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Industrial automation systems and integration — Product data representation and exchange —

Part 108: Integrated application resource: Parameterization and constraints for explicit geometric product models

Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —

Partie 108: Ressources d'application intégrées: Paramétrage et contraintes pour les modèles de produits géométriques explicites

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10303 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10303–108 was prepared by Technical Committee ISO/TC184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

ISO 10303 consists of a series of parts, under the general title *Industrial automation systems and integration — Product data representation and exchange*. The structure of ISO 10303 is described in ISO 10303-1.

Each part of ISO 10303 is a member of one of the following series: description methods, implementation methods, conformance testing methodology and framework, integrated generic resources, integrated application resources, application protocols, abstract test suites, application interpreted constructs, and application modules. This part is a member of the integrated application resources series. The integrated generic resources and the integrated application resources specify a single conceptual product data model.

A complete list of parts of ISO 10303 is available from the Internet:

<http://www.tc184-sc4.org/titles/>

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation of product information and for the exchange of product data. The objective is to provide a neutral mechanism capable of describing products throughout their life cycle. This mechanism is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases, and as a basis for archiving.

This part of ISO 10303 is a member of the integrated resources series. Major subdivisions of this part of ISO 10303 are:

— Parameterization schema;

— Explicit constraint schema;

— Variational representation schema;

— Explicit geometric constraint schema;

— Sketch schema.

This part of ISO 10303 provides representations of parameters and constraint relationships for use in models exchanged using ISO 10303, and specifies mechanisms for the association of such elements with other elements of the models in which they apply. Parameters and constraints are used in CAD systems to indicate, respectively, variant and invariant characteristics of a model under editing operations. This part of ISO 10303 also specifies representations for *sketches*, two-dimensional geometric configurations, possibly including parameters and constraints, that are often used by CAD systems as basic elements in constructional operations.

Models with explicitly represented parameterization and constraints are described as *variational*. The schemas provided are intended in the first instance to supplement the ISO 10303 integrated generic resources to allow the representation of product shape models enhanced with variational information. However, the basic mechanisms provided in the first three schemas can be used for representing parameterization and constraints in the context of any ISO 10303 model, whether of a product, a plan, a process or an organization.

Other resource parts of ISO 10303 provide capabilities for the representation and exchange of models having no associated variational information. That information, if present in the originating system, affects the behaviour of a model under editing operations there; it forms an important part of what is sometimes referred to as *design intent*. The use of this part of ISO 10303 for its capture and transfer potentially allows the reconstruction of key elements of design intent in a receiving system. The transferred variational information asserts relationships that already exist in the exchanged model; its purpose is to initiate processes in the receiving system that will ensure that those relationships are maintained if the model is modified there. This will assist in the efficient modification of the exchanged model in the receiving system, through the use of the original designer's scheme of parameterization and constraints. Such modification of models transferred using ISO 10303 has proved to be difficult or impossible in the absence of design intent information.

EXAMPLE It may be desired to optimize the model in the receiving system for structural integrity, or to modify it to make it cheaper to manufacture.

This part of ISO 10303 is intended to interoperate with other closely related parts, notably ISO 10303-55, which defines procedural and hybrid representations, specified in terms of the constructional operations

used in building a model. The primary forms of shape representation used by many modern CAD systems are of these types. ISO 10303-108 (this document) and ISO 10303-55 between them provide for the capture of the two major aspects of design intent. Procedural representations are outside the normative scope of the present document, but annex F provides some discussion of the role of parameterization and constraints in procedural and hybrid representations, and of the interplay between the explicit and procedural approaches to shape modelling.

A further aspect of modern CAD systems is their provision of feature-based design methods. This part of ISO 10303 does not address the topic of features, though it provides essential resources for the positioning and orientation of features in CAD models.

Three books providing further background on the topics covered by this part of ISO 10303 are given in the Bibliography [3,4,6].

