INTERNATIONAL STANDARD

ISO 10303-511

First edition
2001-04-15

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

Part 511:
Application interpreted construct: Topologically bounded surface

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

Partie 511: Construction interprétée: Surface délimitée topologiquement

Reference number
ISO 10303-511:2001(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

Figures

Tables

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 3.

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.

This International Standard is organized as a series of parts, each published separately. The structure of this International Standard is described in ISO 10303-1.

Each part of this International Standard 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 application interpreted construct series.

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

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

Annexes A and B form a normative part of of this part of ISO 10303. Annexes C and D 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, integrated 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 document specifies the application interpreted construct for topologically bounded surface. This is the final draft of a 500 series part edition of the AIC for the definition of a face with explicit topology and fully defined geometry. The face and edge geometry includes both elementary and free-form geometry.

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

Part 511: Application interpreted construct: Topologically bounded surface

1 Scope

This part of ISO 10303 specifies the interpretation of the itegrated resources to satisfy the requirement for the definition of a face with explicit topological bounds and fully defined geometry.

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

— 3D geometry;

— B-spline curves and surfaces;

— conics;

— elementary curves;

— elementary surfaces;

— polylines;

— pcurves;

— sculptured surfaces;

— surface curves referencing pcurves;

— swept surfaces;

— twisted curves;

— unbounded geometry;

— geometric transformations;

— 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: 1998, *Information technology - Abstract Syntax Notation One (ASN.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: 1996, *Industrial automation systems and integration - Product data representation and exchange - Part 202: Application protocol: Associative draughting*

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.

— axi-symmetric;

— boundary;

— 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 Other definitions

3.4.1

advanced face
A face defined on a surface. This face is a finite portion of the surface that has its boundaries fully defined using topological entities with associated geometric curves. The surface geometry is required to be either an elementary surface, or a swept surface, or a B-spline surface.

3.4.2
sculptured surface
A bi-parametric free-form surface. In this part of ISO 10303 a sculptured surface is represented by a B-spline surface.

3.4.3
swept surface
A surface obtained by translating or revolving a curve.

3.4.4
twisted curve
A parametric curve in three-dimensional space. In this part of ISO 10303 a twisted curve is represented by a B-spline curve.

3.5 Abbreviations

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

AIC Application Interpreted Construct
AP Application Protocol

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.

This application interpreted construct provides a consistent set of geometric and topological entities for the definition of a face with fully defined geometry and explicit topology defining the boundaries. The permissible types of face geometry include elementary surfaces and B-spline surfaces. Edges are required to have their geometry defined by curves, that may include pcurves.

The highest level entity in this AIC is **advanced_face** which is a specialised type of **face_surface** (see ISO 10303-42). The rules on this entity ensure that the topology and geometry are fully defined.

EXPRESS specification:

```
*)
SCHEMA aic_topologically_bounded_surface;
 USE FROM geometry_schema
     (axis2_placement_2d,
      axis2_placement_3d,
      bezier_curve,
      bezier_surface,
      b_spline_curve_with_knots,
      b_spline_surface_with_knots,
      cartesian_point,
      circle,
      composite_curve_on_surface,
      conical_surface,
      cylindrical_surface,
      degenerate_toroidal_surface,
      direction,
      ellipse,
      geometric_representation_context,
      hyperbola,
      line,
      parabola,
      pcurve,
      plane,
      polyline,
      quasi_uniform_curve,
      quasi_uniform_surface,
      rational_b_spline_curve,
      rational_b_spline_surface,
      spherical_surface,
      surface_curve,
      surface_of_linear_extrusion,
      surface_of_revolution,
      swept_surface,
      toroidal_surface,
      uniform_curve,
      uniform_surface,
      vector);
 USE FROM topology_schema
     (edge,
      edge_curve,
      edge_loop,
      face_bound,
      face_outer_bound,
      face_surface,
      oriented_edge,
      path,
      vertex_loop,
      vertex_point);
 USE FROM representation_schema
```



```
     (definitional_representation,
      parametric_representation_context);
 USE FROM measure_schema (parameter_value);
(*
```

NOTE 2 The entities **edge**, **path** and **swept_surface** are explicitly interfaced, i.e., included in the USE FROM lists, to allow rules in the **advanced_face** entity to access attributes of these entities. For the use of this AIC these entities shall only be instantiated as one of their subtypes.

NOTE 3 The schemas referenced above can be found in the following parts of ISO 10303:

`geometry_schema`	ISO 10303-42
`topology_schema`	ISO 10303-42
`representation_schema`	ISO 10303-43
`measure_schema`	ISO 10303-41

4.1 Fundamental concepts and assumptions

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

— advanced_face;

— axis2_placement_2d;

— axis2_placement_3d;

— bezier_curve;

— bezier_surface;

— b_spline_curve_with_knots;

— b_spline_surface_with_knots;

— cartesian_point;

— circle;

— conical_surface;

— definitional_representation;

— degenerate_toroidal_surface;

— cylindrical_surface;

— direction;

— edge_curve;

— edge_loop;

— ellipse;

— face_bound;

— face_outer_bound;

— face_surface;

— geometric_representation_context;

— hyperbola;

— line;

— parabola;

— parametric_representation_context;

— pcurve;

— plane;

— polyline;

— quasi_uniform_curve;

— quasi_uniform_surface;

— rational_b_spline_curve;

— rational_b_spline_surface;

— spherical_surface;

— surface_of_linear_extrusion;

— surface_of_revolution;

— toroidal_surface;

— uniform_curve;

— uniform_surface;

— vector;

— vertex_loop;

— vertex_point.

An application protocol that uses this AIC shall require that all the above entities are supported.

An application protocol that uses this AIC shall require that a **face** entity is instantiated as an **advanced_face**.

