BS ISO 25297-1:2012

BSI Standards Publication

Optics and photonics — Electronic exchange of optical data

Part 1: NODIF information model

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National foreword

This British Standard is the UK implementation of ISO 25297-1:2012. It supersedes BS ISO 25297-1:2010 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPW/172/1, Optics and Photonics - Fundamental Standards.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 76392 2

ICS 37.020

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2012.

Amendments issued since publication

Date	Text affected

BS ISO 25297-1:2012

INTERNATIONAL STANDARD

ISO 25297-1

Second edition
2012-03-01

Optics and photonics — Electronic exchange of optical data —

Part 1: NODIF information model

Optique et photonique — Transfert électronique des données optiques —

Partie 1: Modèle de données NODIF

Reference number
ISO 25297-1:2012(E)

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Published in Switzerland

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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 25297-1 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This second edition cancels and replaces the first edition (ISO 25297-1:2010), which has undergone a minor revision to correctly identify the status of Annex A as being normative rather than informative and to apply corrections to Figures 1, 2, A.8, A.14, A.18 and A.23.

ISO 25297 consists of the following parts, under the general title *Optics and photonics — Electronic exchange of optical data*:

— *Part 1: NODIF information model*

— *Part 2: Mapping to the classes and properties defined in ISO 23584*

Introduction

This part of ISO 25297, dealing with the Neutral Optical Data Interchange Format (NODIF), is the International Standard that describes the way optical information is transferred from one computer-aided-design program (CAD, CAE, CAM) to another, in a machine-independent and language-independent format.

ISO 10303 (all parts) is the International Standard for Exchange of Product model data (STEP) that describes the computer-interpretable representation and exchange of product data. Its objective is to provide a neutral mechanism capable of describing any product data throughout the life cycle of the product, independent of any particular system. This description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and for archiving. ISO 10303 (all parts) has been designed to support an extensive domain of product data-communication requirements, i.e. all product data necessary to completely define any product for all applications over the product's life cycle.

STEP is organized in a series of parts, each published separately. Each part falls into one of the following categories: descriptive methods, integrated resources, application integrated constructs, application protocols, abstract test suites, implementation methods and conformance testing. The series is described in ISO 10303-1.

A fundamental concept is the definition of the application protocol (AP), which is the mechanism for specifying information requirements and for ensuring reliable communication. An application protocol defines the context, scope and information requirements for a particular product and specifies the resource constructs required to satisfy these requirements. Application protocols employ three types of information models:

a) an application activity model (AAM), which describes the activities and processes that use and produce the product data in a specific application context;

b) an application reference model (ARM), which defines the terminology within the application context and specifies the conceptual structures and constraints that are used to describe the information requirements for an application;

c) an application interpreted model (AIM), which is a model of selected integrated resources that are constrained, specialized or completed to satisfy the information requirements of the ARM.

This part of ISO 25297 for NODIF is intended to conform to the requirements of ISO 10303 (all parts) as a member of the application protocol series.

INTERNATIONAL STANDARD ISO 25297-1:2012(E)

Optics and photonics — Electronic exchange of optical data —

Part 1: NODIF information model

1 Scope

This part of ISO 25297 specifies the information requirements for optical systems and parts, and provides an information model to support the processes of optical design, optical evaluation and analysis for these optical systems and parts when using computers with CAD and CAE.

NOTE Generally, an optical system means an optical unit as an optical product, which performs optical functions, and is composed of optical elements and the barrels in which these elements are mounted. In this part of ISO 25297, an optical system is a collection of optical parts and optical assemblies, e.g. the viewfinder system or the taking lens system of a leaf shutter camera.

This information model adds the data peculiar to optical design specification based on STEP to ISO 10303 (all parts). The additional information is product specification information, optical design information, optical evaluation information and analysis information.

This part of ISO 25297 is generically called the Neutral Optical Data Interchange Format (NODIF).

The following are within the scope:

— information on product specification, optical design, optical evaluation and analysis;

— optical systems and parts in imaging systems, such as cameras and copiers, viewing systems for telescopes and microscopes and the other optical systems, such as projectors and pick-up lenses;

— multiple-configuration optical systems, including zoom lenses and inner focusing systems;

— optical path definition, including ray-path sequence and optical surface arrangement;

— optical assemblies, including cemented parts and dynamic parts;

— mathematical description of the optical surface form;

— description of diffractive surfaces;

— machining process designation, such as polishing, moulding or replicating;

— optical material specifications, such as material names, lot numbers and measured refractive indices;

— optical tolerances for the shape and material property of each optical part;

— assembly tolerances, such as separation, parallelism, displacement and tilt;

— effective diameters, coatings and protective surface treatment;

— paraxial evaluation, such as focal length, back focal length, principal points and f-number;

— ray-tracing evaluation, such as geometrical ray-tracing results (i.e. ray directions and intersection points on each surface and optical path lengths), aberrations and wavefront aberration;

— OTF evaluation based on geometrical and/or physical optics;

— illuminance distribution on a detection surface or a projection surface;

— spectral characteristics;

— ghost image evaluation;

— thermal analysis accompanying optical surface deformation and material property value change;

— stress analysis accompanying optical surface deformation and material property value change;

— veiling glare and surface imperfections.

The following are outside the scope of this part of ISO 25297:

— mechanical design, electronic design and embedded software design;

— optical systems in which the optical path is changeable, e.g. beam splitters or variable magnification converters;

— tolerances for mechanical parts;

— parts with a diameter less than 10 times the wavelength of light;

— parts made from materials whose dielectric constant, σ, electric permittivity, ε, and magnetic permittivity, μ, are uninfluenced by interaction between the materials and the light;

— graphical documents resulting from design, evaluation and analysis of products;

— optical wave guide for optical communications;

— product planning information concerning market research and customer analysis;

— product definition and configuration control information irrelevant to design, evaluation and analysis;

— analysis information, except thermal and stress analysis, e.g. vibration analysis;

— information on trial production, production process including production planning and production control, and processes after production, such as shipment and repair;

— ophthalmic optics.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10110-1, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General*

ISO 10110-2:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 2: Material imperfections — Stress birefringence*

ISO 10110-3:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 3: Material imperfections — Bubbles and inclusions*

ISO 10110-4:1997, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 4: Material imperfections — Inhomogeneity and striae*

ISO 10110-5:2007, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 5: Surface form tolerances*

ISO 10110-6:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 6: Centring tolerances*

ISO 10110-7:2008, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 7: Surface imperfection tolerances*

ISO 10110-8, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 8: Surface texture; roughness and waviness*

ISO 10110-12:2007, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 12: Aspheric surfaces*

ISO 10110-17:2004, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 17: Laser irradiation damage threshold*

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

ISO 10303-203, *Industrial automation systems and integration — Product data representation and exchange — Part 203: Application protocol: Configuration controlled 3D design of mechanical parts and assemblies (modular version)*

ISO 23584-2, *Optics and photonics — Specification of reference dictionary — Part 2: Classes' and properties' definitions*[1)]

ISO 25297-2, *Optics and photonics — Electronic exchange of optical data — Part 2: Mapping to the classes and properties defined in ISO 23584*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
application
group of one or more processes creating or using product data

[ISO 10303-1:1994, 3.2.2]

3.1.2
application activity model
AAM
model that describes an application in terms of its processes and information flows

[ISO 10303-1:1994, 3.2.3]

3.1.3
application object
atomic element of an application reference model that defines a unique concept of the application and contains attributes specifying the data elements of the object

[ISO 10303-1:1994, 3.2.6]

3.1.4
application protocol
AP
one of the parts of ISO 10303-1 that specifies an application-interpreted model satisfying the scope and information requirements for a specific application

NOTE This definition differs from the definition used in open system interconnection (OSI) standards. However, since ISO 10303-1 is not intended to be used directly with OSI communications, no confusion should arise.

[ISO 10303-1:1994, 3.2.7]

1) To be published.

3.1.5
application reference model
ARM
information model that describes the information requirements and constraints of a specific application context

[ISO 10303-1:1994, 3.2.8]

NOTE See Annex B for diagrams of example application activity models.

3.1.6
assembly
product that is decomposable into a set of components or other assemblies from the perspective of a specific application

[ISO 10303-1:1994, 3.2.10]

3.1.7
component
product that is not subject to decomposition from the perspective of a specific application

[ISO 10303-1:1994, 3.2.11]

3.1.8
data
representation of information in a formal manner suitable for communication, interpretation or processing by human beings or computers

[ISO 10303-1:1994, 3.2.14]

3.1.9
data exchange
storing, accessing, transferring and archiving of data

[ISO 10303-1:1994, 3.2.15]

3.1.10
design_discipline_product_definition
one of the organizational definitions or views of a part in accordance with ISO 10303-203:2005, 4.2.8

NOTE A part version is the identification of the representation of a part after its design has undergone a formal release or change.

3.1.11
external definition
definition of product information defined outside NODIF

3.1.12
external file reference
locator of an external file to identify a collection of information whose contents are excluded from the data structure of NODIF

3.1.13
information
facts, concepts or instructions

[ISO 10303-1:1994, 3.2.20]

3.1.14
product
thing or substance produced by a natural or artificial process

[ISO 10303-1:1994, 3.2.26]

3.1.15
product data
representation of information about a product in a formal manner suitable for communication, interpretation or processing by human beings or by computers

[ISO 10303-1:1994, 3.2.27]

3.1.16
unit of functionality
collection of application objects and their relationships that defines one or more concepts within the application context such that removal of any component would render the concepts incomplete or ambiguous

[ISO 10303-1:1994, 3.2.33]

3.2 Abbreviated terms

AAM	application activity model
AP	application protocol
ARM	application reference model
BOM	bill of material
CAD	computer-aided design
CAE	computer-aided engineering
ICAM	integrated computer-aided manufacturing
ID	identification
IDEF0	ICAM definition language 0
LEW	line equivalent width
MTF	modulation transfer function
OTF	optical transfer function
PDM	product data management
SED	spot equivalent diameter
STEP	standard for the exchange of product model data (generic term for ISO 10303)
UoF	units of functionality
VGI	veiling glare index

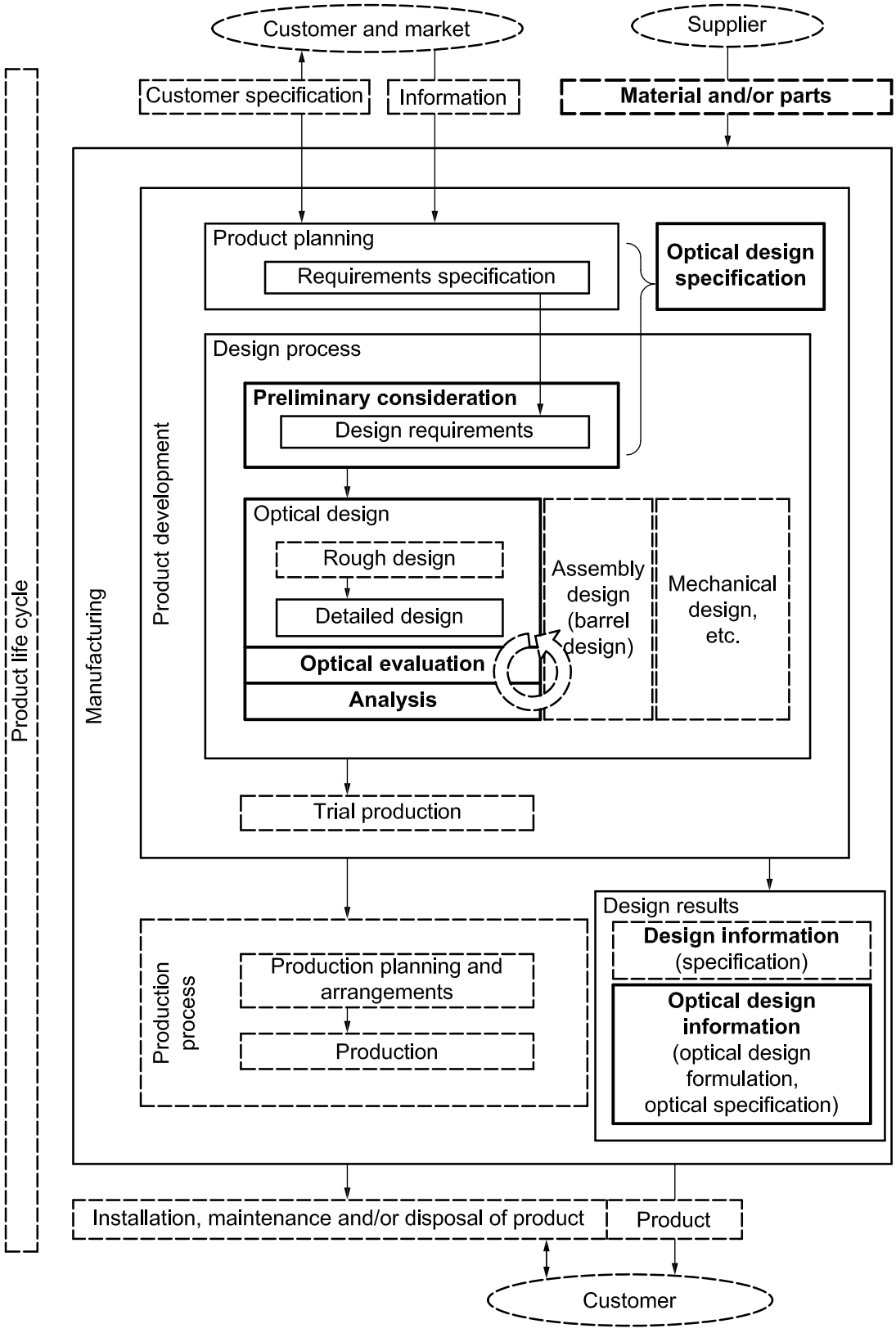
4 Information requirements

4.1 General

In 4.2 and 4.3 the information requirements for NODIF are specified. The information requirements are specified as a set of units of functionality and application objects.

A mapping of these information requirements to the classes and properties defined in ISO 23584-2 is specified in ISO 25297-2.

A diagram of the manufacturing process for optical products is given in Figure 1.



NOTE The dotted line means “out of scope”.

Figure 1 — Manufacturing process of optical products

4.2 Units of functionality

4.2.1 General

4.2.1.1 Subclause 4.2.1 specifies the units of functionality (UoF) for optical design, optical evaluation and analysis in the application protocol of optical systems, parts, and assemblies.

This part of NODIF specifies the following units of functionality:

— optical_part_identification;

— optical_design_specification;

— optical_design_information;

— optical_evaluation_information;

— analysis_information.

4.2.1.2 The following units of functionality make use of UoFs defined in accordance with ISO 10303-203:

— end_item_identification;

— part_identification;

— authorization;

— design_activity_control;

— bill_of_material;

— shape;

— design_information;

— effectivity;

— source_control.

The UoFs and application objects, and the relations between them, are illustrated in the simple ARM diagram shown in Figure 2.

