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ISO/CD 10303-53

Product data representation and exchange: Integrated generic resource: Numerical analysis

ABSTRACT:

This document provides general application independent means of representing analysis problems and their solutions.

KEYWORDS: Numerical Analysis, Idealisation

COMMENTS TO READER:

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation. The formal modeling uses EXPRESS edition 2. This document has been reviewed using the internal review checklist (see WG12 N2172), the project leader checklist (see WG12 N2173), and the convenor checklist (see WG12 N2174).

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 10303–53 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

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 integrated generic resource series. The integrated generic resources and the integrated application resources specify a single conceptual product data model.

A complete list of parts of ISO 10303 is available from the Internet:
`<http://www.nist.gov/sc4/editing/step/titles/>`

Annexes A and B form a normative 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 of product information and for the exchange of product data. The objective is to provide a neutral mechanism capable of describing products throughout their life cycle. This mechanism is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases, and as a basis for archiving.

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

— **product_analysis_schema**;

— **analysis_schema**;

— **product_analysis_relationships_schema**.

The relationships of the schemas in this part of ISO 10303 to other schemas that define the integrated resources of this International Standard are illustrated in Figure 1 using the EXPRESS-G notation. EXPRESS-G is defined in annex D of ISO 10303-11. The schemas identified in the bold boxes are specified in this part of ISO 10303. The **mesh_topology_schema** is specified in part 52 of ISO 10303. The **product_definition_schema**, the **product_property_definition_schema**, and the **support_resource_schema** are specified in part 41 of ISO 10303. The schemas illustrated in Figure 1 are components of the integrated resources.

There are many applications that, in one way or another, generate solutions to engineering and mathematical problems. The applications can range from almost trivial, like solving a linear equation which, if the numbers are simple enough, can be performed mentally, to determining the characteristics of a set of experimental data approximating a normal distribution, which requires at least pencil and paper, to a computational fluid dynamics problem which may require several hours of supercomputer time to resolve.

This part of ISO 10303 provides general application independent means of representing analysis problems and the solutions of such problems.

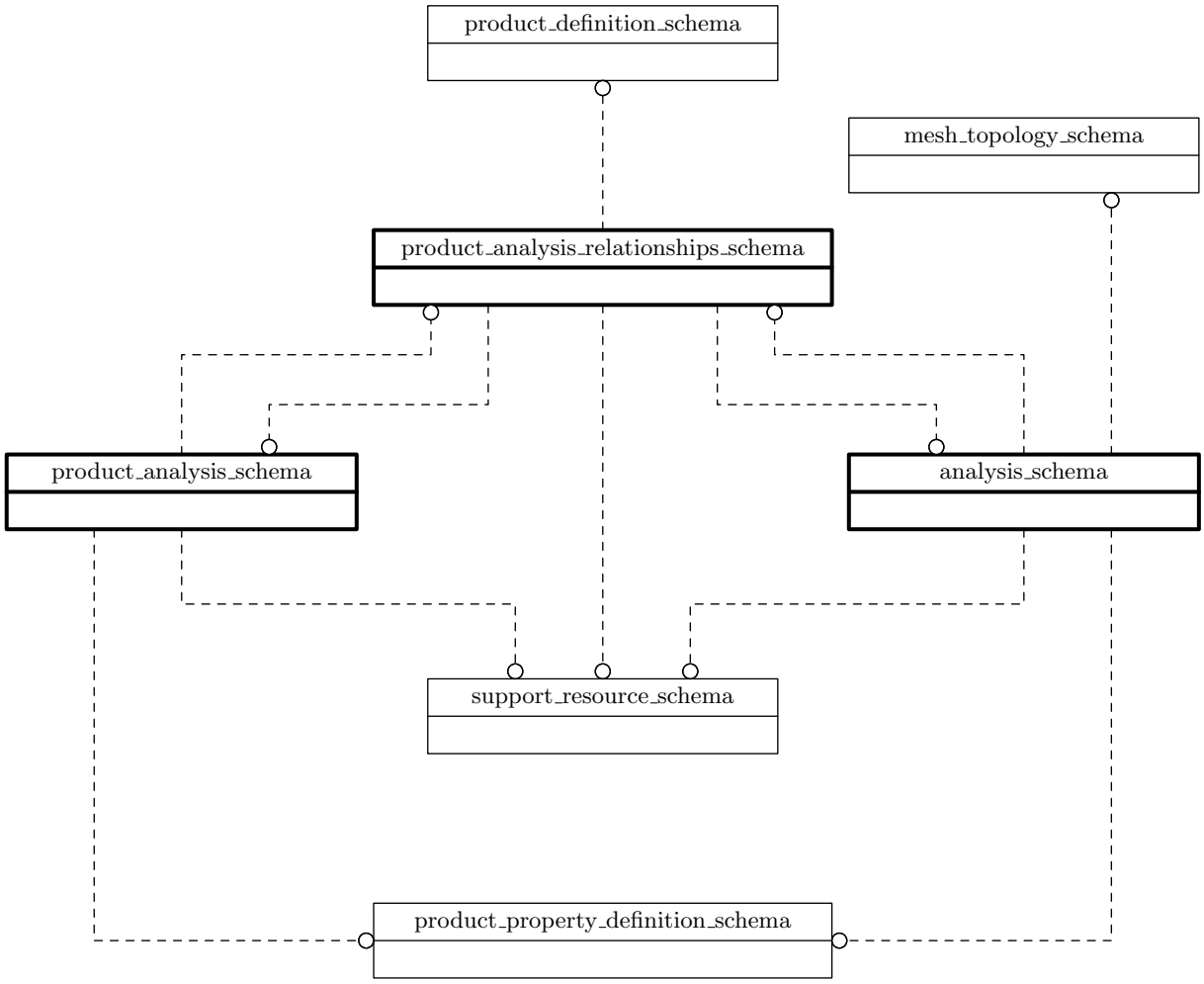

Figure 1 – Schema relationships

Industrial automation systems and integration — Product data representation and exchange — Part 53 : Integrated generic resource: Numerical analysis

1 Scope

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

— application-independent analysis;

— idealisations of product definitions evinced by analyses.

