

**Implementation of
ISO 10303-46 : 1994**

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

**Part 46. Integrated generic resources:
Visual presentation**



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Committees responsible for this British Standard

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Construction Industry Computing Association
Department of Trade and Industry (Services Management Division (TMS))
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INTERNATIONAL STANDARD

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

Part 46:

Integrated generic resources: Visual
presentation

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

Partie 46: Ressources génériques intégrées: Présentation visuelle



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Foreword

The International Organization for Standardization (ISO) 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 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.

International Standard ISO 10303-46 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data and global manufacturing programming languages*.

ISO 10303 consists of the following parts under the general title *Industrial automation systems and integration – Product data representation and exchange*:

- Part 1, Overview and fundamental principles;
- Part 11, Description methods: The *EXPRESS* language reference manual;
- Part 21, Implementation methods: Clear text encoding of the exchange structure;
- Part 22, Implementation methods: Standard data access interface specification;
- Part 31, Conformance testing methodology and framework: General concepts;
- Part 32, Conformance testing methodology and framework: Requirements on testing laboratories and clients;
- Part 41, Integrated generic resources: Fundamentals of product description and support;
- Part 42, Integrated generic resources: Geometric and topological representation;
- Part 43, Integrated generic resources: Representation structures;
- Part 44, Integrated generic resources: Product structure configuration;
- Part 45, Integrated generic resources: Materials;
- Part 46, Integrated generic resources: Visual presentation;
- Part 47, Integrated generic resources: Shape variation tolerances;
- Part 49, Integrated generic resources: Process structure and properties;

- Part 101, Integrated application resources: Draughting;
- Part 104, Integrated application resources: Finite element analysis;
- Part 105, Integrated application resources: Kinematics;
- Part 201, Application protocol: Explicit draughting;
- Part 202, Application protocol: Associative draughting;
- Part 203, Application protocol: Configuration controlled design;
- Part 207, Application protocol: Sheet metal die planning and design;
- Part 210, Application protocol: Printed circuit assembly product design data;
- Part 213, Application protocol: Numerical control process plans for machined parts.

The structure of this International Standard is described in ISO 10303-1. The numbering of the parts of this International Standard reflects its structure:

- Part 11 specifies the description methods;
- Parts 21 and 22 specify the implementation methods;
- Parts 31 and 32 specify the conformance testing methodology and framework;
- Parts 41 to 49 specify the integrated generic resources;
- Parts 101 to 105 specify the integrated application resources;
- Parts 201 to 213 specify the application protocols.

Should further parts be published, they will follow the same numbering pattern.

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

Diskette

Users should note that this part of ISO 10303 comprises a diskette:

- the short names of entities given in annex A are also included on the diskette;
- the EXPRESS listings (annex C) are provided on the diskette only;
- a method to enable users to report errors in the documentation is given. Full details are provided in the file.

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 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 integrated resources series. Major subdivisions of this International Standard are:

- Presentation organization
- Presentation definition
- Presentation appearance
- Presentation resources

This part of ISO 10303 specifies the integrated resources for the visualization of displayable properties of products.

The information given in all four schemas of this part together is sufficient to describe in detail how product information shall be visualized by a receiving system. The presentation information contained in this part can be used only in conjunction with product information suitable for display. Presentation information as contained in this part cannot be displayed by itself without reference to product information.

The presentation organization schema describes the hierarchical and partially recursive structure of the presentation sets, areas and views in which images of the product information are displayed. It also explains how the components of the product information image and its annotation are organized as displayable objects and how these are placed into the context of presentations. This schema also accounts for the definition of the projective process for geometry by means of a camera model and for the specification of lighting and shading models.

The presentation definition schema serves to define how the individual geometric and non-geometric components of the product information are selected, assembled into presentation groups, and associated with presentation styles.

The presentation appearance schema defines the appearance attributes that can be chosen to describe the desired visual appearance of the displayable elements of the product information by enumerating the available graphical presentation styles.

The presentation resource schema provides basic graphical capabilities such as text font definition, symbol definition, and colour definition.

The visual presentation characteristics described in this part are often associated with information from other generic resource parts, especially with geometric and topological representations.

(ISO 10303-42). The Application Protocols determine which resource parts are used together. Applications which make use of the generic resources in this part provide both the product information to be visually presented and the semantic meaning of the presentation. Possible applications include rendered views of product shape, results of scientific visualization, technical drawings, diagrams, charts, and graphics for technical publications.

Relation to graphics standards

The integrated resources specified in this part of ISO 10303 support the visual presentation of the properties of products. The generation of visual images using data specified by these integrated resources requires the use of an appropriate display system. This part of ISO 10303 specifies the input data to such systems, together with the necessary structures and constraints that relate presentation data to other aspects of product data.

Many display systems conform to existing ISO standards for computer graphics, such as GKS-3D (ISO/IEC 8805) and PHIGS/PHIGS PLUS (ISO/IEC 9592). This part of ISO 10303 takes into account the concepts and terminology of these standards. Input data specified by this part of ISO 10303 is therefore intended to be suitable for further processing by displays conforming to graphics standards.



S

Industrial automation systems and integration — Product data representation and exchange — Part 46 : Integrated generic resources: Visual presentation

1 scope

This part of ISO 10303 specifies the integrated resources for the visualization of displayable product information . Presentation data as provided in this part are combined with product data and are exchanged together between systems with the aim that the receiving system can construct one or several pictures of the product information suitable for human perception.

This part specifies the generic resources required to describe the desired visual appearance of product information in its picture. The actual generation of the picture from the product information and its presentation data is left to the receiving system. The actual depiction may deviate from this target because of limitations in the capabilities of graphics systems.

Product information can be visualized in two ways, either by realistic, life-like images according to the rules of projective geometry and light propagation and reflection, or by symbolic presentations that conform with draughting standards and conventions. This part supports both types of presentations. The two types of visualization processes require different kinds of graphical transformations and these may be combined in the same picture.

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

- Association between product data defined by other parts of ISO 10303 and presentation data;
- Support of graphics functionality in compliance with current ISO graphics standards;
- Definition of presentation style attributes for realistic and symbolic visualizations of geometric and non-geometric displayable elements in the product information;
- Control of approximation tolerances for geometric presentation elements;
- Methods for defining the appearance of characters and symbols in fonts;
- Support of externally defined character fonts and symbols;
- Image control by a layer mechanism;
- Nesting of presentation areas.

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

ISO 10303-46:1994(E)

- Definition of product information;
- Exchange of purely graphical information without any relationship to product information;
- Definition of the contents of character font and symbol libraries.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10303. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

¹⁾To be published.

3 Definitions and abbreviations

3.1 Terms defined in ISO 10303-1

This part of ISO 10303 makes use of the following terms defined in ISO 10303-1.

- application
- data
- data exchange
- generic resource
- information
- integrated resource
- presentation
- product
- product data
- product information
- structure

3.2 Terms defined in this part of ISO 10303

For the purpose of this part of ISO 10303, the following definitions apply.

3.2.1 annotation: text and/or symbology used for the purpose of communicating product information.

3.2.2 displayable product information: facts, concepts, or instructions about a product that are displayed through the visualization process.

EXAMPLE 1 – Displayable information of a product are properties such as shape, dimensions and tolerances, and material.

3.2.3 layer: a collection of displayable items for the purpose of controlling visibility and presentation style.

3.2.4 picture: a two-dimensional graphical presentation of product properties for human perception.

ISO 10303-46:1994(E)

3.2.5 presentation information: the information necessary to create a presentation of product information through visualization. Presentation information is meaningful only if it is associated with product information.

3.2.6 realistic presentation of properties: a type of visualization that makes use of physical laws and mathematical principles to produce lifelike images. Realistic presentation makes use of perspective transformations, reflectance calculations, shading transparency, and colour definitions.

3.2.7 state variable: a variable which represents a quantity, e.g. temperature.

3.2.8 symbol: a mark or characters that are interpreted as the conventional sign of some object, idea, function, or process.

3.2.9 symbolic presentation of properties: a type of visualization that makes use of engineering conventions and practices to produce annotation.

3.2.10 synthetic camera model: a model which describes the process of mapping product shape to two dimensions. The model uses an abstraction of the process used by a camera to create a photo.

