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

Part 514: Application interpreted construct: Advanced boundary representation

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

Partie 514: Construction interprétée d'application: Représentation délimitée avancée

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 734 10 79
E-mail copyright@iso.ch
Web www.iso.ch

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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.

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.

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

<http://www.nist.gov/sc4/editing/step/titles/>

This part of ISO 10303 is a member of the application interpreted constructs series.

Annexes A and B form an integral part of this part of ISO 10303. Annexes C, D and E are for information only.

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

This International Standard is organized as a series of parts, each published separately. The parts of ISO 10303 fall into one of the following series: description methods, generic resources, application interpreted constructs, application protocols, abstract test suites, implementation methods, and conformance testing. The series are described in ISO 10303–1. This part of ISO 10303 is a member of the application interpreted construct series.

An application interpreted construct (AIC) provides a logical grouping of interpreted constructs that supports a specific functionality for the usage of product data across multiple application contexts. An interpreted construct is a common interpretation of the integrated resources that supports shared information requirements among application protocols.

This paqrt of ISO 10303 specifies the application interpreted construct for the definition of a boundary representation solid with explicit topology and elementary or free-form geometry. It specialises the generic constructs from ISO 10303-42 for the definition of manifold solid boundary representation models to ensure that such models are completely and unambiguously defined. The faces of the B-rep models defined in this AIC use the **advanced_face** definition from ISO 10303-511.

Industrial automation systems and integration — Product data representation and exchange — Part 514 : Application interpreted construct: Advanced boundary representation

1 Scope

The application interpreted construct defined in this part specifies the interpretation of the generic resources in order to satisfy the following requirements:

— For the definition of an advanced boundary representation model. An advanced B-rep model is a representation composed of one or more **manifold_solid_brep**s each of which is defined with elementary geometry or sculptured geometry.

— For the definition of the unbounded geometry of curves and surfaces used in the definition of the faces of such a B-rep model.

— For the definition of the topological structure of a B-rep model. In particular all surfaces are bounded by defining an associated **advanced_face** and all curves are bounded by reference from a topological **edge_curve**.

This AIC is independent of any industrial application domain.

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

— 3D geometry;

— B-reps;

— B-rep models;

— B-spline curves and surfaces;

— conics;

— elementary curves;

— elementary surfaces;

— geometric transformations;

— polylines;

— pcurves;

— sculptured surfaces;

— surface curves;

— swept surfaces;

— twisted curves;

— unbounded geometry;

— use of topology to bound geometric entities.

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

— 2D geometry other than for the definition of a pcurve in the parameter space of a surface;

— bounded curves other than polylines and B-spline curves;

— bounded surfaces other than B-spline surfaces;

— offset curves and surfaces.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10303. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 8824-1: 1995, *Information technology - Open systems interconnection -Abstract syntax notation one (ASN.1) Part 1 : Specification of basic notation.*

ISO 10303-1: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 1 : Overview and fundamental principles.*

ISO 10303-11: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 11 : Description methods: The EXPRESS language reference manual.*

ISO 10303-41: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 41 : Integrated generic resources: Fundamentals of product description and support.*

ISO 10303-42: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 42 : Integrated generic resources: Geometric and topological representation.*

ISO 10303-43: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 43 : Integrated generic resources: Representation structures.*

ISO 10303-202: 1995, *Industrial automation systems and integration - Product data representation and exchange - Part 202: Application protocol: Associative draughting*

ISO 10303-511: 1999, *Industrial automation systems and integration - Product data representation and exchange - Part 511: Application interpreted construct: topologically bounded surface*

3 Terms, definitions and abbreviations

3.1 Terms defined in ISO 10303-1

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-1 apply.

— application;

— application context;

— application protocol;

— implementation method;

— integrated resource;

— interpretation;

— product data;

3.2 Terms defined in ISO 10303-42

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-42 apply.

— arcwise connected;

— axi-symmetric;

— boundary;

— boundary representation solid model (B-rep);

— bounds;

— coordinate space;

— curve;

— open curve;

— orientable;

— surface;

— topological sense.

3.3 Terms defined in ISO 10303-202

For the purposes of this part of ISO 10303, the following term defined in ISO 10303-202 applies.

3.3.1
application interpreted construct (AIC)
a logical grouping of interpreted constructs that supports a specific functionality for the usage of product data across multiple application contexts.

3.4 Terms defined in ISO 10303-511

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-511 apply.

— advanced face

— sculptured surface

— swept surface

— twisted curve

3.5 Other definitions

3.5.1
advanced B-rep shape representation
a shape representation made up of one or more manifold solid B-reps. Each constituent B-rep is required to have its faces and edges explicitly defined by elementary or free-form geometry.

3.5.2
manifold solid B-rep
an arcwise connected solid, represented by its boundary, such that, for a very small sphere, centred at any point on the boundary of the solid, the interior of the sphere is divided into precisely two regions. One of these regions is inside the solid, the other is outside.

3.6 Abbreviations

For the purposes of this part of ISO 10303, the following abbreviations apply.

AIC	Application Interpreted Construct
AP	Application Protocol
B-rep	Boundary representation solid model

4 EXPRESS short listing

This clause specifies the EXPRESS schema that uses elements from the integrated resources and contains the types, entity specializations, and functions that are specific to this part of ISO 10303.

NOTE 1 There may be subtypes and items of select lists that appear in the integrated resources that are not imported into the AIC. Constructs are eliminated from the subtype tree or select list through the use of the implicit interface rules of ISO 10303-11. References to eliminated constructs are outside the scope of the AIC. In some cases, all items of the select list are eliminated. Because AICs are intended to be implemented in the context of an application protocol, the items of the select list will be defined by the scope of the application protocol.

NOTE 2 This AIC uses all the entities and types from the topology bounded surface AIC (**aic_topologically_bounded_surface**). ISO 10303-511 should be referred to in order to obtain the complete data set.