The contents of the schemas making up this part of ISO 10303 are as follows:

parameterization_schema: Mechanisms for associating parameters with variable quantities in an instantiated EXPRESS model;

explicit_constraint_schema: Definitions of generic constraint relationships between elements of an instantiated EXPRESS model;

variational_representation_schema: Specification of the relationship between parameter and constraint information and the non-variational model with which it is associated;

explicit_geometric_constraint_schema: Specialization of the **explicit_constraint_schema** for the representation of commonly used geometric constraints (such as parallelism or tangency) between explicitly represented elements of geometric models;

sketch_schema: Means for the representation of two-dimensional sketches, which may contain variational elements, for use as basic elements in shape modelling operations.

The relationships of the schemas in this part of ISO 10303 to other schemas that define the integrated resources of ISO 10303 are illustrated in Figure 1 using the EXPRESS-G notation. EXPRESS-G is defined in annex D of ISO 10303-11. The internal relationships among ISO 10303-108 schemas are shown in Figure 2. The schemas occurring in Figure 1 are (with two exceptions that form part of ISO 13584) components of ISO 10303 integrated resources, and they are specified in the following resource parts:

`measure_schema`	ISO 10303-41
`product_property_representation_schema`	ISO 10303-41
`support_resource_schema`	ISO 10303-41
`geometric_model_schema`	ISO 10303-42
`geometry_schema`	ISO 10303-42
`topology_schema`	ISO 10303-42
`representation_schema`	ISO 10303-43
`mathematical_functions_schema`	ISO 10303-50
`ISO13584_generic_expressions_schema`	ISO 13584-20
`ISO13584_expressions_schema`	ISO 13584-20