4.2 aic_topologically_bounded_surface schema entity definition: advanced_face

An **advanced_face** is a special type of **face_surface** that has additional constraints to ensure that the geometry is directly and completely defined. The **advanced_face** is the top level entity that is used to formulate the precise meaning of a topologically bounded surface corresponding to the scope of this AIC.

An **advanced_face** is required to be fully bounded by **edge_loop**s or by **vertex_loops**.

At most one of the **bounds** of the face may be of type **face_outer_bound**

NOTE For some types of closed or partially closed surfaces, it may not be possible to identify a unique outer bound.

EXAMPLE 1 Any **edge_loop** on a plane surface may be used to define a **face_outer_bound** provided it is not enclosed in any other loop in the **face**.

EXAMPLE 2 A circular loop on a **cylindrical_surface** cannot define a **face_outer_bound** since it does not enclose a closed domain in the surface.

EXPRESS specification:

```
*)
ENTITY advanced_face
  SUBTYPE OF (face_surface);
WHERE
  WR1 : SIZEOF (['AIC_TOPOLOGICALLY_BOUNDED_SURFACE.ELEMENTARY_SURFACE',
          'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.B_SPLINE_SURFACE',
          'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.SWEPT_SURFACE'] *
            TYPEOF(face_geometry)) = 1;
  WR2 : SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* bounds |
         'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
```



```
       TYPEOF(bnds.bound)) | NOT (SIZEOF (QUERY
              (oe <* elp_fbnds.bound\path.edge_list |
            NOT('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_CURVE' IN
            TYPEOF(oe\oriented_edge.edge_element)))) = 0))) = 0;
WR3 : SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* bounds |
       'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
            TYPEOF(bnds.bound)) |
          NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
          NOT (SIZEOF (['AIC_TOPOLOGICALLY_BOUNDED_SURFACE.LINE',
                 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.CONIC',
                 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.POLYLINE',
                 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.SURFACE_CURVE',
                 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.B_SPLINE_CURVE'] *
            TYPEOF(oe.edge_element\edge_curve.edge_geometry)) = 1 )
              )) = 0))) = 0;
WR4 : SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* bounds |
         'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
              TYPEOF(bnds.bound)) |
          NOT(SIZEOF(QUERY (oe <* elp_fbnds.bound\path.edge_list |
           NOT((((('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.VERTEX_POINT' IN
              TYPEOF(oe\edge.edge_start)) AND
          ( 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.CARTESIAN_POINT' IN
        TYPEOF(oe\edge.edge_start\vertex_point.vertex_geometry)))) AND
              (('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.VERTEX_POINT' IN
                 TYPEOF(oe\edge.edge_end)) AND
            ( 'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.CARTESIAN_POINT' IN
               TYPEOF(oe\edge.edge_end\vertex_point.vertex_geometry)))
           ))) = 0))) = 0;
WR5 : SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* bounds |
       'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
           TYPEOF(bnds.bound)) |
          'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.ORIENTED_PATH' IN
           TYPEOF(elp_fbnds.bound))) = 0;
WR6 : (NOT ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.SWEPT_SURFACE' IN
                                    TYPEOF(face_geometry))) OR
     (SIZEOF (['AIC_TOPOLOGICALLY_BOUNDED_SURFACE.LINE',
              'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.CONIC',
              'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.POLYLINE',
              'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.B_SPLINE_CURVE'] *
         TYPEOF(face_geometry\swept_surface.swept_curve)) = 1);
WR7 : SIZEOF(QUERY (vlp_fbnds <* QUERY (bnds <* bounds |
      'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.VERTEX_LOOP' IN
           TYPEOF(bnds.bound)) |
           NOT(('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.VERTEX_POINT' IN
          TYPEOF(vlp_fbnds\face_bound.bound\vertex_loop.loop_vertex))
       AND  ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.CARTESIAN_POINT' IN
                 TYPEOF(vlp_fbnds\face_bound.bound\vertex_loop.
                 loop_vertex\vertex_point.vertex_geometry))
           ))) = 0;
WR8 : SIZEOF (QUERY (bnd <* bounds |
       NOT (SIZEOF(['AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP',
       'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.VERTEX_LOOP'] *
```



```
             TYPEOF(bnd.bound)) = 1))) = 0;
  WR9 : SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* bounds |
        'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
             TYPEOF(bnds.bound)) |
         NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
            ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.SURFACE_CURVE' IN
         TYPEOF(oe\oriented_edge.edge_element\edge_curve.edge_geometry))
            AND (NOT (SIZEOF (QUERY (sc_ag <*
            oe.edge_element\edge_curve.edge_geometry\
            surface_curve.associated_geometry |
            NOT ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.PCURVE' IN
            TYPEOF(sc_ag)))) = 0)))) = 0))) = 0;
  WR10 : ((NOT ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.SWEPT_SURFACE' IN
         TYPEOF(face_geometry))) OR
         ((NOT ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.POLYLINE' IN
         TYPEOF(face_geometry\swept_surface.swept_curve))) OR
        (SIZEOF(face_geometry\swept_surface.swept_curve\polyline.points)
         >= 3))) AND
         (SIZEOF (QUERY (elp_fbnds <* QUERY (bnds <* bounds |
         'AIC_TOPOLOGICALLY_BOUNDED_SURFACE.EDGE_LOOP' IN
             TYPEOF(bnds.bound)) |
         NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
         ('AIC_TOPOLOGICALLY_BOUNDED_SURFACE.POLYLINE' IN
         TYPEOF(oe\oriented_edge.edge_element\edge_curve.edge_geometry))
         AND  (NOT (SIZEOF (oe\oriented_edge.edge_element\
         edge_curve.edge_geometry\polyline.points) >= 3)))) = 0))) = 0);
 END_ENTITY;
(*
```

Formal propositions:

WR1: The geometry used in the definition of the face shall be restricted. The face geometry shall be an **elementary_surface**, **swept_surface**, or **b_spline_surface**.