3.2.11 visualization: a process by which displayable product information and presentation information are used to produce a picture.

3.3 Abbreviations

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

CIE	Commission Internationale de l'Eclairage. Used to refer to the CIE universal colour definition system.
HLS	Hue, Lightness, Saturation colour space.
HSV	Hue, Saturation, Value colour space.
RGB	Red, Green, Blue colour space.

4 Presentation organization

The following EXPRESS declaration begins the `presentation_organization_schema` and identifies the necessary external references.

EXPRESS specification:

*)

SCHEMA `presentation_organization_schema`;

REFERENCE FROM `presentation_resource_schema`
 (`colour`,
 `planar_box`,
 `presentation_scaled_placement`);

REFERENCE FROM `geometry_schema`
 (`axis2_placement_2d`,
 `axis2_placement_3d`,
 `cartesian_point`,
 `curve`,
 `direction`,
 `dot_product`,
 `geometric_representation_context`,
 `geometric_representation_item`,
 `plane`
);

REFERENCE FROM `representation_schema`
 (`item_defined_transformation`,
 `item_in_context`,
 `mapped_item`,
 `representation`,
 `representation_item`,
 `representation_map`,
 `representation_relationship`,
 `representation_relationship_with_transformation`);

REFERENCE FROM `measure_schema`
 (`length_measure`,
 `positive_plane_angle_measure`);

REFERENCE FROM `support_resource_schema`
 (`identifier`,
 `label`,
 `text`,
 `bag_to_set`);

(*

NOTES

1 - The schemas referenced above can be found in the following parts of ISO 10303:

<code>presentation_resource_schema</code>	Clause 7 of this part of ISO 10303
<code>geometry_schema</code>	ISO 10303-42
<code>representation_schema</code>	ISO 10303-43
<code>measure_schema</code>	ISO 10303-41
<code>support_resource_schema</code>	ISO 10303-41

2 - The EXPRESS-G diagrams for this schema may be found in Annex E of this part of ISO 10303.

4.1 Introduction

The **presentation_organization_schema** provides a structure for the management of a picture and the components of a picture. It also specifies the relationship between the properties of a product and their representation in a picture. The components of a picture may be related to each other, either as an association between two components that are otherwise independent, or, as one component is an element of the definition of another. These relationships allow complex structures of pictures and components to be created.

The components of a picture may be organized within a hierarchy built of presentation sets, presentation areas, area dependent annotation representations, presentation views, view dependent annotation representations, and product data representation views. The hierarchy consists of the following four levels:

Level 1:

presentation set: A presentation set is a collection of independent pictures that are concerned with the same subject. Examples of presentation sets are a collection of drawing sheets or a collection of the images of several display screens. A presentation set is composed of one or many presentation areas.

Level 2:

presentation area: A presentation area is a generalization of a display that represents a single area on a display screen or device. A presentation area contains any number of presentation areas, presentation views, and area-dependent annotation representations.

Level 3:

presentation view: A presentation view is a two-dimensional presentation of product shape, which includes any annotation that is associated with that view. A presentation

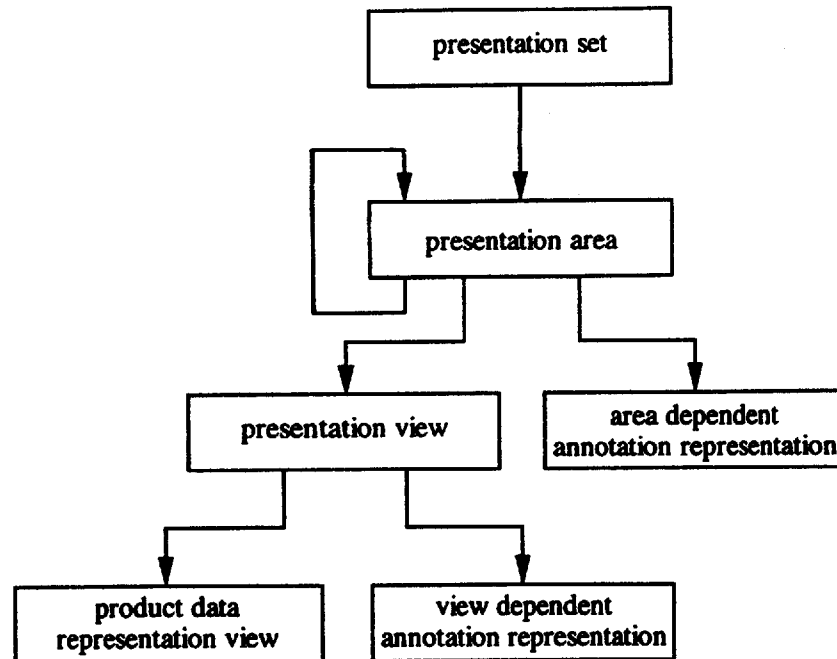


Figure 1 – Presentation hierarchy

view contains any number of product data representation views and view-dependent annotation representations.

area dependent annotation representation: An area dependent annotation representation is all annotation associated with a presentation area.

Level 4:

product data representation view: A product data representation view is a two-dimensional presentation of product shape, which includes any annotation associated with the product shape.

view-dependent annotation representation: A view-dependent annotation representation is the annotation associated with a presentation view.

An actual presentation hierarchy may contain more levels than described above. A single presentation area may itself be composed of several presentation areas. A presentation hierarchy may also contain less levels than described above, because some of the components making up the hierarchy are not required.

NOTE – Figures 1 and 2 illustrate the relationships between the levels of the presentation hierarchy.