EXPRESS specification:

```
*)
SCHEMA aic_advanced_brep;
 USE FROM aic_topologically_bounded_surface;

 USE FROM geometry_schema(cartesian_transformation_operator_3d);

 USE FROM geometric_model_schema
     (manifold_solid_brep,
      brep_with_voids);

 REFERENCE FROM geometric_model_schema(msb_shells);

 USE FROM topology_schema
```

```
      (closed_shell,
       connected_face_set,
       oriented_closed_shell);

  USE FROM representation_schema(mapped_item);

  USE FROM product_property_representation_schema(shape_representation);

(*
```

NOTE 3 The **connected_face_set** entity is explicitly interfaced (i.e. included in the USE FROM lists) to allow rules in the **advanced_brep_shape_representation** entity to access attributes of this entity. For the use of this AIC this entity shall only be instantiated as one of its subtypes.

NOTE 4 The schemas referenced above can be found in the following parts of ISO 10303:

geometry_schema	ISO 10303-42
geometric_model_schema	ISO 10303-42
topology_schema	ISO 10303-42
representation_schema	ISO 10303-43
product_property_representation_schema	ISO 10303-41
aic_topologically_bounded_surface	ISO 10303-511

4.1 Fundamental concepts and assumptions

The following entities[1)] are intended to be independently instantiated in the application protocol schemas that use this AIC:

— advanced_face [511];

— axis2_placement_2d [511];

— axis2_placement_3d [511];

— brep_with_voids;

— bezier_curve [511];

— bezier_surface [511];

— b_spline_curve_with_knots [511];

— b_spline_surface_with_knots [511];

— cartesian_point [511];

[1)] The entities marked [511] are defined in the **aic_topologically_bounded_surface**

— cartesian_transformation_operator_3d;

— circle [511];

— closed_shell;

— conical_surface [511];

— definitional_representation [511];

— degenerate_toroidal_surface [511];

— cylindrical_surface [511];

— direction [511];

— edge_curve [511];

— edge_loop [511];

— ellipse [511];

— face_bound [511];

— face_outer_bound [511];

— face_surface [511];

— geometric_representation_context [511];

— hyperbola [511];

— line [511];

— manifold_solid_brep;

— mapped_item;

— oriented_closed_shell;

— parabola [511];

— parametric_representation_context [511];

— pcurve [511];

— plane [511];

— polyline [511];

— quasi_uniform_curve [511];

— quasi_uniform_surface [511];

— rational_b_spline_curve [511];

— rational_b_spline_surface [511];

— representation_map;

— spherical_surface [511];

— surface_of_linear_extrusion [511];

— surface_of_revolution [511];

— toroidal_surface [511];

— uniform_curve [511];

— uniform_surface [511];

— vector [511];

— vertex_loop [511];

— vertex_point [511].

An application protocol that uses this AIC shall ensure that the **shape_representation** entity is instantiated as an **advanced_brep_shape_representation**.

4.2 aic_advanced_brep schema entity definition: advanced_brep_shape_representation

The **advanced_brep_shape_representation** is a type of **shape_representation** in which the representation items are specialisations of **manifold_solid_brep** entities. These specialisations differ from the more general B-rep in that they shall only use explicit geometric forms for their face and edge geometry. The face geometry is restricted to elementary surfaces, swept surfaces or B-spline surfaces.

EXPRESS specification:

```
*)
```

```
ENTITY advanced_brep_shape_representation
  SUBTYPE OF (shape_representation);
  WHERE
    WR1: SIZEOF(QUERY ( it <* SELF.items | (NOT (SIZEOF([
              'AIC_ADVANCED_BREP.MANIFOLD_SOLID_BREP',
              'AIC_ADVANCED_BREP.FACETED_BREP',
              'AIC_ADVANCED_BREP.MAPPED_ITEM',
              'AIC_ADVANCED_BREP.AXIS2_PLACEMENT_3D'] * TYPEOF(it)) = 1)) ))
              = 0;
    WR2: SIZEOF(QUERY ( it <* SELF.items | (SIZEOF([
              'AIC_ADVANCED_BREP.MANIFOLD_SOLID_BREP',
              'AIC_ADVANCED_BREP.MAPPED_ITEM'] * TYPEOF(it)) = 1) )) > 0;
    WR3: SIZEOF(QUERY ( msb <* QUERY ( it <* SELF.items |
              ('AIC_ADVANCED_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) ) |
             ( NOT (SIZEOF(QUERY ( csh <* msb_shells(msb) |
                             (NOT (SIZEOF(QUERY ( fcs <* csh\
              connected_face_set.cfs_faces | (NOT (
              'AIC_ADVANCED_BREP.ADVANCED_FACE' IN TYPEOF(fcs))) )) = 0)) ))
              = 0)) )) = 0;
    WR4: SIZEOF(QUERY ( msb <* QUERY ( it <* items |
           ( 'AIC_ADVANCED_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) ) |
           (  'AIC_ADVANCED_BREP.ORIENTED_CLOSED_SHELL' IN TYPEOF(msb\
             manifold_solid_brep.outer)) )) = 0;
    WR5: SIZEOF(QUERY ( brv <* QUERY ( it <* items |
          ( 'AIC_ADVANCED_BREP.BREP_WITH_VOIDS' IN TYPEOF(it)) ) | (NOT
             (SIZEOF(QUERY ( csh <* brv\brep_with_voids.voids |
             ( csh\oriented_closed_shell.orientation)))  = 0)) ))
             = 0;
    WR6: SIZEOF(QUERY ( mi <* QUERY ( it <* items |
           ( 'AIC_ADVANCED_BREP.MAPPED_ITEM' IN TYPEOF(it)) ) | (NOT
           ( 'AIC_ADVANCED_BREP.ADVANCED_BREP_SHAPE_REPRESENTATION' IN
             TYPEOF(mi\mapped_item.mapping_source.mapped_representation))) ))
             = 0;
END_ENTITY;
(*
```

Formal propositions:

WR1: the **items** attribute of the **representation** supertype shall contain **manifold_solid_-breps**, **mapped_items** and **axis2_placement_3ds** only; a **faceted_brep** is excluded from the **items** SET since this would be of type **faceted_brep** and of type **manifold_solid_brep**;

WR2: at least one item in the **items** set shall be a **manifold_solid_brep** entity or a **mapped_-item** (see also WR6).