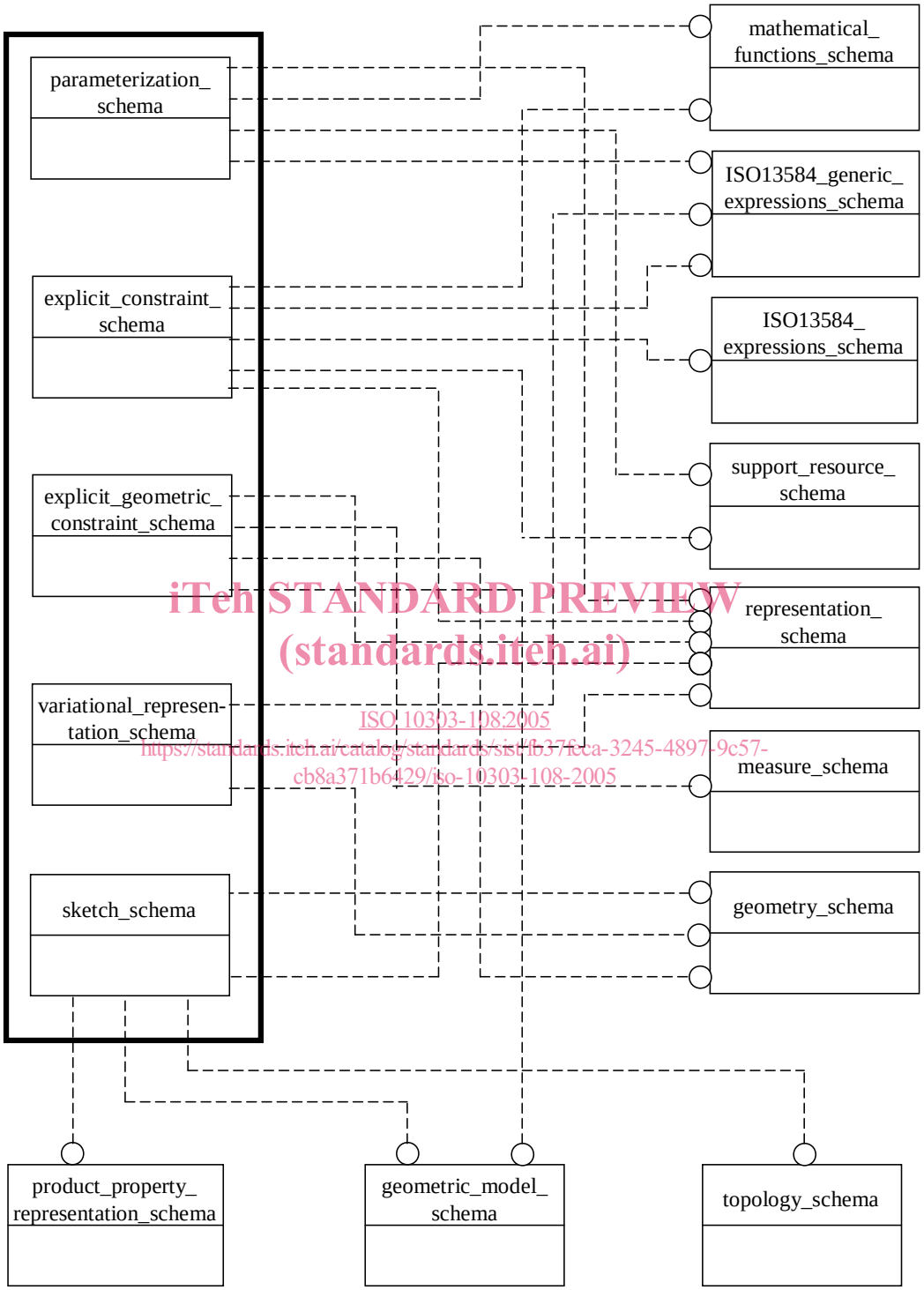

Figure 1 – Schema level diagram of relationships between ISO 10303-108 schemas (inside the box) and other resource schemas

