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Advanced automation technologies and their applications — Requirements for establishing manufacturing enterprise process interoperability —

Part 2: Maturity model for assessing enterprise interoperability

Technologies d'automatisation avancées et leurs applications — Exigences relatives à l'établissement d'un processus d'interopérabilité pour les entreprises de fabrication —

Partie 2: Modèle de maturité pour l'évaluation de l'interopérabilité d'entreprise

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Contents

Page

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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

ISO 11354-2 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 310, *Advanced automation technologies and their applications* (as CEN/TS 16658:2014) and was adopted, under a special "fast-track procedure", by ISO/TC 184 *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*, in parallel with its approval by the ISO member bodies.

ISO 11354 consists of the following parts, under the general title *Advanced automation technologies and their applications — Requirements for establishing manufacturing enterprise process interoperability*:

— *Part 1: Framework for enterprise interoperability*

— *Part 2: Maturity model for assessing enterprise interoperability*

The following parts are planned:

— *Part 3: Requirements for information and communication technology-enabled enterprise interoperability*

Introduction

This part of ISO 11354 is based on ISO 11354-1, which describes the background and motivation for ISO 11354, and provides a framework for enterprise interoperability (FEI) for describing and representing concerns, barriers and approaches to enabling enterprise interoperability. It identifies four levels of concern (business, process, services, data) and three kinds of barriers (conceptual, technological, organizational) that are significant for enterprise interoperability, and specifies three approaches (integrated, unified, federated) to address these concerns and overcome these barriers.

This part of ISO 11354 is also based on work carried out in European projects such as ATHENA[9],[10] and INTEROP NoE[14].

The barriers and concerns identified in ISO 11354-1 are used to characterize five levels of interoperability maturity. For each combination of barriers and concerns, for all levels of interoperability maturity, mechanisms are specified to enable an enterprise to assess its interoperability capabilities, and to evaluate these against characterizations of maturity level. Two methods are then specified for overall assessment:

a) by concern and barrier, or

b) by maturity level.

An illustrative method is provided to show how concern and barrier assessments can be combined into a graphical representation, so providing an overall indication of existing enterprise capability to interoperate with others ("as is"). Additionally this analysis and representation can identify where capabilities that are needed to achieve desired higher levels of interoperability are insufficient and consequently investment or reengineering is required ("to be").

ISO 11354 focuses on, but is not restricted to, enterprise (manufacturing or service) interoperability. It is intended for use by people who are concerned to assess capabilities for enterprise interoperability and identify areas where those might need to be improved to meet the needs and ambitions of the enterprise.

Advanced automation technologies and their applications — Requirements for establishing manufacturing enterprise process interoperability —

Part 2: Maturity model for assessing enterprise interoperability

1 Scope

This part of ISO 11354 specifies:

— levels to represent the capability of an enterprise to interoperate with other enterprises;

— measures for assessing the capability of a specific enterprise to interoperate with other enterprises;

— methods for combining these measures into two kinds of overall assessment:

  — maturity level by concern and barrier, and

  — assessment relative to four designated maturity levels;

— a method for representing concern and barrier overall assessments in a graphical form and for identifying where capabilities are required to achieve desired higher levels of interoperability.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11354-1:2011, *Advanced automation technologies and their applications — Requirements for establishing manufacturing enterprise process interoperability — Part 1: Framework for enterprise interoperability*

3 Terms and definitions

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

3.1
enterprise
one or more organizations sharing a definite mission, goals, and objectives to offer an output such as a product or service

Note 1 to entry: This term includes related concepts such as extended enterprise or virtual enterprise.

[SOURCE: ISO 15704:2000, 3.6]

3.2
enterprise interoperability
ability of enterprises and entities within those enterprises to communicate and interact effectively

Note 1 to entry: Interoperability is considered as significant if the interactions can take place in at least one of the four areas of interoperability concerns: data, service, process and business.

[SOURCE: ISO 11354-1:2011, 2.1]

3.3
enterprise interoperation
interactions between enterprise entities

3.4
maturity level
decimal in the range of 0 to 4 providing a numeric representation of the highest level of enterprise interoperability maturity achieved for a particular combination of interoperability concern and interoperability barrier

Note 1 to entry: A maturity level represents the degree of ability of the set of enterprise ICT-related capabilities that determine the ability of the enterprise to interoperate with other enterprises. Other enterprises may be suppliers, customers, partners, subsidiaries or others.