WR2: The geometry of all bounding edges of the face shall be fully defined as **edge_curve**s.

WR3: The types of curve used to define the geometry of edges shall be restricted to **line**s, **conic**s, **polyline**s, **surface_curve**s, or **b_spline_curve**s.

WR4: All vertices used in the face definition shall be of type **vertex_point** with geometry defined by a **cartesian_point**.

WR5: The use of oriented paths in the definition of the **edge_loop**s of the **advanced_face** is prohibited.

WR6: If the face geometry is of type **swept_surface** then the **swept_curve** used in the definition shall be of type **line**, **conic**, **polyline**, or **b_spline_curve**.

WR7: For any **vertex_loop** used to bound the face the **loop_vertex** shall be of type **vertex_point** and the geometry shall be defined by a **cartesian_point**.

WR8: The face bounds shall be defined by either **edge_loop**s or **vertex_loop**s.

WR9: If a **surface_curve** is used as part of a face bound then the **associated_geometry** attribute shall reference **pcurve**s not **surface**s.

WR10: If a **polyline** is used either to define a **swept_surface** or as part of a face bound, it shall contain at least three points.

Informal propositions:

IP1: Any instance of **advanced_face** which has the geometry of a complete **spherical_surface** shall be bounded by a **vertex_loop** located at the point where the z axis of the placement coordinate system leaves the surface of the sphere, (i.e at the 'North Pole' of the sphere).

EXPRESS specification:

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


Annex A
(normative)

Short names of entities

Table A.1 provides the short names of entities specified in the EXPRESS listing of 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 entities

Entity name	Short name
ADVANCED_FACE	ADVFAC

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(511) 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_topologically_bounded_surface in an open information system, the object identifier

{ iso standard 10303 part(511) version(1) object(1) aic-topologically-bounded-suface(1) }

is assigned to the aic_topologically_bounded_surface 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/part511/

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;

— trimming_select;

— vector_or_direction.

NOTE 2 The rules on **advanced_face** exclude the instantiation of some entities which are implicitly interfaced and, therefore, shown in the diagrams. These entities are marked with a $*$ in the diagrams.

