HARMONIZATION OF STANDARDS FOR ENTERPRISE INTEGRATION AN URGENT NEED

Martin Zelm

CIMOSA Association
Gehenbuehlstr 18a, D-70499 Stuttgart
e-mail: martin.zelm@cimosa.de

Abstract: Business globalisation requires fast and easy exchange of products, services and all related information. This can most easily be achieved through global standards. Unfortunately the area of standards is rather fragmented itself with national and international standardisation on one side and industry driven initiatives on the other side. Even within the international standardisation scene there are competing standards with large overlaps, ambiguous terminology and even contradicting contents. The paper demonstrates the needs for harmonisations of standards using a particular example from international standardisation. Two standards developed in ISO and in IEC are compared and needs for harmonisations are identified.

Keywords: Standardisation, enterprise integration, control system,

1. INTRODUCTION

The new global business environment requires cooperation between business partners across the globe, which usually work according to different business and legal rules, and within different cultural environments. In order to benefit from business globalisation, the envisioned exchange of products, services and related information has to be easy and with a minimum of time required for the exchange process itself. Globally available and globally recognized standards would significantly improve these exchanges, by providing common understanding as well as easy handling and maintenance of the items to be exchanged.

The problem encountered in standardization, which hampers global applicability of standards, stems partly from the current practice of standardization itself. National and international standard organizations and industry driven consortia develop standards according to perceived needs as seen in a particular community and with little coordination across the different parties involved, leading to inconsistencies and incompatibilities between standards which have to be used together.

To improve this situation, it is necessary to analyse the relations between similar standards in order to identify their concepts as well as similarities in entities and features addressed or overlaps, differences in context and purpose. Hence, in the applications of such standards, overlaps, duplication of work, as well as redundancies can be avoided. The needs in term of interfaces for further developments can be determined and the consistency and interoperability between standardization efforts in a given area can be improved.

Integrating the enterprise control system will produce various benefits, namely to improve communications between all parties, advance the supply chain and reduce costs. Two standards both coping with the enterprise control system integration, developed by

IEC and by ISO have been analysed. These standards, described in section 2 and section 3, address interfaces between manufacturing control functions and other enterprise functions (IEC 62264) as well as the representation of manufacturing management information (ISO 15531), respectively. The two standards are described identifying their scope, main concepts and normative references. The comparison of the two standards identifies commonalities and differences of the two standards focusing on the items described in the following two sections. The comparison has been initiated by a request from the German standards organization DIN/NAM. IEC and ISO have initiated a joint working group JWG 15 - IEC/SC65A /ISO /TC184 /SC5, to cope with the harmonization of Enterprise Control System Integration in the IEC/ISO 62264 multi part standard series. (JWG15, 2005) Related work on integration of the control system is ongoing in OMG, for instance in the Business Integration Domain Task Force. (OMG, 2005).

2. IEC 62264: 'ENTERPRISE-CONTROL SYSTEM INTEGRATION'

This multi-part standard, which is nearly identical with ISA 95.00.01 (2000) defines the interface content between manufacturing-control functions and other enterprise functions. The standard is based on the Purdue Reference Model (Williams, 1992) in the hierarchical form as published in ISA 95.00.01 and presents a reference model as defined in ISO 15704 (2000). Further, the standard employs a graphical representation in UML (Unified Modeling Language) to capture the models, the entities and the content of the interfaces.

Figure 1 depicts the different levels of the Function Hierarchy Model, a simplified version of the Purdue Reference Model (Williams, 1992): on level 4 business planning & logistics, on level 3 manufacturing operations & control, and on levels 2,1,0 batch, continuous, or discrete control.

The models and terminology presented in this standard emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems. The models can be used to improve existing integration capabilities of manufacturing control systems with enterprise systems; and can be applied regardless of the degree of automation.

This standard provides in three parts a consistent set of concepts and models for integrating control systems with enterprise systems in order to improve communications between all enterprise parties involved. The content of the three parts is as follows (IEC 62264-3, 2003): Part 1: Models and Terminology, Hierarchy models, Functional Data Flow Models; Object Models; Part 2: Object Model Attributes, with models covering a large range of models applicable to manufacturing enterprises; Part 3: Activity Models of Manufacturing Information Operations.