WR3: for each **manifold_solid_brep** in the **items** set each face shall be an **advanced_face**. This ensures that the following conditions are met:

— each **face** is a **face_surface**;

— each **face_surface** has its geometry defined by an **elementary_surface**, **swept_surface** or a **b_spline_surface**;

— the **edge**s used to define the boundaries of the **face** shall all reference an **edge_curve**;

— each curve used to define the geometry of the faces and face bounds shall be either a **conic**, or a **line** or a **polyline** or a **b_spline_curve**;

— the edges used to define the **face** boundaries shall all be trimmed by vertices of type **vertex_point**;

— no loop used to define a **face_bound** shall be of the oriented subtype.

NOTE 1 The call to function **msb_shells** in WR3 is correct since, although the generic type of the argument 'msb' is **representation_item**, 'msb' has been selected by QUERY to be of type **manifold_solid_brep**.

WR4: For each **manifold_solid_brep** in the **items** set the outer shell attribute shall not be of the oriented subtype.

WR5: If a **brep_with_voids** is included in the **items** set then each shell in the **voids** set shall be an **oriented_closed_shell** with orientation value FALSE.

WR6: If a **mapped_item** is included in the **items** set then the **mapped_representation** of the **mapping_source** attribute shall be an **advanced_brep_shape_representation**.

NOTE 2 If a **cartesian_transformation_operator_3d** is included as **mapped_item.mapping_target** with an **axis2_placement_3d** corresponding to the original coordinate system as **mapped_representation.mapping_origin** then the resulting **mapped_item** is a transformed copy of the **advanced_brep_shape_representation**. The precise definition of the transformation, including translation, rotation, scaling and, if appropriate, mirroring, is given by the transformation operator.

EXPRESS specification:

```
*)
 END_SCHEMA; -- end AIC_ADVANCED_BREP SCHEMA
(*
```

Annex A
(normative)

Short names of entities

Table A.1 provides the short names of entities specified in this part of ISO 10303. Requirements on the use of the short names are found in the implementation methods included in ISO 10303.

Table A.1 – Short names of aic_advanced_brep entities

Entity name	Short name
ADVANCED_BREP_SHAPE_REPRESENTATION	ABSR

Annex B
(normative)

Information object registration

B.1 Document identification

To provide for unambiguous identification of an information object in an open system, the object identifier

{ iso standard 10303 part(514) version(1) }

is assigned to this part of ISO 10303. The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

B.2 Schema identification

To provide for unambiguous identification of the aic_advanced_brep in an open information system, the object identifier

{ iso standard 10303 part(514) version(1) object(1) aic-advanced-brep(1) }

is assigned to the aic_advanced_brep schema (see 4). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

Annex C
(informative)

Computer-interpretable listings

This annex provides a listing of the EXPRESS entity names and corresponding short names as specified in this Part of ISO 10303 without comments or other explanatory text. This annex is available in computer-interpretable form and can be found at the following URLs:

Short names: http://www.mel.nist.gov/div826/subject/apde/snr/
EXPRESS: http://www.mel.nist.gov/step/parts/part514/

If there is difficulty accessing these sites contact ISO Central Secretariat or contact the ISO TC 184/SC4 Secretariat directly at: sc4sec@cme.nist.gov.

NOTE – The information provided in computer-interpretable form at the above URLs is informative. The information that is contained in the body of this part of ISO 10303 is normative.

Annex D
(informative)

EXPRESS-G diagrams

Figures D.1 through D.8 correspond to the EXPRESS generated from the short listing given in clause 4 using the interface specifications of ISO 10303-11. The diagrams use the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in annex D of ISO 10303-11.

NOTE 1 The following select types are interfaced into the AIC expanded listing according to the implicit interface rules of ISO 10303-11. These select types are not used by other entities in this part of ISO 10303.

— geometric_set_select;

— reversible_topology;

— shell;

— trimming_select;

— vector_or_direction.

NOTE 2 The implicit interface rules of ISO 10303-11 also introduce some entities whose instantiation is prohibited by rules on the **advanced_brep_shape_representation**. These entities are marked " * " in the EXPRESS-G diagrams.