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

— analysis applications;

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

ISO 10303-11:2003, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description method: The EXPRESS language reference manual.*

ISO 10303-41:2000, *Industrial automation systems and integration — Product data representation and exchange — Part 41: Integrated generic resource: Fundamentals of product description and support.*

ISO 10303-52:—[1)], *Industrial automation systems and integration — Product data representation and exchange — Part 52: Integrated generic resource: Mesh-based topology.*

ISO/IEC 8824-1:1998, *Information technology — Abstract Syntax Notation One (ASN.1): Specification of basic notation.*

[1)] To be published.

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 protocol (AP)

— generic resource

— integrated resource

3.2 Other terms and definitions

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

3.2.1
idealisation
a representation of one thing by another thing that in a particular context is both simpler than, and an approximation to, the first thing.

EXAMPLE 1 In the context of a numerical calculation the numbers 3, 22/7, 355/113, and 3.14159265 are all idealisations of the mathematical constant π, in increasing order of reality.

EXAMPLE 2 In the context of a finite element analysis a mesh of elements is an idealisation of the shape of the thing being analysed.

3.3 Abbreviations

FEA	Finite Element Analysis
URL	Universal Resource Locator

4 Product analysis

The following EXPRESS declaration begins the **product_analysis_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
SCHEMA product_analysis_schema;
  REFERENCE FROM analysis_product_relationships_schema  -- ISO 10303-53
    (idealisation_relationship);
  REFERENCE FROM product_property_definition_schema     -- ISO 10303-41
    (general_property);
  REFERENCE FROM support_resource_schema                -- ISO 10303-41
    (bag_to_set,
     identifier,
     label,
     text);
(*
```

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

analysis_product_relationships_schema	this part of ISO 10303
product_property_definition_schema	ISO 10303-41
support_resource_schema	ISO 10303-41

4.1 Introduction

This schema defines and describes the structures for describing a view of the objects (products, activities and states) that may be the subject of an analysis.

4.2 product_analysis_schema entity definitions

4.2.1 behavioural_decomposition_of_temporal_spatial_domain

A **behavioural_decomposition_of_temporal_spatial_domain** is a decomposition of a **temporal_spatial_domain** into specifications for different behaviours.

EXPRESS specification:

```
*)
ENTITY behavioural_decomposition_of_temporal_spatial_domain;
  parts : SET [2:?] OF temporal_spatial_domain;
  whole : temporal_spatial_domain;
END_ENTITY;
(*
```

Attribute definitions:

parts: the instances of **temporal_spatial_domain** that are assembled to give the **whole**;

whole: the whole **temporal_spatial_domain** that is decomposed into the **parts**.

4.2.2 domain_property

A **domain_property** is a specification of a property within a **temporal_spatial_domain**.

EXAMPLE The specification of the temperature distribution within the solid parts of engine type XYZ_123 during the start-up activity is a **domain_property**. This varies with respect to space and time.

EXPRESS specification:

```
*)
ENTITY domain_property;
  domain        : temporal_spatial_domain;
  property_type : general_property;
END_ENTITY;
(*
```

Attribute definitions:

domain: the **temporal_spatial_domain**;

property_type: the type of the property.

4.2.3 physical_action_domain

A **physical_action_domain** is a **temporal_spatial_domain** that has a finite time dimension.

EXAMPLE the specification of the start-up activity for engine type XYZ_123 (including the fluids within it) is a **physical_action_domain**.

EXPRESS specification:

```
*)
ENTITY physical_action_domain
  SUBTYPE OF (temporal_spatial_domain);
  initial   : physical_state_domain;
  final     : physical_state_domain;
END_ENTITY;
(*
```

Attribute definitions:

initial: the **physical_state_domain** that exists at the beginning of the **physical_action_domain**;

final: the **physical_state_domain** that exists at the end of the **physical_action_domain**.

4.2.4 physical_product_domain

A **physical_product_domain** is a **temporal_spatial_domain** that has an indefinite time dimension and that performs a number of activities during its life.

NOTE A **physical_product_domain** is often the specification for a manufactured item.

EXAMPLE The specification of the solid parts of engine type XYZ_123 is a **physical_product_domain**.

EXPRESS specification:

```
*)
ENTITY physical_product_domain
  SUBTYPE OF (temporal_spatial_domain);
  temporal_parts : SET OF physical_action_domain;
END_ENTITY;
(*
```

Attribute definitions:

temporal_parts: the instances of **physical_action_domain** that are performed by the **physical_product_domain**.

4.2.5 physical_state_domain

A **physical_state_domain** is a **temporal_spatial_domain** that has no time dimension.

An individual physical object at an instant in time can be a member of a **physical_state_domain**.

EXAMPLE The specification of the displacements. stresses and strains within the solid parts of engine type XYZ_123 when running is a **physical_state_domain**.

EXPRESS specification:

```
*)
ENTITY physical_state_domain
  SUBTYPE OF (temporal_spatial_domain);
END_ENTITY;
(*
```

4.2.6 spatial_decomposition_of_temporal_spatial_domain

A **spatial_decomposition_of_temporal_spatial_domain** is a decomposition of a **temporal_spatial_domain** into specifications for different spatial regions.

EXAMPLE The specification of the start-up activity for engine type XYZ_123 (including the fluids within it) is a **temporal_spatial_domain**. For this activity there are distributions of temperature, displacement and stress within the solid parts of the engine, and distributions of temperature, flow velocity and pressure within the contained fluids.

The specification of the start-up activity for the solid parts of engine type XYZ_123 is a **temporal_spatial_domain**. This is a part of the start-up activity for the assembly of the solid parts and the contained fluids.

EXPRESS specification:

```
*)
ENTITY spatial_decomposition_of_temporal_spatial_domain;
  parts : SET [2:?] OF temporal_spatial_domain;
  whole : temporal_spatial_domain;
END_ENTITY;
(*
```

Attribute definitions:

parts: the instances of **temporal_spatial_domain** that are assembled to give the **whole**;

whole: the whole **temporal_spatial_domain** that is decomposed into the **parts**.

4.2.7 temporal_decomposition_of_action_domain

A **temporal_decomposition_of_action_domain** is a decomposition of a **physical_action_domain** into specifications for different times.

EXPRESS specification:

```
*)
ENTITY temporal_decomposition_of_action_domain;
  parts : LIST [2:?] OF physical_action_domain;
  whole : physical_action_domain;
END_ENTITY;
(*
```

Attribute definitions:

parts: the instances of **physical_action_domain** that are assembled to give the **whole**;

whole: the whole **physical_action_domain** that is decomposed into the **parts**.

4.2.8 temporal_spatial_domain

A **temporal_spatial_domain** is a specification of a quantity of space, time, or both, which may or may not contain matter.

EXAMPLE 1 The specification of the volume of air/fuel/combustion products mixture within engine type XYZ_123 during transient T3 is a **temporal_spatial_domain**. This **temporal_spatial_domain** has distributions of chemical composition, pressure, density, velocity, and temperature.

EXAMPLE 2 The specification of the volume of space (not occupied by matter) within electrodynamic device type D_1234 in state S3 is a **temporal_spatial_domain**. This **temporal_spatial_domain** has distributions of electical and magnetic field strengths.

EXPRESS specification:

```
*)
ENTITY temporal_spatial_domain;
  description : text;
  id          : identifier;
  name        : label;
WHERE
  wr1: definition_for_temporal_spatial_domain(SELF);
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_temporal_spatial_domain FOR
                   temporal_spatial_domain;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

Attribute definitions:

id: an identifier;

description: annotation;

name: user-specified instance identifier.

Formal propositions:

wr1: the **temporal_spatial_domain** shall be associated with a **product_definition** via an **idealisation_relationship**.

4.3 product_analysis_schema function definitions

4.3.1 definition_for_temporal_spatial_domain

The **definition_for_temporal_spatial_domain** function determines whether or not the given **temporal_spatial_domain** is associated with a **product_definition** by an **idealisation_relationship**.

The **idealisation_relationship** can be:

— with the given **temporal_spatial_domain**; or

— with another **temporal_spatial_domain** of which the given **temporal_spatial_domain** is a part, either directly or indirectly.

The function returns TRUE if there is an association, Otherwise it returns a value of FALSE.

EXPRESS specification:

```
*)
FUNCTION definition_for_temporal_spatial_domain
```



```
        (domain : temporal_spatial_domain): BOOLEAN;
  LOCAL
    spatial_set     : SET OF
                      spatial_decomposition_of_temporal_spatial_domain;
    behavioural_set : SET OF
                      behavioural_decomposition_of_temporal_spatial_domain;
    domains         : SET OF temporal_spatial_domain := [];
    idealising      : BAG OF idealisation_relationship;
    spatial_bag     : BAG OF spatial_decomposition_of_temporal_spatial_domain;
    behavioural_bag : BAG OF behavioural_decomposition_of_temporal_spatial_domain;
  END_LOCAL;

  idealising := USEDIN(domain,
    'ANALYSIS_PRODUCT_RELATIONSHIPS_SCHEMA.IDEALISATION_RELATIONSHIP.IDEALISATION');
  IF SIZEOF(idealising) > 0 THEN
    RETURN(TRUE);
  END_IF;

  spatial_bag := USEDIN(domain,
    'PRODUCT_ANALYSIS_SCHEMA.SPATIAL_DECOMPOSITION_OF_TEMPORAL_SPATIAL_DOMAIN.PARTS');
  IF SIZEOF(spatial_bag) > 0 THEN
    spatial_set := bag_to_set(spatial_bag);
    REPEAT i := 1 TO HIINDEX(spatial_set);
      domains := domains + spatial_set[i].whole;
    END_REPEAT;
  END_IF;

  behavioural_bag := USEDIN(domain,
    'PRODUCT_ANALYSIS_SCHEMA.BEHAVIOURAL_DECOMPOSITION_OF_TEMPORAL_SPATIAL_DOMAIN.PARTS');
  IF SIZEOF(behavioural_bag) > 0 THEN
    behavioural_set := bag_to_set(behavioural_bag);
    REPEAT i := 1 TO HIINDEX(behavioural_set);
      domains := domains + behavioural_set[i].whole;
    END_REPEAT;
  END_IF;

  IF SIZEOF(domains) > 0 THEN
    REPEAT i := 1 TO HIINDEX(domains);
      IF definition_for_temporal_spatial_domain(domains[i]) THEN
        RETURN(TRUE);
      END_IF;
    END_REPEAT;
  END_IF;
  RETURN(FALSE);
END_FUNCTION; -- definition_for_temporal_spatial_domain
(*
```

Argument definitions:

domain: (input) the **temporal_spatial_domain** to be checked.