Note 2 to entry: The five maturity level integer values of 0, 1, 2, 3 and 4 are designated to have the following meanings: 0 – unprepared, 1 – defined, 2 – aligned, 3 – organized, 4 – adaptive, possibly with intermediate values representing partial and intermediate states between these levels. These five level values are further specified in 7.2.

3.5
interoperability approach
manner in which interoperability problems are solved and barriers are overcome

Note 1 to entry: ISO 11354-1 defines three interoperability approaches: integrated, unified and federated.

[SOURCE: ISO 11354-1:2011, 2.4]

3.6
interoperability barrier
incompatibility between entities within the enterprise that obstructs the exchange of information and other items, the utilization of services or the common understanding of exchanged items

Note 1 to entry: ISO 11354-1 defines three categories of barriers: conceptual, technological and organizational.

[SOURCE: ISO 11354-1:2011, 2.2]

3.7
interoperability concern
aspect of interaction or interoperation that is of interest to an enterprise stakeholder

Note 1 to entry: ISO 11354-1 defines four areas of interoperability concerns: data, service, process and business.

[SOURCE: ISO 11354-1:2011, 2.3]

3.8
interoperability practice measure
assessment, evaluated relative to each of the five specific maturity level values 0 to 4, for each of the four kinds of interoperability concern (business, process, service and data) of an enterprise's practices and hence capability to overcome each of the three kinds of interoperability barrier (conceptual, technological, organizational), expressed in terms of the most appropriate interoperability level

3.9
interoperability practice classification
enterprise practice classification corresponding to each combination of concern, barrier and level

3.10
maturity model
representation of degree of the ability of the set of enterprise ICT-related capabilities to interoperate with other enterprises

Note 1 to entry: The model will cover only those parts (entities) of the enterprise, which are to be involved in the information exchange.

4 Abbreviated terms

ATHENA	Advanced Technologies for Heterogeneous Enterprise Networks and their Applications
FEI	Framework for Enterprise Interoperability
ICT	Information and Communication Technology
INTEROP	Interoperability Research for Networked Enterprises Applications and Software
SME	Small or Medium size Enterprise

5 Conformity with this part of ISO 11354

In order to claim conformity with this part of ISO 11354, any particular interoperability solution shall address the normative requirements of Clauses 7, 8 and 9.

6 Basic concepts of enterprise interoperability

6.1 Enterprise interoperability

The concept of enterprise interoperability refers to the ability of enterprises (or part of them) to interact with other enterprises (or other parts of the same enterprise) through the exchange of information and other items such as material objects, energy, etc. Interoperability is seen as a necessary support to allow business collaboration to happen, but interoperability is only a means and not the business collaboration itself. It should also be noted that the concept of enterprise interoperability generally applies to both inter- and intra-enterprise activities and includes extended enterprise, virtual enterprise and sub-systems of one enterprise, be they distributed, networked or located in a single site, and whatever their type (discrete or continuous production), nature (for example manufacturing or service) or scale (large companies or SMEs).

NOTE 1 Enterprise interoperability is not an all or nothing situation. There are different extents and different kinds of enterprise interoperability. It is not appropriate to say that enterprise A is interoperable but that enterprise B is not. One needs to say how much interoperability (what extent? which functionality?) exists or is needed within the appropriate business context and the tasks on hand.

NOTE 2 Enterprise interoperability is not aiming at providing interchange ability for the enterprise system as a whole, but at providing the necessary means only for those parts directly involved in the interaction.

A high level of interoperability cannot be achieved for free. It is generally costly and time consuming. Each enterprise shall define its needed interoperability requirements and the maturity level to reach. It is not recommended that all enterprises seek to reach the highest interoperability level regardless of their needs. An enterprise will need to carry out an assessment of the benefits, costs and impacts of making such a move, and the particular need to consider environmental aspects in that assessment by reference to the CEN environmental checklist and similar documents.

6.2 Framework for enterprise interoperability

ISO 11354-1 defines a three-dimensional framework (illustrated in Figure 1) that allows one to identify and relate causes and effects of interoperability problems, and to identify relevant approaches and potential solutions for those problems.