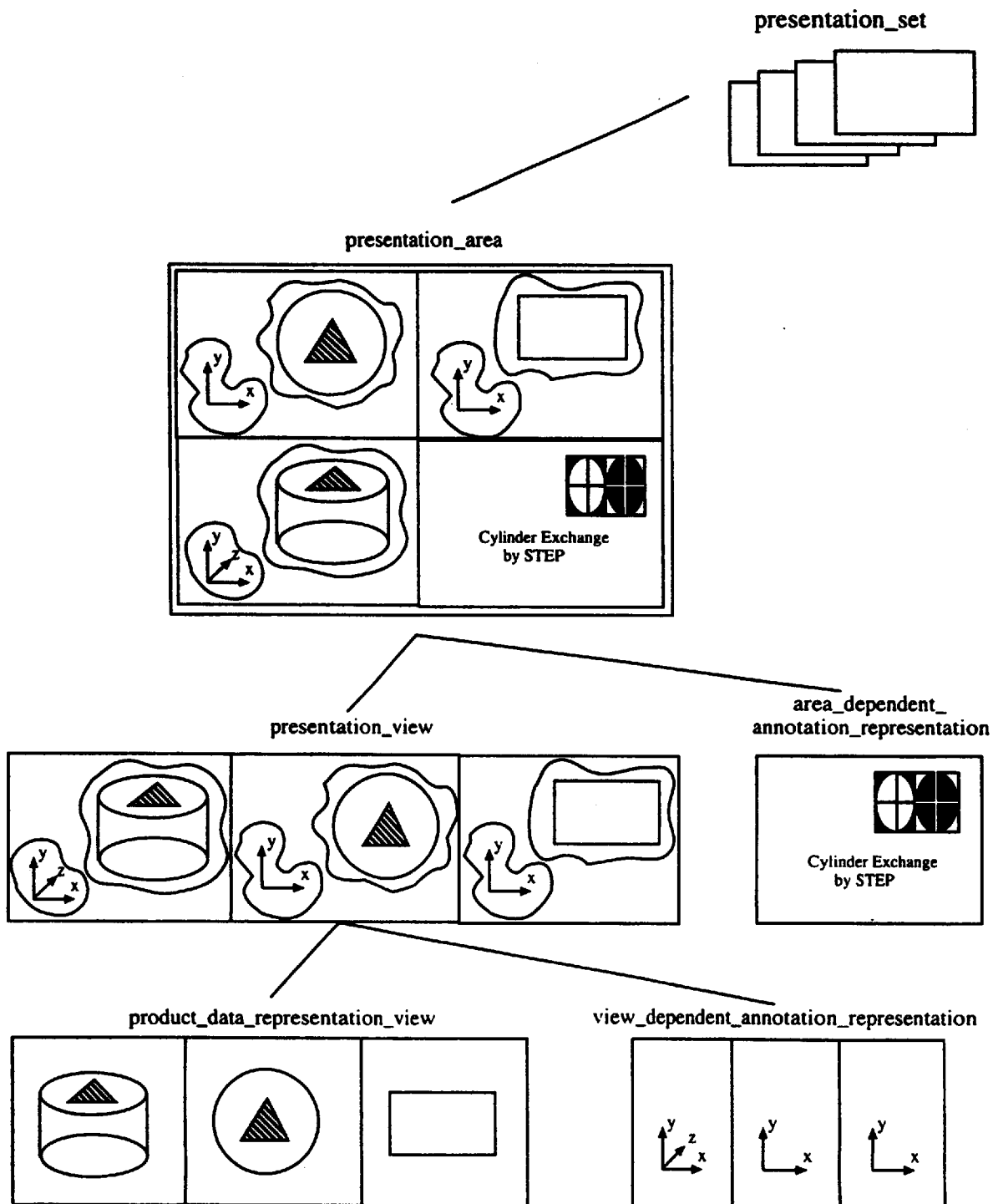


Figure 2 – Example of a presentation hierarchy

4.2 Fundamental concepts and assumptions

4.2.1 Presentation hierarchy

Within the presentation hierarchy, only a presentation area contains sufficient information to allow the unambiguous generation of a picture using a suitable output device such as a computer screen, printer, or plotter.

Other elements in the hierarchy do not provide the necessary placement information for proper positioning on a display device. Presentation views or other lower-level components are displayable only when related directly or indirectly to a presentation area.

The **presentation_organization_schema** describes the presentation hierarchy through representation of the different elements of the hierarchy and the relationships between them.

NOTE 1 – The concepts of representation and of relationships between representations are described in ISO 10303-43.

Each element of the presentation hierarchy is described using the **presentation_representation** entity, a subtype of **representation**. Subtypes of the **presentation_representation** entity describe different elements within the hierarchy.

NOTE 2 – The **representation** entity is defined in ISO 10303-43.

The context of each element of the presentation hierarchy is described using the **geometric_representation_context** entity; this is constrained to be two dimensional.

NOTE 3 – The **geometric_representation_context** entity is defined in ISO 10303-42.

The contents of each element of the presentation hierarchy are described by the set of items of each **presentation_representation**. The items are either two-dimensional geometry or annotation that are to be presented in the element, or the results of including other elements.

Some elements of the hierarchy are constrained with respect to their contents, or to the relationships that they may play with other elements. Specific semantics are associated with these constraints; for example, the **product_data_representation_view** entity describes an element of the hierarchy that only includes the results of projecting three-dimensional geometry or annotation.

The topmost level of the presentation hierarchy is represented by the entities **presentation_set**, **presentation_area**, and **area_in_set**. The **area_in_set** entity supports many-to-many relationships between presentation sets and presentation areas.

Other elements of the presentation hierarchy are related to each other using either the **presentation_representation_relationship** entity, or the **mapped_item** and **representation_map** entities.

NOTE 4 – The **mapped_item** and **representation_map** entities are defined in ISO 10303-43.

An association between two elements of the hierarchy which are independently defined is described using the **presentation_representation_relationship** entity. This describes the relationship between two instances of the **presentation_representation** entity; in this relationship, one **presentation_representation** is denoted as the parent, the other as the child. In the description of a transformation is included in the relationship; this transformation is the geometric

relationship between the items of the parent **presentation_representation** and those of the child **presentation_representation**.

EXAMPLE 2 – To define a hierarchy which consists of a single **presentation_area**, two **presentation_views** and a single **area_dependent_annotation_representation**, three instances of **presentation_representation_relationship** are required as shown in figure 3.

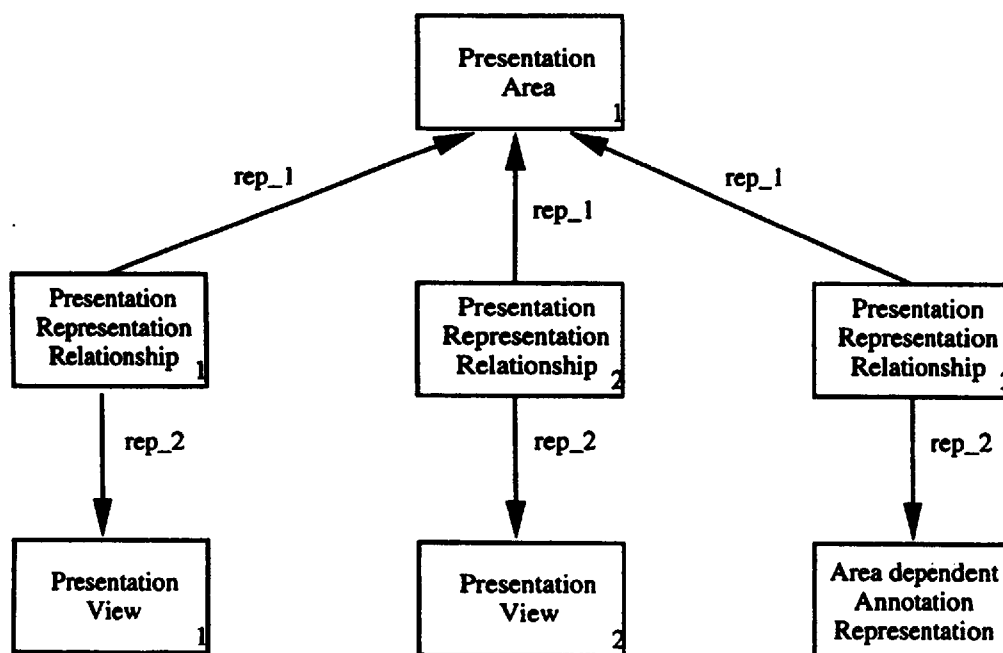


Figure 3 – Mapping the presentation hierarchy to instances of entities

An association between two elements of the hierarchy, where one participates in the definition of the other, is described using the **mapped_item** and **representation_map** entities.

Such an association is described by an instance of the **mapped_item** entity. This instance is included as one of the **items** of the **presentation_representation** that contains the other. The second **presentation_representation** is referenced as the **mapped_representation** of a **representation_map**, that is specified as the **mapping_source** of the **mapped_item**. The transformation that describes the geometric relationship between the **items** of the two **presentation_representations** is described by the **mapping_target** of the **mapped_item** and the **mapping_origin** of the **representation_map**.

EXAMPLE 3 – To include a **presentation_view** within a **presentation_area** requires one instance of **mapped_item**, one instance of **representation_map**, and two instances of **axis2_placement_2d** that act as the origin and the target for the mapping, as shown in figure 4.

NOTE 5 – The **axis2_placement_2d** entity is defined in ISO 10303-42.

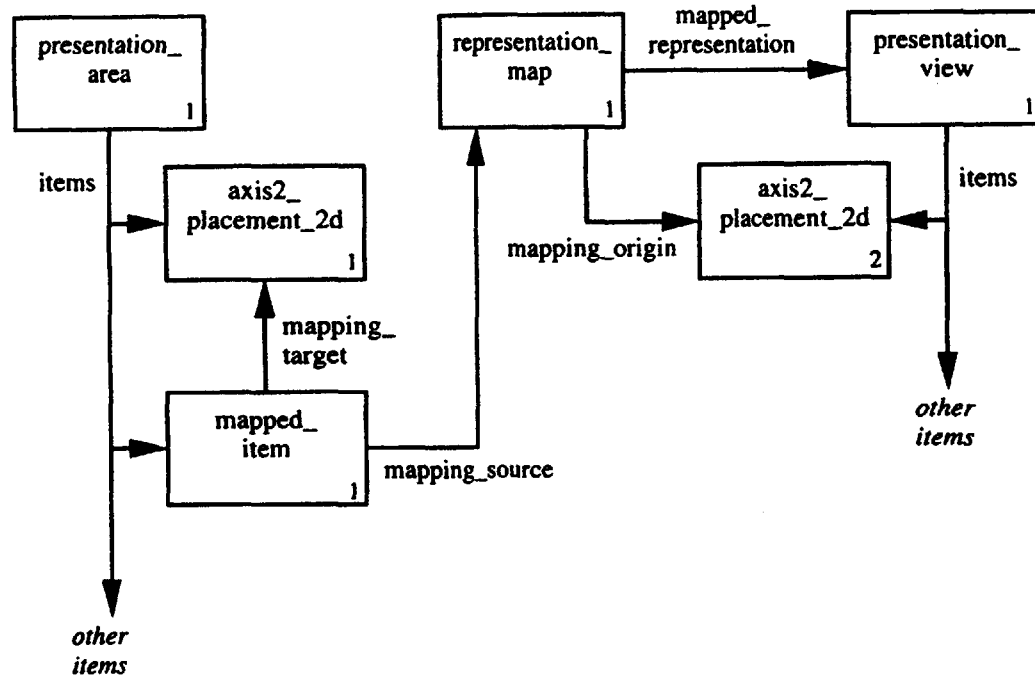


Figure 4 – Association of presentation_view and presentation_area using mapped_item