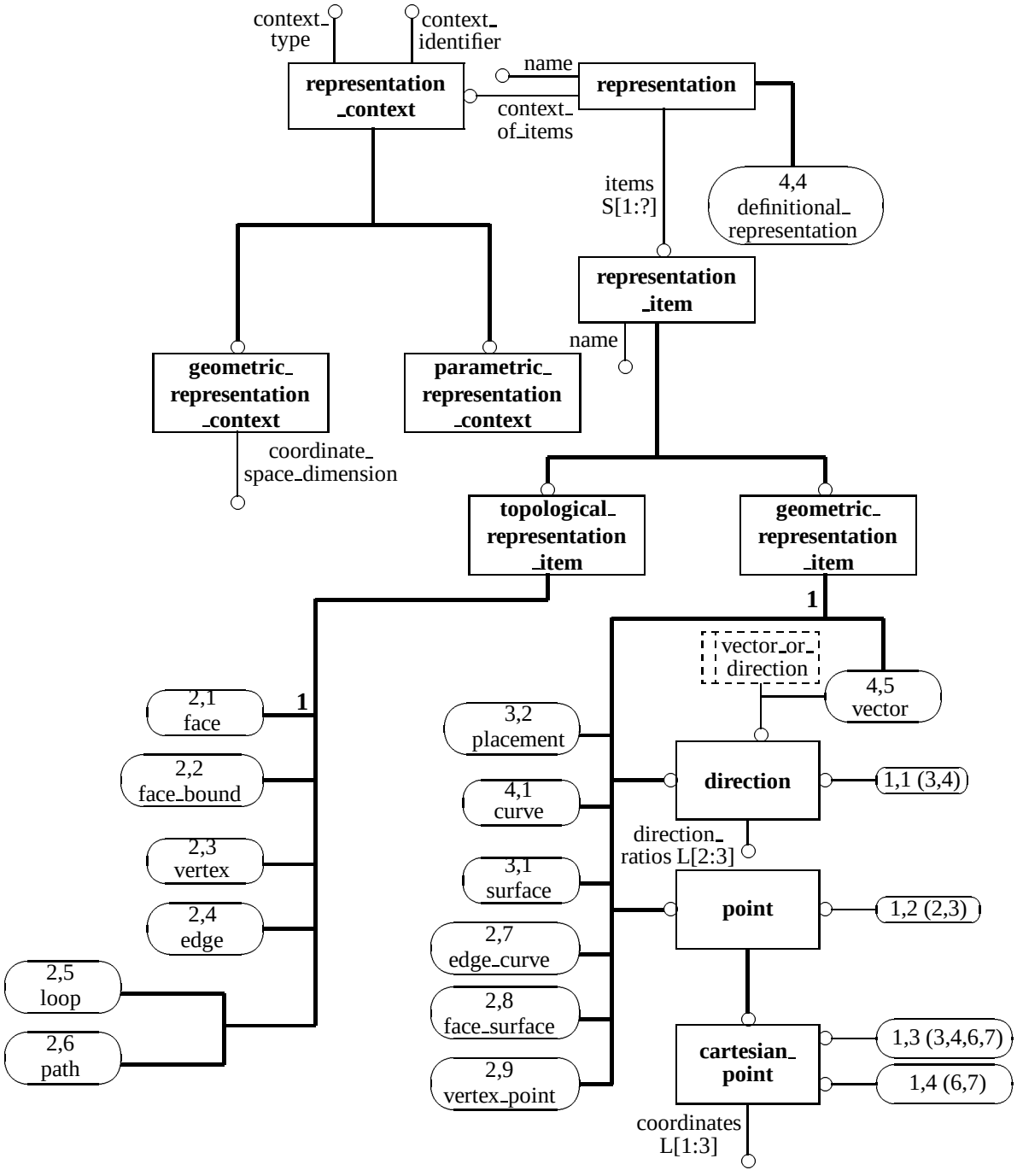


Figure D.1 – aic_topologically_bounded_surface EXPRESS-G diagram page 1 of 8

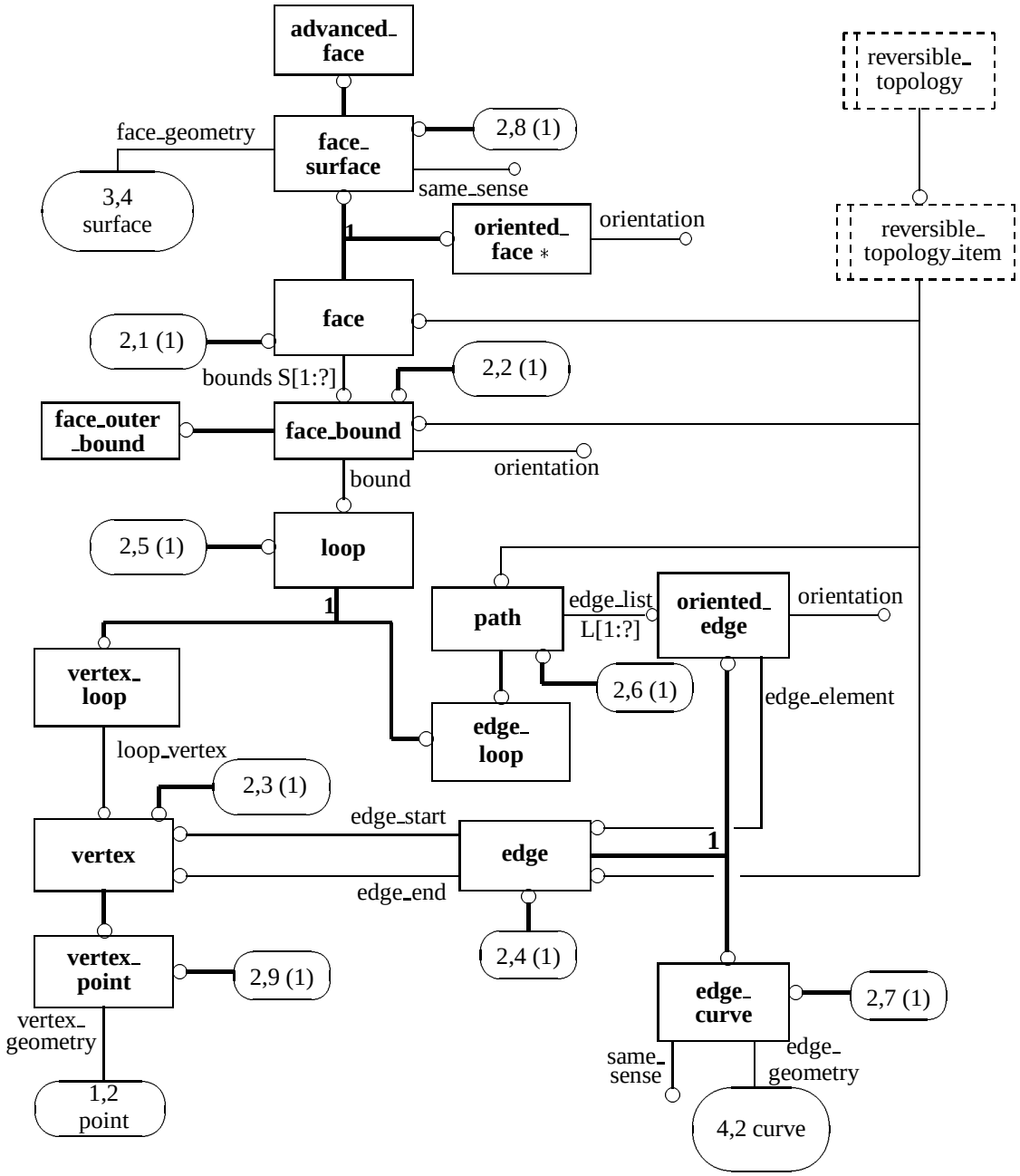


Figure D.2 – aic_topologically_bounded_surface EXPRESS-G diagram page 2 of 8