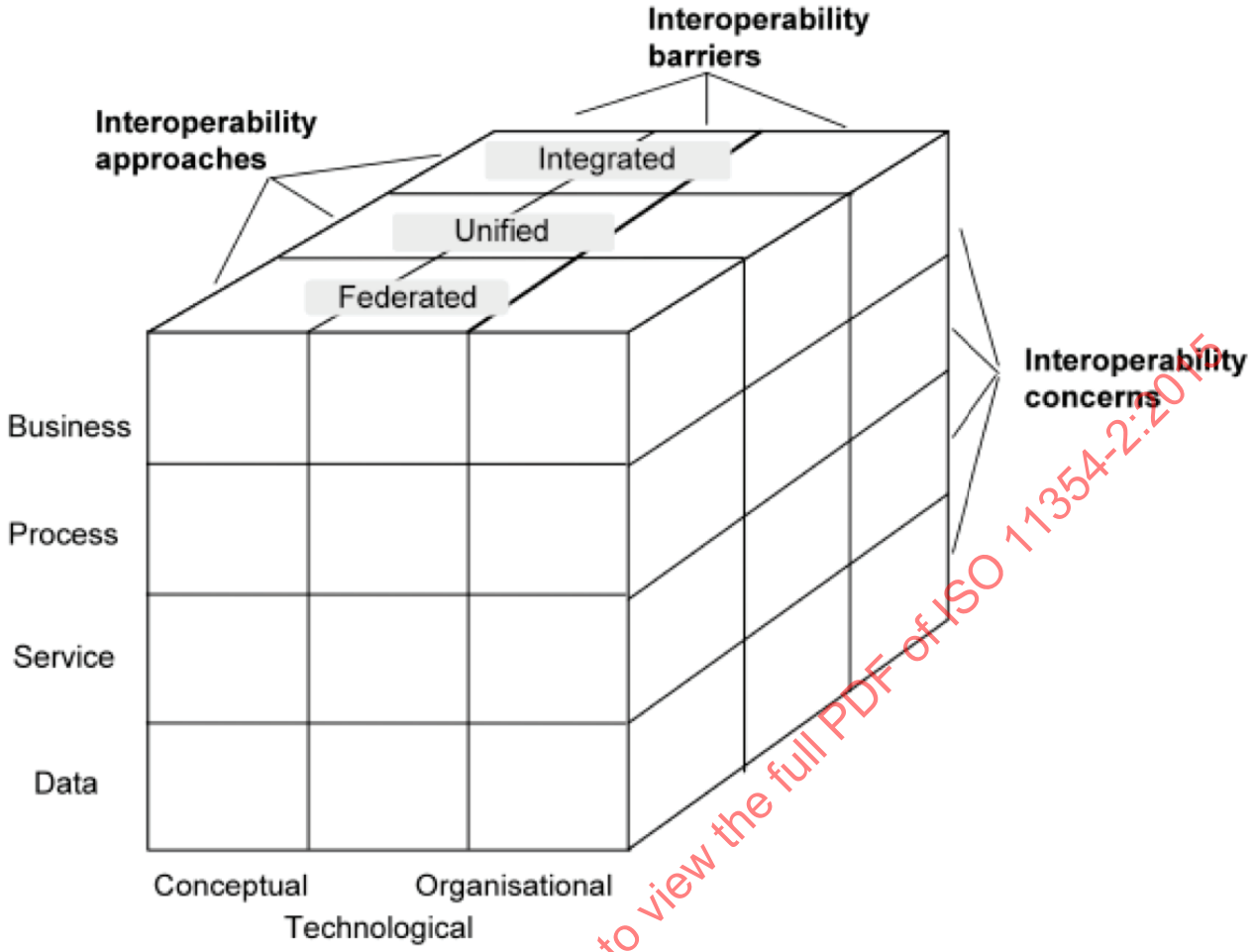

Figure 1 — Framework for enterprise interoperability

7 The maturity model for enterprise interoperability (MMEI)

7.1 Scope of model

The MMEI covers the two main dimensions of the Framework for Enterprise Interoperability (four kinds of interoperability concern and three kinds of interoperability barrier). It also considers relations to the dimension of the interoperability approach (integrated, unified or federated).