4.2.2 Camera model and projection

Each level of the presentation hierarchy consists only of two-dimensional geometry or annotation. A three-dimensional synthetic camera model must be specified to associate a presentation with a three-dimensional product shape or planar annotation in three-dimensional space. This model specifies how the projection of three-dimensional geometry and annotation to two dimensions shall be executed by the displaying system. The three-dimensional synthetic camera model is defined in analogy to the graphics standards GKS-3D and PHIGS. More details about the synthetic camera model can be found in [6], [7] and in computer graphics literature, e.g., in [11] or [12]. For draughting requirements, a two-dimensional camera model is also supported. This two-dimensional model performs scaling and translation in two-dimensional space.

The **product_data_representation_view** is the only component of the presentation hierarchy which may consist of two-dimensional projections of associated three-dimensional product shape or of annotation in three-dimensional space. Because this part of ISO 10303 does not define the projected picture, but all information necessary to compute the projection, only a placeholder for that picture is part of the **product_data_representation_view**. This placeholder is called **camera_image** and refers to the camera model and the two- or three-dimensional product shape elements or annotation.

To allow more realistic presentations of three-dimensional objects, hidden line and hidden surface removal, as well as light sources, can be specified for a three-dimensional camera model.

4.2.3 Layers

A layer is a collection of product shape elements, annotation elements, or components of the presentation hierarchy grouped for the purpose of controlling visibility and style. The set of all items associated with a layer can be defined as visible or invisible within a component of the presentation hierarchy. A single item can be associated with several layers and a single layer can be used in several components of the presentation hierarchy. For an item which is associated with several layers, a different presentation style can be assigned to each layer. A layer is defined by a **presentation_layer_assignment**. The visibility and style assignment of a given layer within a component of the presentation hierarchy is specified by a **presentation_layer_usage**.

4.2.4 Association of presentation with a product model

This part of ISO 10303 allows the association of presentation information with the product information which is presented. This association is achieved through the use of a **presented_item_representation**. This entity relates the item which is presented with the presentation of that item. The **presented_item** shall be specialized by Application Protocols.

EXAMPLE 4 – Presented items are the body design of a car, the layout of an electronic chip, or the architecture of a building.

4.3 Presentation organization schema type definitions

4.3.1 presentation_size_assignment_select

The **presentation_size_assignment_select** type specifies the objects to which a size may be assigned.

EXPRESS specification:

```
*)
TYPE presentation_size_assignment_select = SELECT
    (presentation_view,
     presentation_area,
     area_in_set);
END_TYPE;
(*
```

4.3.2 area_or_view

The **area_or_view** type indicates the things that may be assigned a background colour.

EXPRESS specification:

```
*)
TYPE area_or_view = SELECT
    (presentation_area,
     presentation_view);
END_TYPE;
(*
```

4.3.3 central_or_parallel

A **central_or_parallel** indicates the type of perspective transformation that is used by the **camera_model**. The types are either a parallel projection onto the viewing plane or a central projection from the **projection_point** to the viewing plane. See figures 7 and 8.

EXPRESS specification:

```
*)
TYPE central_or_parallel = ENUMERATION OF
    (central,
     parallel);
END_TYPE;
(*
```

Enumerated item definitions:

central: the projection is made along lines emanating from a **projection_point** and intersecting with the **view_window**.

parallel: the projection is made parallel to the line from a **projection_point** to the geometric centre of the **view_window**.

4.3.4 layered_item

The **layered_item** specifies items to be grouped into layers by a **presentation_layer_assignment**.

EXPRESS specification:

```
*)
TYPE layered_item = SELECT
    (presentation_representation,
     representation_item);
END_TYPE;
(*
```

Informal propositions:

IP1: A **representation_item** that is assigned to a layer shall be a **styled_item**, or shall be defined by one or more **styled_item**.

4.3.5 presentation_representation_select

A **presentation_representation_select** is used to allow **presented_item_representation** to associate a presentation with the item being presented.

EXPRESS specification:

```
*)
TYPE presentation_representation_select = SELECT
    (presentation_representation,
     presentation_set);
END_TYPE;
(*
```

4.4 Presentation organization schema entity definitions: presentation hierarchy

4.4.1 presentation_set

The **presentation_set** is a collection of **presentation_areas**.

EXPRESS specification:

```
*)
ENTITY presentation_set;
INVERSE
    areas : SET [1:?] OF area_in_set FOR in_set;
END_ENTITY;
(*
```

Attribute definitions:

areas: the set of **presentation_area** entities which make up the **presentation_set**.

4.4.2 presentation_representation

A **presentation_representation** represents the definition of the picture to be generated by a system which displays the presentation information. The picture refers to an object which may consist of two-dimensional geometry, three-dimensional geometry, and annotation. The reference to geometry and annotation is made indirectly by building a hierarchy of **presentation_representations**. Lower levels of this hierarchy are constrained to contain only geometry or annotation.

NOTE 1 – For the description of the presentation hierarchy see 4.1.

EXPRESS specification:

```
*)
ENTITY presentation_representation
    SUBTYPE OF (representation);
WHERE
    WR1: SELF\representation.
        context_of_items\geometric_representation_context.
        coordinate_space_dimension = 2;
    WR2: 'GEOMETRY_SCHEMA.GEOMETRIC_REPRESENTATION_CONTEXT'
        IN TYPEOF (SELF\representation.context_of_items);
END_ENTITY;
(*
```

Formal propositions:

WR1: The picture shall have a dimensionality of 2.

WR2: A **presentation_representation** shall have a geometric context.

NOTES

2 – When presenting a three-dimensional object, a two-dimensional projection of that three-dimensional object is used. A **presentation_representation** is a picture that represents things after they have been projected.

3 – The actual projected geometry does not exist in this part of ISO 10303. Instead, the **presentation_representation** stands for the projected geometry, and the information needed to create the projection is also included in the model.

4.4.3 presentation_area

The **presentation_area** represents a picture that can contain other pictures and can itself be contained in another picture which is also a **presentation_area**.

The size of the **presentation_area** is defined by the **presentation_size** entity. Every **presentation_area** is either given a size directly by its use in a **presentation_size** entity, or indirectly by its use in **area_in_set** entities. Clipping of a picture based on the **presentation_area** size is executed by the system that creates an actual display based on the presentation information. If a **presentation_area** is contained within another **presentation_area**, then the boundaries of the containing **presentation_area** are also used to clip the contained **presentation_area**.

A background colour may be specified through the use of a **presentation_area** in the **background_colour** entity. Only one **background_colour** entity shall use any **presentation_area**.

EXPRESS specification:

*)

ENTITY presentation_area

SUBTYPE OF (presentation_representation);

WHERE

```
WR1: (((SIZEOF (QUERY (ais <+ USEDIN (SELF, 'PRESENTATION_ORGANIZATION_SCHEMA.' +
                                     'AREA_IN_SET.AREA') |
                               SIZEOF (USEDIN (ais, 'PRESENTATION_ORGANIZATION_SCHEMA.' +
                                     'PRESENTATION_SIZE.UNIT')) =1)) > 0) OR
      (SIZEOF (USEDIN (SELF, 'PRESENTATION_ORGANIZATION_SCHEMA.' +
                                     'PRESENTATION_SIZE.UNIT')) =1));
```

END_ENTITY;

(*

Formal propositions:

WR1: A **presentation_area** shall be contained in a **presentation_set** through participation in **area_in_set.area**, where the **area_in_set** participates in **presentation_size.unit**, or, non-exclusively, a **presentation_area** shall get its size directly from a **presentation_size**.