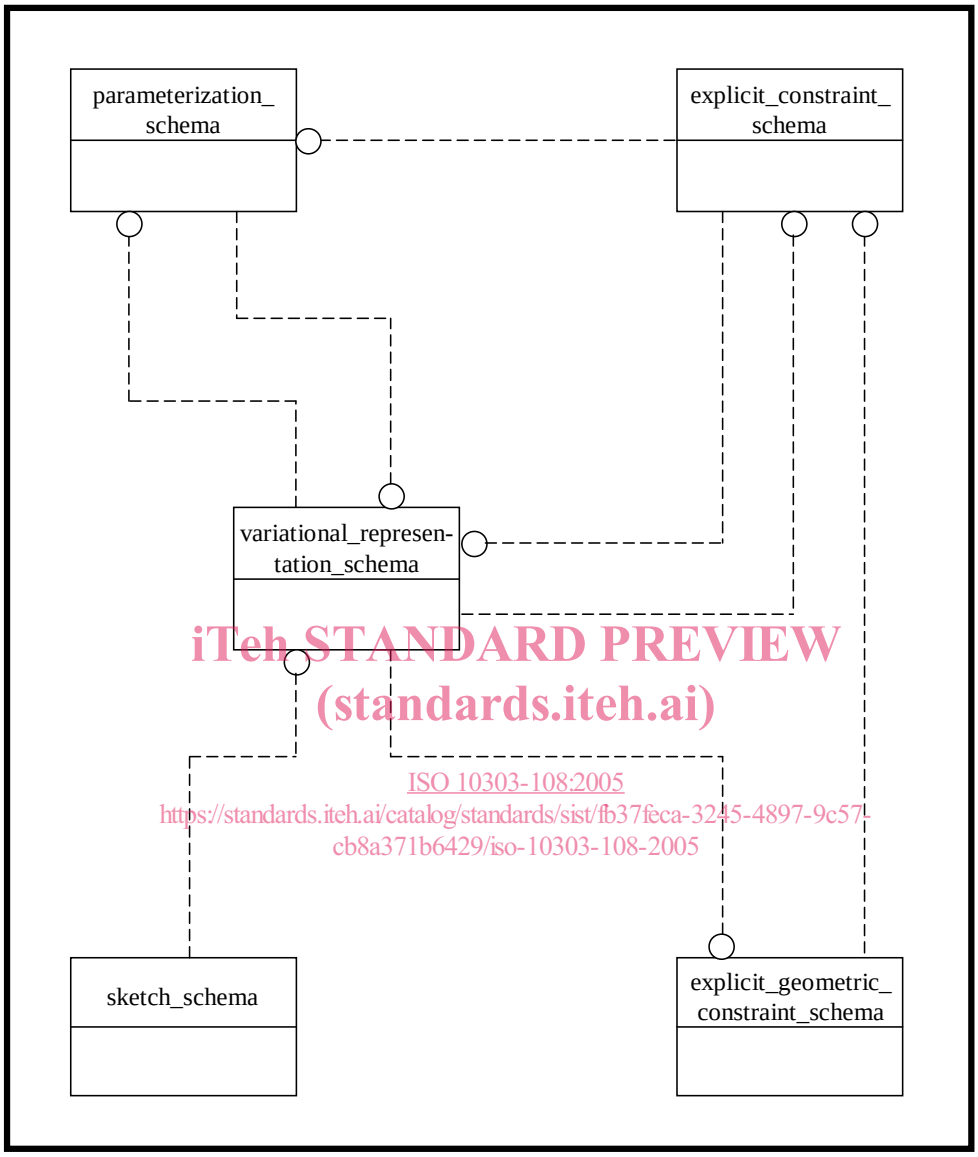

Figure 2 – Schema level diagram of relationships among ISO 10303-108 schemas

Industrial automation systems and integration — Product data representation and exchange —

Part 108: Integrated application resource: Parameterization and constraints for explicit geometric product models

1 Scope

This part of ISO 10303 specifies the resource constructs for the representation of model parameters and constraints, together with the mechanisms necessary for associating them with geometric or other elements of transferred models. The use of these capabilities potentially allows certain aspects of the behaviour of a model in its originating system to be conveyed together with the basic model itself. The intention in transferring this additional information is to provide the receiving system with data that will enable it to reconstruct corresponding behavioural characteristics in the model following the transfer. Ideally, this will enable the model to be edited in the receiving system just as as though it had been created there. That would not be possible without the exchange of what is known as *design intent* information. This part of ISO 10303 enables the capture and transfer of an important aspect of design intent.

Clause 4 defines a means for the association of model parameters with individual quantities in the model, to provide for the editing of dimensional values and other variable attributes. Clause 5 provides for the modelling of constraint relationships in terms of mathematical relationships among model parameters. Such constraints are not restricted to the modelling of product shape; they are designed to be applicable in any situation where it may be useful to capture and transfer mathematically specified relationships. Clause 5 also defines a class of descriptive (non-mathematical) constraints. Clause 6 defines a *variational representation*, containing a model together with all the associated parameters and constraints that potentially facilitate its effective editing following a transfer. Clause 7 defines specialized representations for a set of explicit geometric constraints applicable specifically to elements of shape models of the boundary representation and closely related types. These are subtypes of the descriptive constraints specified in clause 5. Finally, clause 8 provides representations for two-dimensional sketches, which form the basis of many shape construction methods in CAD modelling. Sketches are an important application area for the parameterization and constraint information defined in earlier clauses. The capabilities provided in this schema may also be used as a basis for the representation of parameterized drawings.

The following are within the scope of this part of ISO 10303:

— Parameterization of models through the association of variables with quantities occurring in them;

— Constraints defining mathematical relationships between parameters;

— Constraints on models expressed as relationships between their constituent elements or attributes of those elements;

— Association of parameters and constraints with models at the **representation** level, to create variational models of products, plans, processes or organizations;

— Specific representations for the geometric constraints commonly used in product shape modelling;

— Applications of parameterization and constraints to two- and three-dimensional shape models, in particular two-dimensional geometric sketches;

— Representation of models that are incompletely defined in the sense that certain values in the model may be regarded as not fully constrained.