The activity models defined in Part 3 enable the integration of enterprise system and control system. These activity models are consistent with the data models and the content of Level 3 'Manufacturing Operations System' defined in Part 1. The activity models operate between business planning and logistics functions, which are defined as Level 4 functions and the Level 2 process control functions. The scope of the Part 3 is limited to the definition of a model of the activities associated with Level 3 'Manufacturing Operations System' functions and an identification of the data that flow among these activities. Figure 1 shows the Function Hierarchy Model.

The comparison of the two standards is mainly concerned with Part 3 of the IEC 62264 standard. Some of the benefits of the standard will be reduced user times for building up production levels for new products and enabling vendors to supply appropriate tools for implementing the integration of control systems with enterprise systems. Users will be able to better identify their needs like, reducing the costs of automating manufacturing processes, optimising supply chains, transferring production lines or parts of it in networked enterprises and reducing life-cycle engineering efforts.

2.1 Scope of IEC 62264

The purpose of the standard is to specify the interface content for the data exchange between Business systems and Manufacturing Operations systems. The interfaces considered are the interfaces between Level 4 and Level 3 of the Function Hierarchy Model, defined by this standard.

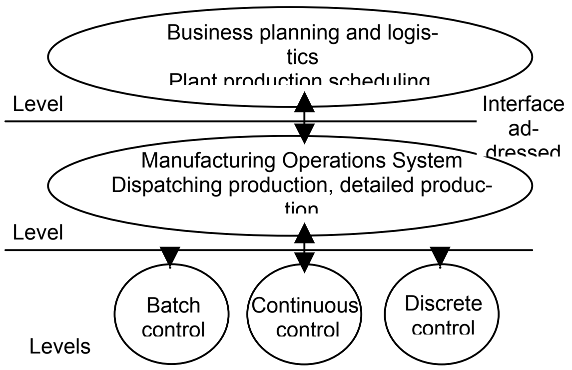

Figure 1: Function Hierarchy Model (ISA 95.00.01)

As shown in Figure 1, the upper Level 4 contains asset objects of the enterprise, a site or an area. Level 3 three is concerned with objects for a production line, a production unit or a process cell. The Purdue Reference Model (Williams, 1992) defines only two types of tasks in a manufacturing enterprise: Enterprise functions are the manufacturing operations themselves, whereas control functions supervise and steer enterprise functions.

The goal of the standard is to reduce the risk, cost, and errors associated with implementing these interfaces thereby obtaining enterprise systems and control systems that inter-operate and integrate easily. The standard may be used as a reference to reduce the effort associated with implementing new product offerings.

The scope of this standard is focusing on a) a presentation of the manufacturing operations and control domain, b) a discussion of the organization of physical assets of an enterprise involved in manufacturing; c) a listing of the functions associated with the interface between control functions and enterprise functions; and d) a description of the information that is shared between control functions and enterprise functions.

2.2 Main concepts of IEC 62264

The Purdue Reference Model for Computer Integrated Manufacturing (CIM) in its hierarchical form is the fundamental concept of the standard. It permits the life cycle enabled decomposition of enterprise functions and control functions into sub-processes and into activities. Activities have inputs and outputs; they use and produce information objects. The information exchanged or the information flow between the functions is represented by the content of their interfaces. The interface content, another basic concept of the standard, is defined through a set of object models and their attributes, represented in the neutral format of UML diagrams. Furthermore, the UML notation is deployed to define classes and class diagrams of models for product, process segment, equipment, material, personnel etc. Further, UML enables, the implementation and execution of a model, independent from a given application or system via the translation into XML data schemas.

An important concept of the standard is the modelling of committed, available or unattainable production capacities and capabilities rather than to model resources only. Another concept concerns the provision of reference models of a user domain in the activity models that can be adapted and customised to an individual enterprise. In summary, the concepts of this standard support the modelling of many enterprise aspects – via the modelling of processes, organisation and systems.