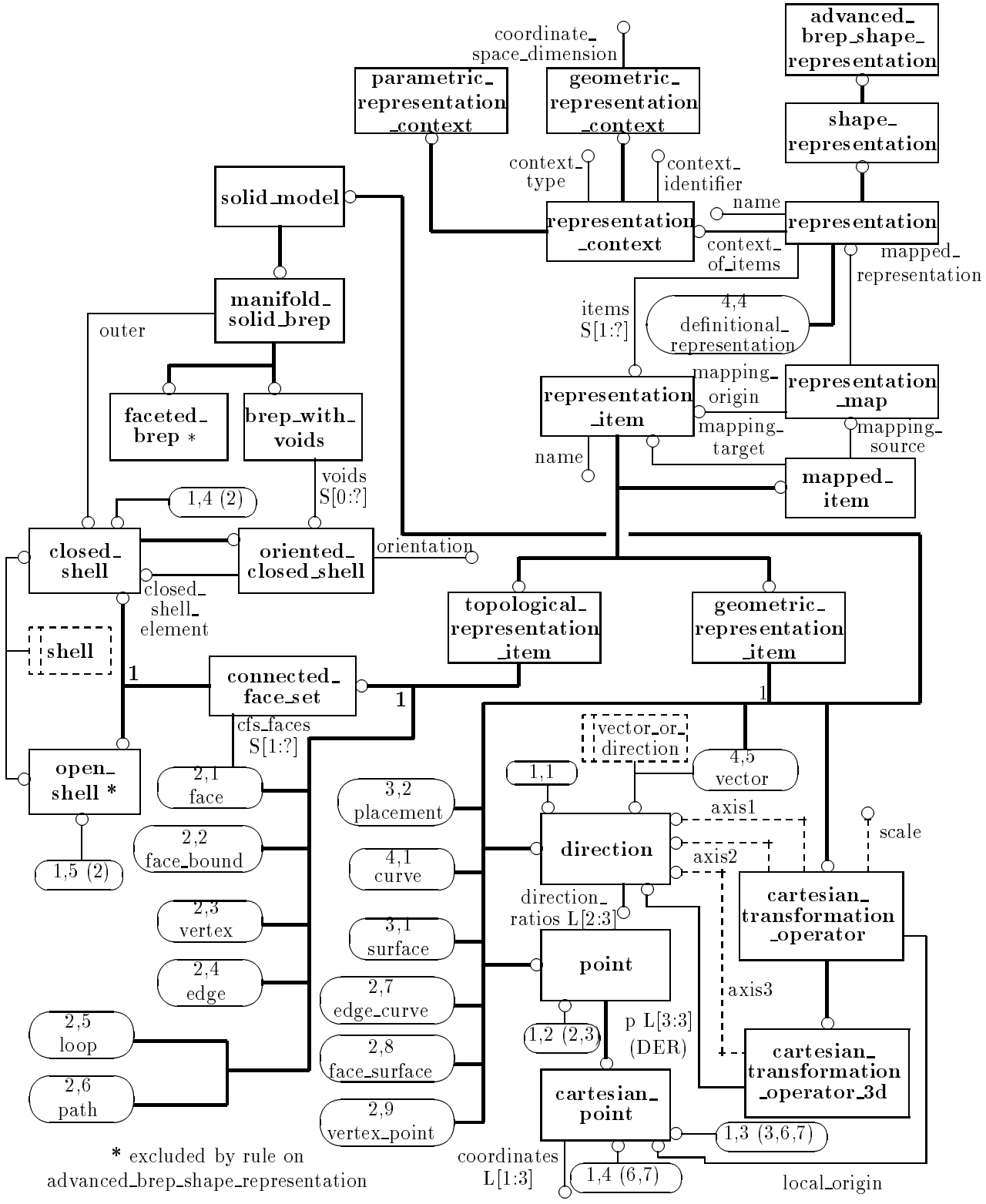


Figure D.1 – aic_advanced_brep EXPRESS-G diagram, page 1 of 8

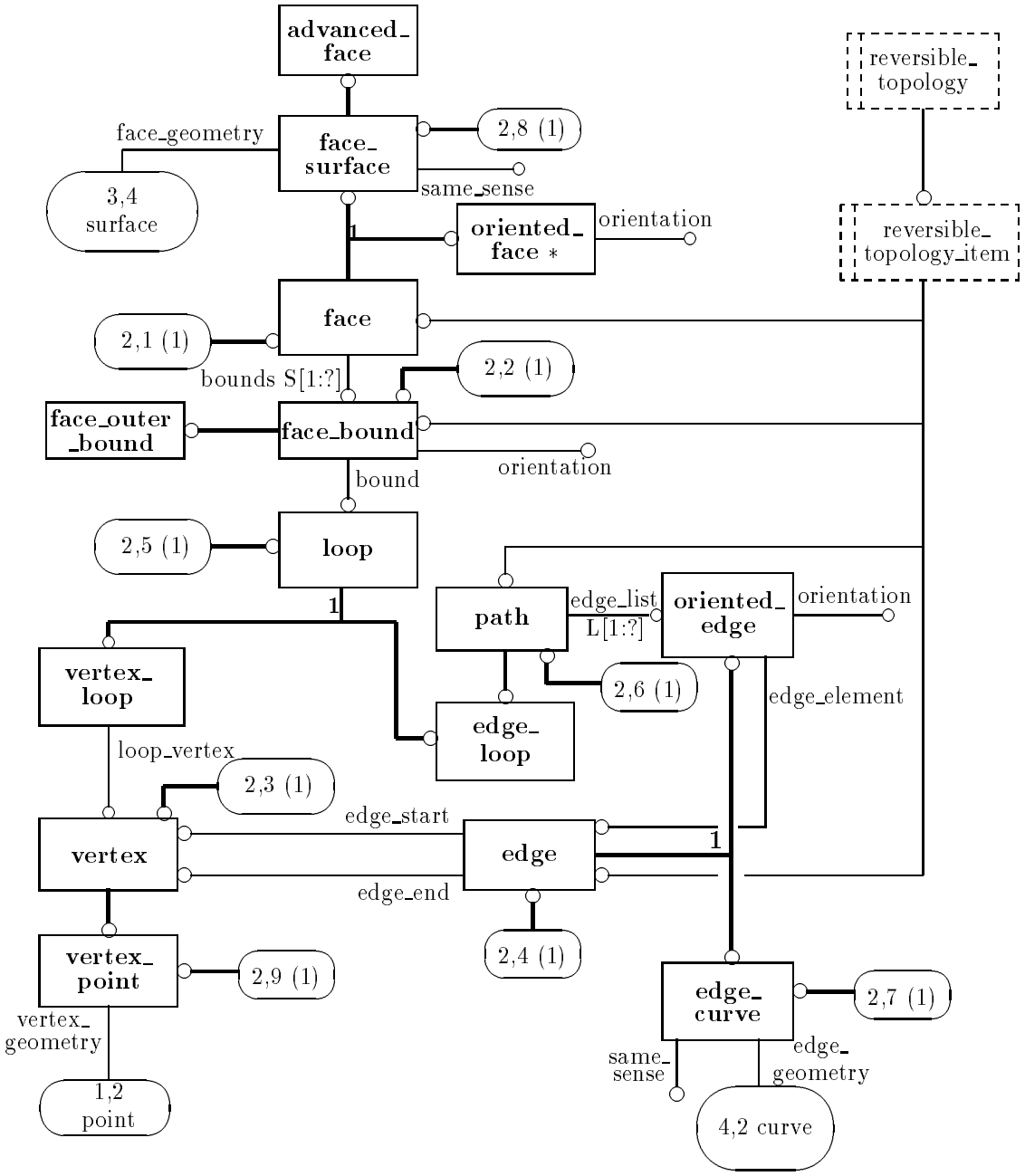


Figure D.2 – aic_advanced_brep EXPRESS-G diagram, page 2 of 8

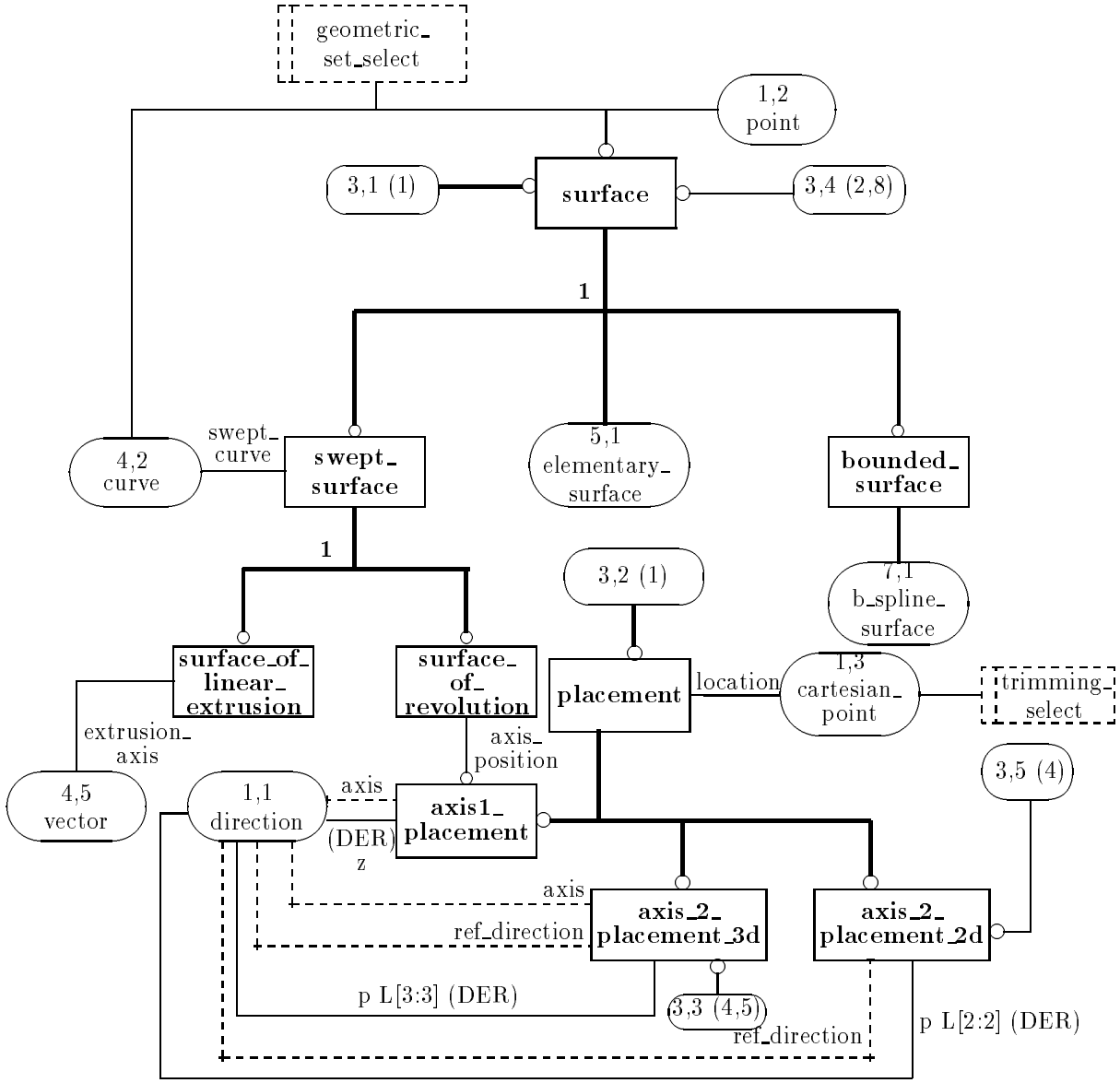