7.2 Overview of the levels of interoperability maturity

Enterprise interoperability maturity can be evaluated in two situations:

a) *a priori*, where the evaluation relates to the interoperability potentiality (i.e. with a possible future other enterprise whose identity is not known at the moment of evaluation), or

b) *a posteriori*, where interoperation between known other enterprises is needed and the assessment is concerned with the existing interoperability situation (i.e. considering the incompatibilities between two known systems).

The five specific levels of enterprise interoperability maturity shall be defined as shown in the Table 1 and further detailed in Clause 8. Each level identifies a certain degree of capability required to establish or improve interoperability.

Enterprise interoperability maturity can be represented in two different ways:

— relative to each combination of concern and barrier, or

— relative to each of the five specific maturity level values of 0 to 4.

Table 1 — Enterprise interoperability maturity levels

Maturity level	Capability for interoperation
Level 0 - Unprepared	The enterprise has no capability for or intention to enable interoperation
Level 1 - Defined	The enterprise is capable of properly modelling and describing its systems to prepare for limited interoperation
Level 2 - Aligned	The enterprise is capable of making necessary changes to align its operation to common formats or standards
Level 3 - Organized	The enterprise is capable of using meta modelling to achieve the mappings needed to interoperate with other compatible enterprises
Level 4 - Adaptive	The enterprise is capable of negotiating with and dynamically accommodating any other enterprise

Levels 0 and 1 correspond to the situation where there are no or only ad hoc interoperations. From levels 2 to 4, levels of maturity are defined corresponding to the interoperability approach dimension of the FEI (integrated, unified and federated).

Table 2 shows the mapping between maturity levels and interoperation environments created according to the different approaches identified in the framework.

Table 2 — Maturity levels vs. interoperation environments

Maturity level	Interoperation environments
Level 0 - Unprepared	Isolated: The interoperation environment can exchange information only through manual mechanisms (document, fax, etc.)
Level 1 - Defined	Connected: In the interoperation environment information can be exchanged only though simple electronic exchange such as messaging
Level 2 - Aligned	Integrated: The interoperation environment has a commonly agreed format (or standard) to which all other enterprises can build their systems or components thereof
Level 3 - Organized	Unified: The interoperation environment uses meta-models, so allowing heterogeneous systems to be mapped one to another
Level 4 - Adaptive	Federated: The interoperation environment has no pre-defined format or meta-models, instead interoperation can adjust and accommodate dynamically using information which has been defined a priori (e.g. available capability and capacity, entity profiles)

Each level of maturity also corresponds to a degree of interoperability ranging from no interoperability to full interoperability as shown in Table 3.

Table 3 — Maturity levels and degree of interoperability

Maturity level	Interoperability degree
Level 0 - Unprepared	Interoperability is non-existent or required manual intervention
Level 1 - Defined	Interoperability is limited with only some ad hoc interoperations
Level 2 - Aligned	Interoperability is restricted to peer-to-peer relations that use a common format or standard
Level 3 - Organized	Interoperability is extended, allowing many-to-many relations with multiple heterogeneous other enterprises
Level 4 - Adaptive	Interoperability is generally achieved, allowing full interoperability with many other enterprises

Table 4 gives one high level view of the MMEI characterizing the different kinds of interoperability barriers.

Table 4 — Characterizing the kinds of interoperability barriers

Conceptual	Technological	Organizational
Different concepts for entity representation (incompatibilities in graphics, syntactics, semantics and semiotics)	Discontinuities in the entity exchange path (incompatible interfaces, exchange protocols, services, and data storage devices)	Inability of management to accommodate changes sufficiently in a timely fashion

Table 5 gives another view of the MMEI showing the kind of capability characterizing each maturity level for each kind of interoperability barrier. Characterizations are further detailed in Clause 8.