Informal propositions:

IP1: Any **presentation_representation** shall be presented in the context of a tree which has as its root a **presentation_area**.

IP2: The size of a **presentation_area** shall not be specified more than once.

NOTE - Constraints on the usage of this entity are found in the rules of **presentation_representation**-relationship.

4.4.4 area_in_set

An **area_in_set** specifies the participation of a **presentation_area** in a **presentation_set**. A **presentation_area** may participate in many **presentation_sets**; a **presentation_set** includes at least one **presentation_area**.

EXPRESS specification:

```
*)
ENTITY area_in_set;
    area : presentation_area;
    in_set : presentation_set;
END_ENTITY;
(*
```

Attribute definitions:

area: the **presentation_area** that participates in the specified **presentation_set**.

in_set: the **presentation_set** in which the specified **presentation_area** participates.

4.4.5 presentation_view

A **presentation_view** is a picture that may contain other pictures and may itself be contained in a picture. It does not represent a complete picture and shall not be displayed without being placed in a **presentation_area**.

The size of a **presentation_view** may be defined by its reference from a **presentation_size** entity. Clipping based on the **presentation_view** size is executed by the system that creates an actual display based on the presentation information. If a **presentation_view** size is not defined, then clipping is executed solely based on the size of the **presentation_area** in which the **presentation_view** is contained.

A background colour may be specified through the use of the **background_colour** entity.

EXPRESS specification:

```
*)
ENTITY presentation_view
    SUBTYPE OF (presentation_representation);
END_ENTITY;
(*
```

NOTE - Constraints on the usage of this entity are found in the rules of **presentation_representation**-relationship.

4.4.6 area_dependent_annotation_representation

An **area_dependent_annotation_representation** is a picture that may be contained in the picture of a **presentation_area**. The picture it represents is made up of those of its items which

are **annotation_occurrence** entities. An **area_dependent_annotation_representation** may be related only to a **presentation_area**.

EXPRESS specification:

```

*)
ENTITY area_dependent_annotation_representation
  SUBTYPE OF (presentation_representation);
WHERE
  WR1: SIZEOF (QUERY (item <* SELF\representation.items |
    NOT (SIZEOF (['PRESENTATION_DEFINITION_SCHEMA.' +
      'ANNOTATION_OCCURRENCE',
      'GEOMETRY_SCHEMA.AXIS2_PLACEMENT'] *
        TYPEOF(item)) = 1
    ))) = 0;
  WR2: SIZEOF (QUERY (item <* SELF\representation.items |
    ('PRESENTATION_DEFINITION_SCHEMA.ANOTATION_OCCURRENCE' IN
      TYPEOF (item))
    )) >= 1;
END_ENTITY;
(*

```

Formal propositions:

WR1: The only kinds of **representation.items** that shall be in the set of **items** in an **area_dependent_annotation_representation** are **annotation_occurrence** or **axis2_placement** entities.

WR2: At least one of the **items** in an **area_dependent_annotation_representation** shall be an **annotation_occurrence**.

Informal propositions:

IP1: When an **area_dependent_annotation_representation** is presented, it shall be contained in a **presentation_area**.

NOTE - Constraints on the usage of this entity are found in the rules of **presentation_representation**-**relationship**.

4.4.7 product_data_representation_view

A **product_data_representation_view** is a picture that consists of two-dimensional projections of geometry, annotation, or both. It may contain other pictures, and may be contained in a picture. It does not represent a complete picture and shall not be displayed without being placed in a **presentation_view**.

EXPRESS specification:

```

*)
ENTITY product_data_representation_view
  SUBTYPE OF (presentation_representation);
WHERE
  WR1: SIZEOF (QUERY (item <* SELF\representation.items |
    NOT (SIZEOF (['PRESENTATION_ORGANIZATION_SCHEMA.CAMERA_IMAGE',
      'GEOMETRY_SCHEMA.AXIS2_PLACEMENT'] *

```



```

        TYPEOF (item)) = 1
    ))) = 0;
WR2: SIZEOF (QUERY (item <* SELF\representation.items |
    ('PRESENTATION_ORGANIZATION_SCHEMA.CAMERA_IMAGE' IN
        TYPEOF (item))
    )) >= 1;
END_ENTITY;
(*)

```

Formal propositions:

WR1: The items in a **product_data_representation_view** shall be either **camera_images** or **axis2_placements**.

WR2: At least one of the items in a **product_data_representation_view** shall be a **camera_image**.

Informal propositions:

IP1: When a **product_data_representation_view** is presented, it shall be contained in a **presentation_view**.

NOTE – Constraints on the usage of this entity are found in the rules of **presentation_representation_relationship**.

4.4.8 view_dependent_annotation_representation

A **view_dependent_annotation_representation** is a picture that may be contained in the picture of a **presentation_view**. The picture that it represents contains only items which are **annotation_occurrence** entities. A **view_dependent_annotation_representation** may be related only to a **presentation_view**.

EXPRESS specification:

```

(*)
ENTITY view_dependent_annotation_representation
    SUBTYPE OF (presentation_representation);
WHERE
    WR1: SIZEOF (QUERY (item <* SELF\representation.items |
        NOT (SIZEOF (['PRESENTATION_DEFINITION_SCHEMA.' +
            'ANNOTATION_OCCURRENCE',
            'GEOMETRY_SCHEMA.AXIS2_PLACEMENT'] *
                TYPEOF(item)) = 1
        ))) = 0;
    WR2: SIZEOF (QUERY (item <* SELF\representation.items |
        ('PRESENTATION_DEFINITION_SCHEMA.ANNOTATION_OCCURRENCE' IN
            TYPEOF (item))
        )) >= 1;
END_ENTITY;
(*)

```

Formal propositions:

WR1: The only kinds of **representation_items** that shall be in the set of items in a **view_-dependent_annotation_representation** are **annotation_occurrence** or **axis2_placement** entities.

WR2: At least one of the items in a **view_-dependent_annotation_representation** shall be an **annotation_occurrence**.

Informal propositions:

IP1: When a **view_-dependent_annotation_representation** is presented, it shall be contained in a **presentation_view**.

NOTE – Constraints on the usage of this entity are found in the rules of **presentation_representation_-relationship**.

4.4.9 presentation_size

A **presentation_size** is used to define the size of a **presentation_area** or **presentation_view**. The size for a **presentation_area** may be assigned directly or may be assigned dependent on a **presentation_set** which contains a **presentation_area**. This allows the assignment of different sizes to a single **presentation_area** for each **presentation_set** which contains the area.

EXPRESS specification:

```
*)
ENTITY presentation_size;
    unit : presentation_size_assignment_select;
    size : planar_box;
WHERE
    WR1: (('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_REPRESENTATION'
        IN TYPEOF (SELF.unit)) AND
        item_in_context (SELF.size,
            SELF.unit\representation.context_of_items)
    )
    OR
    (
        ('PRESENTATION_ORGANIZATION_SCHEMA.AREA_IN_SET'
        IN TYPEOF (SELF.unit)) AND
        (SIZEOF (QUERY ( ais <* SELF.unit\area_in_set.in_set.areas |
            NOT item_in_context (SELF.size, ais.area\representation.
                context_of_items) )) = 0)
    );
END_ENTITY;
(*
```

Attribute definitions:

unit: a **presentation_view**, **presentation_area**, or an **area_in_set** as it relates a **presentation_area** with a **presentation_set**.

size: a **planar_box** which describes the size of a unit.

Formal propositions:

WR1: If the unit is a **presentation_representation**, the **planar_box** shall be an item in a representation which has the same context as the unit. If the unit is an **area_in_set** the **planar_box** shall be an item in the context of each area belonging to the set.

4.4.10 background_colour

A **background_colour** is the colour used for the background of a presentation area or view.