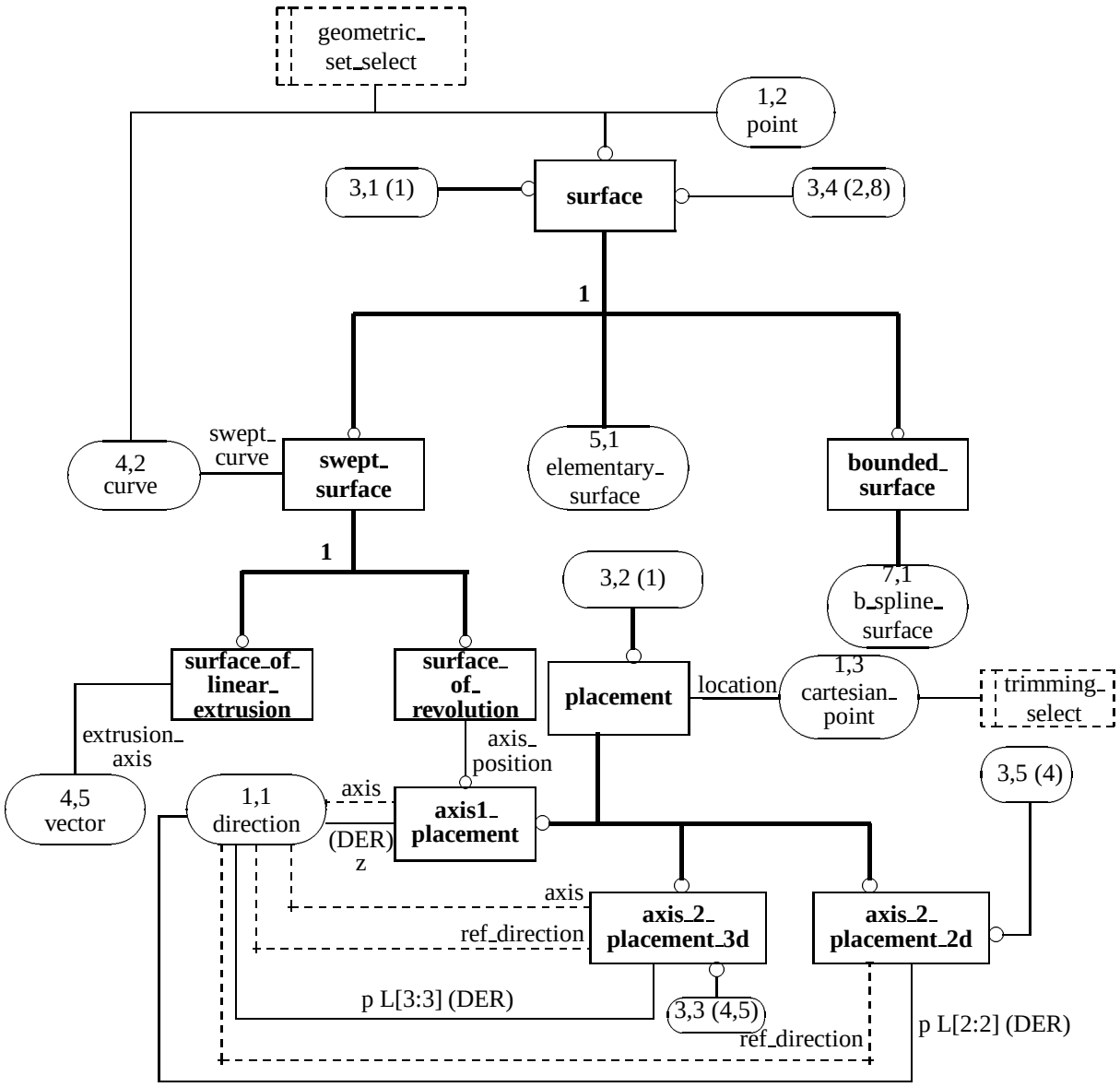


Figure D.3 – aic_topologically_bounded_surface EXPRESS-G diagram page 3 of 8

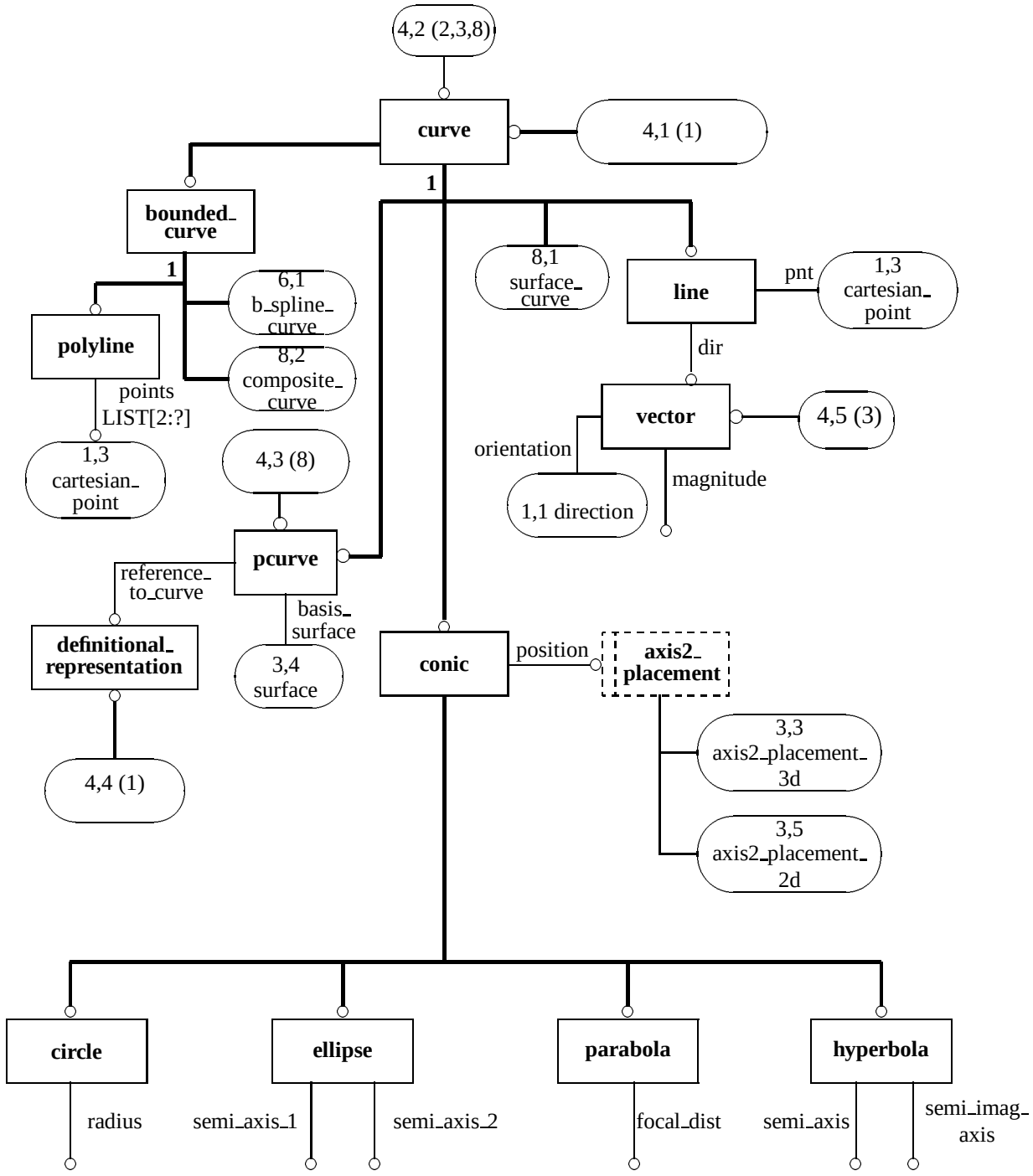