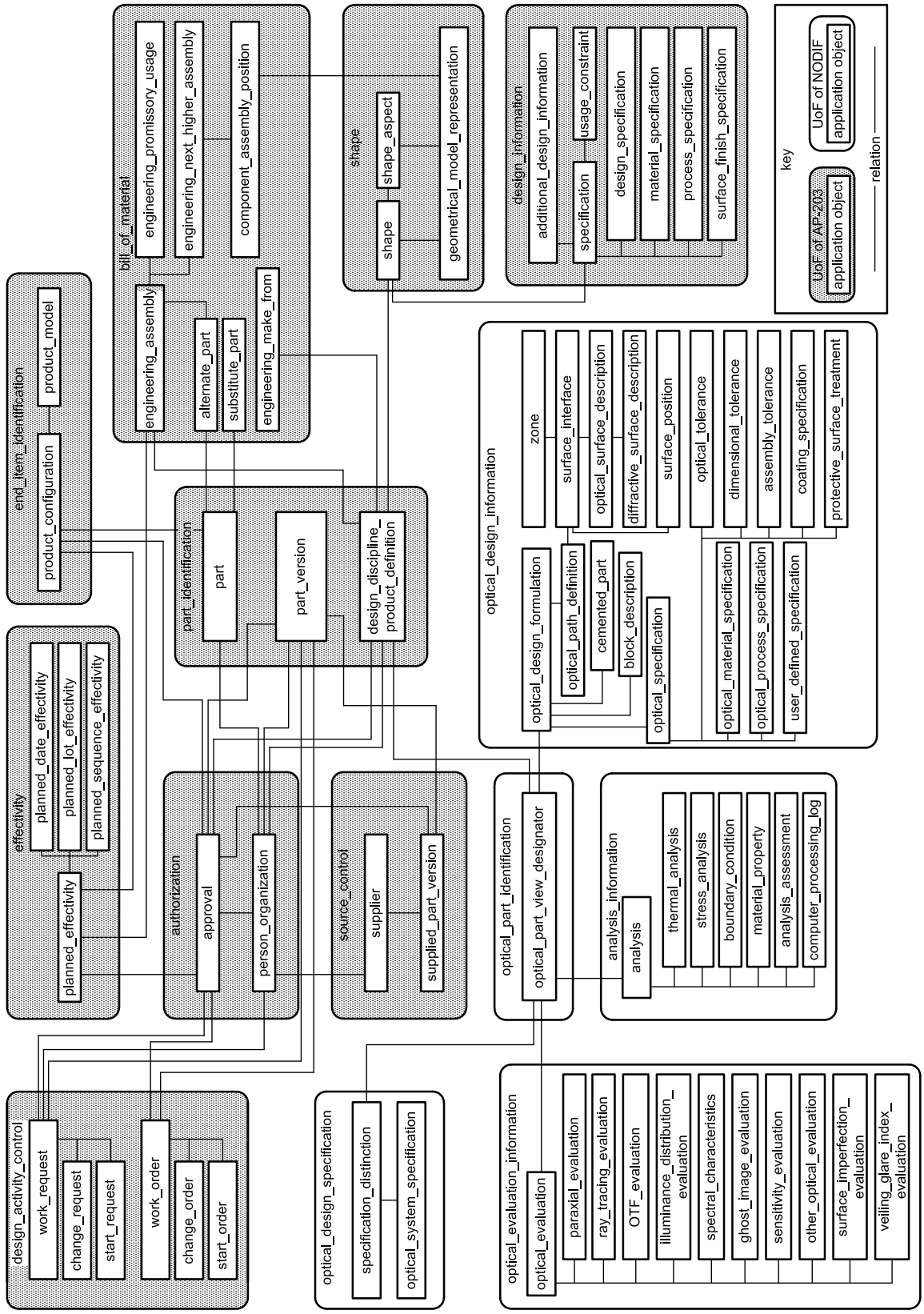


Figure 2 — NODIF simple ARM diagram

4.2.2 optical_part_identification

The optical_part_identification UoF contains the linkage between the information on optical systems and parts described in NODIF and the information on assemblies and parts described in other APs in ISO 10303, especially AP 203. The application object, optical_part_view_designator, is used in the optical_part_identification UoF.

4.2.3 optical_design_specification

The optical_design_specification UoF contains optical design specifications, such as optical performance, accuracy, quality, operating environment, dimensions and mass for an optical system. The following application objects are used in the optical_design_specification UoF:

— specification_distinction;

— optical_system_specification.

4.2.4 optical_design_information

The optical_design_information UoF contains a collection of information on optical design. The following application objects are used in the optical_design_information UoF:

— optical_design_formulation;

— block_description;

— cemented_part;

— optical_path_definition;

— surface_interface;

— surface_position;

— optical_surface_description;

— diffractive_surface_description;

— optical_specification;

— optical_material_specification;

— optical_process_specification;

— optical_tolerance;

— dimensional_tolerance;

— assembly_tolerance;

— zone;

— coating_specification;

— protective_surface_treatment;

— user-defined_specification.

4.2.5 optical_evaluation_information

An optical_evaluation_information UoF contains a collection of information concerned with optical evaluations, such as initial conditions and computation results. The following application objects are used in an optical_evaluation_information UoF:

— optical_evaluation;

— paraxial_evaluation;

— ray_tracing_evaluation;

— OTF_evaluation;

— illuminance_distribution_evaluation;

— spectral_characteristics;

— ghost_image_evaluation;

— optical_sensitivity_evaluation;

— surface_imperfection_evaluation;

— veiling_glare_index_evaluation;

— other_optical_evaluation.

4.2.6 analysis_information

The analysis_information UoF contains a collection of information on thermal analysis, stress analysis and the assessment results from these analyses. Thermal change causes deformation of shapes and optical surfaces, and material property changes. This information is described in thermal_analysis. Stress also causes deformation of shapes and optical surfaces and material property changes. This information is described in stress_analysis. The following application objects are used in the analysis_information UoF:

— analysis;

— thermal_analysis;

— stress_analysis;

— boundary_condition;

— material_property;

— analysis_assessment;

— computer_processing_log.

4.3 Application objects

4.3.1 General

In 4.3 are specified the application objects for NODIF. Each application object is an atomic element that embodies a unique application concept and contains attributes specifying the data elements of the object. The application objects and their definitions are given in 4.3.2.

The application objects and their attributes are specified in ARM diagrams using the EXPRESS-G graphical notation; see Figures A.1 to A.25.

The default unit of length for dimensions, positions and coordinates is millimetres. The default unit of wavelength is nanometres.

4.3.2 optical_part_view_designator

An optical_part_view_designator indicates the linkage between the information on optical systems and parts described in NODIF and the information on assemblies and parts in other APs in ISO 10303 (all parts), especially AP 203.

4.3.3 specification_distinction

4.3.3.1 General

A specification_distinction indicates a type of optical design specification: official specification requirements of an optical system or design requirements for an optical system. The data associated with a specification_ distinction are the specification_type.

4.3.3.2 specification_type

The specification_type represents a type used to indicate specification requirements or design requirements.

4.3.4 optical_system_specification

4.3.4.1 General

An optical_system_specification is a collection of specifications of an optical system. The data associated with an optical_system_specification are the following:

— specification_item;

— literal_specification_data;

— numerical_specification_data;

— specification_item_adjective;

— specification_unit.

4.3.4.2 specification_item

The specification_item specifies the item that is being specified for an optical system. See examples in Table 1.

Table 1 — Examples of specification items in optical systems

angle of view	angular aperture	angular magnification
aperture ratio	back focal distance	circle of least confusion
clear aperture	cost	cover glass thickness
diameter	dioptre adjustment range	dioptre scale
entrance pupil diameter	exit pupil diameter	eye relief
field number	field of view	filter size
flange focus	f-number	focal length
image size	image distance	length
magnification	mechanical tube length	MTF
numerical aperture	object distance	optical tube length
parfocalizing distance	reference wavelength	resolving power
veiling glare index (VGI)	vignetting factor	wavelength range
mass	working distance	zoom ratio

4.3.4.3 literal_specification_data

The literal_specification_data specifies the character data in specification items.

4.3.4.4 numerical_specification_data

The numerical_specification_data specifies the numerical data in specification items.

4.3.4.5 specification_item_adjective

The specification_item_adjective specifies an adjective of a specification item.

EXAMPLE Maximum, minimum.

4.3.4.6 specification_unit

The specification_unit specifies a unit of one of the numerical specification data.

4.3.5 optical_design_formulation

4.3.5.1 General

An optical_design_formulation is a collection of information relevant to optical design. The data associated with an optical_design_formulation are the following:

— optical_design_code;

— optical_design_source;

— optical_design_addition.

4.3.5.2 optical_design_code

The optical_design_code identifies an optical_design_formulation. The code is unique within the source organization.

4.3.5.3 optical_design_source

The optical_design_source specifies the organization that is responsible for the optical_design_formulation.

4.3.5.4 optical_design_addition

The optical_design_addition specifies an external file reference whose file can contain documents and drawings associated with an optical design.

EXAMPLE Optical drawings or coating characteristics can be stored in an external file.

4.3.6 Block_description

4.3.6.1 General

A block_description indicates the moving range of an optical block to vary optical characteristics, such as for zoom blocks and an adjustment block. The data associated with a block_description are the following:

— block_purpose;

— block_first_surface;

— block_last_surface.

4.3.6.2 block_purpose

The block_purpose represents the application purpose of an optical block.

EXAMPLE Zoom, focusing, floating, auxiliary diaphragm (for preventing flare), image stabilization, tilt and/or shift lens, collapse, adjustment.

4.3.6.3 block_first_surface

The block_first_surface designates the first surface of an optical block.

4.3.6.4 block_last_surface

The block_last_surface designates the last surface of an optical block.

4.3.7 Cemented_part

4.3.7.1 General

A cemented_part indicates cemented optical parts. The data associated with a cemented_part are the following:

— optical_element;

— optical_adhesive.

4.3.7.2 optical_element

The optical_element designates an optical element that is being cemented.

4.3.7.3 optical_adhesive

The optical_adhesive designates an optical adhesive for cementing optical elements.

4.3.8 optical_path_definition

4.3.8.1 General

An optical_path_definition specifies the data necessary to trace rays through an optical system. The data associated with an optical_path_definition include the following:

— coordinate_system;

— optical_axis;

— meridional_plane;

— surface_sequence;

— non-sequential_path_range;

— multiplicity;

— number_of_change_positions;

— multi-configuration.

4.3.8.2 coordinate_system

The coordinate_system specifies a coordinate system in which to express an optical surface form.

4.3.8.3 optical_axis

The optical_axis specifies an axis in a coordinate system that acts as the optical axis for expressing an optical surface form.

4.3.8.4 meridional_plane

The meridional_plane specifies the plane defined by the optical axis and another axis of the coordinates.

4.3.8.5 surface_sequence

The surface_sequence specifies the order of optical surfaces in the ray-tracing sequence. The surface_sequence is a list of surface_interface data (see 4.3.9).

4.3.8.6 non-sequential_path_range

The non-sequential_path_range designates the range of non-sequential path elements. It is composed of the following detailed data:

— non-sequential_path_entrance;

— non-sequential_path_exit.

NOTE A sequential path is a ray-tracing path in which rays travel through surfaces in the same sequential order as the optical surfaces are input into an optical CAD. A non-sequential path is a ray-tracing path that specifies the order in which the rays actually encounter the optical surfaces; this is not the sequential order in which the surfaces are input into an optical CAD. Examples of non-sequential path elements are multi-reflective optical elements, e.g. rod lenses or indecisive reflective optical elements such as corner cube prisms and pentagonal roof prisms, and cases in ghost images generated by optical surfaces.

4.3.8.7 non-sequential_path_entrance

The non-sequential_path_entrance designates the entrance optical surface in a non-sequential path element.

4.3.8.8 non-sequential_path_exit

The non-sequential_path_exit designates the exit optical surface in a non-sequential path element.

4.3.8.9 multiplicity

The multiplicity specifies the maximum configuration number of multiple configurations in an optical system that has dynamic blocks. Typical dynamic blocks are zoom blocks and focusing blocks. The multiplicity of an optical system without a dynamic block is unity.

4.3.8.10 number_of_change_positions

The number_of_change_positions specifies the number of dynamic blocks in an optical system.

4.3.8.11 multi-configuration

The multi-configuration specifies the information of multiple configurations in an optical system. It is composed of the following detailed data:

— multi-configuration_comment;

— change_position.

4.3.8.12 multi-configuration_comment

A multi-configuration_comment represents the supplementary explanation of a configuration.

EXAMPLE Infrared focusing position, image stabilization, collapse (in a collapsible lens), wide position, intermediate position, telephoto position and closest position.

4.3.8.13 change_position

4.3.8.13.1 General

The change_position specifies the arrangement of dynamic blocks in an optical system. It is composed of the following detailed data:

— surface_interface_change_designator;

— applied_surface_position.

4.3.8.13.2 surface_interface_change_designator

The surface_interface_change_designator designates the first surface of a dynamic block.

4.3.8.13.3 applied_surface_position

The applied_surface_position specifies a surface_position (see 4.3.10) of a dynamic block after a position change, which includes the surface distance or local coordinate for a designated surface.

4.3.9 surface_interface

4.3.9.1 General

A surface_interface represents the information necessary for ray-tracing at each interface. The data associated with a surface_interface include the following:

— optical_surface_identification;

— preceding_material;

— following_material;

— transit_mode;

— transit_direction;

— effective diameter.

4.3.9.2 optical_surface_identification

The optical_surface_identification represents the identifier of an optical surface used to link an optical_surface_description (see 4.3.11) and a surface_position (see 4.3.10).

4.3.9.3 preceding_material

The preceding_material designates the material traced by ray on the incident side on an optical surface.

4.3.9.4 following_material

The following_material designates the material traced by ray outgoing from an optical surface. An exit side material is designated in the case of a transmitting ray.

4.3.9.5 transit_mode

The transit_mode specifies the behaviour of a ray on a surface, i.e. refraction, reflection, or total reflection. The default of transit_mode is refraction.

4.3.9.6 transit_direction

The transit_direction specifies the direction of exit rays on a surface, i.e. forward or backward. The default of transit_direction is forward.

4.3.9.7 effective_diameter

The effective_diameter specifies the optically effective diameter, expressed in millimetres, on an optical surface based on a zone (see 4.3.19).

4.3.10 Surface_position

4.3.10.1 General

A surface_position indicates the position of an optical surface defined by the surface distance or local coordinate. The data associated with a surface_position are the following:

— surface_distance;

— local_coordinate_transformation.

4.3.10.2 surface_distance

The surface_distance specifies the distance, expressed in millimetres, between an optical surface designated by an optical_surface_identification and the surface which precedes it.

4.3.10.3 local_coordinate_transformation

4.3.10.3.1 General

The local_coordinate_transformation specifies the origin of the local coordinate system and coordinate transformation to locate an optical surface. It is composed of the following detailed data:

— local_coordinate_system_origin;

— coordinate_transformation.

4.3.10.3.2 local_coordinate_system_origin

The local_coordinate_system_origin specifies the origin of the coordinate system for locating an optical surface as an absolute coordinate system or a local coordinate system based on the preceding surface of the designated surface.

4.3.10.3.3 coordinate_transformation

The coordinate_transformation specifies the three-dimensional vector as a coordinate transformation based on the local coordinate system.

4.3.11 optical_surface_description

4.3.11.1 General

An optical_surface_description is the mathematical expression of an optical surface form. Optical surfaces include an object surface and an image surface. The data associated with an optical_surface_description are the following:

— surface_type;

— surface_expression_parameter.

4.3.11.2 surface_type

4.3.11.2.1 General

The surface_type specifies a type of optical surface form. It is composed of the following detailed data:

— spherical_surface;

— plane_surface;

— general_aspheric_surface;

— conical_surface_with_power_series;

— cylindrical_surface_with_power_series;

— surface_of_revolution;

— user-defined_surface.

4.3.11.2.2 spherical_surface

The spherical_surface specifies a spherical optical surface that is parameterized by the curvature or the radius of curvature.

4.3.11.2.3 plane_surface

The plane_surface specifies an optical surface whose radius of curvature is infinity.