Table 5 — Characterizing MMEI levels by enterprise capabilities for interoperation

→Maturity barriers Maturity levels↓	Conceptual	Technological	Organizational
Level 0 – Unprepared	Unidentified entities	Inaccessible platforms and applications	Undefined authorities/ responsibilities
Level 1 – Defined	Described and modelled entities	Connectable platforms and applications	Specified authorities and responsibilities
Level 2 – Aligned	Accepted enterprise concepts (commonly represented and understood or understandable by other enterprises)	Arranged infrastructure (pre-configured resources which enable information exchange)	Coordinated organization (aligned organization structures enabling coherent management of interoperation)
Level 3 – Organized	Established relations (meta modelling for mapping between relevant enterprises' concepts)	Harmonized infrastructure (meta modelling for mapping between components – an open architecture)	Harmonized organizations (meta modelling for mapping between organizational structures)
Level 4 – Adaptive	Accommodated concepts (preconceived or mutually agreed adoption of enabling concepts)	Dynamically reconfigurable infrastructure (the communication paths are adjusted automatically)	Agile and proactive management (capable of fast organizational reconfiguration to accommodate changes)

In the following clauses, each maturity level is defined by a table based on the FEI dimensions of interoperability concern and interoperability barrier. Each cell lists capabilities that are necessary to reach a particular interoperability maturity level. The transition from one level to a higher one corresponds generally to a removal of interoperability barriers and satisfaction of requirements.

NOTE A lower interoperability maturity for a company does not mean a systematic dysfunction at all levels and for all functions of the company. The maturity is only evaluated from the interoperability point of view and cannot be applied for other purpose.

8 Specification of the five maturity levels

8.1 Maturity level 0 — Unprepared

The lowest level of interoperability maturity shall be characterized by the proprietary and heterogeneous nature of systems. None of the system resources is intended to be shared with other systems. Systems modelling and description are not complete or even non-existent. The organizational structure and responsibilities are not explicitly specified. There is in general no collaboration and, in particular, no interoperation with other enterprises. Communication with others remains mainly through manual exchange. Systems run stand-alone and are not prepared for interoperation.

The level 0 of interoperability maturity is characterized in Table 6.

Table 6 — Description of the interoperability maturity level 0

		Conceptual	Technological	Organizational
Level 0 - Unprepared	Business	Heterogeneous visions, strategies, and policies, not described or modelled	Islands of automation. lacking enterprise wide ICT infrastructures or platforms	
	Process	Heterogeneous processes, not properly described	Manual processes without ICT support	Responsibilities and authorities not explicitly defined, or not identifiable by other enterprises
	Service	Heterogeneous services, not described or modelled	Stand-alone services and applications	
	Data	Heterogeneous data, not described or modelled	Data storage devices not interconnected, only manual data exchange	

8.2 Maturity level 1 — Defined

This level of interoperability maturity shall be characterized by the limited extent of possible interoperations and ability to interconnect. Although the actual or envisaged systems are still entirely distinct, some ad hoc interoperations can take place but the interoperability remains very limited. Some basic ICT devices are connectable. Simple electronic data exchange becomes possible. In general, systems and organizations are defined and possibly modelled. Modelling tools may be in place and used at design time when specifying systems, but these tools are technology dependent and can run only on specific platforms. Responsibilities and authorities to define, model, update and maintain data, services and processes are also explicitly defined and formally documented.

The description of this level is characterized in Table 7.

Table 7 — Description of interoperability maturity level 1

		Conceptual	Technological	Organizational
Level 1 - Defined	Business	Described and documented business strategies and policies	Installed and in-use basic ICT infrastructure and platforms	
	Process	Defined and documented processes	Limited ICT support for processes, enabling ad hoc process information exchange	Defined and established organizational structures
	Service	Defined and documented services	Connectable services and applications, providing ad hoc information exchange	Identified responsibilities and authorities
	Data	Defined and documented data models	Connectable data storage devices, enabling simple electronic exchange	

8.3 Maturity level 2 — Aligned

This level of interoperability maturity corresponds to the integrated environment approach defined in the Framework for Enterprise Interoperability

It is characterized by the use of common formats that are either accepted by or imposed on another enterprise. Relevant standards shall also be used as much as possible. Some flexibility is evident in an organizational structure. ICT infrastructure and platforms are connected or connectable. Interoperability training has been performed for key personnel. Some guidelines / procedures exist to describe how interoperability can occur and how to adjust the system if needed. Reaching this level of interoperability maturity allows an enterprise to have a stable environment in which long term and stable partnerships can be established with its known suppliers, sub-contractors and customers.

Generally speaking the effort in time and cost to make changes in systems is large and in general not easily reversible. The degree of interoperability achieved by aligning to a common format or standard is limited in the sense that it is confined to specific other enterprises or situations such as company mergers or fusion. However, it should also be noted that environment integration may be limited to those parts only that are to be involved in the information exchange.