2.3 Major normative references of IEC 62264

This chapter identifies the references most relevant for this comparison. With regards to the production enterprise environment, IEC 62264 makes references to IEC 61512-1 (1997), Batch control – Part 1: Models and terminology. For information modelling, it references IEC 65512-2 (2001), Data structures and guidelines for languages, ISO/IEC 19501-1 Unified Modeling Language - UML and ISO 10303-1/11 (1994), Product data representation and exchange - STEP/EXPRESS. References towards standards on architectures and frameworks include ISO 15531-1 (1999), Industrial manufacturing management data, Resources usage management and ISO 15704 (2000) Requirements for enterprise reference architectures and methodologies, CEN 40003 (1990) Framework for enterprise modelling and CEN 12204 (1996) Constructs for enterprise modelling.

3. ISO 15531: 'MANUFACTURING MANAGEMENT DATA EXCHANGE'

This standard on manufacturing data (MANDATE) is also a multi-part standard. It provides for the representation of data relating to the management of the production process and the exchange and sharing of management data within or between enterprises. The parts of the standard are grouped in: Overview and fundamental principles (Part 1), Production data for external exchanges (Parts 21-23), Manufacturing resources usage management data (Parts 31-33); and Manufacturing flow management data (Parts 41-45). Our comparison is concerned with the concepts and the resources usage management defined in parts 15531-31 and -32, which address the modelling of resource usage management data with a manufacturing management purpose - including scheduling - at the shop-floor or plant level.

The ISO 15531 3X series is concerned with the development of the models, and attributes capable of residing in an industrial manufacturing company's resource database and which are to be used by manufacturing management for the purpose of resource usage management. The standard defines the representation of data – in the conceptual Resource Information Model (RIM) - related to the resources usage management in a production process.

3.1 Scope of ISO 15531-1

Part 1 of the standard specifies the characteristics to represent manufacturing management information. It provides the necessary mechanisms and definitions to enable manufacturing management data to be shared and exchanged within a factory, with other plants or companies.

The following properties are within the scope of ISO 15531-31/32: a) the representation of information needed to manage production and resources, b) the exchange and sharing of production information and resources information including storing, transferring, accessing and archiving.

3.2 Main concepts of ISO 15531

The resource model of ISO 15531 defines resources without inputs (for example, raw material, consumables) or outputs (for example, product, components, finished goods) of the system. The Resource Information Model (RIM) of ISO 15531 is very generic and includes humans, devices, software and data sets that may contribute to the transformation of inputs into outputs. ISO 15531 uses the concepts of capacity and capability to describe functional aspects of manufacturing resources. Another concept is to employ the modelling of product data using the STEP model, ISO 10303-1, (1994) and the EXPRESS language, ISO 10303-11, (1994). Both the STEP model and the EXPRESS language are independent of a given application or system.

Table 1: Differences in scope and normative references between IEC 62264-3 and ISO 1553-31/32

IEC 62264-3	ISO 15531 31/32	Comments
Scope:		
A model-based standard used for integrated enterprise control.	A model based standard for enterprise resource usage management	
Normative References		
An explicit normative reference to ISO 15531-31/32 is missing, but there is a reference to 15531-1.	There is only a normative reference to IEC 62264	
Referenced Standards: ISA-S88.01, CEN 12204, CEN 40003, ISO 10303*, ISO 14258*, ISO 15704*, ISO 15531-1, ISO/IEC 19501 –1	*Referenced Standards:* ISO 10303*, ISO 8824, ISO 8879, ISO 10303*, ISO 13584, ISO 15531-1*, ISO/IEC 2382, ISO 14258*, ISO 15704*, ISO 15926, IEC 62264-1	Standards on Modelling frameworks (CEN 40003) and modelling language (CEN 12204) are only referenced in IEC 62264

* References appear in both standards

Table 2: Differences in modelling concepts between IEC 62264-3 and ISO 15531-31/32