EXPRESS specification:

```
*)
ENTITY background_colour
  SUBTYPE OF (colour);
  presentation : area_or_view;
UNIQUE
  UR1: presentation;
END_ENTITY;
(*
```

Attribute definitions:

presentation: a **presentation_area** or **presentation_view** for which this background colour is specified.

Formal propositions:

UR1: Only one background colour may be specified for any **presentation_area** or **presentation_view**.

4.4.11 presentation_representation_relationship

A **presentation_representation_relationship** is a relationship between **presentation_representation** entities. The relationship is directed, meaning that the child representation (**rep_2**) is transformed into the parent representation (**rep_1**), and no meaning is intended for the inverse transformation. The **presentation_representation_relationship** restricts the relationships between certain **presentation_representations** to ensure that **presentation_representation** entities are arranged in a hierarchy as described in clause 4.1.

EXPRESS specification:

```
*)
ENTITY presentation_representation_relationship
  SUBTYPE OF (representation_relationship_with_transformation);
WHERE
  WR1: 'PRESENTATION_DEFINITION_SCHEMA.PRESENTATION_REPRESENTATION' IN
    TYPEOF (SELF\representation_relationship.rep_1);
  WR2: 'PRESENTATION_DEFINITION_SCHEMA.PRESENTATION_REPRESENTATION' IN
    TYPEOF (SELF\representation_relationship.rep_2);
  WR3: acyclic_presentation_representation_relationship (SELF,
    [SELF\representation_relationship.rep_2]);
  WR4: NOT (('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_AREA' IN
    TYPEOF (SELF\representation_relationship.rep_1))
```

```

AND
NOT (SIZEOF (['PRESENTATION_ORGANIZATION_SCHEMA.' +
              'PRODUCT_DATA_REPRESENTATION_VIEW',
              'PRESENTATION_ORGANIZATION_SCHEMA.' +
              'VIEW_DEPENDENT_ANNOTATION_REPRESENTATION'] *
            TYPEOF (SELF\representation_relationship.rep_2)) = 0));
WR5: NOT (('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_VIEW'
          IN TYPEOF (SELF\representation_relationship.rep_1))
AND
NOT (SIZEOF (['PRESENTATION_ORGANIZATION_SCHEMA.' +
              'PRESENTATION_AREA',
              'PRESENTATION_ORGANIZATION_SCHEMA.' +
              'PRESENTATION_VIEW',
              'PRESENTATION_ORGANIZATION_SCHEMA.' +
              'AREA_DEPENDENT_ANNOTATION_REPRESENTATION'] *
            TYPEOF (SELF\representation_relationship.rep_2))=0));
WR6: (NOT ('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_VIEW' IN
          TYPEOF (SELF\representation_relationship.rep_2)))
XOR
('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_AREA' IN
TYPEOF (SELF\representation_relationship.rep_1));
WR7: (NOT ('PRESENTATION_ORGANIZATION_SCHEMA.' +
          'PRODUCT_DATA_REPRESENTATION_VIEW' IN
          (TYPEOF (SELF\representation_relationship.rep_1) +
           TYPEOF (SELF\representation_relationship.rep_2))))
XOR
('PRESENTATION_ORGANIZATION_SCHEMA.PRESENTATION_VIEW' IN
TYPEOF (SELF\representation_relationship.rep_1))
AND
('PRESENTATION_ORGANIZATION_SCHEMA.PRODUCT_DATA_REPRESENTATION_VIEW' IN
TYPEOF (SELF\representation_relationship.rep_2));
WR8: 'PRESENTATION_ORGANIZATION_SCHEMA.GRAPHICAL_TRANSFORMATION' IN
TYPEOF (SELF\representation_relationship_with_transformation.
        transformation_operator);
END_ENTITY;
(*)

```

Attribute definitions:

SELF\representation_relationship.rep_1: the presentation_representation that plays the role of a parent in a tree of presentation_representations.

SELF\representation_relationship.rep_2: the presentation_representation that plays the role of a child in a tree of presentation_representations.

Formal propositions:

WR1: rep_1 shall be a presentation_representation.

WR2: rep_2 shall be a presentation_representation.

WR3: A presentation_representation_relationship shall not participate in a tree of presentation_representations where the root of the tree is also a leaf of its own tree.

WR4: Pictures represented by **product_data_representation_view** or **view_dependent_annotation_representation** shall not be related to a picture represented by a **presentation_area**.

WR5: Pictures represented by **presentation_area**, **presentation_view**, or **area_dependent_annotation_representation** shall not be related to a picture represented by a **presentation_view**.

WR6: The picture represented by a **presentation_view** may only be related to the picture represented by a **presentation_area**.

WR7: A **product_data_representation_view** shall only participate in a **presentation_representation_relationship**, if the **rep_1** is a **presentation_view**.

WR8: Pictures that are related to other pictures relate to those pictures by **graphical_transformations**.

4.4.12 graphical_transformation

A **graphical_transformation** is a transformation which allows arbitrary two-dimensional positioning, rotation, and uniform scaling. It is used by **presentation_representation_relationship** to define the transformation between related **presentation_representations**. The transformation is defined as follows.

The **transform_item_1.location** is transformed into the **transform_item_2.placement.location**. Additionally the x axis defined by **transform_item_1.p[1]** is mapped to the x axis **transform_item_2.placement.p[1]**. A similar mapping is performed for the y axes **transform_item_1.p[2]** and **transform_item_2.placement.p[2]**. Finally the scaling specified by **transform_item_2.scaling** is applied.

NOTE 1 - Figure 5 shows the mechanism of **graphical_transformation**.

EXPRESS specification:

```
*)
ENTITY graphical_transformation
  SUBTYPE OF (item_defined_transformation);
WHERE
  WR1: 'GEOMETRY_SCHEMA.AXIS2_PLACEMENT_2D' IN
    TYPEOF (SELF\item_defined_transformation.transform_item_1);
  WR2: 'PRESENTATION_RESOURCE_SCHEMA.PRESENTATION_SCALED_PLACEMENT' IN
    TYPEOF (SELF\item_defined_transformation.transform_item_2);
END_ENTITY;
(*
```

Attribute definitions:

SELF\item_defined_transformation.transform_item_1: an **axis2_placement_2d** specifying the starting point of the transformation.

SELF\item_defined_transformation.transform_item_2: a **presentation_scaled_placement** specifying the ending point of the transformation.

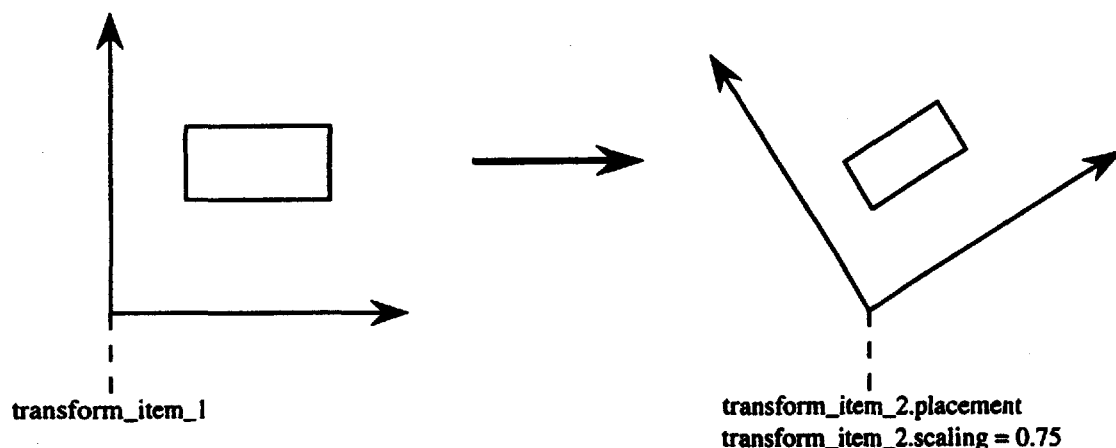


Figure 5 – Graphical transformation

Formal propositions:

WR1: The `transform_item_1` attribute of a `graphical_transformation` shall be an `axis2_placement_2d`.

WR2: The `transform_item_2` attribute of a `graphical_transformation` shall be a `presentation_scaled_placement`.

NOTE 2 – The attributes `transform_item_1` and `transform_item_2` are defined in ISO 10303-43.