EXPRESS specification:

```
*)
END_SCHEMA;  -- end of product_analysis_schema
```



```
(*
```

5 Analysis

The following EXPRESS declaration begins the **analysis_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
SCHEMA analysis_schema;
  REFERENCE FROM mesh_topology_schema                    -- ISO 10303-52
    (mesh);
  REFERENCE FROM analysis_product_relationships_schema   -- ISO 10303-53
    (view_relationship);
  REFERENCE FROM product_property_definition_schema      -- ISO 10303-41
    (general_property);
  REFERENCE FROM support_resource_schema                 -- ISO 10303-41
    (bag_to_set,
     identifier,
     label,
     text);
(*
```

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

mesh_topology_scheam	ISO 10303-52
analysis_product_relationships_schema	this part of ISO 10303
product_property_definition_schema	ISO 10303-41
support_resource_schema	ISO 10303-41

5.1 Introduction

This schema defines and describes the structures for describing analyses.

5.2 analysis_schema entity definitions

5.2.1 behavioural_decomposition_of_numerical_model

A **behavioural_decomposition_of_numerical_model** is a decomposition of a **numerical_model** into different subbehaviours.

EXPRESS specification:

```
*)
ENTITY behavioural_decomposition_of_numerical_model;
  parts : SET [2:?] OF numerical_model;
  whole : numerical_model;
END_ENTITY;
(*
```


Attribute definitions:

parts: the set of instances of **numerical_model** that are subbehaviours of the **whole**;

whole: the **numerical_model** that is the union of the **parts**.

5.2.2 model_action_domain

A **model_action_domain** is the response of an **numerical_model** during a period of time.

EXAMPLE Beam type XYZ regarded as a set of cross-sections for time instants during loading procedure L1 is a **model_action_domain**. This **model_action_domain** is the domain of distributions which vary in two dimensions — position along the beam and time. The distributions include rotation for each position for each instant, and bending moment for each position for each instant.

EXPRESS specification:

```
*)
ENTITY model_action_domain
  SUBTYPE OF (numerical_model);
  initial   : model_state_domain;
  final     : model_state_domain;
END_ENTITY;
(*
```

Attribute definitions:

initial: the **model_state_domain** that is a boundary of the **model_action_domain** for the initial time;

final: the **model_state_domain** that is a boundary of the **model_action_domain** for the final time;

5.2.3 model_product_domain

A **model_product_domain** is an **numerical_model** that is only a spatial decomposition and that has an indefinite time dimension.

EXAMPLE Beam type XYZ regarded as a set of cross sections is a **model_product_domain**.

EXPRESS specification:

```
*)
ENTITY model_product_domain
  SUBTYPE OF (numerical_model);
  temporal_parts : SET OF model_action_domain;
END_ENTITY;
(*
```


Attribute definitions:

temporal_parts: the instances of **model_action_domain** that are performed by the **model_product_domain**.

NOTE Each member of a **model_product_domain** corresponds to a **physical_product**. For each referenced **model_action_domain** there is a subset (itself a **model_action_domain**) that corresponds to the **physical_product**. This subset is a view of a **physical_action** performed by the **physical_product**.

5.2.4 model_product_domain_with_mesh

A **model_product_domain_with_mesh** is a **model_product_domain** that has a mesh.

EXPRESS specification:

```
*)
ENTITY model_product_domain_with_mesh
  SUBTYPE OF (model_product_domain);
  model_mesh : mesh;
END_ENTITY;
(*
```

Attribute definitions:

model_mesh: the **mesh**.

5.2.5 model_property_distribution

A **model_property_distribution** is a function that has an **numerical_model** and a property space as its range. Each member of the **numerical_model** has a value within the property space.

There can be distributions with respect to space and time for a **model_action_domain**. There can be distributions with respect to space for a **model_product_domain**.

EXPRESS specification:

```
*)
ENTITY model_property_distribution;
  creating_software : text;
  domain            : numerical_model;
  range             : general_property;
END_ENTITY;
(*
```


Attribute definitions:

creating_software: the name of the software used to create the **model_property_distribution**. The vendor, version, computer system, operating system and description shall be specified;

domain: the **numerical_model** that is the domain of the **model_property_distribution**;

range: the **general_property** that is the range of the **model_property_distribution**.

5.2.6 model_state_domain

A **model_state_domain** is an **numerical_model** that has no time dimension. A **model_state_domain** is either independent of time, or a time slice.

For a time slice:

— usually, each member of the domain has the same time: or

— exceptionally for 'inclined time planes', different members may have different times. In this case the domain does not include members with the same spatial position and different times.

EXAMPLE Beam type XYZ regarded as a set of cross-sections at the end of loading procedure L1 is a **model_state_domain**. This **model_state_domain** is the domain of distributions which vary in one dimension — position along the beam. The distributions include rotation for each position, and bending moment for each position.

EXPRESS specification:

```
*)
ENTITY model_state_domain
  SUBTYPE OF (numerical_model);
END_ENTITY;
(*
```

5.2.7 numerical_model

A **numerical_model** is the aspect of a physical object relevant to a particular type of behaviour. A **numerical_model** takes a particular view of its domain in terms of dimensionality and continuity.

EXAMPLE 1 Examples include: 3D continuum (e.g., volume elements in FEA); 2D continuum (e.g., shell elements in FEA); 1D continuum (e.g., beam elements in FEA); lumped masses (e.g., in a many-body problem).

A **numerical_model** is a view of a **temporal_spatial_object** specification as a set or space. The members of the set or space may consist of:

— points in space-time;

— spatial or temporal aggregations that are finite in one or more dimensions.

NOTE 1 Only an object that is a set or space can be the domain of a distribution function.

EXAMPLE 2 Beam type XYZ during loading procedure L1 regarded as a point set is an **numerical_model**. This **numerical_model** is the domain of distributions which vary in four dimensions — position and time. The distributions include displacement for each position for each instant, and stress for each position for each instant.

EXAMPLE 3 Beam type XYZ during loading procedure L1 regarded as a set of cross-sections for time instants is an **numerical_model**. This **numerical_model** is the domain of distributions which vary in two dimensions — position along the beam and time. The distributions include rotation for each position for each instant, and bending moment for each position for each instant.

EXAMPLE 4 Beam type XYZ during heating procedure H1 regarded as a set of 10 segments for time instants is an **numerical_model**. This **numerical_model** is the domain of distributions which vary in two dimensions (one discrete and one continuous) — sub-beam and time. The distributions include average temperature for each segment for each instant, and thermal energy for each segment for each instant.

EXAMPLE 5 Beam type XYZ during heating procedure H1 regarded as a set of 10 segments for 20 time steps is an **numerical_model**. This **numerical_model** is the domain of distributions which vary in two dimensions (both discrete) — sub-beam and time. The distributions include average temperature for each segment for each step, and total thermal energy gain for each segment for each step.

NOTE 2 A **temporal_spatial_object** is a specification or class that an individual physical object in the real world can be a member of. The members of an **numerical_model** are instances of **temporal_spatial_object**.

EXAMPLE 6 Beam type XYZ during loading procedure L1 is a **physical_activity**; a specification that has an individual beam of type XYZ being loaded according to L1 as a member.

Beam type XYZ during loading procedure L1, regarded as a set of cross-sections for time instants is a **model_action_domain**. The cross-section at end 2 of the beam at the end of the loading procedure is a **physical_state** that is a member of this set or space.

The cross-section at end 2 of an individual beam of type XYZ that has been loaded according to procedure L1 is a member of this **physical_state**.

EXPRESS specification:

```
*)
ENTITY numerical_model;
  description            : text;
  id                     : identifier;
  name                   : label;
  creating_software      : text;
  intended_analysis_code : SET [1:?] OF text;
  analysis_type          : text;
WHERE
  wr1 : temporal_spatial_domain_for_model(SELF);
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_numerical_model FOR
                   numerical_model;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```


Attribute definitions:

description: annotation;

id: an identifier;

name: user-specified instance identifier;

creating_software: the name of the software used to create **numerical_model**. The version of the software shall be specified;

intended_analysis_code: the set of one or many names of the intended analysis code that a **numerical_model** was created for. Each intended analysis code shall have the vendor, version, computer system, operating system and descriptions specified;

analsis_type: a description of what type of analysis is to be performed with this **numerical_analysis**.

Formal propositions:

wr1: the **numerical_model** shall be associated with a **temporal_spatial_domain** via a **view_relationship**.

5.2.8 simulation_run

A **simulation_run** is an individual activity that simulates a **numerical_model**.

EXAMPLE A particular run carried out on a particular computer by a particular analysis code at a particular time is a **simulation_run**.

EXPRESS specification:

```
*)
ENTITY simulation_run;
  description : text;
  id          : identifier;
  name        : label;
  simulated   : numerical_model;
  results     : SET OF model_property_distribution;
END_ENTITY;
(*
```

Attribute definitions:

description: annotation;

id: an identifier;

name: user-specified instance identifier;

simulated: the **numerical_model** that is simulated;

results: the instances of **model_property_distribution** that result from the simulation.

5.2.9 spatial_decomposition_of_numerical_model

A **spatial_decomposition_of_numerical_model** is a decomposition of a **numerical_model** into different subspaces.

EXPRESS specification:

```
*)
ENTITY spatial_decomposition_of_numerical_model;
  parts : SET [2:?] OF numerical_model;
  whole : numerical_model;
END_ENTITY;
(*
```

Attribute definitions:

parts: the set of instances of **numerical_model** that are subspaces of the **whole**;

whole: the **numerical_model** that is the union of the **parts**.

5.2.10 temporal_decomposition_of_model_action

A **temporal_decomposition_of_model_action** is a decomposition of a **model_action_domain** into different time instants.

EXPRESS specification:

```
*)
ENTITY temporal_decomposition_of_model_action;
  parts : LIST [2:?] OF model_action_domain;
  whole : model_action_domain;
END_ENTITY;
(*
```

Attribute definitions:

parts: the set of instances of **model_action_domain** at different times;

whole: the **model_action_domain** that is the union of the **parts**.

5.3 analysis_schema function definitions

5.3.1 temporal_spatial_domain_for_model

The **temporal_spatial_domain_for_model** function determines whether or not the given **numerical_model** is associated with a **temporal_spatial_domain** by a **view_relationship**.

The **view_relationship** can be:

— with the given **numerical_model**; or

— with another **numerical_model** of which the given **numerical_model** is a part, either directly or indirectly.

The function returns TRUE if there is an association, Otherwise it returns a value of FALSE.