IEC 62264 Part3	ISO 15531 31/32	Comments
Model		
Identifies Activity Models of batch manufacturing production. Activity Models are derived from the Purdue Reference model for Computer Integrated Manufacturing. Models include the support of production resources. Employ UML to represent objects and the content of interfaces e.g. data flow.	Provides the Resource Information Model (RIM) a conceptual model for modelling resource management activities and the information required to perform these activities. Employs STEP/EXPRESS for product modelling	The 62264 Activity Model is process centred. The Resource Information Model of 15531 is rather product data centred. Hence, it may depend on the model designer which standard to use, depending on his preference of processes or of information aspects.
Modelling construct		
Provides adapted sub-types of modelling constructs mainly activity subtypes such as manufacturing operation, production operation and quality assurance operation	Provides generic construct types for Business process, activity, capability, capacity, resource, data object etc. But also derived sub-types as resource hierarchy, resource configuration, resource status etc.	IEC 62264-3 defines constructs on a lower level of modelling abstraction and closer to the user application. Constructs can be mapped onto each other e.g. sub-types can be instantiated from types.
Terminology		
Has own definitions of terms. Example Capacity: A measure of the ability to take action, a subset of a capability	Has own definitions of terms. Example Capacity: *The capability of a system, sub-system or resource to perform its expected function*	For the same terms the definitions should be equal.

It should be noted that EXPRESS and UML might be merged in the next version of UML. More details on UML and on further integration efforts in data modelling can be found in the Annex of IEC 62264-1. In summary, the concepts of ISO 15531-31/32 support the modelling of resource use via the modelling of resources, employing a comprehensive product.

3.3 Major normative references of ISO 15531

The most relevant references for this comparison are that of the production enterprise environment, namely the standards IEC 62264 Models and terminology and ISO 13584-1(1997) Parts Libraries. The predominant references in information modelling are ISO/IEC 8824-1 (1994), Open systems interconnection, ISO 10303-1/11 (1994) (STEP/EXPRESS) and

ISO 8879 (1986), (SGML). References towards standards on architectures and frameworks include ISO 14258 (1998) Concepts and rules for enterprise models, ISO 15704 (1999), Requirements for enterprise-reference architectures and methodologies, CEN 40003 (1990), Frameworks for enterprise modelling and CEN 12204 (1996), Constructs for enterprise modelling.

4. COMPARISON OF IEC/ISO 62264-3 AND ISO 15531

This comparison, depicted in Table 1 and in Table 2 is limited to the scope, normative references and specifications of the major concepts employed in the two standards being analysed. The focus is especially on Part 3 of IEC 62264 and the first two parts of the ISO 15531 3X series, in an attempt to capture their differences and overlaps. Further, the comparison is emphasizing on the modelling principles employed.

4.1 Commonalities of the two standards IEC 62264-3 and ISO 1553-31/32

- In the following the common concepts of the two standards are listed:
- Both standards are concerned with the management of manufacturing data.
- Both standards are modelling resources and managing the usage of resources.
- Both standards define generic interfaces for information exchange.
- Both standards reference the ISO standards on a) concepts and rules for modelling and b) requirements for reference architectures and methodologies as well as c) each others standard.
- Both standards employ the concept of a modelling framework as per CEN 40003.
- There are differences but no apparent contradictions in concept, the set of common constructs and methodology in the two standards.

5. CONCLUSIONS

IEC 62264 defines the information exchanged between manufacturing control functions and other enterprise functions; Part 3 is focusing on Activity Models for the batch-manufacturing scenario. ISO 15531 defines representations of product data exchange. Both standards share common and overlapping concepts with regards to modelling resources and managing these resources. Yet there are differences, therefore IEC 62264 Part 3 is needed in the context of integration of the control system in particular besides and in addition to ISO 15531 with its aim of general applicability in resource modelling.

Some suggestions for further work to improve the harmonization of standards: The notation and definitions should be the same in both standards or at least a mapping should be provided. The same terminology should be used. An open library of reference models and activity types and tasks should be defined.

Further, a more comprehensive framework might be developed to link several specific system definitions like IEC 62264 enterprise model with the resource information model of ISO 15531-3X. The comprehensive framework should be able to integrate different system definitions. For instance, IEC 62264 is limited to batch oriented production procedures with push oriented control systems.

In multi-part standards, normative references applying to all parts should be made either only once in the overview part or in all parts of the set of standards. One root of the problem seems to be the uncoordinated definition process of standards. This could be improved by having more links between standardisation bodies for instance via joint working groups or committees.