4.5 Presentation organization schema entity definitions: camera model and projection

4.5.1 camera_model

A `camera_model` contains the information needed to create a projection or mapping from a representation to a picture of that representation.

EXPRESS specification:

*)

ENTITY `camera_model`

SUPERTYPE OF (ONEOF(`camera_model_d2`, `camera_model_d3`))

SUBTYPE OF (`geometric_representation_item`);

WHERE

WR1: (SIZEOF (USEDIN (SELF, 'REPRESENTATION_SCHEMA.' +
'ITEM_DEFINED_TRANSFORMATION.' +
'TRANSFORM_ITEM_1')) +
SIZEOF (USEDIN (SELF, 'REPRESENTATION_SCHEMA.' +
'REPRESENTATION_MAP.MAPPING_ORIGIN'))



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```
    ) > 0;  
    WR2: SIZEOF(USEDIN(SELF, 'PRESENTATION_APPEARANCE_SCHEMA.' +  
        'STYLED_ITEM.ITEM')) = 0;  
END_ENTITY;  
(*
```

Formal propositions:

WR1: A **camera_model** shall specify the projection for at least one **representation**.

WR2: A **camera_model** shall not be referenced by a **styled_item** entity.

4.5.2 camera_model_d2

A **camera_model_d2** contains the information needed to create a two-dimensional mapping from a **representation** to a picture of that **representation**.

EXPRESS specification:

```
*)  
ENTITY camera_model_d2  
    SUBTYPE OF (camera_model);  
    view_window          : planar_box;  
    view_window_clipping : BOOLEAN;  
WHERE  
    WR1: SELF\geometric_representation_item.dim = 2;  
END_ENTITY;  
(*
```

Attribute definitions:

view_window: the rectangular boundaries in the coordinate space of the **representation** that is being projected into the **product_data_representation_view**. A translation and possibly non-uniform scaling are applied to the **view_window** so, that the edges of the **view_window** coincide with the edges of the **mapping_target** of the **camera_image**.

view_window_clipping: the determination of whether or not clipping is performed against the **view_window**. A value of TRUE indicates that clipping against the **view_window** is performed. A value of FALSE indicates that no clipping against the **view_window** is performed.

NOTES

1 – If **view_window_clipping** has a value of FALSE, the two-dimensional projection may extend beyond the boundaries of the **mapping_target** specified by the **camera_image**.

2 – Clipping is performed prior to projection.

Formal propositions:

WR1: A **camera_model_d2** shall be two-dimensional.

NOTE 3 – The mechanism of the **camera_model_d2** is shown in figure 6.

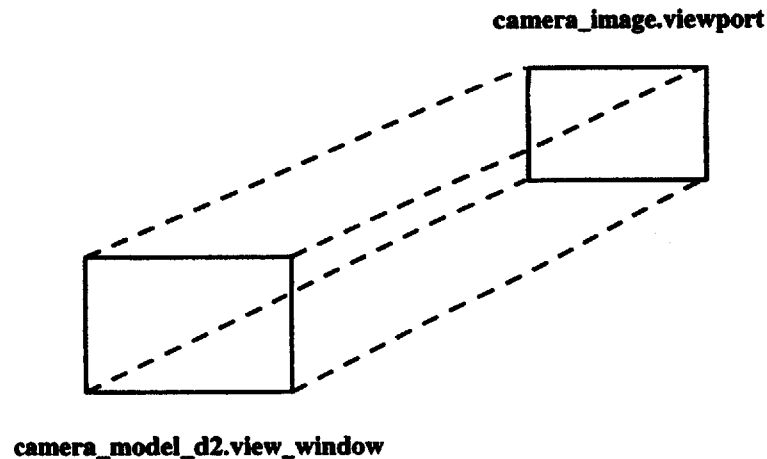


Figure 6 – Camera model d2

4.5.3 camera_model_d2_shape_clipping

A **camera_model_d2_shape_clipping** is a **camera_model_d2** with additional clipping specified for the mapped representation.

EXPRESS specification:

```
*)
ENTITY camera_model_d2_shape_clipping
  SUBTYPE OF (camera_model_d2);
  shape_clipping : curve;
END_ENTITY;
(*
```

Attribute definitions:

shape_clipping: a closed curve indicating a clipping region for the representation which is projected.

NOTE – If **view_window_clipping** has a value of TRUE, the representation which is projected is clipped against both the **view_window** and the region specified by **shape_clipping**.

Informal propositions:

IP1: The curve specified for **shape_clipping** shall be closed and not self-intersecting.

4.5.4 camera_model_d3

A **camera_model_d3** contains the information needed to create the projection from a three-dimensional representation to a two-dimensional picture of that representation. See 4.5.1 for details of the projection.

EXPRESS specification:

*)

```
ENTITY camera_model_d3
  SUBTYPE OF (camera_model);
  view_reference_system : axis2_placement_3d;
  perspective_of_volume : view_volume;
WHERE
  WR1: (dot_product (SELF.view_reference_system.p[3],
    SELF.perspective_of_volume.view_window.placement.p[3]) = 1.0)
    AND
    (SELF.view_reference_system.location.coordinates[3] =
      SELF.perspective_of_volume.view_window.
        placement.location.coordinates[3]);
  WR2: SELF\geometric_representation_item.dim = 3;
END_ENTITY;
(*
```

Attribute definitions:

view_reference_system: an intermediate three-dimensional coordinate space in the coordinate space of the representation being projected.

perspective_of_volume: the information needed to determine how to project the geometry of the representation. The **perspective_of_volume** is defined in the intermediate three-dimensional coordinate space of the **view_reference_system**.

Formal propositions:

WR1: the rectangle indicated by the **view_window** of the **perspective_of_volume** is in the same plane as the x and y axis of the **axis2_placement** indicated by the **view_reference_system**.

WR2: A **camera_model_d3** is three-dimensional.

4.5.5 view_volume

A **view_volume** is defined in the **view_reference_system** of the camera model which uses the volume. It defines a volume that is projected onto the viewport of the **product_data_representation_view**. This volume is either a truncated pyramid or a parallelepiped. The contents of this volume are projected onto the rectangle defined by the **view_window** which is then mapped onto the viewport.

If the type of projection is **parallel**, the projection is made parallel to the line from the **projection_point** to the geometric centre of the **view_window**, and the **view_volume** is a parallelepiped. If the type of projection is **central**, the projection is made along lines emanating from a **projection_point** and intersecting with the **view_window**, and the **view_volume** is a truncated pyramid. See figure 8 for the definition of the parallelepiped and figure 7 for the definition of the truncated pyramid.

EXPRESS specification:

*)