Figure D.4 – aic_topologically_bounded_surface EXPRESS-G diagram page 4 of 8

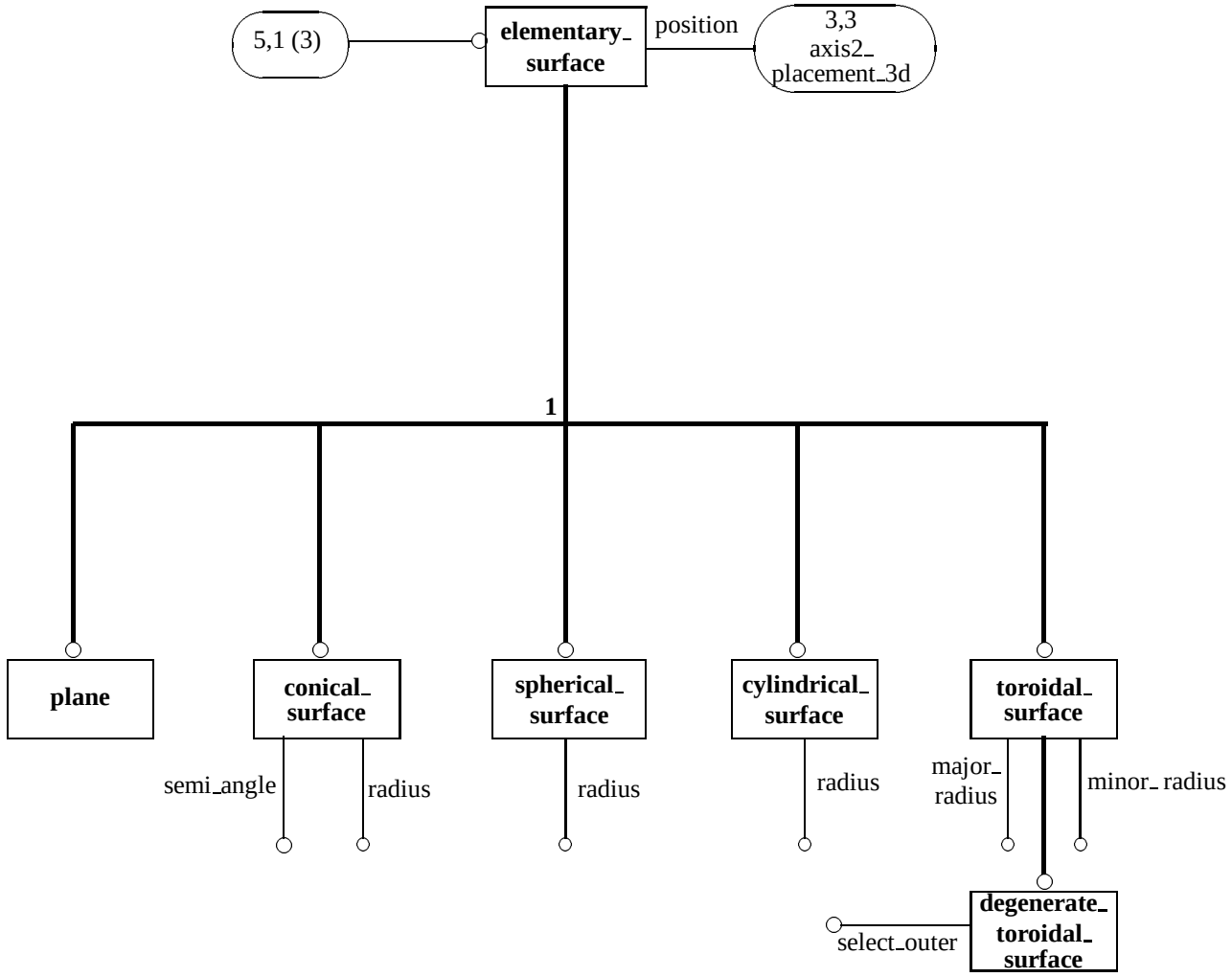


Figure D.5 – aic_topologically_bounded_surface EXPRESS-G diagram page 5 of 8

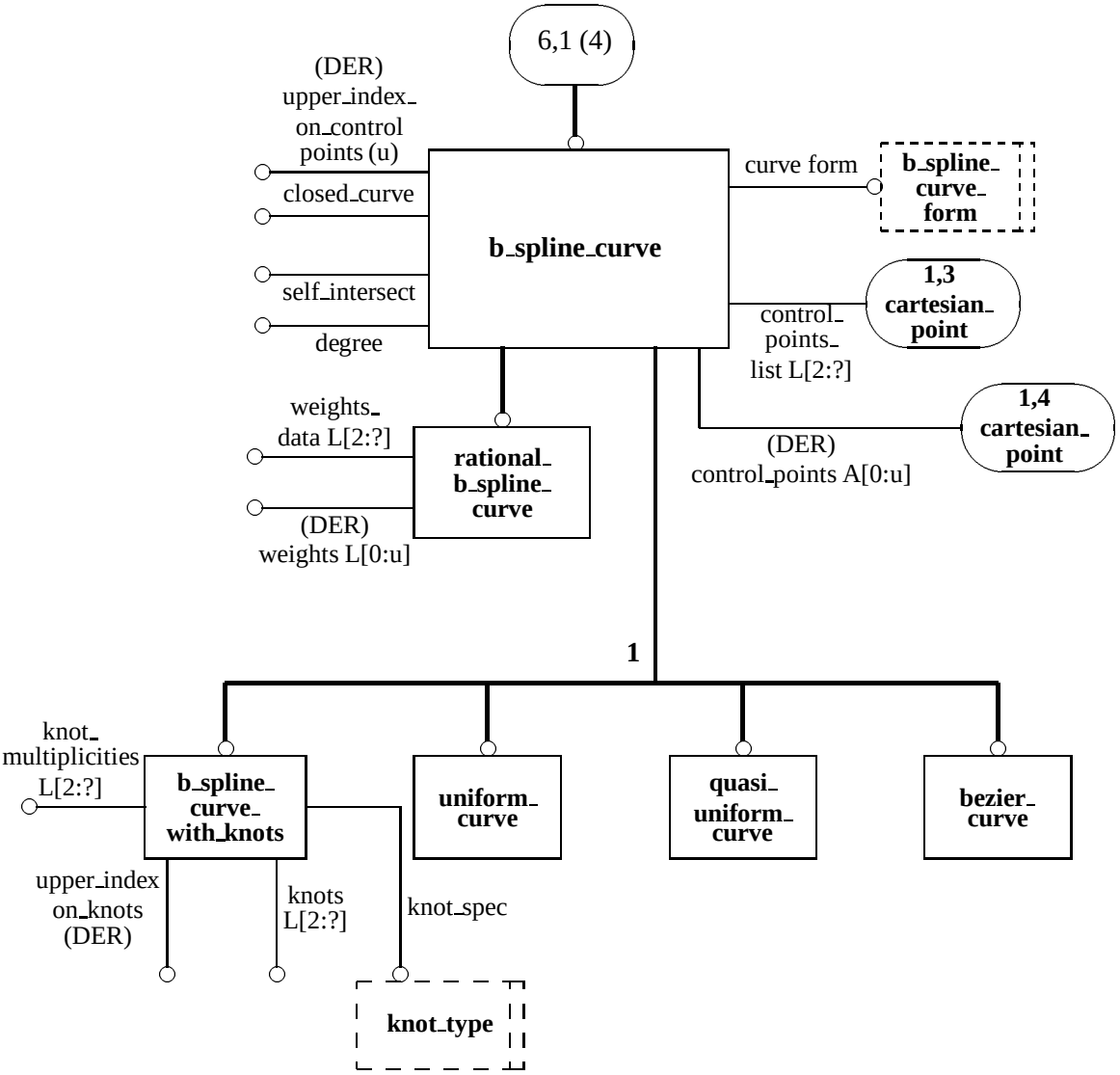