There appears to be a difference in the level of abstraction. IEC 62264 Part 3 provides Activity Models of manufacturing scenarios with instantiated constructs (sub-types of constructs) whereas ISO 15531 provides generic constructs (types of constructs).

REFERENCES

CEN 12204 (1996). Advanced Manufacturing Technology – Systems Architecture – Constructs for Enterprise Modelling, *CEN TC 310/WG1*

CEN 40003 (1990). Computer Integrated Manufacturing – Systems Architecture – Framework for Modelling, *CEN TC 310/WG1*

CEN-ISO 19439 (2002). Framework for Enterprise Modeling *CEN TC 310* and *ISO TC 184/SC5*

CEN-ISO 19440 (2003). Constructs for Enterprise Modeling, *CEN TC 310 and ISO TC 184/SC5*

IEC 61512-1 (1997). Batch control – Part 1: Models and terminology, *IEC SC 65A*

IEC 62264-1 (2003). Enterprise Control Systems Integration, Part 1: Models and Terminology, *IEC SC 65A*

IEC 62264-2 (2003). Enterprise Control Systems Integration Part 2: Object model attributes; *IEC SC 65A*

IEC 62264-3, (2004). Enterprise Control System Integration, Part 3: Activity Models of Manufacturing Operations, *IEC SC 65A*

IEC 65512-2 (2001). Data structures and guidelines for languages, *IEC SC 65A*

ISA-S88.01 (1995). Batch Control – Part 1: Models and Terminology, *Instrumentation, Systems and Automation Society*.

ISA 95.00.01 (2000). Enterprise-Control System Integration Part 1: Models and Terminology. *Instrumentation, Systems and Automation Society*.

ISA 95.00.02 (2001). Enterprise-Control System Integration Part 2: Object Model Attributes. *Instrumentation, Systems and Automation Society*.

ISA 95.00.03-Draft15 (2003). Enterprise-Control System Integration Part 3: Models of Manufacturing, *Systems and Automation Society*

ISO/IEC 8824-xx (1994). Information Technology - Open systems interconnection (OSI), *JTC1/SC6*

ISO/IEC 8879 (1986). Information Technology - Open systems interconnection, Abstract Syntax Notation One – Part1: Specification of basic Notation, *JTC1/SC34*

ISO/IEC 19501-1 Information Technology – Unified Modeling Language (UML) – Part 1: Specification *(To be published),*

ISO 10303-1 (1994), Industrial Automation Systems and Integration – Product data representation and exchange – Part 1: Overview and fundamental principles, *ISO TC 184/SC4*

ISO 10303-11 (1994). Industrial Automation Systems and Integration - Product data representation and exchange - Part 11: Description methods: The EXPRESS language reference manual, *ISO TC 184/SC4*

ISO 13584-1 (1997). Parts Library – Conceptual descriptions - Part 1: Overview and fundamental principles. *ISO TC 184/SC4*

ISO 14258 (1998). Industrial Automation Systems and Integration - Concepts and rules for enterprise models, *ISO TC 184/SC5*

ISO 15531-1 (2000), Industrial Automation System and Integration - Industrial manufacturing management data, General overview, *ISO TC 184/SC4*

ISO 15531-31 (2000). Manufacturing Management Data Exchange: Resources usage management data: Resource information model, *ISO TC 184/SC4*

ISO 15531-32 (2001). Industrial Automation System and Integration - Manufacturing management data exchange: Resources usage management: Part 32: Conceptual model for resources usage management data, *ISO TC 184/SC4*

ISO 13584-42 (1997). Parts Library - Description methodology - Part 42: Methodology for structuring parts families, *ISO TC 184/SC4*

ISO 15704 (2000). Industrial Automation System and Integration - Requirements for enterprise reference architecture and methodologies, *ISO TC 184/SC5*

JWG 15, (2005). dnBrandl@BRLConsulting.com

OMG (2005) Object Management Group, http://www.omg.org/.

Williams, T.J. (1992). The Purdue Enterprise Reference Architecture – A Technical Guide for CIM Planning and Implementation, *Instrument Society of America*