4.3.11.2.4 general_aspheric_surface

The general_aspheric_surface specifies an optical surface based on Formula (1), given in ISO 10110-12:2007, Annex A.

$$z = \frac{\frac{x^2}{R_x} + \frac{y^2}{R_y}}{1 + \sqrt{1 - (1+\kappa_x)\left(\frac{x}{R_x}\right)^2 - (1+\kappa_y)\left(\frac{y}{R_y}\right)^2}} + \left(A_4 x^4 + B_4 y^4 + A_6 x^6 + B_6 y^6 + \cdots + C_3 |x|^3 + \cdots + D_3 |y|^3 + \cdots\right) \quad (1)$$

The substitutions $R = R_x = R_y$, $\kappa = \kappa_x = \kappa_y$, and $h = \sqrt{x^2 + y^2}$ give Formula (2):

$$z = \frac{h^2}{R\left[1 + \sqrt{1 - (1+\kappa)\left(\frac{h}{R}\right)^2}\right]} + \left(A_3 h^3 + A_4 h^4 + A_5 h^5 + \cdots\right) \quad (2)$$

Formula (3) is equivalent to Formula (2) with curvature substituted for radius.

$$z = \frac{x^2 C_x + y^2 C_y}{1 + \sqrt{1 - (1+\kappa_x)(xC_x)^2 - (1+\kappa_y)(yC_y)^2}} + \left(A_4 x^4 + B_4 y^4 + A_6 x^6 + B_6 y^6 + \cdots + C_3 |x|^3 + \cdots + D_3 |y|^3 + \cdots\right) \quad (3)$$

The substitutions $C = C_x = C_y$, $\kappa = \kappa_x = \kappa_y$ and $h = \sqrt{x^2 + y^2}$ give Formula (4):

$$z = \frac{h^2 C}{1 + \sqrt{1 - (1+\kappa) h^2 C^2}} + \left(A_3 h^3 + A_4 h^4 + A_5 h^5 + \cdots\right) \quad (4)$$

4.3.11.2.5 conical_surface_with_power_series

The conical_surface_with_power_series specifies an optical surface based on Formula (5), taken from ISO 10110-12:2007, Annex A.

$$z = c\sqrt{\frac{x^2}{a^2} + \frac{y^2}{b^2} + \left(A_4 x^4 + B_4 y^4 + A_6 x^6 + B_6 y^6 + \cdots + C_3 |x|^3 + \cdots + D_3 |y|^3 + \cdots\right)} \quad (5)$$

The substitutions $a = b$ and $h = \sqrt{x^2 + y^2}$ give Formula (6):

$$z = \frac{c}{a} h + \left(A_3 h^3 + A_4 h^4 + A_5 h^5 + \cdots\right) \quad (6)$$

4.3.11.2.6 cylindrical_surface_with_power_series

The cylindrical_surface_with_power_series specifies an optical surface based on Formula (7), specified in ISO 10110-12:2007, Annex A.

$$z = \frac{u^2}{R_u\left[1 + \sqrt{1 - (1+\kappa_u)\left(\frac{u}{R_u}\right)^2}\right]} + \left(A_4 u^4 + A_6 u^6 + \cdots + C_3 |u|^3 + \cdots\right) \quad (7)$$

where u represents x or y.

Formula (8) is equivalent to Formula (7) with curvature substituted for radius.

$$z = \frac{u^2 C_u}{1+\sqrt{1-(1+\kappa_u)u^2 C_u^2}} + \left(A_4 u^4 + A_6 u^6 + \cdots + C_3 |u|^3 + \cdots\right) \tag{8}$$

where u represents x or y.

4.3.11.2.7 surface_of_revolution

The surface_of_revolution specifies an optical surface based on Formula (9), taken from ISO 10110-12:2007, Annex A.

The surface_of_revolution is represented by Formula (9) when the defining curve lies on the xz plane and the rotating axis is parallel to the x axis.

$$z = R_y \mp \sqrt{\left[R_y - g(x)\right]^2 - y^2} \tag{9}$$

$$g(x) = \frac{x^2}{R_x\left[1+\sqrt{1-(1+\kappa_x)\left(\frac{x}{R_x}\right)^2}\right]} + \left(A_4 x^4 + A_6 x^6 + \cdots + C_3 |x|^3 + C_5 |x|^5 \cdots\right) \tag{10}$$

The surface_of_revolution is represented by Formula (11) when the defining curve lies on the yz plane and the rotating axis is parallel to the y axis.

$$z = R_x \mp \sqrt{\left[R_x - g(y)\right]^2 - x^2} \tag{11}$$

$$g(x) = \frac{y^2}{R_y\left[1+\sqrt{1-(1+\kappa_y)\left(\frac{y}{R_y}\right)^2}\right]} + \left(B_4 y^4 + B_6 y^6 + \cdots + D_3 |y|^3 + D_5 |y|^5 \cdots\right) \tag{12}$$

4.3.11.2.8 user-defined_surface

The user-defined_surface specifies an optical surface form expressed by an external definition.

4.3.11.3 surface_expression_parameter

4.3.11.3.1 General

The surface_expression_parameter specifies a parameter set for each surface type to express an optical surface form. The data are composed of the following detailed data:

— radius;

— curvature;

— x_radius;

— x_curvature;

— y_radius;

— y_curvature;

— conic_constant;

— x_conic_constant;

— y_conic_constant;

— aspheric_coefficient;

— x_aspheric_coefficient;

— y_aspheric_coefficient;

— defining_curve_variable;

— rotational_radius;

— rotation_axis;

— user-defined_surface_reference;

— user-defined_surface_coefficient;

— conic_parameter_a;

— conic_parameter_b;

— conic_parameter_c.

4.3.11.3.2 radius

The radius specifies the radius of curvature of a spherical surface or that at the vertex of a rotationally symmetric aspheric surface, expressed in millimetres.

4.3.11.3.3 curvature

The curvature specifies the curvature of a spherical surface or that at the vertex of a rotationally symmetric aspheric surface.

4.3.11.3.4 x_radius

The x_radius specifies the radius, R_x, of a generalized aspheric surface in the xz plane at $z = 0$, expressed in millimetres.

4.3.11.3.5 x_curvature

The x_curvature specifies the curvature, C_x, of a generalized aspheric surface in the xz plane at $z = 0$.

4.3.11.3.6 y_radius

The y_radius specifies the radius, R_y, of a generalized aspheric surface in the yz plane for $z = 0$, expressed in millimetres.

4.3.11.3.7 y_curvature

The y_curvature specifies the curvature, C_y, of a generalized aspheric surface in the yz plane at $z = 0$.

4.3.11.3.8 conic_constant

The conic_constant specifies the conic constant, κ, in a rotationally symmetric generalized aspheric surface. If the quadratic term of a generalized aspheric surface is intersected with a plane including the z axis, then, depending on value of the conic constant, κ, intersection lines of the following types are produced:

$\kappa > 0$ oblate ellipse;

$\kappa = 0$ circle;

$-1 < \kappa < 0$ prolate ellipse;

$\kappa = -1$ parabola;

$\kappa < -1$ hyperbola.

4.3.11.3.9 x_conic_constant

The x_conic_constant specifies the x conic constant, κ_x, in a generalized aspheric surface. If the quadratic term of a generalized aspheric surface is intersected with the xz plane, then, depending on the value of the x conic constant, κ_x, intersection lines of the following types are produced:

$\kappa_x > 0$ oblate ellipse;

$\kappa_x = 0$ circle;

$-1 < \kappa_x < 0$ prolate ellipse;

$\kappa_x = -1$ parabola;

$\kappa_x < -1$ hyperbola.

4.3.11.3.10 y_conic_constant

The y_conic_constant specifies the y conic constant κ_y in a generalized aspheric surface. If the quadratic term of a generalized aspheric surface is intersected with the yz plane, then, depending on the value of the y conic constant, κ_y, intersection lines of the following types are produced:

$\kappa_y > 0$ oblate ellipse;

$\kappa_y = 0$ circle;

$-1 < \kappa_y < 0$ prolate ellipse;

$\kappa_y = -1$ parabola;

$\kappa_y < -1$ hyperbola.

4.3.11.3.11 aspheric_coefficient

The aspheric_coefficient identifies the coefficient of power series in polynomial terms of a generalized aspheric surface when the surface is rotationally symmetric about the z axis. The aspheric coefficient, A_i, is the coefficient of the ith power with respect to height $h = \sqrt{x^2 + y^2}$ from the z axis.

4.3.11.3.12 x_aspheric_coefficient

The x_aspheric_coefficient identifies the coefficient of the x power series in polynomial terms of a generalized aspheric surface. The x aspheric coefficient, A_i, is the coefficient of the even ith power term with respect to the x coordinate, and the other x aspheric coefficient, C_j, is the coefficient of the odd jth power term with respect to the x coordinate.

4.3.11.3.13 y_aspheric_coefficient

The y_aspheric_coefficient identifies the coefficient of the y power series in polynomial terms of a generalized aspheric surface. The y aspheric coefficient, B_i, is the coefficient of the even ith power term with respect to the y coordinate, and the other y aspheric coefficient, D_j, is the coefficient of the odd jth power term with respect to the y coordinate.

4.3.11.3.14 defining_curve_variable

The defining_curve_variable specifies the variable, either x or y, in the expression of a cylindrical surface with a power series or a defining curve.

4.3.11.3.15 rotational_radius

The rotational_radius specifies the radius, expressed in millimetres, in rotating the defining curve of a toric surface.

4.3.11.3.16 rotation_axis

The rotation_axis specifies the axis of rotation for the defining curve of a toric surface.

4.3.11.3.17 user-defined_surface_reference

The user-defined_surface_reference specifies the external file reference whose file contains the expression of a user-defined surface.

4.3.11.3.18 user-defined_surface_coefficient

The user-defined_surface_coefficient specifies the name and value of a coefficient for a user-defined surface.

4.3.11.3.19 conic_parameter_a

The conic_parameter_a specifies the parameter, a, of a conical surface.

4.3.11.3.20 conic_parameter_b

The conic_parameter_b specifies the parameter, b, of a conical surface.

4.3.11.3.21 conic_parameter_c

The conic_parameter_c specifies the parameter, c, of a conical surface.

4.3.12 Diffractive_surface_description

4.3.12.1 General

A diffractive_surface_description describes a diffractive optical surface. The data associated with a diffractive_surface_description are the following:

— diffractive_surface_type;

— diffraction_order;

— construction_wavelength;

— phase_term_type;

— phase_term_coefficient.

4.3.12.2 diffractive_surface_type

The diffractive_surface_type specifies a type of diffractive element.

EXAMPLE Diffraction grating, DOE, HOE.

4.3.12.3 diffraction_order

The diffraction_order specifies the diffraction order of a diffractive surface.

4.3.12.4 construction_wavelength

The construction_wavelength specifies the wavelength value, expressed in nanometres, used to calculate the optical path difference caused by the phase factor of a diffractive element.

4.3.12.5 phase_term_type

The phase_term_type specifies a type of phase term when a diffractive surface is given by a phase function.

4.3.12.6 phase_term_coefficient

The phase_term_coefficient specifies the name and value of the phase term coefficient of a diffractive element.

4.3.13 optical_specification

An optical_specification is a document that contains an optical_material_specification (see 4.3.14), an optical_process_specification (see 4.3.15), an optical_tolerance (see 4.3.16), a dimensional_tolerance (see 4.3.17), an assembly_tolerance (see 4.3.18), a coating_specification (see 4.3.20), a protective_surface_treatment (see 4.3.21) or a user-defined_specification (see 4.3.22).

4.3.14 optical_material_specification

4.3.14.1 General

An optical_material_specification specifies a type of optical_specification (see 4.3.13) relating to the material properties of an optical part made of optical glass or plastic. In addition, the object space medium, the image space medium and the media between optical parts and blocks, such as gasses, water, immersion oils or optical adhesives, can be described in this section if these media are used in design and evaluation, notwithstanding that they are not parts of an optical system. Refractive indices of a material can be described by catalogue values or measured values. The data associated with an optical_material_specification include the following:

— maker_name;

— material_name;

— lot_identification;

— refractive_index_description;

— catalogue_identification;

— Abbe_number;

— internal_transmittance;

— laser_irradiation_damage_threshold.

4.3.14.2 maker_name

The maker_name specifies the name of the maker producing optical materials.

4.3.14.3 material_name

The material_name specifies the name of an optical material, such as optical glass, plastic, an optical adhesive or an immersion oil.

4.3.14.4 lot_identification

The lot_identification specifies the lot name of optical material produced at the same time.

4.3.14.5 refractive_index_description

4.3.14.5.1 General

The refractive_index_description specifies a set of refractive index values and relevant wavelength values. These values shall be identified by refractive_index_source, meaning either a measurement or a maker catalogue. If the refractive_index_source is by measurement, then measured values of a lot shall be specified. If it is from a catalogue, then listed values from the catalogue shall be specified. The refractive_index_description includes the following data:

— wavelength;

— refractive_index;

— refractive_index_source.

4.3.14.5.2 wavelength

The wavelength specifies the wavelength value, which is described by a value, expressed in nanometres, or its spectral line name.

4.3.14.5.3 refractive_index

The refractive_index specifies the value of the refractive index at a definite wavelength.

4.3.14.5.4 refractive_index_source

The refractive_index_source designates the source proving the refractive index values referenced. A source is either a measurement or a catalogue.

4.3.14.6 catalogue_identification

4.3.14.6.1 General

The catalogue_identification identifies the catalogue referenced. This includes the following data:

— catalogue_name;

— date_of_issue;

— catalogue_version.

4.3.14.6.2 catalogue_name

The catalogue_name specifies the name of a referenced catalogue.

4.3.14.6.3 date_of_issue

The date_of_issue specifies the publication date of a referenced catalogue.

4.3.14.6.4 catalogue_version

The catalogue_version specifies the version of a referenced catalogue.

4.3.14.7 Abbe_number

The Abbe_number specifies the Abbe number, ν_e or ν_d, of an optical material. The Abbe numbers, ν_e and ν_d, are calculated as given in Formulae (13) and (14), respectively.

$$\nu_e = \frac{n_e - 1}{n_{F'} - n_{C'}} \tag{13}$$

$$\nu_d = \frac{n_d - 1}{n_F - n_C} \tag{14}$$

4.3.14.8 internal_transmittance

4.3.14.8.1 General

The internal_transmittance specifies wavelength values, internal transmittance of an optical material according to the wavelengths, and thickness of a material piece through which transmittance is measured. This includes the following data:

— wavelength;

— transmittance;

— piece_thickness.

4.3.14.8.2 wavelength

The wavelength specifies wavelength values, expressed in nanometres, for measuring material transmittance in the standard air.

4.3.14.8.3 transmittance

The transmittance specifies internal transmittance of an optical material.

4.3.14.8.4 piece_thickness

The piece_thickness specifies the thickness of a material piece, expressed in millimetres, whose transmittance is measured.

4.3.14.9 laser_irradiation_damage_threshold

The laser_irradiation_damage_threshold specifies the threshold above which laser irradiation damage is caused to a material. This is defined as an item with the code number 6 in the technical drawings in ISO 10110-17:2004.

4.3.15 optical_process_specification

4.3.15.1 General

An optical_process_specification identifies a type of optical_specification (see 4.3.13) describing machining processes, such as machinability of an optical part and a machining method of an aspheric surface. The data associated with an optical_process_specification are the following:

— machinability;

— aspheric_surface_machining_method.

4.3.15.2 machinability

The machinability specifies both the machinability of an optical part and the results based on machining condition analysis.

4.3.15.3 aspheric_surface_machining_method

The aspheric_surface_machining_method identifies the machining method of an aspheric surface.

EXAMPLES Polishing, moulding, replicating.

4.3.16 Optical_tolerance

4.3.16.1 General

An optical_tolerance specifies a type of optical_specification (see 4.3.13) describing optical tolerances mainly defined in ISO 10110 (all parts). This includes the following:

— stress_birefringence;

— bubbles_and_inclusions;

— inhomogeneity_and_striae;

— surface_form_tolerance;

— centring_tolerance;

— surface_imperfection_tolerance;

— surface_texture;

— refractive_index_tolerance_description;

— Abbe_number_tolerance.