EXPRESS specification:

```
*)
FUNCTION temporal_spatial_domain_for_model
         (domain : numerical_model): BOOLEAN;
  LOCAL
    spatial_set     : SET OF spatial_decomposition_of_numerical_model;
    behavioural_set : SET OF behavioural_decomposition_of_numerical_model;
    domains         : SET OF numerical_model := [];
    viewing         : BAG OF view_relationship;
    spatial_bag     : BAG OF spatial_decomposition_of_numerical_model;
    behavioural_bag : BAG OF behavioural_decomposition_of_numerical_model;
  END_LOCAL;

  viewing := USEDIN(domain,
    'ANALYSIS_PRODUCT_RELATIONSHIPS_SCHEMA.VIEW_RELATIONSHIP.VIEW');
  IF SIZEOF(viewing) > 0 THEN
    RETURN(TRUE);
  END_IF;

  spatial_bag := USEDIN(domain,
    'ANALYSIS_SCHEMA.SPATIAL_DECOMPOSITION_OF_NUMERICAL_VIEW.PARTS');
  IF SIZEOF(spatial_bag) > 0 THEN
    spatial_set := bag_to_set(spatial_bag);
    REPEAT i := 1 TO HIINDEX(spatial_set);
      domains := domains + spatial_set[i].whole;
    END_REPEAT;
  END_IF;

  behavioural_bag := USEDIN(domain,
    'ANALYSIS_SCHEMA.BEHAVIOURAL_DECOMPOSITION_OF_NUMERICAL_VIEW.PARTS');
  IF SIZEOF(behavioural_bag) > 0 THEN
    behavioural_set := bag_to_set(behavioural_bag);
    REPEAT i := 1 TO HIINDEX(behavioural_set);
      domains := domains + behavioural_set[i].whole;
    END_REPEAT;
  END_IF;

  IF SIZEOF(domains) > 0 THEN
    REPEAT i := 1 TO HIINDEX(domains);
      IF temporal_spatial_domain_for_model(domains[i]) THEN
        RETURN(TRUE);
      END_IF;
    END_REPEAT;
  END_IF;
  RETURN(FALSE);
END_FUNCTION; -- temporal_spatial_domain_for_model
(*
```


Argument definitions:

domain: (input) the **numerical_model** to be checked.

EXPRESS specification:

```
*)
END_SCHEMA; -- end of analysis_schema
(*
```

6 Product analysis relationships

The following EXPRESS declaration begins the **product_analysis_relationships_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
SCHEMA analysis_product_relationships_schema;
  REFERENCE FROM analysis_schema              -- ISO 10303-53
    (numerical_model);
  REFERENCE FROM product_analysis_schema      -- ISO 10303-53
    (temporal_spatial_domain);
  REFERENCE FROM product_definition_schema    -- ISO 10303-41
    (product_definition);
  REFERENCE FROM support_resource_schema      -- ISO 10303-41
    (identifier,
     label,
     text);
(*
```

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

analysis_schema	this part of ISO 10303
product_analysis_schema	this part of ISO 10303
product_definition_schema	ISO 10303-41
support_resource_schema	ISO 10303-41

6.1 Introduction

This schema specifies relationships between the definitions of objects and analyses.

6.2 product_analysis_relationships_schema entity definitions

6.2.1 idealisation_relationship

An **idealisation_relationship** specifies that a particular **temporal_spatial_domain** is an idealisation of a particular **product_definition**.

EXPRESS specification:

```
*)
ENTITY idealisation_relationship;
  description  : text;
  id           : identifier;
  name         : label;
  idealised    : product_definition;
  idealisation : temporal_spatial_domain;
END_ENTITY;
(*
```

Attribute definitions:

description: annotation;

id: an identifier for an instance of an **idealisation_relationship**;

name: user-specified human interpretable instance identifier;

idealised: the **product_definition** that is idealised;

idealisation: the **temporal_spatial_domain** that idealises the **product_definition**.

6.2.2 view_relationship

A **view_relationship** specifies that a particular **numerical_model** is a view of a particular **temporal_spatial_domain**.

EXPRESS specification:

```
*)
ENTITY view_relationship;
  description : text;
  id          : identifier;
  name        : label;
  viewed      : temporal_spatial_domain;
  view        : numerical_model;
END_ENTITY;
(*
```

Attribute definitions:

description: annotation;

id: an identifier for an instance of an **view_relationship**;

name: user-specified human interpretable instance identifier;

viewed: the **temporal_spatial_domain** that is viewed;

view: the **numerical_model** that is a view of the **temporal_spatial_domain**.

EXPRESS specification:

```
*)
END_SCHEMA; -- end of analysis_product_relationships_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 short names are found in the implementation methods included in ISO 10303.

NOTE The short names are available from the Internet — see annex C.

Table A.1 – Short names of entities

Entity data types names	Short names
behavioural_decomposition_of_numerical_model	BDONM
behavioural_decomposition_of_temporal_spatial_domain	BDOTSD
domain_property	DMNPRP
idealisation_relationship	IDLRLT
model_action_domain	MDACDM
model_product_domain	MDPRDM
model_product_domain_with_mesh	MPDWM
model_property_distribution	MDPRDS
model_state_domain	MDSTDM
numerical_model	NMRMDL
physical_action_domain	PHACDM
physical_state_domain	PHSTDM
simulation_run	SMLRN
spatial_decomposition_of_numerical_model	SDONM
spatial_decomposition_of_temporal_spatial_domain	SDOTSD
temporal_decomposition_of_action_domain	TDOAD
temporal_decomposition_of_model_action	TDOMA
temporal_spatial_domain	TMSPDM
view_relationship	VWRLT

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(53) 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 schema-name in an open information system, the object identifier

{ iso standard 10303 part(53) version(1) schema(1) product-analysis-schema(1) }

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

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

{ iso standard 10303 part(53) version(1) schema(1) analysis-schema(1) }

is assigned to the **analysis_schema** schema (see 5). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

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

{ iso standard 10303 part(53) version(1) schema(1) product-analysis-relationships-schema(1) }

is assigned to the **product_analysis_relationships_schema** schema (see 6). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

Annex C
(informative)
EXPRESS listing

This annex references a listing of the EXPRESS entity data type names and corresponding short names as specified in this part of ISO 10303. It also references a listing of each EXPRESS schema specified in this part of ISO 10303, without comments or other explanatory text. These listings are 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/part53/cd/>`

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

The diagrams in this annex correspond to the EXPRESS schemas specified in this part of ISO 10303. The diagrams use the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in annex D of ISO 10303-11.