```

ENTITY view_volume;
  projection_type           : central_or_parallel;
  projection_point          : cartesian_point;
  view_plane_distance       : length_measure;
  front_plane_distance      : length_measure;
  front_plane_clipping     : BOOLEAN;
  back_plane_distance      : length_measure;
  back_plane_clipping      : BOOLEAN;
  view_volume_sides_clipping : BOOLEAN;
  view_window              : planar_box;
END_ENTITY;

```

(*)

Attribute definitions:

projection_type: the indication of whether the projection is central or parallel.

projection_point: the centre of the projection, i.e., the location from which the items are viewed. For a parallel projection, this point indicates a line from itself to the geometric centre of the view_window. For a central projection, this point is the apex of the truncated pyramid.

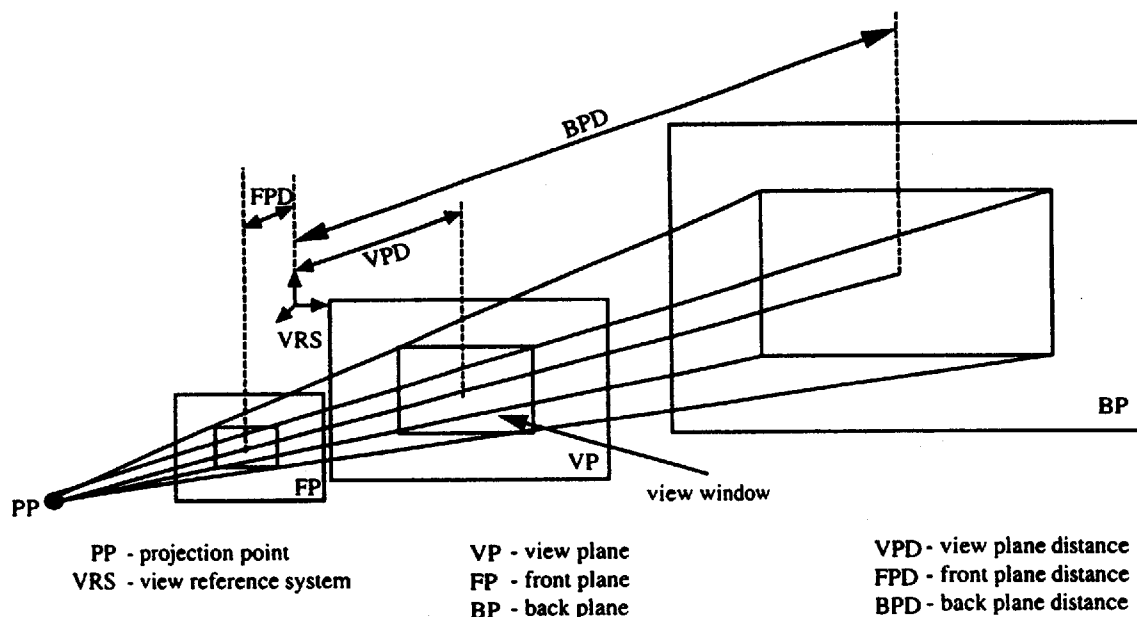


Figure 7 - View volume, projection type CENTRAL

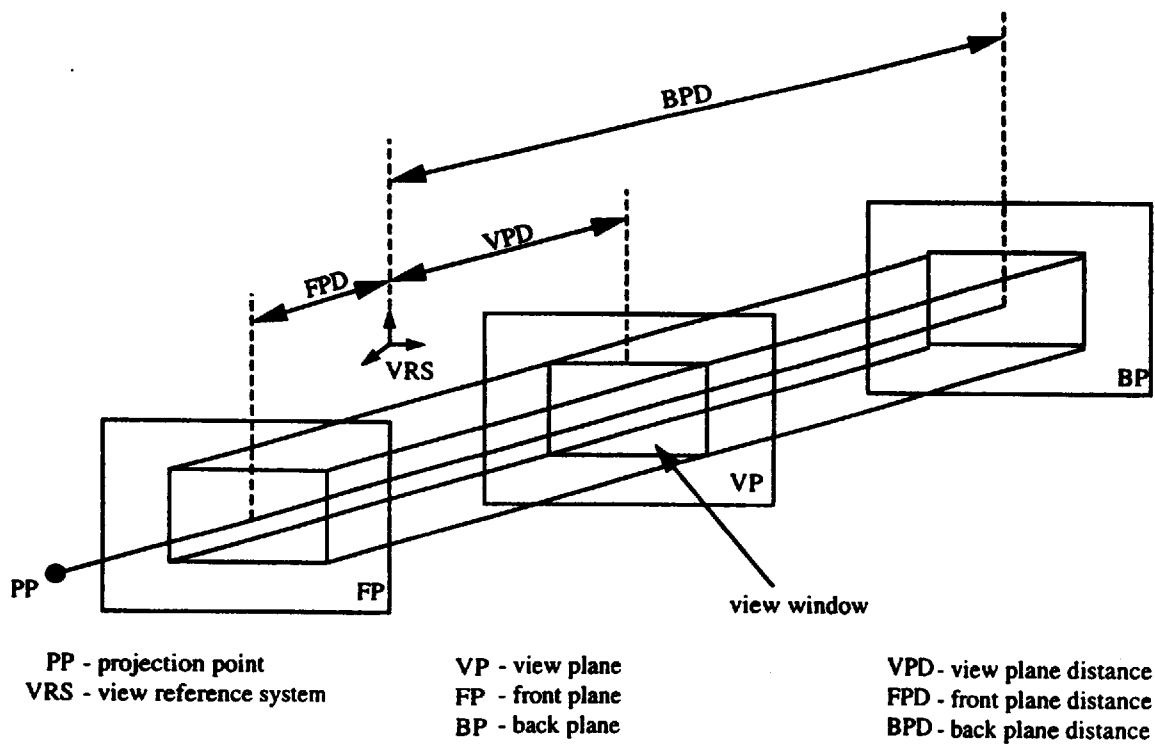


Figure 8 – View volume, projection type PARALLEL

view_plane_distance: a distance along the z axis of the **axis2_placement** indicated by the **view_reference_system**. This distance positions the origin of the **view_window**.

front_plane_distance: a signed distance along the z axis of the **axis2_placement** indicated by the **view_reference_system**. This distance specifies a plane parallel to the **view_window** plane. It is the distance to either the top of the truncated pyramid or the front of the parallelepiped, depending on the type of projection.

front_plane_clipping: the indication of whether or not to clip the geometry of the projected representation against the plane represented by the **front_plane_distance**. A value of TRUE indicates that clipping is performed; a value of FALSE indicates that clipping is not performed.

NOTE 1 - If **front_plane_clipping** has a value of FALSE, objects behind the projection point may be visible. Behind in this sense means in the opposite direction from the projection point than the view plane.

back_plane_distance: a distance along the z axis of the **axis2_placement** indicated by the **view_reference_system** attribute. This distance specifies a plane parallel to the **view_window** plane. It is either the bottom of the truncated pyramid or the back of the parallelepiped, depending on the type of projection.

back_plane_clipping: the indication of whether or not to clip the geometry of the projected representation against the plane represented by the **back_plane_distance**. A value of TRUE indicates that clipping is performed; a value of FALSE indicates that clipping is not performed.

view_volume_sides_clipping: the indication of whether or not to clip the geometry of the projected representation against the planes which are the sides of the volume defined by the **view_volume**. A value of TRUE indicates that clipping is performed; a value of FALSE indicates that clipping is not performed.

NOTE 2 - If **view_volume_sides_clipping** has a value of FALSE, the two-dimensional projection may extend beyond the boundaries of the **viewport** specified by the **camera_image**.

view_window: a rectangle on the **view_plane**. The representation is mapped to this rectangle which is then mapped to the **viewport** of a **camera_image**.

Informal propositions:

IP1: The plane represented by the **front_plane_distance** shall be closer to the **projection_point** than the plane represented by the **back_plane_distance**.

IP2: The rectangle indicated by the **view_window** attribute shall be in the view plane.

IP3: The **projection_point** shall not lie in the view plane.

4.5.6 camera_model_d3_with_hlshr

A **camera_model_d3_with_hlshr** is a **camera_model_d3** that indicates whether hidden line and hidden surface removal shall be performed.

EXPRESS specification:

```
*)  
ENTITY camera_model_d3_with_hlshr  
  SUBTYPE OF (camera_model_d3);  
  hidden_line_surface_removal : BOOLEAN;  
END_ENTITY;  
(*
```

Attribute definitions:

hidden_line_surface_removal: an indication of whether hidden lines and hidden surfaces shall be removed while projecting a three-dimensional representation. A value of TRUE indicates that hidden lines and hidden surfaces shall be removed during projection. A value of FALSE indicates that hidden lines and hidden surfaces shall not be removed during projection.

4.5.7 camera_model_d3_multi_clipping

A **camera_model_d3_multi_clipping** contains the information needed to create a projection from a representation to a picture of that representation using planes in the coordinate space of the projected representation to clip the geometry of the representation prior to projection.

EXPRESS specification:

```
*)  
ENTITY camera_model_d3_multi_clipping  
  SUBTYPE OF (camera_model_d3);  
  shape_clipping : SET [1:?] OF plane;  
END_ENTITY;  
(*
```

Attribute definitions:

shape_clipping: The planes that bound the clipping region. Each plane defines an acceptance region, which is the infinite halfspace defined by the plane and its positive normal. The clipping region is defined as the intersection of all acceptance regions.

NOTES

- 1 – The clipping region defined by **shape_clipping** may be infinite.
- 2 – Clipping is performed prior to projection.

4.5.8 camera_model_with_light_sources

A **camera_model_with_light_sources** contains the information needed to create a projection from a representation to a picture of that representation with additional information about the light sources to be used for shading.