4.3.16.2 stress_birefringence

The stress_birefringence specifies the allowance for stress birefringence of an optical element. Stress birefringence is defined as an item with the code number 0 in technical drawings in ISO 10110-2:1996.

4.3.16.3 bubbles_and_inclusions

The bubbles_and_inclusions specify the allowance for bubbles and inclusions of an optical element. Bubbles and inclusions are defined as an item with the code number 1 in technical drawings in ISO 10110-3:1996.

4.3.16.4 inhomogeneity_and_striae

The inhomogeneity_and_striae specify the allowance for inhomogeneity and striae of an optical element. The inhomogeneity and striae are defined as an item with the code number 2 in technical drawings in ISO 10110-4:1997.

4.3.16.5 surface_form_tolerance

4.3.16.5.1 General

The surface_form_tolerance specifies tolerances for an optical surface form. Surface form tolerances are defined as an item with the code number 3 in technical drawings in ISO 10110-5:2007. This includes the following data:

— sagitta_deviation;

— irregularity;

— rotationally_invariant_irregularity;

— rms_deviation_type.

4.3.16.5.2 sagitta_deviation

The sagitta_deviation specifies the sagitta deviation of an optical surface form in the number of interference fringes defined as a unit of fringe spacing in ISO 10110-5.

4.3.16.5.3 irregularity

The irregularity specifies the irregularity of an optical surface form in the number of interference fringes defined as a unit of fringe spacing in ISO 10110-5.

4.3.16.5.4 rotationally_invariant_irregularity

The rotationally_invariant_irregularity specifies the rotationally invariant irregularity of an optical surface form in the number of interference fringes defined as a unit of fringe spacing in ISO 10110-5.

4.3.16.5.5 rms_deviation_type

The rms_deviation_type specifies a type of root-mean square, rms, deviation of an optical surface form.

4.3.16.6 centring_tolerance

The centring_tolerance specifies the centring tolerance for an optical part such as a single lens. A centring tolerance is defined as an item with the code number 4 in technical drawings in ISO 10110-6:1996.

4.3.16.7 surface_imperfection_tolerance

The surface_imperfection_tolerance specifies the allowance for surface imperfections on an optical surface. The surface imperfection tolerance is defined as an item with the code number 5 in technical drawings in ISO 10110-7:2008. Line equivalent width (LEW) and spot equivalent diameter (SED) can be described in this section.

4.3.16.8 surface_texture

The surface_texture specifies the texture allowance for an optical surface. Surface texture is defined in technical drawings in ISO 10110-8. Types of surface texture include matt and specular (optically smooth).

4.3.16.9 refractive_index_tolerance_description

4.3.16.9.1 General

The refractive_index_tolerance_description specifies the tolerance on the refractive index of an optical material. This includes the following data:

— refractive_index_tolerance;

— wavelength.

4.3.16.9.2 refractive_index_tolerance

The refractive_index_tolerance specifies the tolerance on the refractive index.

4.3.16.9.3 wavelength

The wavelength designates the wavelength described by a value, expressed in nanometres, or its spectral line name.

4.3.16.9.4 Abbe_number_tolerance

The Abbe_number_tolerance specifies the tolerances for the Abbe numbers v_e and v_d.

4.3.17 dimensional_tolerance

4.3.17.1 General

A dimensional_tolerance specifies a type of optical_specification (see 4.3.13) describing the tolerances for dimensions of an optical part which are defined mainly in ISO 10110-1. The data associated with a dimensional_ tolerance are the following:

— radius_tolerance;

— thickness_tolerance;

— diameter_tolerance;

— other_tolerance.

4.3.17.2 radius_tolerance

The radius_tolerance specifies the tolerance, expressed in millimetres, for the radius of curvature of an optical surface as defined in ISO 10110-1. A radius_tolerance can be indicated in interferometric terms.

4.3.17.3 thickness_tolerance

The thickness_tolerance specifies the tolerance, expressed in millimetres, for the centre thickness of an optical part such as a single lens as defined in ISO 10110-1.

4.3.17.4 diameter_tolerance

The diameter_tolerance specifies the diameter tolerance, expressed in millimetres, for an optical part such as a single lens as defined in ISO 10110-1.

4.3.17.5 other_tolerance

4.3.17.5.1 General

The other_tolerance specifies the dimensional or angular tolerances for an optical part other than the above such as the radius, the thickness and the diameter tolerances. This includes the following data:

— tolerance_item;

— tolerance_value.

EXAMPLES Bevel tolerances, length and angle tolerances of a prism.

4.3.17.5.2 tolerance_item

The tolerance_item specifies an item of another tolerance.

4.3.17.5.3 tolerance_value

The tolerance_value specifies the value according to another tolerance item.

4.3.18 assembly_tolerance

4.3.18.1 General

An assembly_tolerance specifies a type of optical_specification (see 4.3.13) describing the assembly tolerances for an optical system, optical assemblies and optical parts. The assembly tolerances include cement tolerance for cemented optical parts, separation tolerance between parts or blocks, and centring tolerance in assembling. This includes the following:

— separation_tolerance;

— centring_tolerance.

4.3.18.2 separation_tolerance

The separation_tolerance specifies the tolerance, expressed in millimetres, on an axial separation between optical parts or blocks when assembling an optical system. Not only fixed but also variable separations between optical blocks are included.

4.3.18.3 centring_tolerance

The centring_tolerance specifies centring tolerances for an optical part or an optical sub-system when assembling an optical block or an optical system. Tolerances for cemented lenses can be also specified in this section.

4.3.19 Zone

4.3.19.1 General

A zone defines an optically effective area such as an optically effective diameter, a coating area and a protective-surface-treatment area. The area of a unit zone is defined by an element area called the base zone. If a zone has an opening, an area called the exclusive zone is excluded from the base zone. See Figure 3. The form of an element area is a circle, an ellipse, a polygon or a B-spline closed curve. The data associated with a zone are the following:

— zone_form;

— circle_zone;

— ellipse_zone;

— polygon_zone;

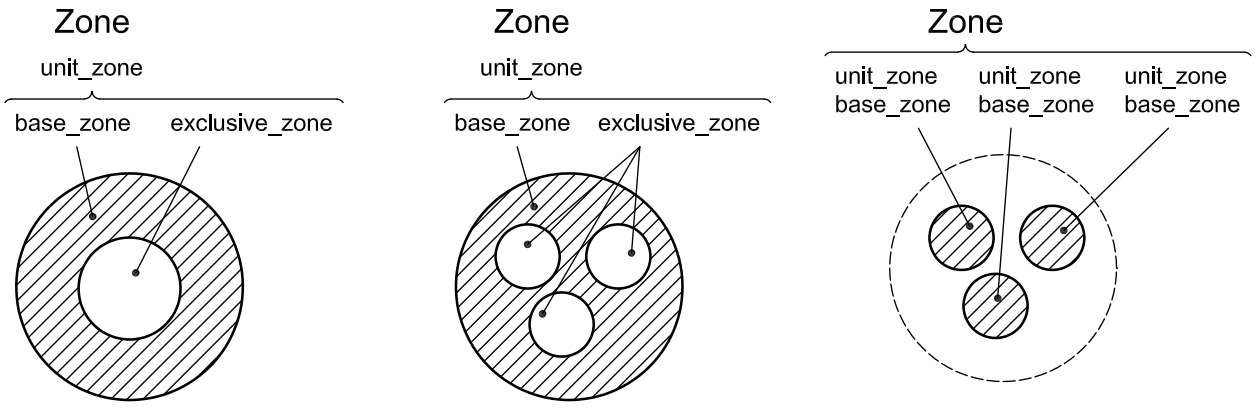
— B-spline_zone;

— unit_zone;

— base_zone;

— exclusive_zone;

— zone_parameters.



a) Example 1 **b) Example 2** **c) Example 3**

Figure 3 — Illustration of the data "unit_zone", "base_zone" and "exclusive_zone"

4.3.19.2 zone_form

The zone_form specifies the form of an element area. The area of an element is the canonical inside of the form. Forms include a circle, an ellipse, a polygon and a B-spline closed curve.

4.3.19.3 circle_zone

The circle_zone specifies a circle as the form of an element area. A circle_zone is defined by the radius and centre coordinates.

4.3.19.4 ellipse_zone

The ellipse_zone specifies an ellipse as the form of an element area. An ellipse_zone is defined by the major axis, minor axis, argument of the minor axis and centre coordinates.

4.3.19.5 polygon_zone

The polygon_zone specifies a polygon as the form of an element area. A polygon_zone is defined by vertex coordinates and the number of vertices. The form of a polygon is represented by sides connected to adjoining vertices. Sides cannot cross each other.

4.3.19.6 B-spline_zone

The B-spline_zone specifies a B-spline closed curve as the form of an element area. A B-spline_zone is defined by B-spline degree, B-spline knot vector, coordinates of control points and the number of the points. Any segment of the closed curve cannot cross another.

4.3.19.7 unit_zone

The unit_zone specifies a unit area of a zone.

4.3.19.8 base_zone

The base_zone specifies the form of a unit zone.

4.3.19.9 exclusive_zone

The exclusive_zone specifies the form of exclusive area in a base zone. An exclusive area is defined as the union of element areas.

4.3.19.10 zone_parameters

4.3.19.10.1 General

The zone_parameters specify parametric values of the form and position of an element area. These include the following data:

— centre_coordinates;

— radius;

— major_axis;

— minor_axis;

— major_axis_argument;

— number_of_points;

— vertex_coordinates;

— control_point_coordinates;

— B-spline_degree;

— B-spline_knot_vector.

4.3.19.10.2 centre_coordinates

The centre_coordinates specify the centre coordinates of a circle or an ellipse, expressed in millimetres.

4.3.19.10.3 radius

The radius specifies the radius value of a circle, expressed in millimetres.

4.3.19.10.4 major_axis

The major_axis specifies the major axis of an ellipse, expressed in millimetres.

4.3.19.10.5 minor_axis

The minor_axis specifies the minor axis of an ellipse, expressed in millimetres.

4.3.19.10.6 major_axis_argument

The major_axis_argument specifies the argument of the major axis of an ellipse, expressed in degrees.

4.3.19.10.7 number_of_points

The number_of_points specifies the number of vertices of a polygon or control points of a B-spline closed curve.

4.3.19.10.8 vertex_coordinate

The vertex_coordinate specifies the coordinates of vertices of a polygon, expressed in millimetres.

4.3.19.10.9 control_point_coordinate

The control_point_coordinate specifies the coordinates of control points of a B-spline closed curve, expressed in millimetres.

4.3.19.10.10 B-spline_degree

The B-spline_degree specifies the B-spline degree of a B-spline closed curve.

4.3.19.10.11 B-spline_knot_vector

The B-spline_knot_vector specifies B-spline knot vector of a B-spline closed curve.

4.3.20 coating_specification

4.3.20.1 General

A coating_specification specifies a type of optical_specification (see 4.3.13) describing coatings such as anti-reflection coatings or mirrors. The data associated with a coating_specification are the following:

— coating_name;

— coating_type;

— coating_characteristics;

— coating_zone.

4.3.20.2 coating_name

The coating_name specifies the name of a coating applied to an optical surface.

4.3.20.3 coating_type

The coating_type specifies a type of coating as in the following examples.

EXAMPLES Mirror, semi-transparent mirror, anti-reflection, wavelength selection, polarization separation.

4.3.20.4 coating_characteristics

The coating_characteristics specify coating characteristics such as layer composition and designed values or measured values for reflectance and transmittance.

4.3.20.5 coating_zone

The coating_zone specifies the area of an optical surface on which to apply a coating, based on a zone (see 4.3.19).

4.3.21 protective_surface_treatment

4.3.21.1 General

A protective_surface_treatment is a type of optical_specification (see 4.3.13) describing the black paint used to prevent stray light or to protect optical parts. The data associated with a protective_surface_treatment are the following:

— protective_surface_treatment_type;

— protective_surface_treatment_zone.

4.3.21.2 protective_surface_treatment_type

The protective_surface_treatment_type specifies a type of protective surface treatment, such as black paint.

4.3.21.3 protective_surface_treatment_zone

The protective_surface_treatment_zone specifies the area of an optical part on which to apply protective surface treatment, based on a zone (see 4.3.19).

4.3.22 user-defined_specification

4.3.22.1 General

A user-defined_specification describes a specification based on an external definition. The data associated with a user-defined_specification are the following:

— user-defined_specification_item;

— user-defined_specification_data.

4.3.22.2 user-defined_specification_item

The user-defined_specification_item specifies an item of a user-defined specification.

4.3.22.3 user-defined_specification_data

The user-defined_specification_data specifies data according to a user-defined specification item.

4.3.23 optical_evaluation

4.3.23.1 General

An optical_evaluation contains the conditions and results related to optical evaluations.

Each optical_evaluation is a paraxial_evaluation (see 4.3.24), a ray_tracing_evaluation (see 4.3.25), an OTF_evaluation (see 4.3.26), an illuminance_distribution_evaluation (see 4.3.27), a spectral_characteristics (see 4.3.28), a ghost_image_evaluation (see 4.3.29), an optical_sensitivity_evaluation (see 4.3.30), a surface_imperfection_evaluation (see 4.3.31), a veiling_glare_index_evaluation (see 4.3.32) or an other_optical_evaluation (see 4.3.33). The data associated with an optical_evaluation are the following:

— optical_evaluation_code;

— optical_evaluation_source;

— optical_evaluation_addition.

4.3.23.2 optical_evaluation_code

The optical_evaluation_code specifies the identifier of an optical_evaluation. The code is unique within the source organization.

4.3.23.3 optical_evaluation_source

The optical_evaluation_source specifies the organization that is responsible for the optical_evaluation.

4.3.23.4 optical_evaluation_addition

The optical_evaluation_addition specifies the external file reference relating to the documents and drawings of optical evaluations.

4.3.24 paraxial_evaluation

4.3.24.1 General

A paraxial_evaluation describes paraxial ray-tracing and paraxial quantities. The data associated with a paraxial_evaluation include the following:

— wavelength;

— focal-afocal_distinction;

— angular_magnification;

— lateral_magnification;

— paraxial_ray_tracing;

— focal_length;

— entrance_pupil_position;

— exit_pupil_position;

— front_principal_point_position;

— back_principal_point_position;

— back_focal_distance.

4.3.24.2 wavelength

The wavelength specifies the wavelength value, expressed in nanometres, in paraxial ray-tracing.

4.3.24.3 focal-afocal_distinction

The focal-afocal_distinction classifies an optical system as a focal system or an afocal system.

4.3.24.4 angular_magnification

The angular_magnification specifies the angular magnification of an optical system in afocal systems.

4.3.24.5 lateral_magnification

The lateral_magnification specifies the lateral magnification of an optical system in focal systems.

4.3.24.6 paraxial_ray_tracing

The paraxial_ray_tracing specifies a list of paraxial ray-tracing results such as incident angles and ray heights according to surface sequence.

4.3.24.7 focal_length

The focal_length specifies the focal length of an optical system, expressed in millimetres.

4.3.24.8 entrance_pupil_position

The entrance_pupil_position specifies the paraxial entrance pupil position of an optical system, expressed in millimetres.

4.3.24.9 exit_pupil_position

The exit_pupil_position specifies the paraxial exit pupil position of an optical system, expressed in millimetres.

4.3.24.10 front_principal_point_position

The front_principal_point_position specifies the position of the first principal point of an optical system, expressed in millimetres.

4.3.24.11 back_principal_point_position

The back_principal_point_position specifies the position of the second principal point of an optical system, expressed in millimetres.