The description of level 2 is characterized in Table 8.

Table 8 — Description of interoperability maturity level 2

		Conceptual	Technological	Organizational
Level 2 - Aligned	Business	Common business concept representations, acceptable to other enterprises	Alignable or configurable ICT infrastructures	Aligned organizational structures; personnel trained for interoperability
	Process	Established process models, using common formats and standards	Alignable process tools and platforms	Established procedures for interoperability of processes
	Service	Service models using common or alignable formats and standards	Alignable or configurable service architecture and interfaces	Established procedures for services interoperability
	Data	Data models using common or alignable formats and standards	Connectable databases, based on standard protocols	Established rules and methods for data management

8.4 Maturity level 3 — Organized

This level of interoperability maturity corresponds to the unified environment approach defined in the Framework for Enterprise Interoperability. It characterizes an organization of the enterprise that is capable of dealing with interoperability challenges. This level enables interoperation with heterogeneous systems and multiple heterogeneous other enterprises, and often in a networked context. Although enterprises' systems remain heterogeneous, meta-modelling can be performed and mapping using meta-models can be generally applied.

The enterprise organization has achieved a certain degree of flexibility and is organized to deal with interoperability simultaneously with several heterogeneous partners. Services and applications can be shared with different partners. It is also possible to define different rules and methods regarding data management according to different requirements from partners, such as for example, security or public vs. private data. Level 3 interoperability maturity allows an enterprise to work simultaneously with different partners in an unstable partnership environment (partners can change) without the necessity to reengineer its systems each time.

The development of

a) an ontology of meta reference models, and

b) standardized meta data models is required. Level 3 also requires that people are been trained in collaborative approaches and interoperability notions and guidelines.

The description of the level 3 is characterized in Table 9.

Table 9 — Description of interoperability maturity level 3

		Conceptual	Technological	Organizational
Level 3 - Organized	Business	Business models enabling multi-partnership and collaborative enterprises	Open ICT infrastructure enabling relations between enterprise infrastructure and platforms	Flexible organization structure enabling relations between organizations
	Process	Process models enabling mappings between collaborative processes	Platforms and tools for collaborative execution of processes	Established cross-enterprise collaborative management of processes
	Service	Service models enabling mappings between collaborative services	Service orchestration or choreography enabling collaboration between shared applications	Established collaborative services and application management
	Data	Data models enabling mappings between collaborative databases	Remote access to databases for applications	Personalized data management for different partners

8.5 Maturity level 4 — Adaptive

This level corresponds to the federated environment approach defined in the Framework for Enterprise Interoperability. It is the highest level of interoperability maturity and shall be characterized by the ability of companies to dynamically adjust and accommodate their cooperation as needed (*impromptu*). At this level, there is usually a shared domain ontology.

At level 4, companies are able to interoperate with multi-lingual and multi-cultural heterogeneous enterprises. At this level all information and interoperability itself becomes a subject of continuous improvement (evolutionary and adaptable). This level is rarely reached by current systems.

The description of this level is characterized in Table 10.

Table 10 — Description of interoperability maturity level 4

		Conceptual	Technological	Organizational
Level 4 - Adaptive	Business	Continuous evaluation and alignment of co-operative business concepts	Adaptable and reconfigurable ICT infrastructures and platforms	Agile organizational structure enabling proactive management during co-operation
	Process	Dynamic re-engineering of co-operative processes	Dynamic and adaptive process tools	Dynamic and agile cooperative process management
	Service	On-demand and adaptive modelling of co-operative services	Dynamically composable services for networked applications	Dynamic and agile cooperative service management
	Data	Adaptive and co-operative data models	Direct database exchange capability and full data conversion tools	Dynamic and agile data management rules and methods

9 Concern-based assessment of maturity levels

9.1 Approach

Assessing maturity from a specific concern viewpoint ensures that the text in each kind of barrier column (conceptual, technological, organizational) contains terms appropriate to that concern. This makes it easier to compare capabilities and working practices and so helps in coming to a conclusion on the most appropriate degree of interoperability for each maturity level. Conclusions may also be that characteristics for a particular maturity level are only partly met. Identification of missing criteria may indicate needs for further improvements.