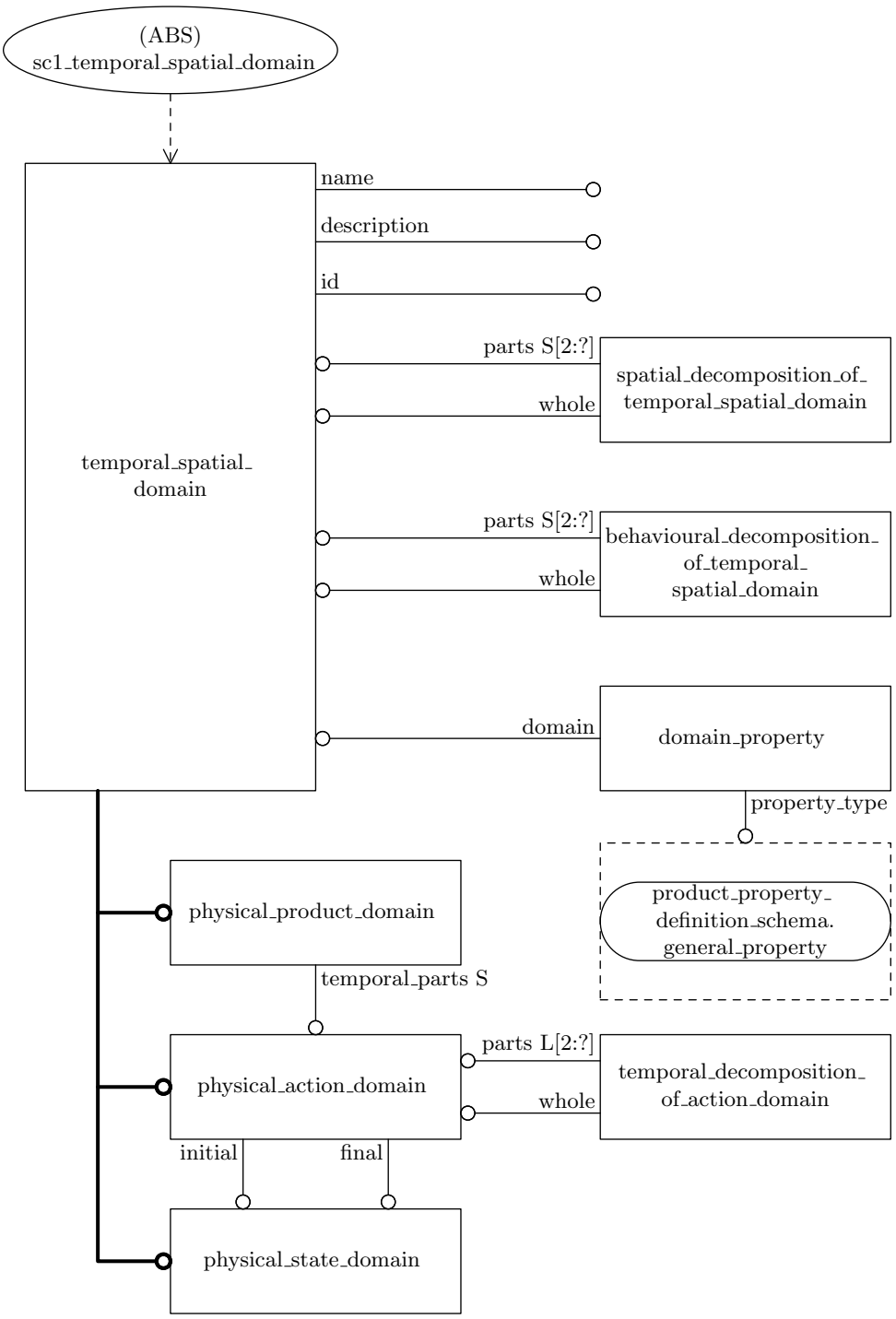

Figure D.1 – Entity level diagram of product_analysis_schema schema (page 1 of 1)