4.3.24.12 back_focal_distance

The back_focal_distance specifies the back focal distance of an optical system, expressed in millimetres.

4.3.25 ray_tracing_evaluation

4.3.25.1 General

A ray_tracing_evaluation describes the information relating to a real ray-tracing. The data associated with a ray_tracing_evaluation include the following:

— object_position;

— field_angle;

— object_height;

— wavelength;

— aperture;

— front_pupil_position;

— back_pupil_position;

— evaluating_position;

— ray_tracing;

— aberration.

4.3.25.2 object_position

The object_position specifies the position of the object point, expressed in millimetres.

4.3.25.3 field_angle

The field_angle specifies the incident angle, expressed in degrees, in the object space as an initial value in real ray-tracing that is within the possible range of imaging, projection or observation by eye.

4.3.25.4 object_height

The object_height specifies the height of the object, expressed in millimetres, as an initial value in real ray-tracing that is within the possible range of imaging, projection or observation by eye.

4.3.25.5 wavelength

The wavelength specifies the wavelength value, expressed in nanometres, used in real ray-tracing.

4.3.25.6 aperture

4.3.25.6.1 General

The aperture specifies an aperture type and aperture value as initial values in real ray-tracing. This includes the following data:

— aperture_type;

— aperture_value.

4.3.25.6.2 aperture_type

The aperture_type specifies a type of aperture of an optical system. The aperture type includes f-number, NA, entrance pupil diameter or aperture angle.

4.3.25.6.3 aperture_value

The aperture_value specifies the value of aperture of an optical system in real ray-tracing.

4.3.25.7 front_pupil_position

The front_pupil_position specifies the front pupil position of an optical system, expressed in millimetres, in real ray-tracing.

4.3.25.8 back_pupil_position

The back_pupil_position specifies the back pupil position of an optical system, expressed in millimetres, in real ray-tracing.

4.3.25.9 evaluating_position

The evaluating_position specifies the position for evaluating an optical system, expressed in millimetres, in real ray-tracing.

4.3.25.10 ray_tracing

The ray_tracing describes a list of real ray-tracing data, such as incident angles, in radians, and coordinates of rays, in millimetres, for every surface ranging from the object surface to the image surface according to surface sequence.

4.3.25.11 aberration

4.3.25.11.1 General

The aberration specifies optical aberrations. This includes the following detailed data:

— spherical_aberration;

— coma;

— radial_image_position;

— tangential_image_position;

— distortion;

— wavefront_aberration.

4.3.25.11.2 spherical_aberration

The spherical_aberration specifies the longitudinal spherical aberration, expressed in millimetres, on a real ray traced through an optical system.

4.3.25.11.3 coma

The coma specifies the coma, expressed in millimetres, on a real ray traced through an optical system.

4.3.25.11.4 radial_image_position

The radial_image_position specifies the radial image position, expressed in millimetres, on a real ray traced through an optical system.

4.3.25.11.5 tangential_image_position

The tangential_image_position specifies the tangential image position, expressed in millimetres, on a real ray traced through an optical system.

4.3.25.11.6 distortion

The distortion specifies the distortion, expressed as a percentage, on a real ray traced through an optical system.

4.3.25.11.7 wavefront_aberration

The wavefront_aberration specifies the wavefront aberration, expressed in units of wavelength, on a real ray traced through an optical system.

4.3.26 OTF_evaluation

4.3.26.1 General

An OTF_evaluation describes the data required for the calculation and evaluation of an optical transfer function. The data associated with an OTF_evaluation are the following:

— OTF_computation_method;

— wavelength_weight;

— number_of_defocus;

— defocus_position;

— frequency;

— evaluation_direction;

— aperture;

— object_position;

— field_angle;

— object_height;

— image_height;

— evaluating_position;

— MTF.

4.3.26.2 OTF_computation_method

The OTF_computation_method specifies a method of OTF computation.

EXAMPLE Geometrical optics, FFT, autocorrelation.

4.3.26.3 wavelength_weight

The wavelength_weight specifies a set of wavelength values, expressed in nanometres, and wavelength weight for evaluating polychromatic OTF.

4.3.26.4 number_of_defocus

The number_of_defocus specifies the number of defocusing positions required to evaluate the OTF.

4.3.26.5 defocus_position

The defocus_position specifies a defocus position, expressed in millimetres, required to evaluate the OTF.

4.3.26.6 frequency

The frequency specifies a set of spatial frequencies, expressed per millimetre, required to evaluate the OTF.

4.3.26.7 evaluation_direction

The evaluation_direction specifies a pair of orthogonal directions required to evaluate the OTF.

4.3.26.8 aperture

4.3.26.8.1 General

The aperture specifies the aperture value required to evaluate the OTF. This includes the following data:

— aperture_type;

— aperture_value.

4.3.26.8.2 aperture_type

The aperture_type specifies a type of aperture of an optical system required to evaluate the OTF. An aperture type includes f-number, NA, entrance pupil diameter or aperture angle.

4.3.26.8.3 aperture_value

The aperture_value specifies the value of aperture required to evaluate the OTF.

4.3.26.9 object_position

The object_position specifies the position of an object point, expressed in millimetres, required to evaluate the OTF.

4.3.26.10 field_angle

The field_angle specifies the field angle, expressed in degrees, required to evaluate the OTF.

4.3.26.11 object_height

The object_height specifies the height of the object, expressed in millimetres, as an initial value for evaluating the OTF.

4.3.26.12 image_height

The image_height specifies the image height, expressed in millimetres, required to evaluate the OTF.

4.3.26.13 evaluating_position

The evaluating_position specifies the position, expressed in millimetres, required to evaluate the OTF.

4.3.26.14 MTF

The MTF specifies the computational results for modulation transfer function, expressed as a percentage, in OTF evaluation.

4.3.27 illuminance_distribution_evaluation

4.3.27.1 General

An illuminance_distribution_evaluation describes the data on illuminance distribution. The data associated with an illuminance_distribution_evaluation include illuminance_distribution.

4.3.27.2 illuminance_distribution

The illuminance_distribution describes the results of illuminance distribution evaluation.

4.3.28 spectral_characteristics

4.3.28.1 General

A spectral_characteristics describes the data based on spectral characteristics evaluation. The data associated with a spectral_characteristics include the following:

— wavelength;

— spectral_transmittance.

4.3.28.2 wavelength

The wavelength specifies a set of wavelength values, expressed in nanometres, for evaluating spectral characteristics.

4.3.28.3 spectral_transmittance

The spectral_transmittance describes the data on spectral transmittance.

4.3.29 ghost_image_evaluation

4.3.29.1 General

A ghost_image_evaluation describes the data of ghost image evaluation. The data associated with a ghost_image_evaluation include the following:

— light_source_location;

— light_source_spectra;

— light_source_intensity;

— optical_surface_combination;

— ghost_result.

4.3.29.2 light_source_location

The light_source_location specifies the location of a light source in evaluating ghost images.

4.3.29.3 light_source_spectra

The light_source_spectra specifies the spectral characteristics of a light source in evaluating ghost images.

4.3.29.4 light_source_intensity

The light_source_intensity specifies the intensity of a light source in evaluating ghost images.

4.3.29.5 optical_surface_combination

The optical_surface_combination specifies a pair of optical surfaces which generate ghost images.

4.3.29.6 ghost_result

The ghost_result specifies the results of ghost image evaluation.

4.3.30 optical_sensitivity_evaluation

4.3.30.1 General

An optical_sensitivity_evaluation describes the data on optical sensitivity evaluation. The data associated with an optical_sensitivity_evaluation include the following:

— optical_element_parameter;

— change_value;

— evaluation_item;

— sensitivity_result.

4.3.30.2 optical_element_parameter

The optical_element_parameter specifies the changeable parameters of an optical part in evaluating sensitivity.

4.3.30.3 change_value

The change_value specifies the amount of change of an optical element parameter in evaluating sensitivity.

4.3.30.4 evaluation_item

The evaluation_item specifies an optical evaluation item in evaluating sensitivity.

EXEMPLES Paraxial quantities, MTF, aberrations.

4.3.30.5 sensitivity_result

The sensitivity_result describes the results of sensitivity evaluation.

4.3.31 surface_imperfection_evaluation

4.3.31.1 General

A surface_imperfection_evaluation describes the data on surface imperfections. The data associated with a surface_imperfection_evaluation include surface_imperfections.

4.3.31.2 surface_imperfections

The surface_imperfections describes the results of surface imperfection evaluation.

4.3.32 veiling_glare_index_evaluation

4.3.32.1 General

A veiling_glare_index_evaluation describes the data on a veiling glare index. The data associated with a veiling_glare_index_evaluation include veiling_glare_index.

4.3.32.2 veiling_glare_index

The veiling_glare_index describes the results of veiling glare index evaluation.

4.3.33 other_optical_evaluation

4.3.33.1 General

An other_optical_evaluation describes the data on an optical evaluation other than the above. The data associated with an other_optical_evaluation include the following:

— evaluation_item;

— evaluation_result.

4.3.33.2 evaluation_item

The evaluation_item specifies a type of other optical evaluation.

4.3.33.3 evaluation_result

The evaluation_result describes the results of other optical evaluation.

4.3.34 Analysis

4.3.34.1 General

An analysis describes data on conditions and results related to the analysis. The analysis is a thermal_analysis (see 4.3.35) or a stress_analysis (see 4.3.36). The data associated with an analysis include the following:

— analysis_code;

— analysis_source;

— analysis_addition.

4.3.34.2 analysis_code

The analysis_code specifies an identifier of an analysis. The code is unique within the source organization.

4.3.34.3 analysis_source

The analysis_source specifies the organization responsible for the analysis.

4.3.34.4 analysis_addition

The analysis_addition specifies the external file reference, the relevant file of which can contain documents and drawings on the analysis.

4.3.35 thermal_analysis

4.3.35.1 General

A thermal_analysis describes the data on thermal analysis. The data associated with a thermal_analysis include the following:

— deformation_quantity;

— temperature_distribution;

— stress_distribution;

— strain.

4.3.35.2 deformation_quantity

The deformation_quantity specifies the displacement before and after a change in an optical part deformed by heat. It can be illustrated as a distribution diagram of displacement.

4.3.35.3 temperature_distribution

The temperature_distribution specifies the temperature distribution caused by heat at each node. It can be illustrated as a contour map or a shaded contour map.

4.3.35.4 stress_distribution

The stress_distribution specifies the stress distribution, expressed in megapascals, caused by heat at each node. It can be illustrated as a contour map or a shaded contour map.

4.3.35.5 strain

The strain specifies strain values caused by heat at each node. It can be illustrated as a contour map or a shaded contour map.

4.3.36 stress_analysis

4.3.36.1 General

A stress_analysis describes the data on stress analysis. The data associated with a stress_analysis include the following:

— deformation_quantity;

— change_value_of_material_constant;

— stress_distribution;

— strain.

4.3.36.2 deformation_quantity

The deformation_quantity specifies the displacement before and after change in an optical part deformed by stress. It can be illustrated as a distribution diagram of the displacement.

4.3.36.3 change_value_of_material_constant

The change_value_of_material_constant specifies the difference between material constants before and after the change by stress.

EXAMPLE When a part is loaded heavily, the yield begins from high-stress points in the part, and Young's modulus changes. The change value of the material constant, then, specifies the difference of Young's modulus before and after the change.

4.3.36.4 stress_distribution

The stress_distribution specifies the stress distribution, expressed in megapascals, caused by stress at each node. It can be illustrated as a contour map or a shaded contour map.

4.3.36.5 strain

The strain specifies strain values caused by stress at each node. It can be illustrated as a contour map or a shaded contour map.

4.3.37 boundary_condition

4.3.37.1 General

A boundary_condition describes the conditions of restraints and loads on nodal points of boundaries. The data associated with a boundary_condition include the following:

— load;

— restraint.

4.3.37.2 load

The load specifies the force, expressed in newtons, with which an optical part is loaded.

4.3.37.3 restraint

The restraint has two types: one is a geometric restraint (such as fix, horizontal, perpendicular, rectangular, parallel, concentric, midpoint, tangent, coincidence and connect) and the other is a measurement restraint (such as distance, angle, and radius). The restraint specifies one or both of them.

4.3.38 material_property

4.3.38.1 General

The material_property specifies the material constants used in analysis. Young's modulus, Poisson's ratio of a material at operating temperature and specific gravity, if necessary, are described in stress analysis. A linear expansion coefficient, thermal conductivity and specific heat, if necessary, are described in thermal analysis. The data associated with a material_property include the following:

— Young's_modulus;

— Poisson's_ratio;

— specific_gravity;

— linear_expansion_coefficient;

— thermal_conductivity;

— specific_heat.

4.3.38.2 Young's_modulus

The Young's_modulus specifies the Young's modulus of a material used in analysis, expressed in gigapascals.

4.3.38.3 Poisson's_ratio

The Poisson's_ratio specifies the Poisson's ratio of a material used in analysis.

4.3.38.4 specific_gravity

The specific_gravity specifies the specific gravity of a material used in analysis.

4.3.38.5 linear_expansion_coefficient

The linear_expansion_coefficient specifies the coefficient of linear expansion of a material used in thermal stress analysis, expressed in per kelvin.

4.3.38.6 thermal_conductivity

The thermal_conductivity specifies the thermal conductivity of a material used in thermal conduction analysis, expressed in watts per metre-kelvin.

4.3.38.7 specific_heat

The specific_heat specifies the specific heat of a material used in irregular thermal conduction analysis, expressed in joules per kilogram-kelvin.

4.3.39 analysis_assessment

An analysis_assessment specifies whether or not the result of the assessment meets analysis aims.

4.3.40 computer_processing_log

4.3.40.1 General

A computer_processing_log describes an analysis solver name, an analysis solver version, the processing time, error messages and storage information. The data associated with a computer_processing_log include the following:

— application_software_name;

— application_software_version;

— processing_time;

— error_message;

— report_number;

— storage_information.

4.3.40.2 application_software_name

The application_software_name specifies the name of software used in an analysis.

4.3.40.3 application_software_version

The application_software_version specifies an identifier for the software used in an analysis.

4.3.40.4 processing_time

The processing_time specifies the computer processing time in an analysis.

4.3.40.5 error_message

The error_message specifies the contents of error messages displayed during or after analysis.

4.3.40.6 report_number

The report_number identifies the document in which analysis contents are described.

4.3.40.7 storage_information

The storage_information specifies storage location, storage volume and storage term on input and output for analysis.

Annex A
(normative)

NODIF ARM diagrams using the EXPRESS-G graphical notation

NOTE The EXPRESS type definition of optical_part_view_designator is not a part of NODIF, but is a sample.