The assessment is only concerned with those enterprise entities, which are to be involved in the information exchange. This implies that the business concern is relevant only in the case of very close collaboration (for example, a company merger).

9.2 Maturity assessment guidelines

The assessment is an activity that can be performed either as part of an improvement initiative or as part of a maturity determination approach. The first step when conducting an assessment process is to define the purpose of the assessment, its scope, what constraints should be applied to it and any additional information that needs to be gathered. Assessors should collect information through a series of interviews. The content of the assessment interview depends on the assessment scope and the enterprise needs.

In Table 11 the characteristics from previous tables are restated but laid out in a different format to guide the assessment. It contains the same information as in Tables 7, 8, 9 and 10, but presents it in such a way as to allow comparisons to be made easily between the levels for each combination of concern and barrier.

In the case that an enterprise has no capability for or intention to enable interoperation, level 0 has no significance (no assessment is to be carried out) and Table 6 information is therefore omitted from Table 11. Similarly, the business concern column can be disregarded unless close collaboration is intended.

For each cell a level score in the range 1 to 4 is to be assigned based on which level is most appropriate – half level scores can be used for situations where the capability is somewhat but not completely present and therefore lies between two adjacent levels (so the only possible scores are 1, 1.5, 2. 2.5, 3, 3.5, 4).

These questions will also help to identify the different types of barriers expected in the areas of concern.

Table 11 — Maturity assessment questions

	Conceptual	Technological	Organizational
Business	Which level best describes how visions, strategies and policies are described? 1 Described and documented business strategies and policies 2 Common business concept representations, acceptable to other enterprises 3 Business models enabling multi-partnership and collaborative enterprises 4 Continuous evaluation and alignment of co-operative business concepts	Which level best describes how well the ICT infrastructure is interconnected? 1 Installed and in-use basic ICT infrastructure and platform 2 Alignable or configurable ICT infrastructures 3 Open ICT infrastructure enabling relations between enterprise infrastructure and platforms 4 Adaptable and reconfigurable ICT infrastructures and platforms	Which level best describes the degree to which business responsibilities and authorizations are defined explicitly? 1 Defined and established organizational structures; identified responsibilities and authorities 2 Aligned organizational structures; personnel trained for interoperability 3 Flexible organization structure enabling relations between organizations 4 Agile organizational structure enabling proactive management during co-operation

Table 11 *(continued)*

	Conceptual	Technological	Organizational
Process	Which level best describes how enterprise processes are described and documented? 1 Defined and documented processes 2 Established process models, using common formats and standards 3 Process models enabling mappings between collaborative processes 4 Dynamic re-engineering of co-operative processes	Which level best describes compatibility of the process support systems? 1 Limited ICT support for processes, enabling ad hoc process information exchange 2 Alignable process tools and platforms 3 Platforms and tools for collaborative execution of processes 4 Dynamic and adaptive process tools	Which level best describes the degree to which process responsibilities and authorizations are defined explicitly? 1 Defined and established organizational structures; identified responsibilities and authorities 2 Established procedures for interoperability of processes 3 Established cross-enterprise collaborative management of processes 4 Dynamic and agile cooperative process management
Service	Which level best describes how enterprise services are defined, described and documented? 1 Defined and documented services 2 Service models using common or alignable formats and standards 3 Service models enabling mappings between collaborative services 4 On-demand and adaptive modelling of co-operative services	Which level best describes how connectable enterprise services are? 1 Connectable services and applications, providing ad hoc information exchange 2 Alignable or configurable service architecture and interfaces 3 Service orchestration or choreography enabling collaboration between shared applications 4 Dynamically composable services for networked applications	Which level best describes the degree to which service responsibilities and authorizations are defined explicitly? 1 Defined and established organizational structures; identified responsibilities and authorities 2 Established procedures for services interoperability 3 Established collaborative services and application management 4 Dynamic and agile cooperative service management
Data	Which level best describes how enterprise data are described and documented? 1 Defined and documented data models 2 Data models using common or alignable formats and standards 3 Data models enabling mappings between collaborative databases 4 Adaptive and co-operative data models	Which level best describes how connectable enterprise databases are? 1 Connectable data storage devices, enabling simple electronic exchange 2 Connectable databases, based on standard protocols 3 Remote access to databases for applications 4 Direct database exchange capability and full data conversion tools	Which level best describes the degree to which data responsibilities and authorizations are defined explicitly? 1 Defined and established organizational structures; identified responsibilities and authorities 2 Established rules and methods for data management 3 Personalized data management for different partners 4 Dynamic and agile data management rules and methods

The scores shall be presented in a summary table in the format shown in Table 12.