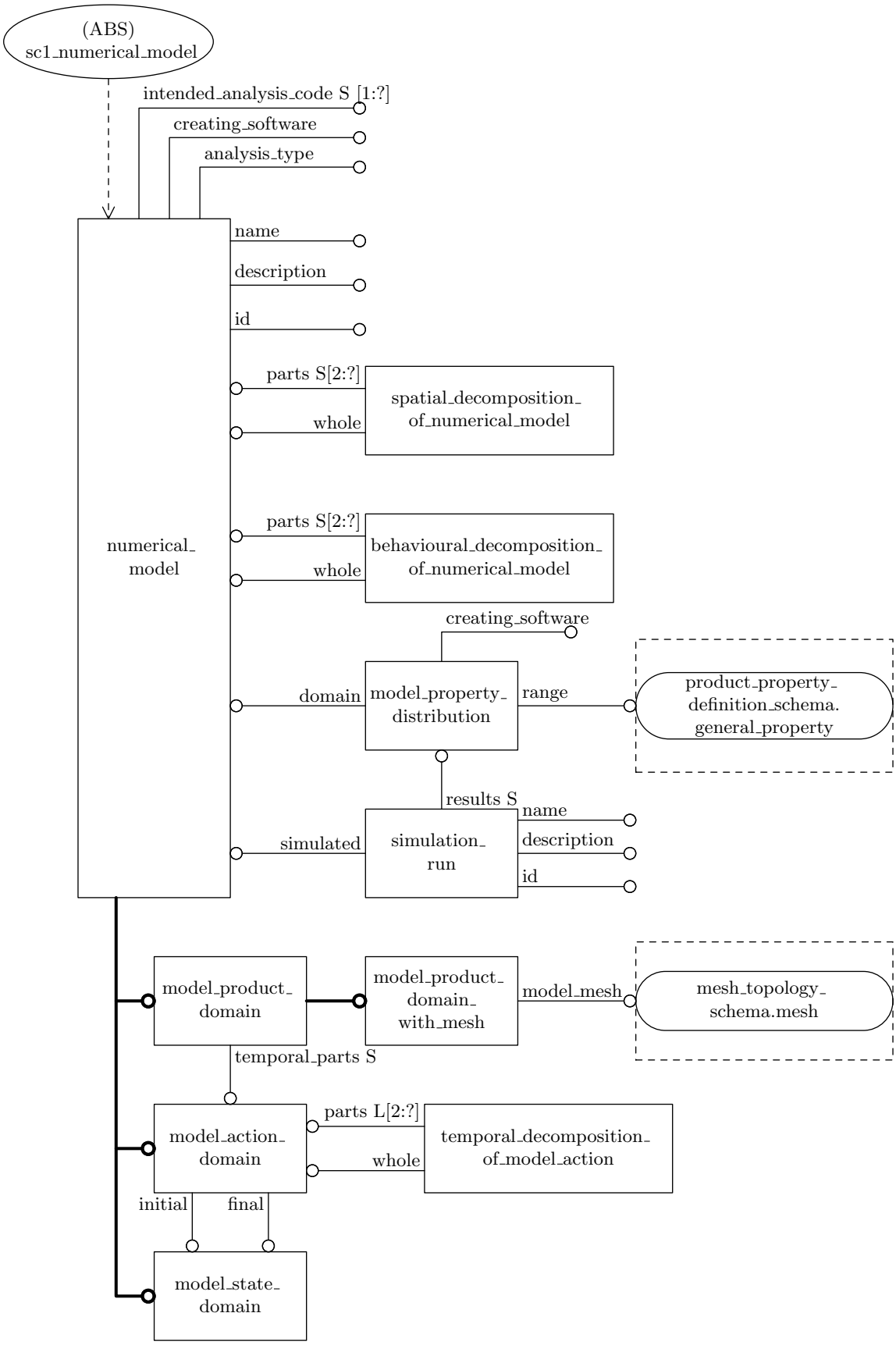

Figure D.2 – Entity level diagram of analysis_schema schema (page 1 of 1)

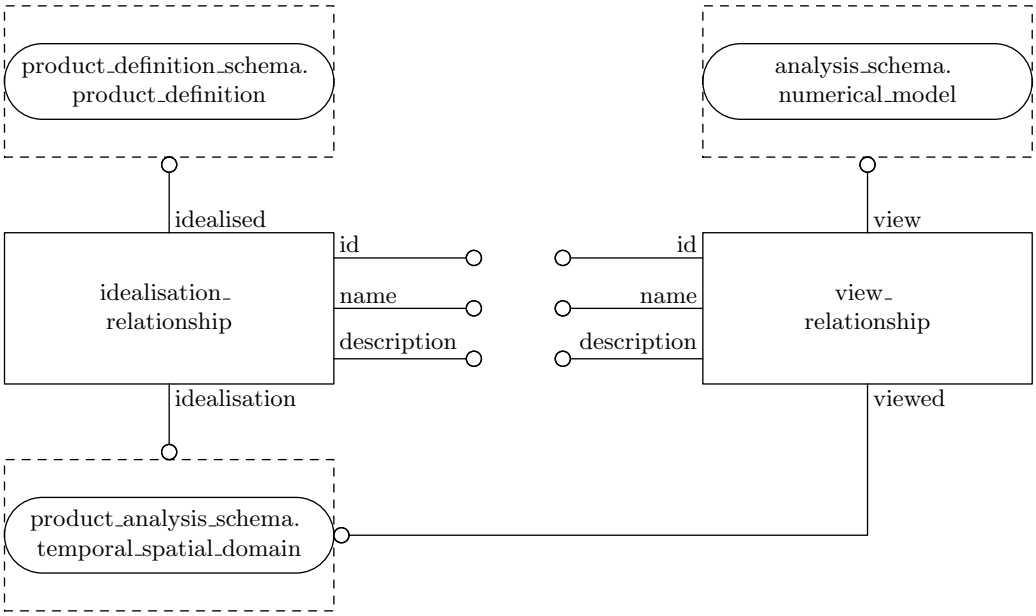

Figure D.3 – Entity level diagram of product_analysis_relationships_schema schema (page 1 of 1)

Annex E
(informative)
Additional information

Table E.1 lists the elements of the **product_analysis_schema** that are used by other schemas.

Table E.1 – Elements of product_analysis_schema used by other schemas

Element	Used in schema	By element
temporal_spatial_domain	**product_analysis_relationships_schema**	**idealisation_relationship** **view_relationship**

Table E.2 lists the elements of the **analysis_schema** that are used by other schemas.

Table E.2 – Elements of analysis_schema used by other schemas

Element	Used in schema	By element
numerical_model	**product_analysis_relationships_schema**	**view_relationship**

Table E.3 lists the elements of the **analysis_product_relationships_schema** that are used by other schemas.

Table E.3 – Elements of analysis_product_relationships_schema used by other schemas

Element	Used in schema	By element
idealisation_relationship **view_relationship**	**product_analysis_schema** **analysis_schema**	**definition_for_temporal_-spatial_domain** **temporal_spatial_domain_for_model**

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