Figure A.1 — NODIF ARM diagram 1 of 25 in EXPRESS-G: optical_part_view_designator

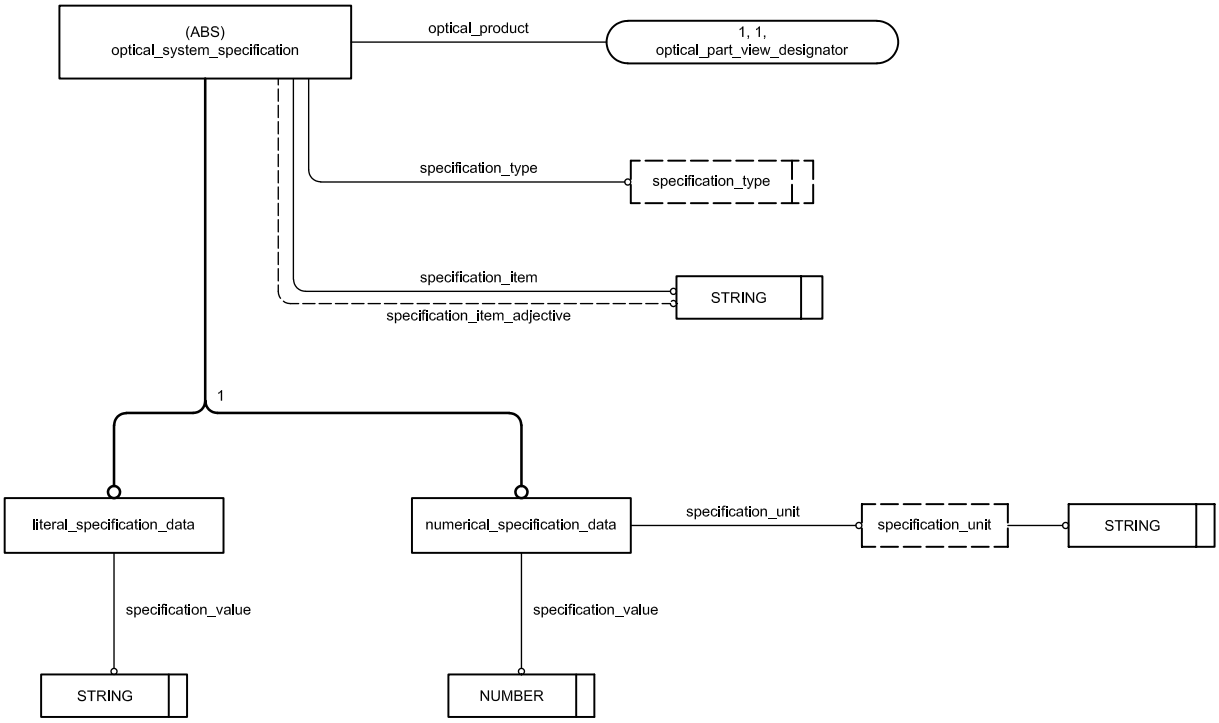


Figure A.2 — NODIF ARM diagram 2 of 25 in EXPRESS-G: optical_system_specification

