level 2 defines the activities of monitoring and controlling the physical processes. Level 2 typically operates on time frames of hours, minutes, seconds and sub-seconds.
- Level 3 defines the activities of the work flow to produce the desired end-products. It includes the activities of maintaining records and coordinating the processes. Level 3 typically operates on time frames of days, shifts, hours, minutes and seconds.
- Level 4 defines the business-related activities needed to manage a manufacturing organization. Manufacturing-related activities include establishing the basic plant schedule (such as material use, delivery and shipping), determining inventory levels and making sure that materials are delivered on time to the right place for production. The information of Level 3 is critical to Level 4 activities. Level 4 typically operates on time frames of months, weeks and days.

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