Table 12 — Pro forma for enterprise interoperability summary

	Conceptual	Technological	Organizational	Concern average (average of row)
Business levels	----------	----------	----------	----------
Process levels	----------	----------	----------	----------
Service levels	----------	----------	----------	----------
Data levels	----------	----------	----------	----------
			Summary enterprise score ---->	---------- (minimum of column above)

The rationale for setting the summary enterprise score as the minimum of the leverage levels is that the enterprise shall reach at least a certain level for each of the interoperability concerns for a summary score to be meaningful.

9.3 Illustrative data

Tables 13 to 16 present illustrative assessments and summaries for two fictitious enterprises, Red and Blue respectively. The results are represented graphically in Figures 2 and 3.

Table 13 — Maturity assessment – Example Blue enterprise

	Conceptual	**Technological**	**Organizational**
Business	The available business models allow relevant mappings between enterprises – visions, strategies and policies are described using modelling standard ABC (Level 3)	The ICT infrastructure is capable of interoperation (Level 2)	Organization structures are defined and can be aligned (Level 2)
Process	Process models allow to map between processes of different enterprises – models describe functional operations, using modelling standard ABC (Level 3)	Many process interfaces are compatible with available standards but some are not (Level 2.5)	Organization structure and responsibilities/authorization are identified (Level 1)
Service	ICT communication service descriptions enable mapping between the services of enterprises involved in information exchange (Level 3)	Enterprise ICT services are capable of collaborative orchestration (Level 3)	Organization structures are defined and can be aligned (Level 2)
Data	Enterprise data are documented and described using common format (Level 2)	Enterprise databases can be accessed by relevant applications (Level 3)	Organization structure and responsibilities/authorization are identified and some are aligned (Level 1.5)

Table 14 — Maturity assessment – Example Blue enterprise summary

	Conceptual	**Technological**	**Organizational**	**Concern average (average of row to nearest half-integer)**
Business levels	3	2	2	2.5
Process levels	3	2.5	1	2
Service levels	3	3	2	3
Data levels	2	3	1.5	2
			Summary enterprise score ---- >	2

Table 15 — Maturity assessment – Example Red enterprise data

	Conceptual	Technological	Organizational
Business	Business models allow relevant mappings between enterprises – visions, strategies and policies are described to modelling standard ABC (Level 3)	The ICT infrastructure is capable of interoperation (Level 2)	Organization structures are defined and can be aligned (Level 2)
Process	Process models use two different standards (Level 2)	Process execution tools are platform dependent and some can be executed in co-operation (Level 2)	Organization structures are defined and can be aligned (Level 2)
Service	ICT internet service models use common standards (Level 2)	Service execution tools are platform dependent (Level 2)	Relations between organizations can be defined (Level 3)
Data	Enterprise data are documented and described using common formats (Level 2)	Data storage devices and databases are connectable and most applications are able to access relevant databases (Level 2.5)	Relations between organizations can be defined (Level 3)

Table 16 — Maturity assessment – Example Red enterprise summary

	Conceptual	Technological	Organizational	Concern average (average of row to nearest half-integer)
Business levels	3	2	2	2.5
Process levels	2	2	2	2
Service levels	2	2	3	2.5
Data levels	2	2.5	3	2.5
			Summary enterprise score ---- >	2

9.4 Graphical representation of maturity level by concern and barrier

The interoperability summary assessment results of an enterprise as presented in Tables 14 and 16 can be represented in various ways. Figure 2 shows a representation as a Kiviat graph (radar plot) that allows one to represent the five maturity levels in relation to the four concerns and three barrier types that are identified in the FEI.

Figure 2 also shows an illustrative example of an assessment of two the two enterprises' interoperability capabilities (blue and red lines). Depending on the enterprise goal to reach a particular capability level being 1, 2, 3 or 4, the areas where the capabilities are already sufficient can be recognized, and areas where capabilities need some degree of improvement can be identified.