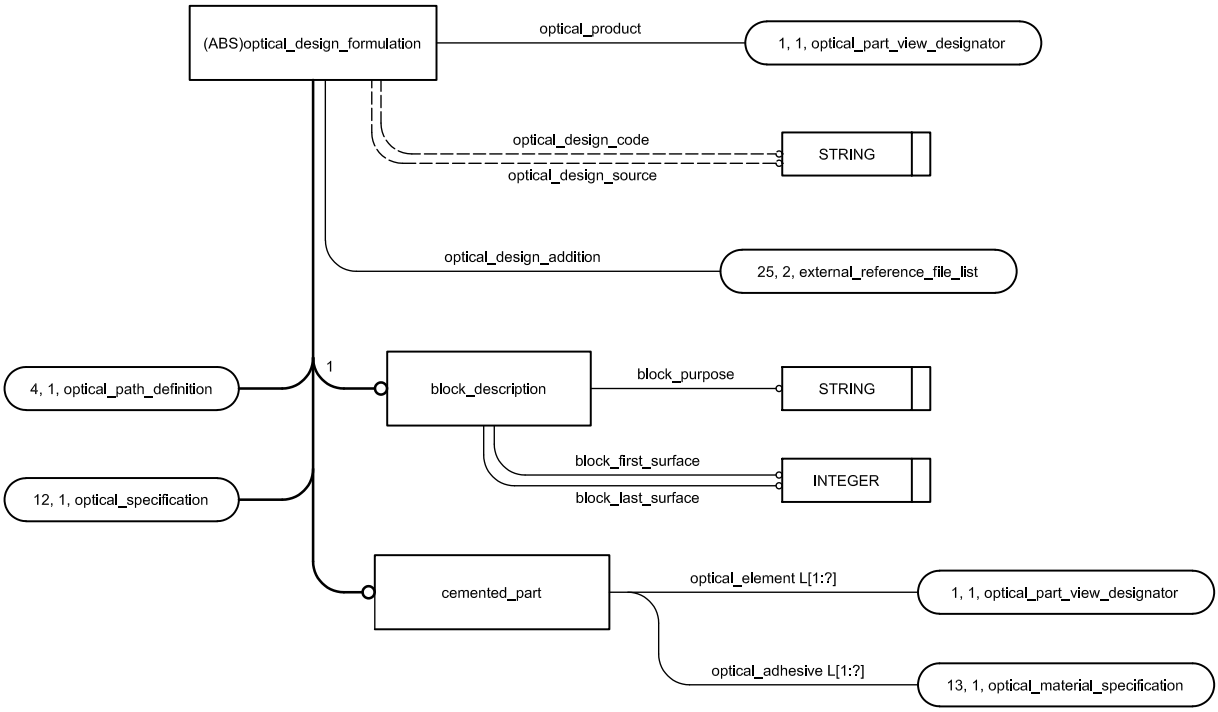


Figure A.3 — NODIF ARM diagram 3 of 25 in EXPRESS-G: optical_design_formulation

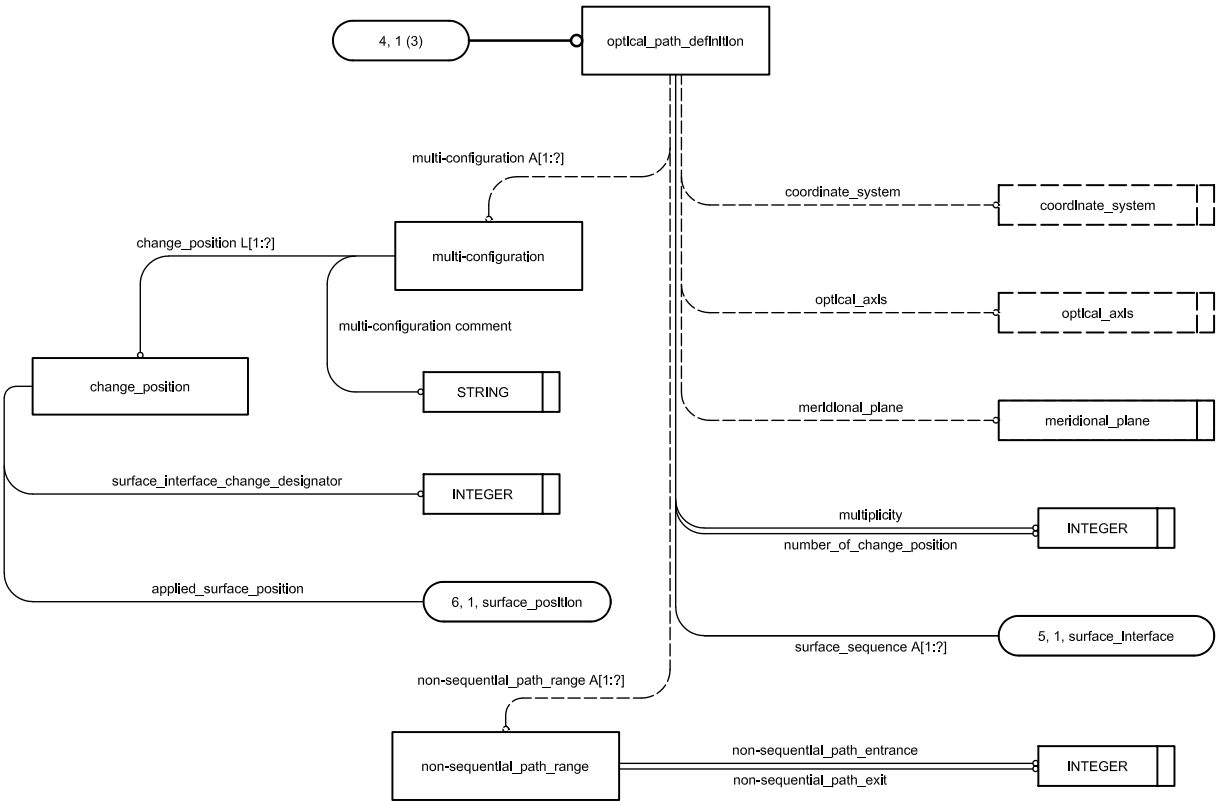


Figure A.4 — NODIF ARM diagram 4 of 25 in EXPRESS-G: optical_path_definition

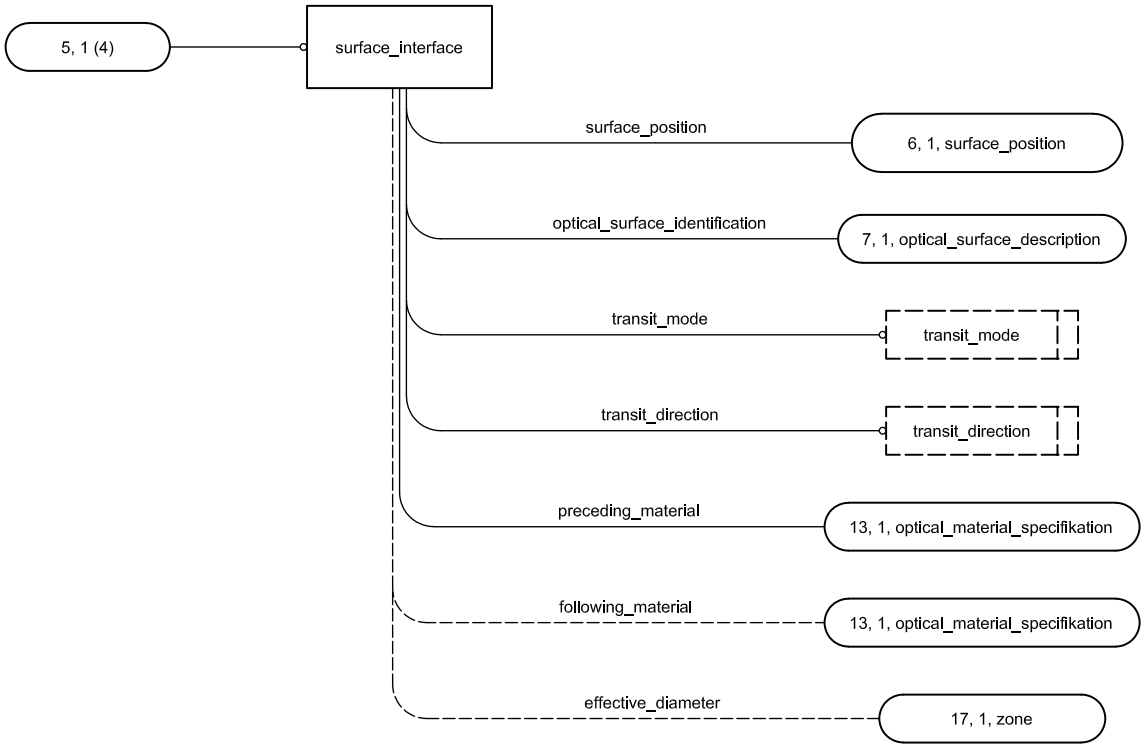


Figure A.5 — NODIF ARM diagram 5 of 25 in EXPRESS-G: surface_interface

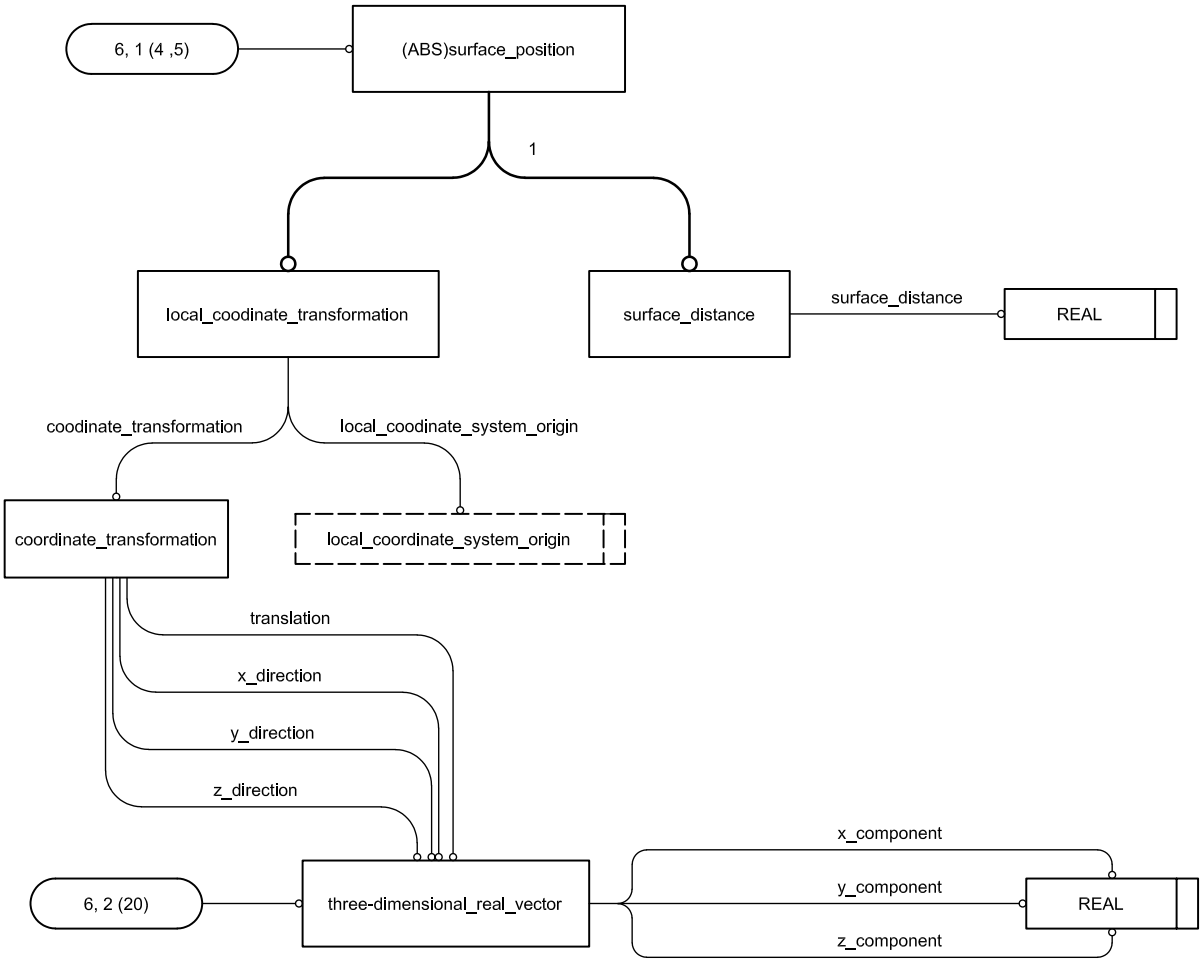


Figure A.6 — NODIF ARM diagram 6 of 25 in EXPRESS-G: surface_position

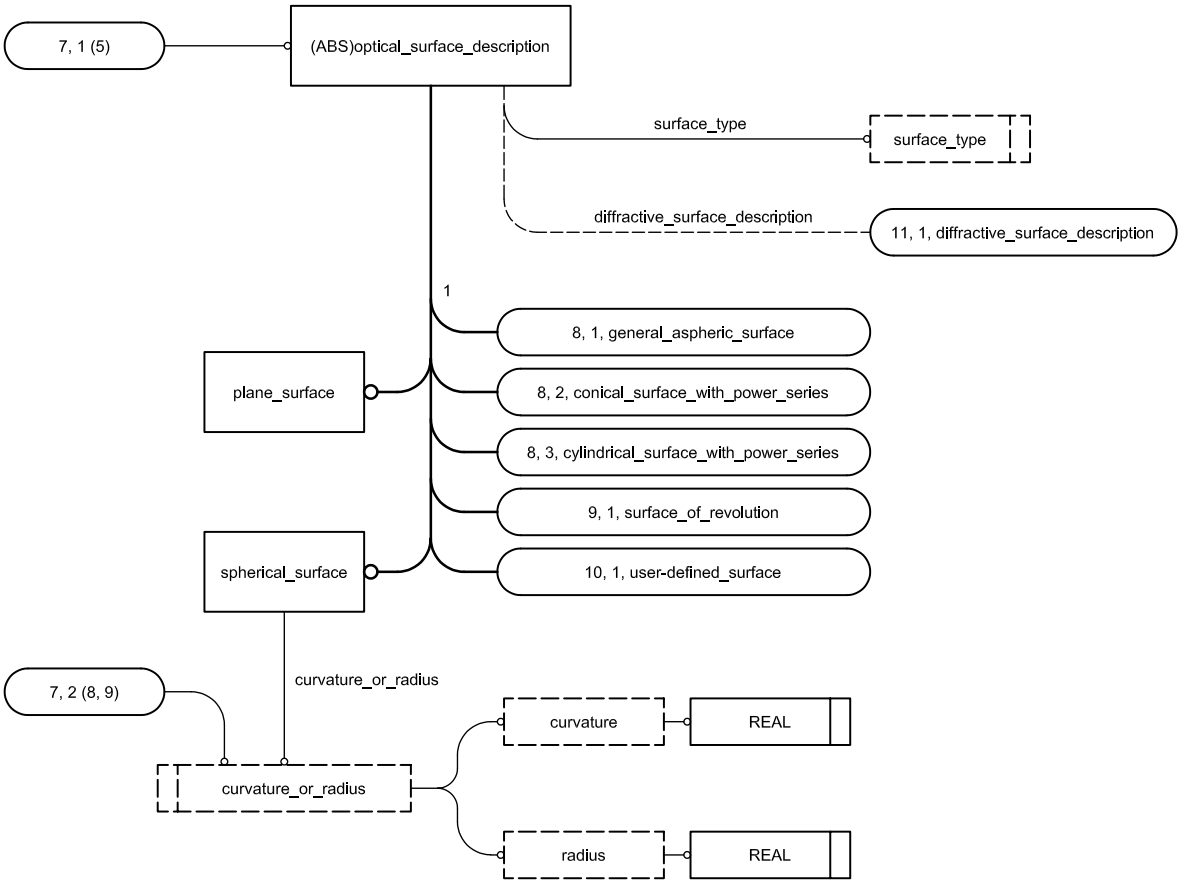


Figure A.7 — NODIF ARM diagram 7 of 25 in EXPRESS-G: optical_surface_description

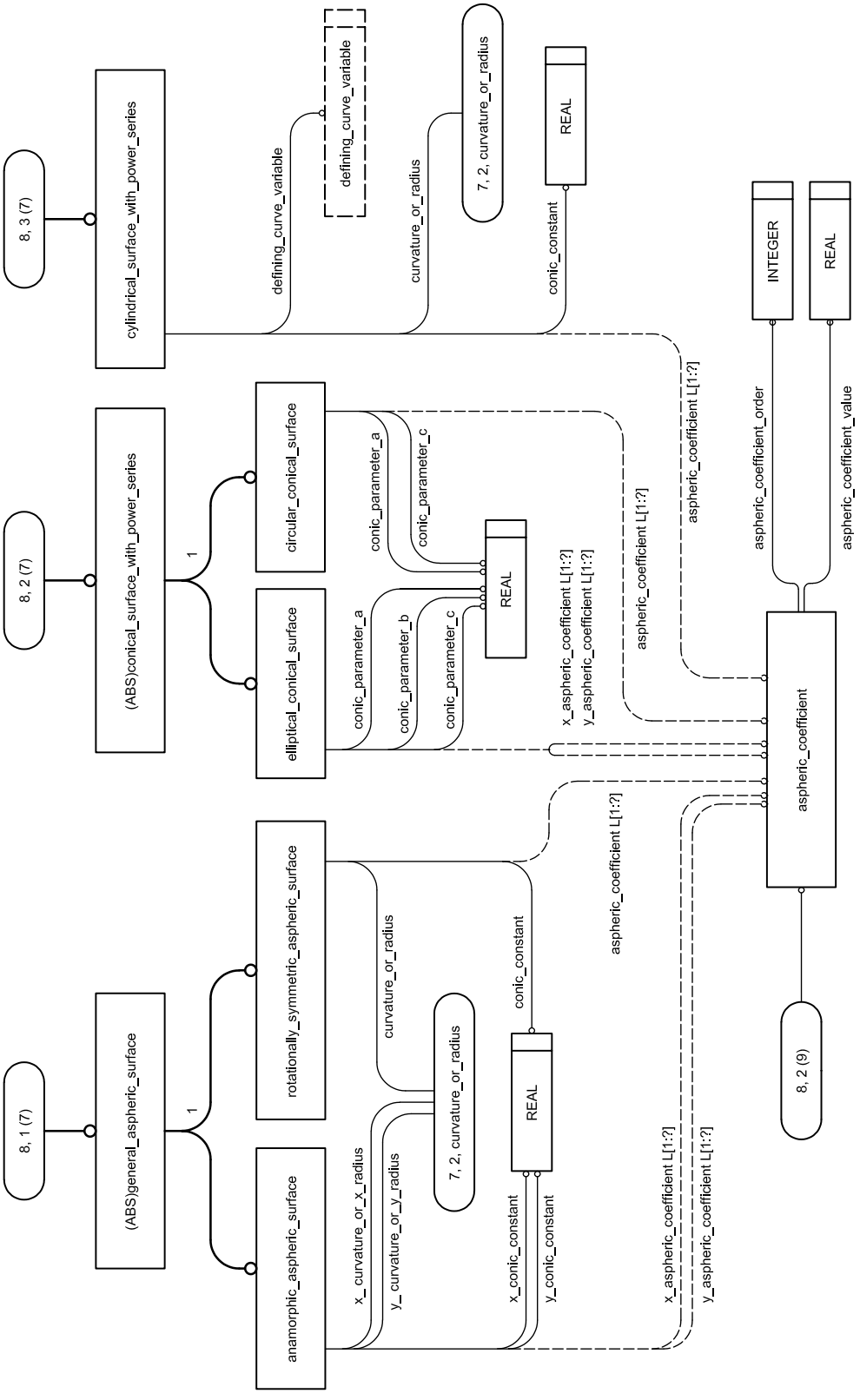


Figure A.8 — NODIF ARM diagram 8 of 25 in EXPRESS-G: aspheric_surfaces

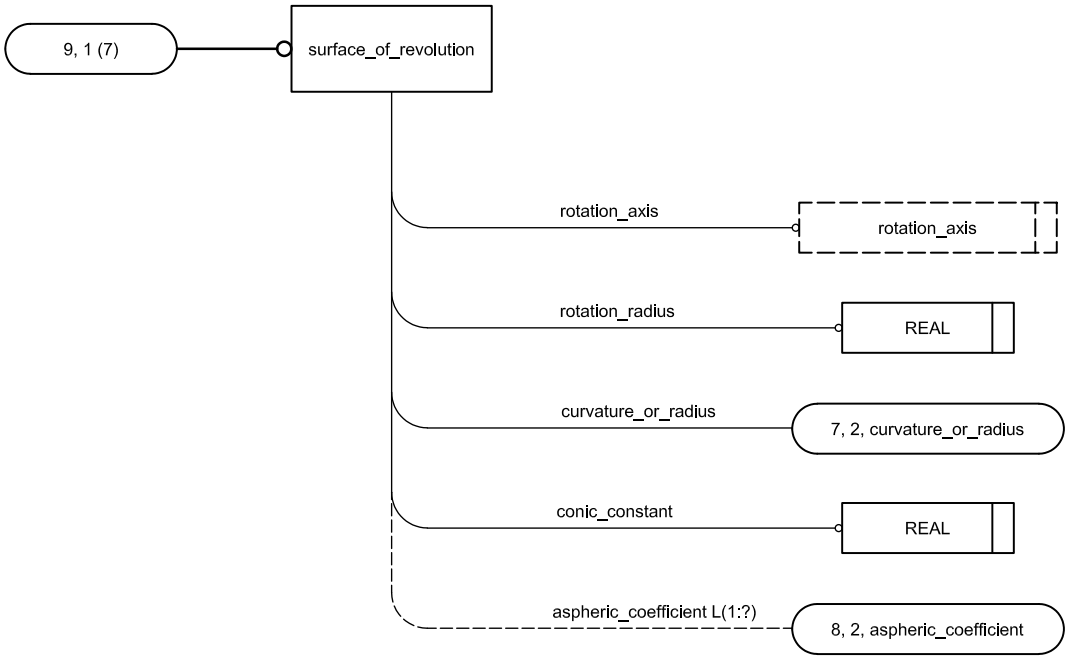


Figure A.9 — NODIF ARM diagram 9 of 25 in EXPRESS-G: surface_of_revolution

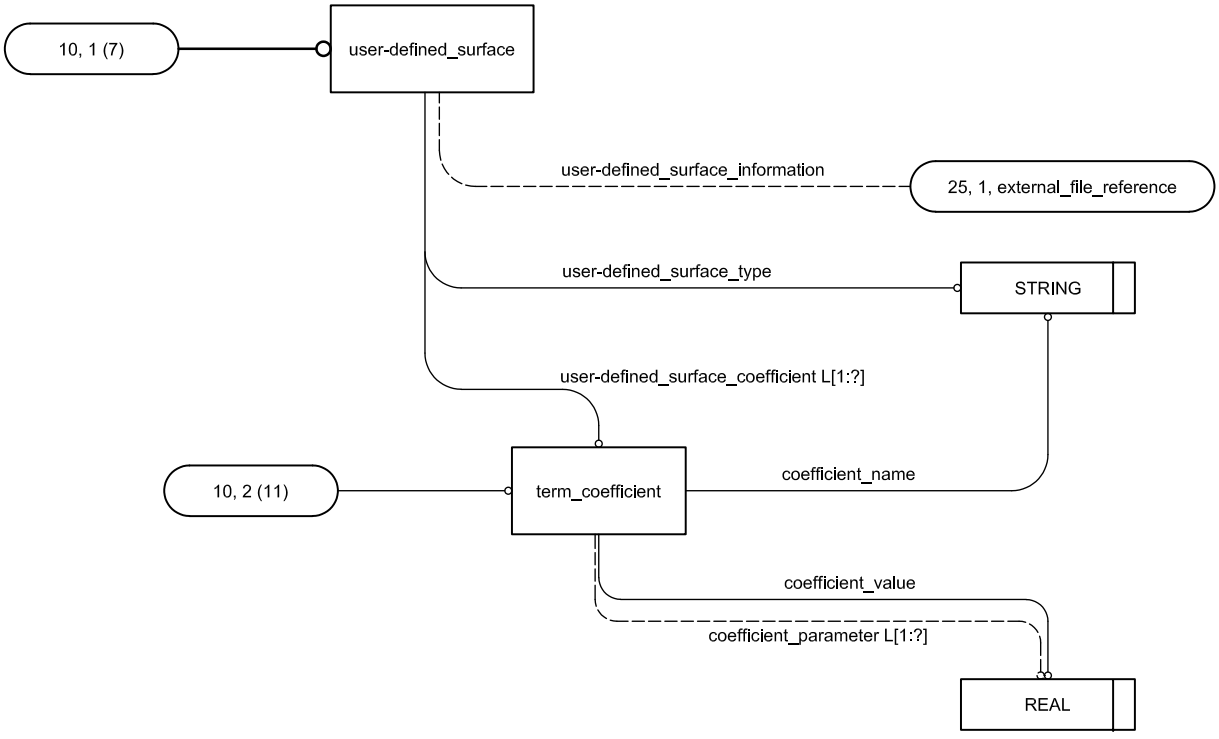


Figure A.10 — NODIF ARM diagram 10 of 25 in EXPRESS-G: user-defined_surface

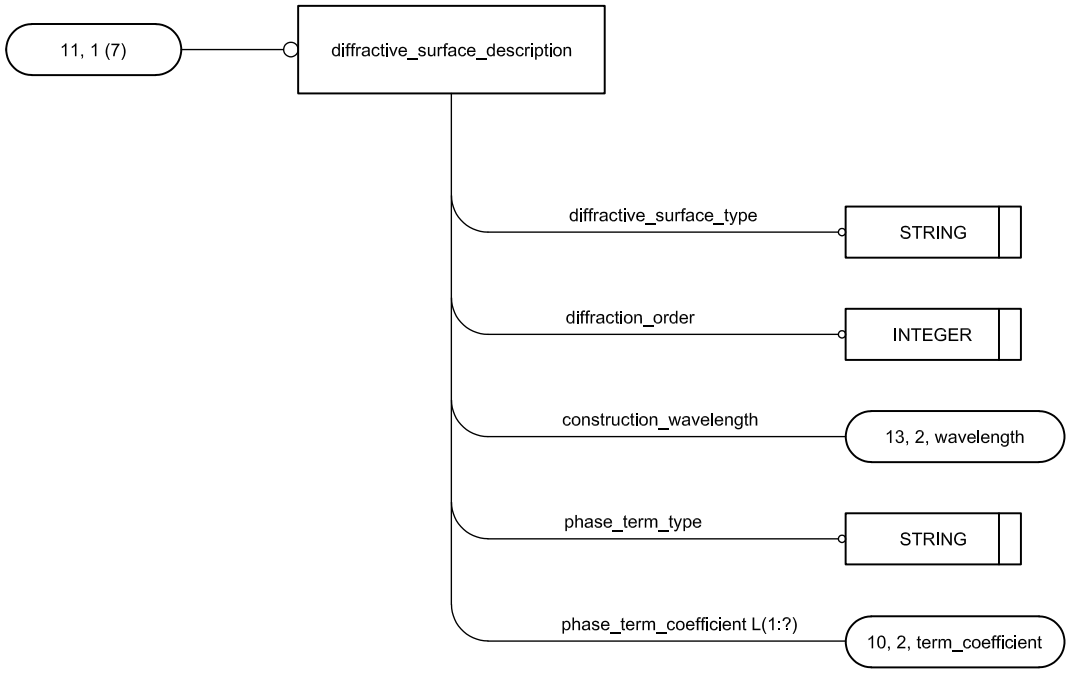


Figure A.11 — NODIF ARM diagram 11 of 25 in EXPRESS-G: diffractive_surface_description