Figure D.6 – aic_topologically_bounded_surface EXPRESS-G diagram page 6 of 8

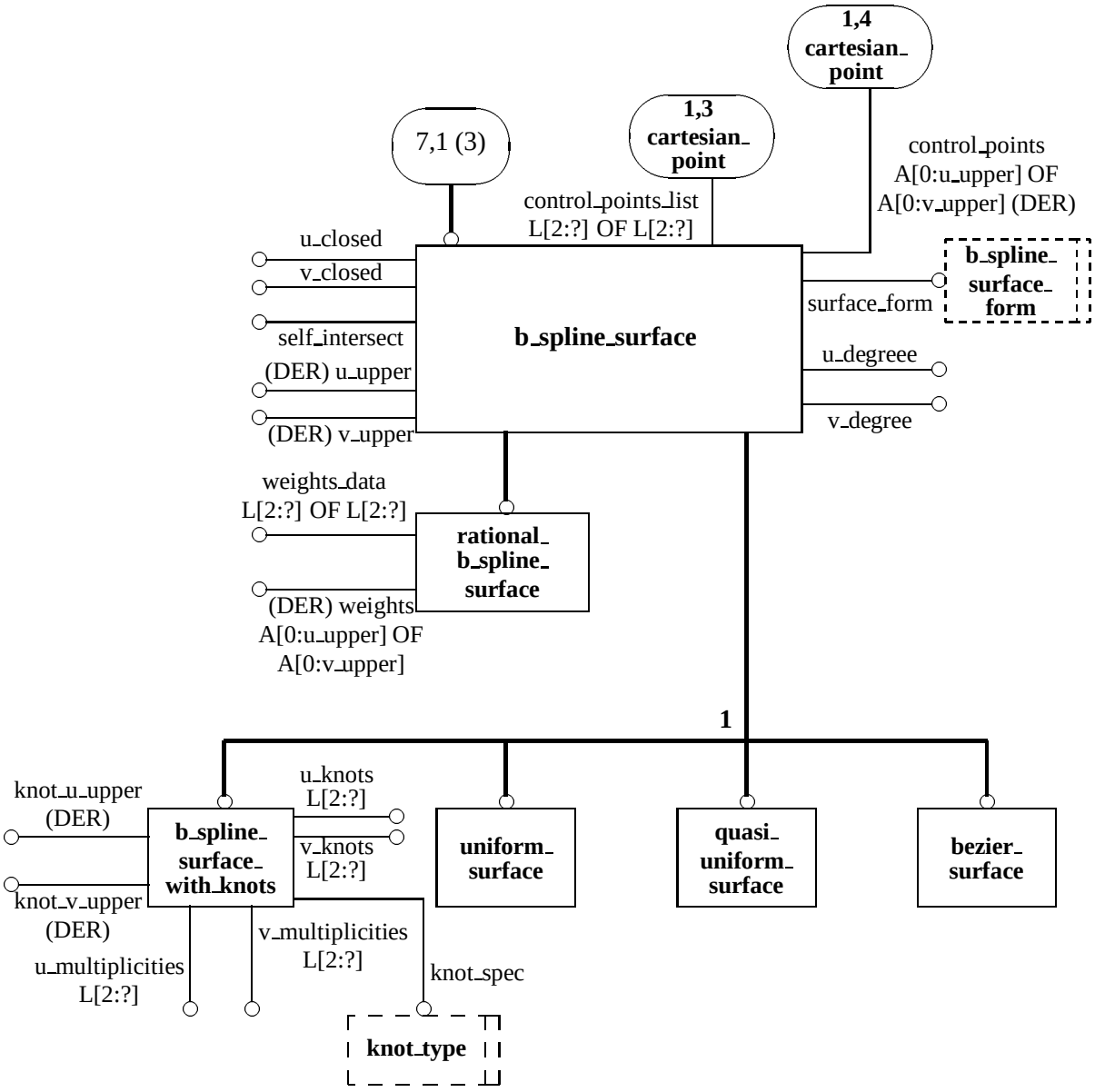
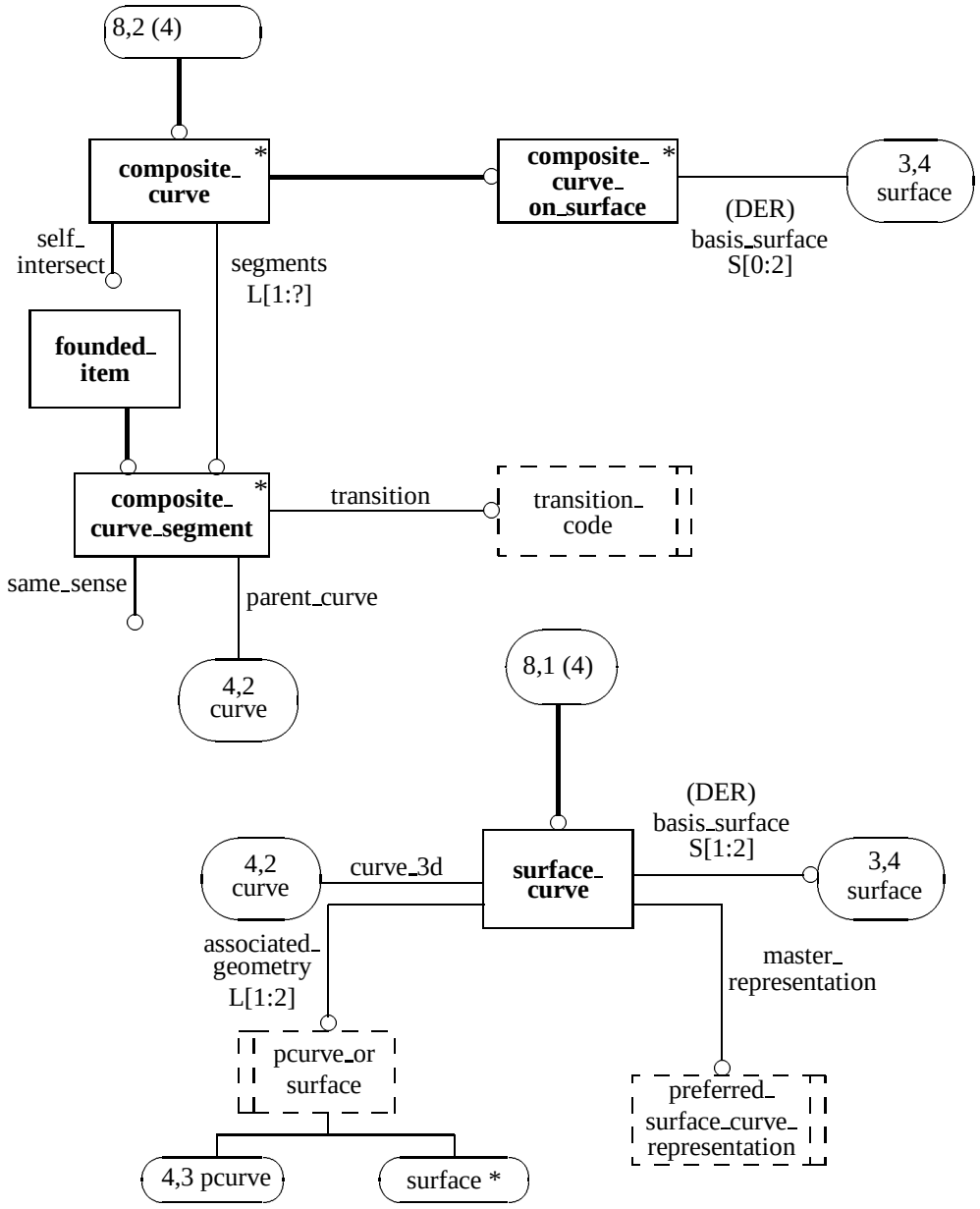


Figure D.7 – aic_topologically_bounded_surface EXPRESS-G diagram page 7 of 8



* note: excluded by rule on advanced_face

Figure D.8 – aic_topologically_bounded_surface EXPRESS-G diagram page 8 of 8

Index

ICS 25.040.40

Price based on 24 pages