NOTE 1 The scopes of the individual schemas comprising this part of ISO 10303 are specified in more detail in clauses 1.1 – 1.5.

The following are outside the scope of this part of ISO 10303:

— Procedural or history-based model representations, expressed in terms of sequences of constructional operations;

NOTE 2 Procedural or history-based representations are the subject of ISO 10303-55.

— Implicit or procedurally defined constraints;

— Solution methods for systems of constraint equations;

— Form features of shape models;

— Behaviour of a system in which a variational model is edited following a transfer;

NOTE 3 The information transmitted by the use of this part of ISO 10303 is intended to allow implementers to provide ‘reasonable’ or ‘intuitive’ behaviour by their systems in the circumstances mentioned, but this document does not prescribe the detailed nature of such behaviour or of its presentation to the system user.

— Considerations of accuracy in constraint satisfaction.

NOTE 4 Such considerations are essentially the same in this context as those arising in the geometric modelling of product shape. Limited general means are provided elsewhere in ISO 10303 for addressing accuracy issues.

Clauses 4, 5 and 6 of this part of ISO 10303 are applicable to any representation specified using the EXPRESS language defined in ISO 10303-11. The capabilities provided in those three schemas allow the association of parameters with attributes of entity data type instances and the specification of constraint relationships between such attributes in instantiated EXPRESS representations in general. These may include models of products, plans, processes or organizations, for example. Clauses 7 and 8 of this part of ISO 10303 are applicable more specifically to shape representations associated with discrete products. They provide additional specialization for the association of parameterization and constraints with geometric elements. The scopes of the individual clauses are given in more detail below.

1.1 Parameterization schema

The following are within the scope of the parameterization schema:

— The representation of variable parameters in an ISO 10303 model;

— The association of such variable parameters with quantities in an ISO 10303 model expressed as values of attributes of entity data type instances in a populated schema;

— The specification of allowable domains for model parameters;

— The specification of entity data type instance attribute values that are required to be fixed, i.e., whose allowable domains are each restricted to a single value. The intention is that these values should not be modified in a receiving system following a transfer.

NOTE 1 The last provision allows, in particular, for dimensional values to be fixed in appropriate cases.

NOTE 2 The presence of parameters in a model, and of specified relationships between parameters, indicate possibilities for changes that are permissible after a model transfer. This preserves part of the intention of the model's creator, as expressed by the parameterization imposed on the model in the originating system.

1.2 Explicit constraint schema

The following are within the scope of the explicit constraint schema:

— Specification of constraint relationships between constituent elements in a model, expressing the intention that these relationships should be preserved on modification of the model following an ISO 10303 transfer;

— Constraint relationships of the following specific types:

a) Free-form constraints enabling the capture and transmission of explicitly defined mathematical relationships between quantities in a model;

b) Defined constraints, for the representation of relationships defined descriptively, with implied mathematical semantics;

NOTE A constraint imposed in an originating system typically encapsulates requirements for the preservation of specific aspects of the functionality or validity of the modelled object. The transmission of such constraint information in a model exchange is intended to enable these requirements to be maintained during any subsequent modification of the model in the receiving system.

— Specification of sets of constraints that are required to hold simultaneously in the model.

The following are outside the scope of the explicit constraint schema:

— The actual representation of mathematical expressions, functions or procedures (such representations are provided elsewhere in ISO 10303);

— Solution methods for systems of constraint equations;

— Sequential application of constraints;

— Implicit or procedurally defined constraints.

1.3 Variational representation schema

The following are within the scope of the variational representation schema:

— Characterization of parameterization and constraint information as*variational*;