Figure D.3 – aic_advanced_brep EXPRESS-G diagram, page 3 of 8

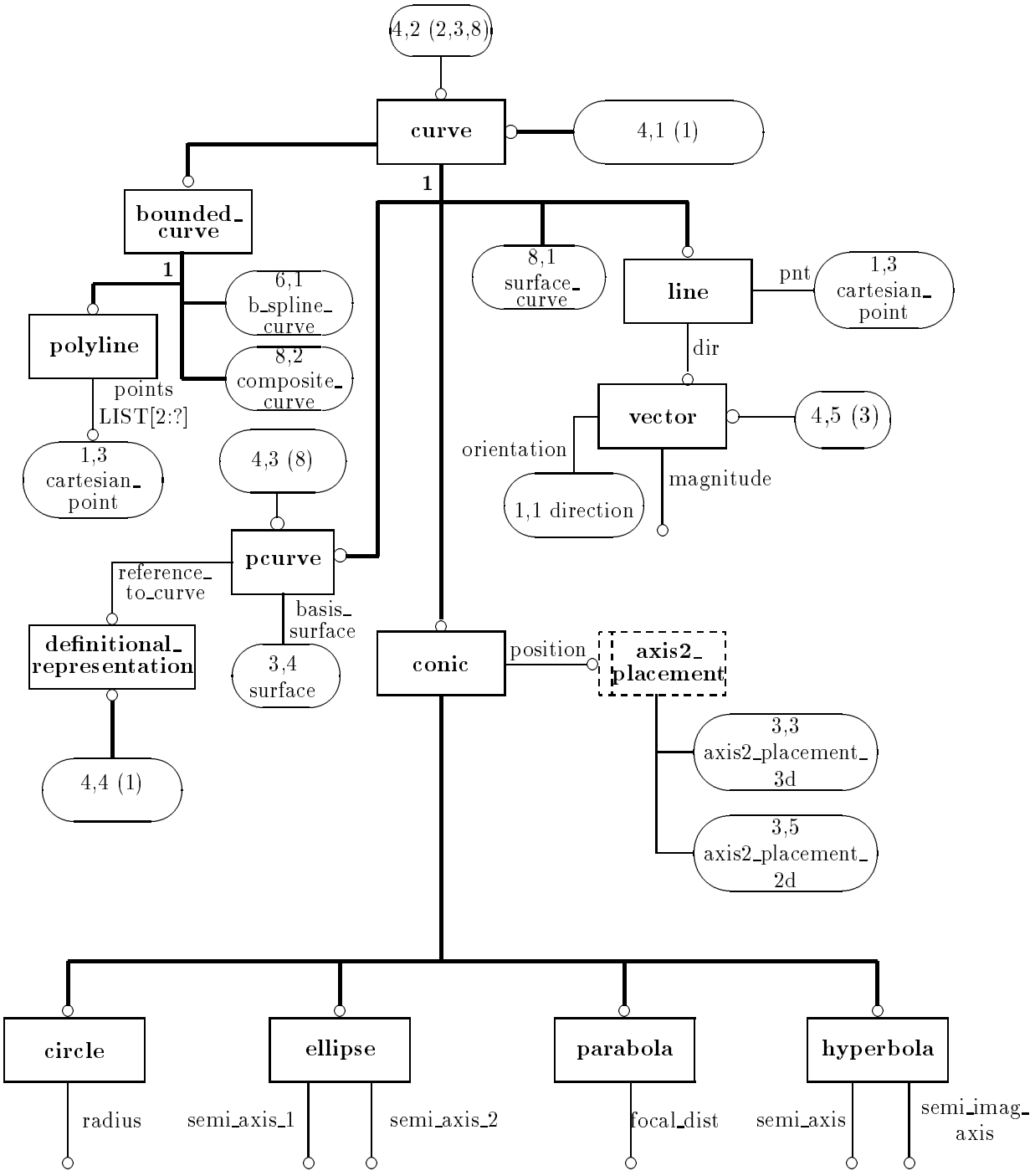


Figure D.4 – aic_advanced_brep EXPRESS-G diagram, page 4 of 8

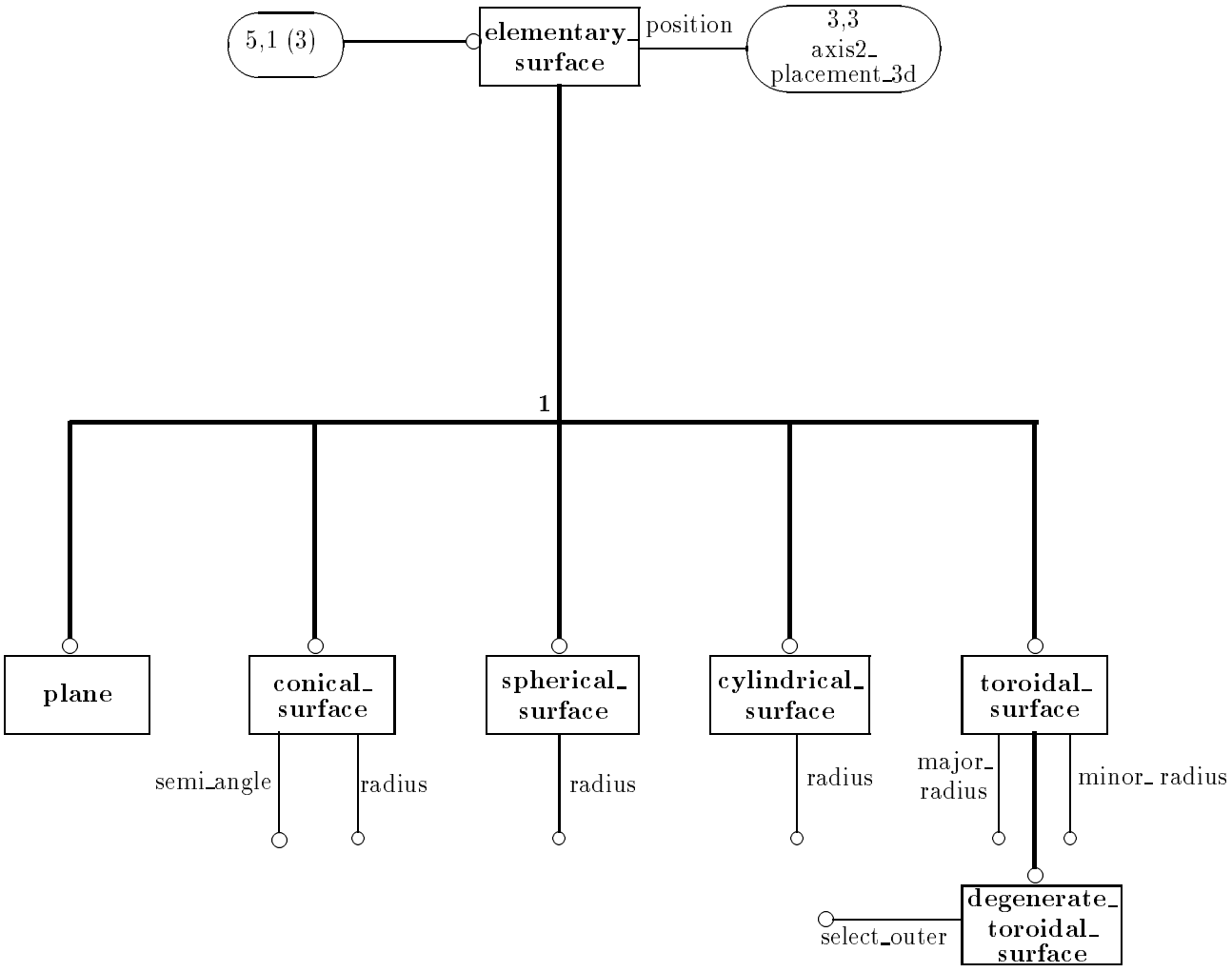


Figure D.5 – aic_advanced_brep EXPRESS-G diagram, page 5 of 8

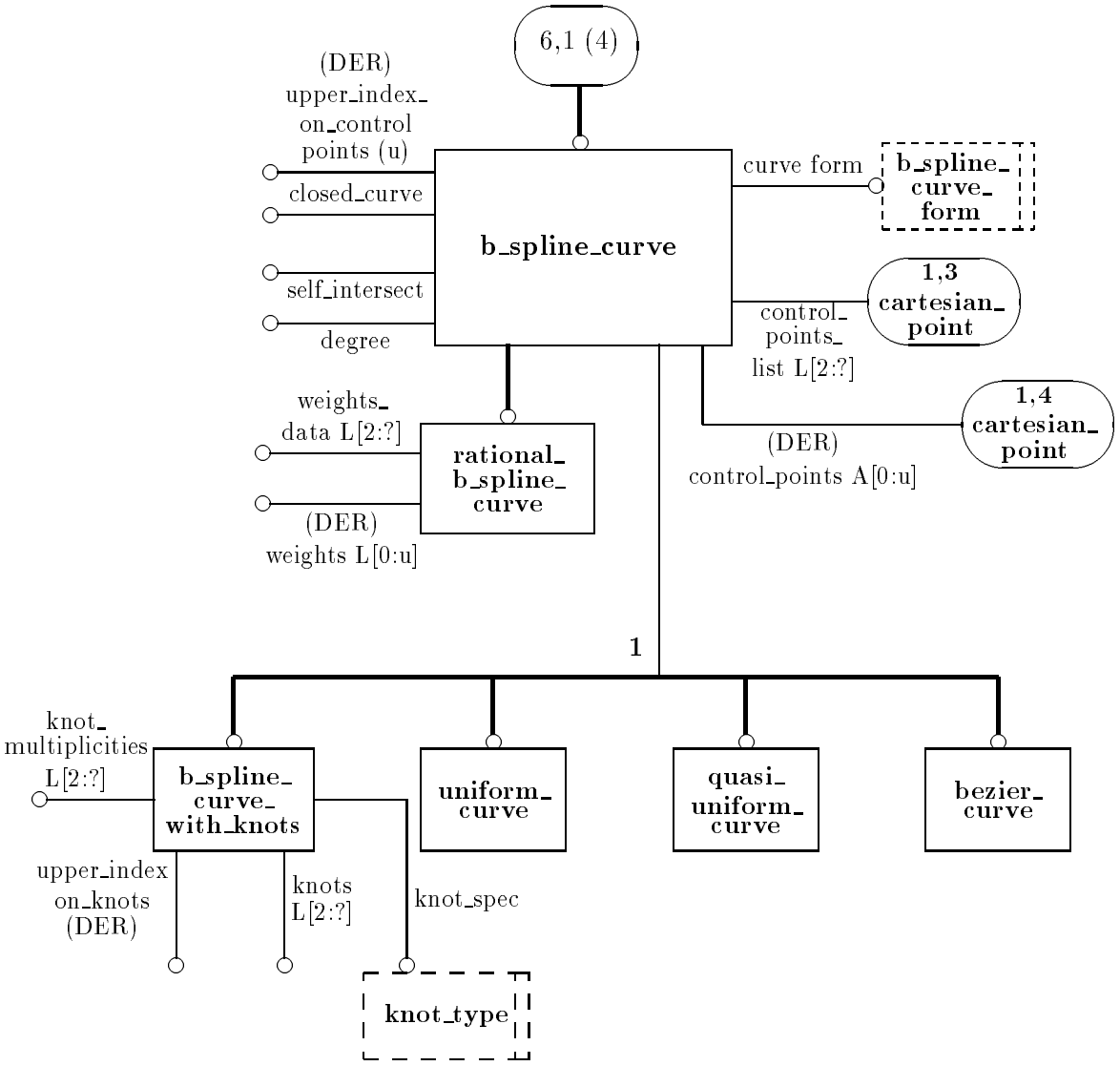


Figure D.6 – aic_advanced_brep EXPRESS-G diagram, page 6 of 8

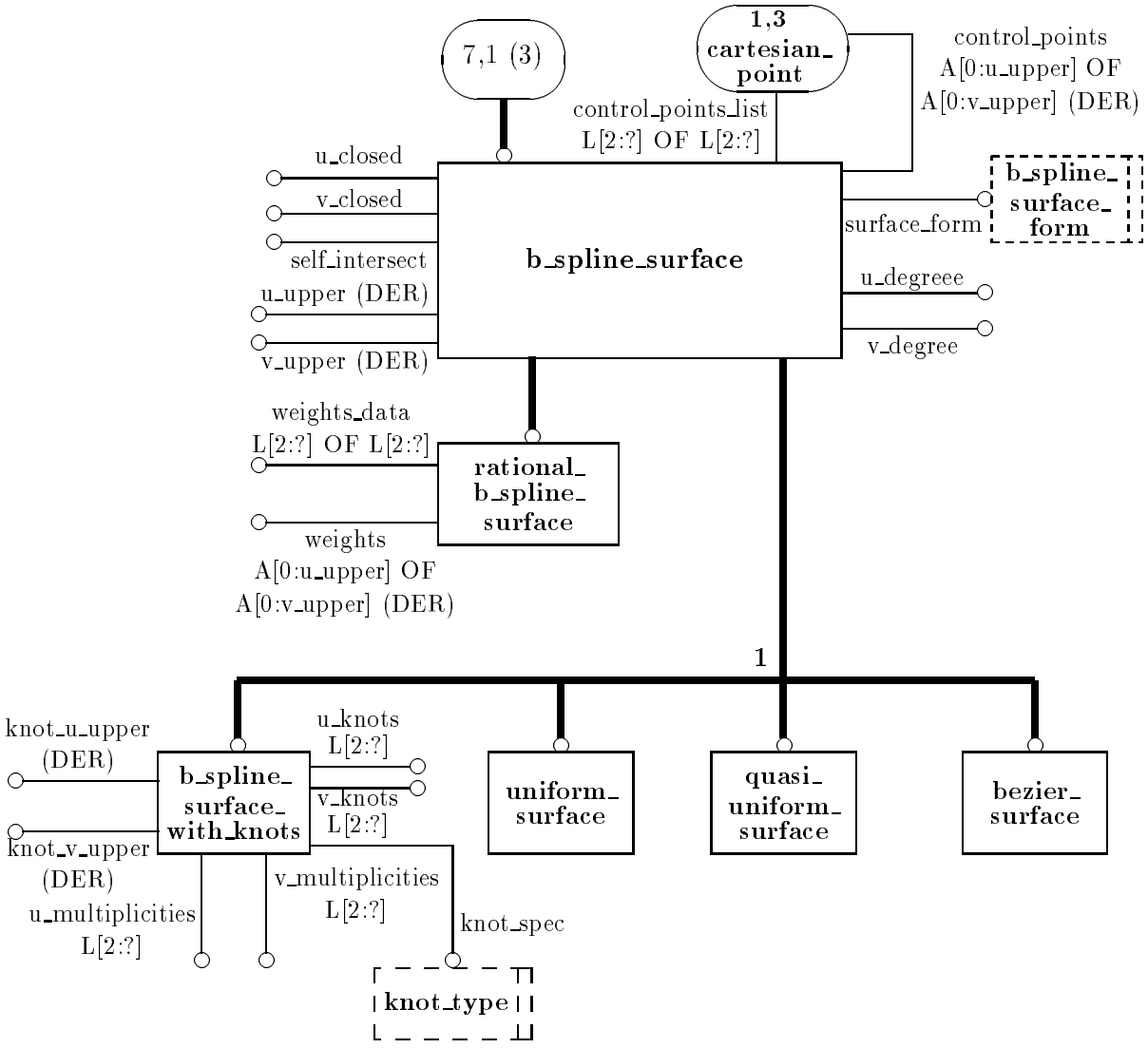
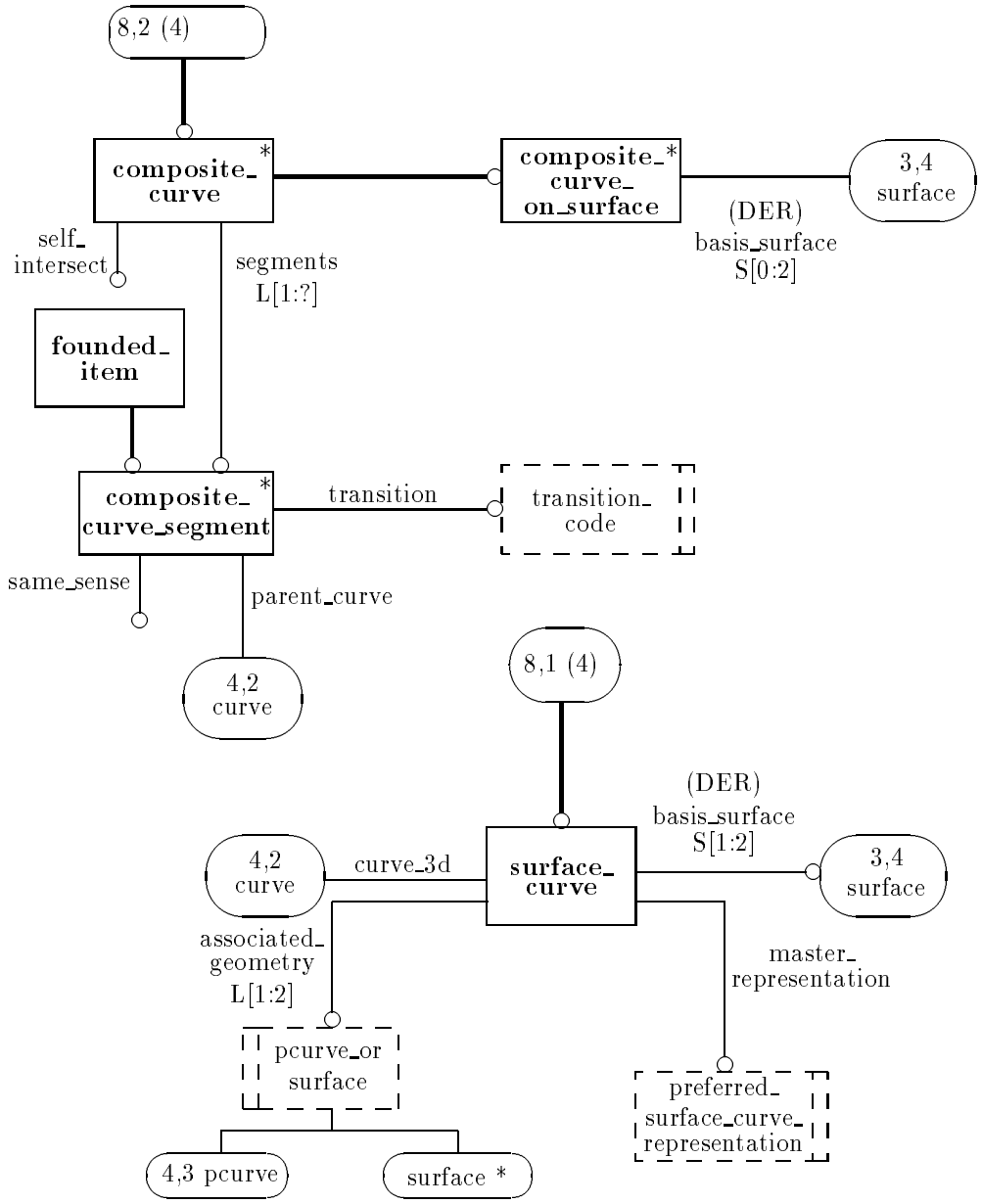


Figure D.7 – aic_advanced_brep EXPRESS-G diagram, page 7 of 8



* note: excluded by rule on advanced_face

Figure D.8 – aic_advanced_brep EXPRESS-G diagram, page 8 of 8

Annex E
(informative)

AIC conformance requirements and test purposes

Conformance to this part of iSO 10303 means that all the defined types and entity types defined in the AIM EXPRESS long form shall be supported. The only legitimate use, within the context of this AIC, for a geometric or topological entity instance is for the purpose of defining an **advanced_brep_shape_representation**.

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