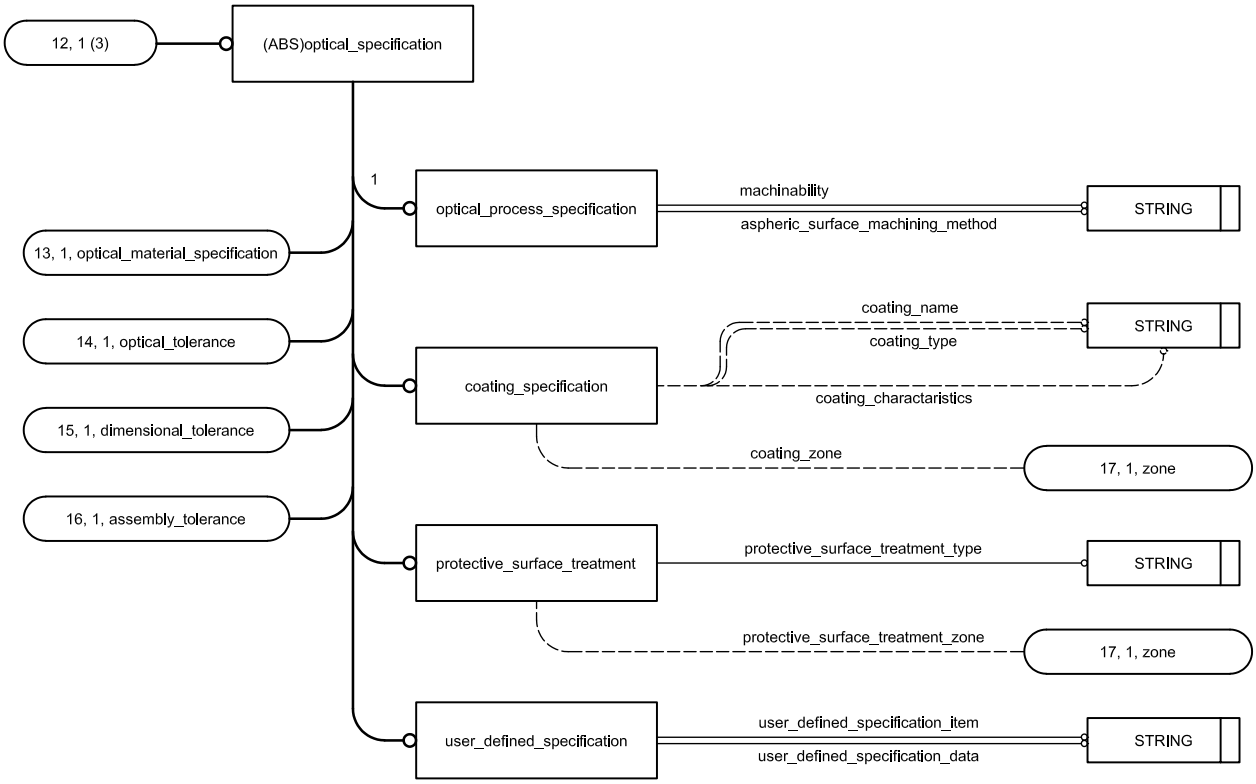


Figure A.12 — NODIF ARM diagram 12 of 25 in EXPRESS-G: optical_specification

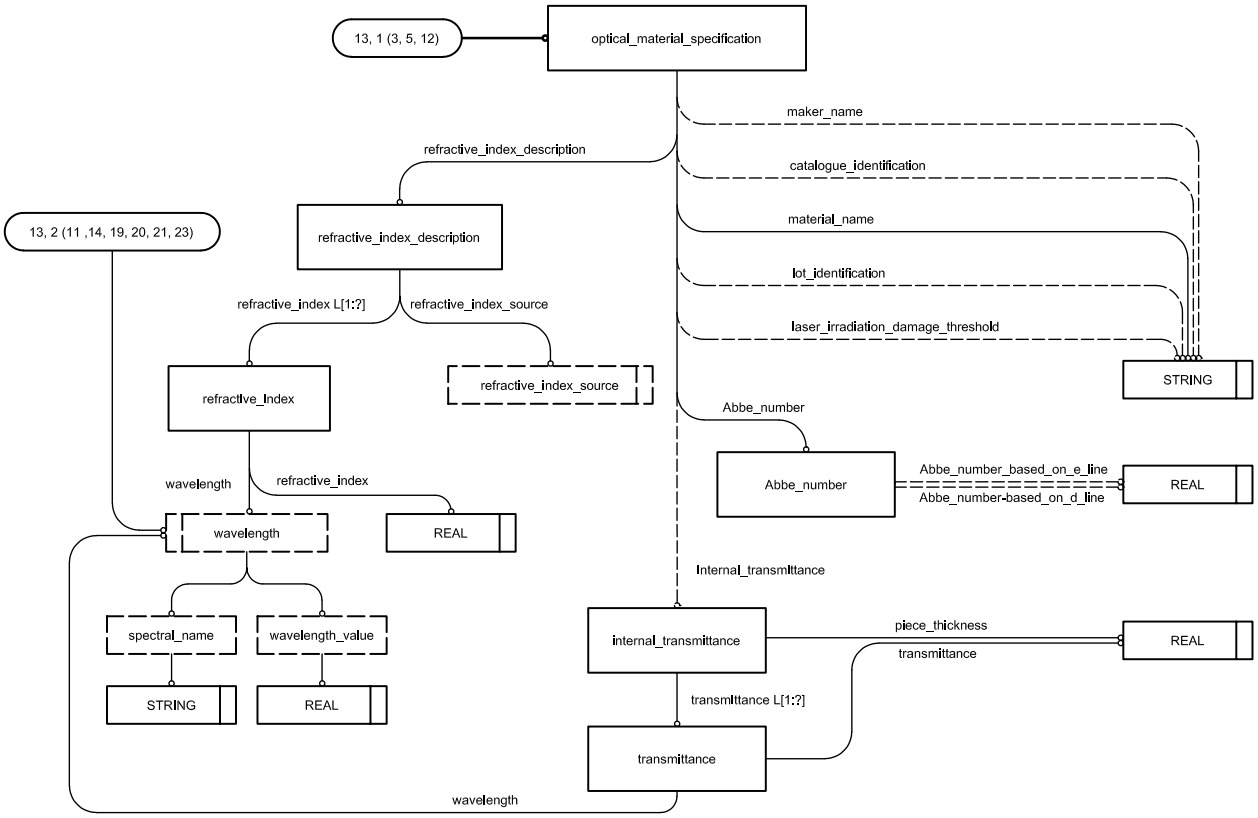


Figure A.13 — NODIF ARM diagram 13 of 25 in EXPRESS-G: optical_material_specification

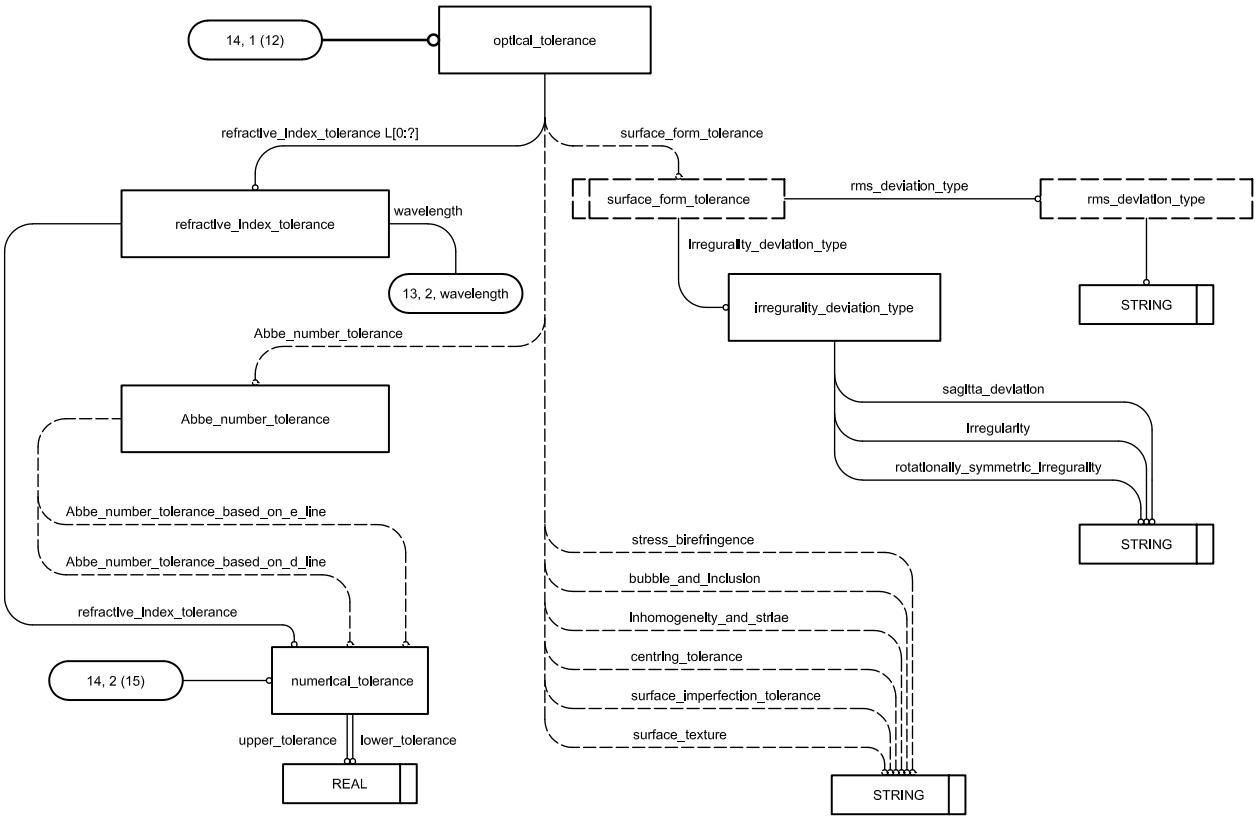


Figure A.14 — NODIF ARM diagram 14 of 25 in EXPRESS-G: optical_tolerance

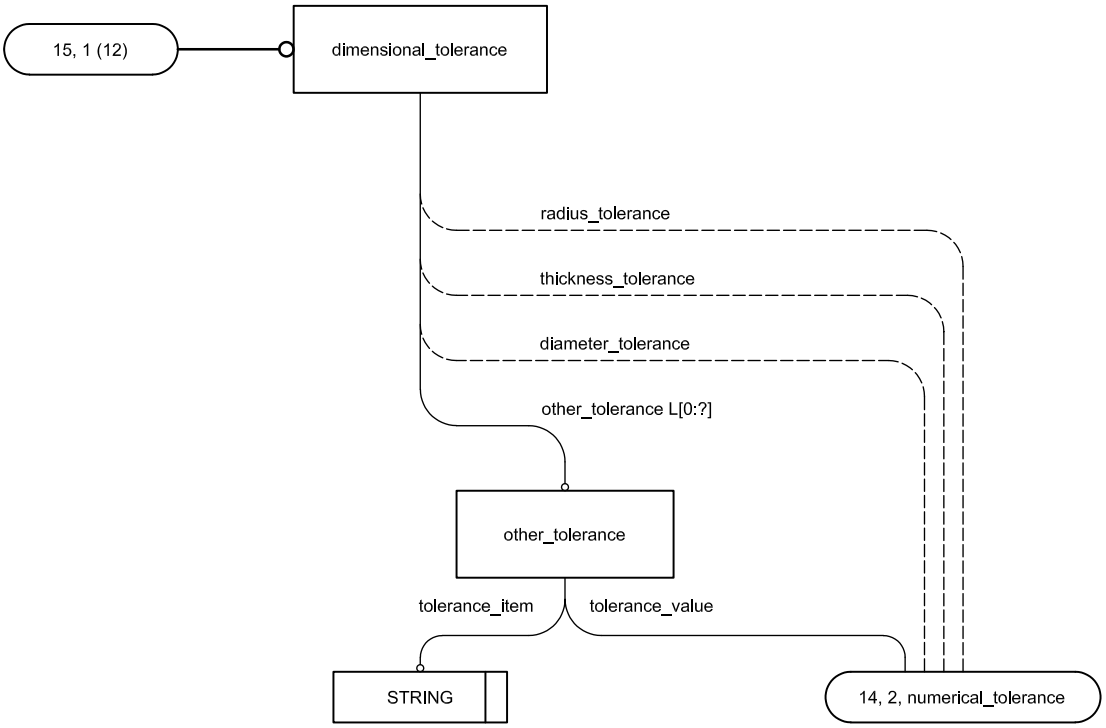


Figure A.15 — NODIF ARM diagram 15 of 25 in EXPRESS-G: dimensional_tolerance

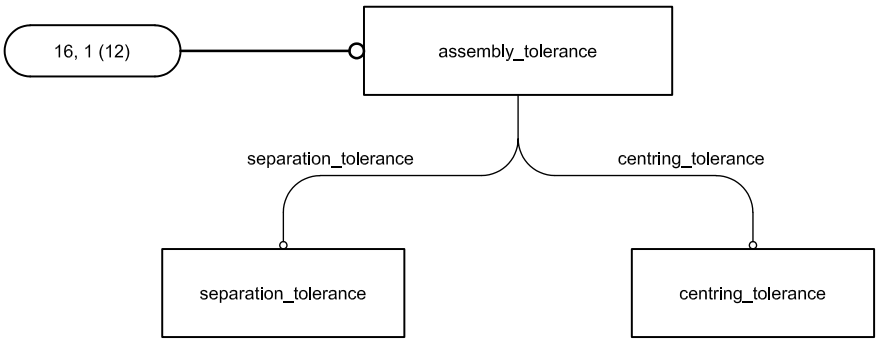


Figure A.16 — NODIF ARM diagram 16 of 25 in EXPRESS-G: assembly_tolerance

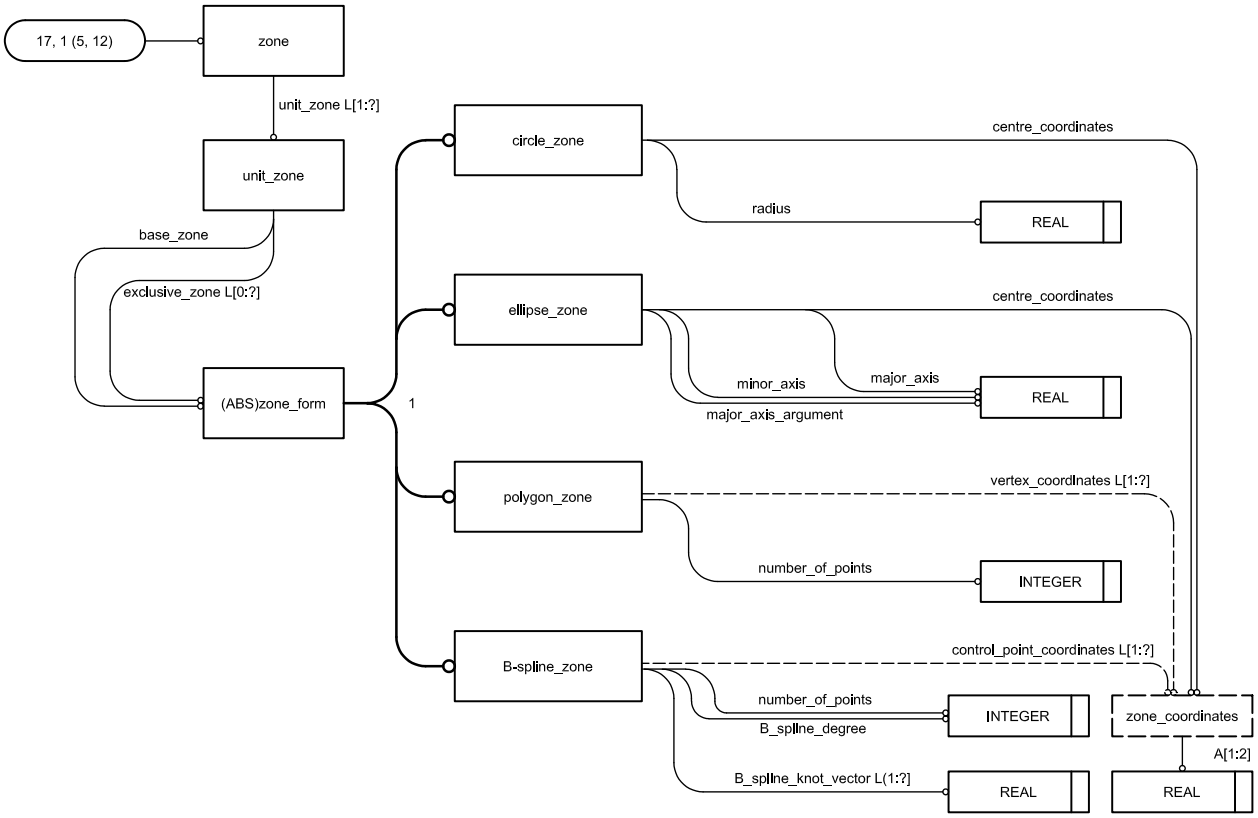


Figure A.17 — NODIF ARM diagram 17 of 25 in EXPRESS-G: zone

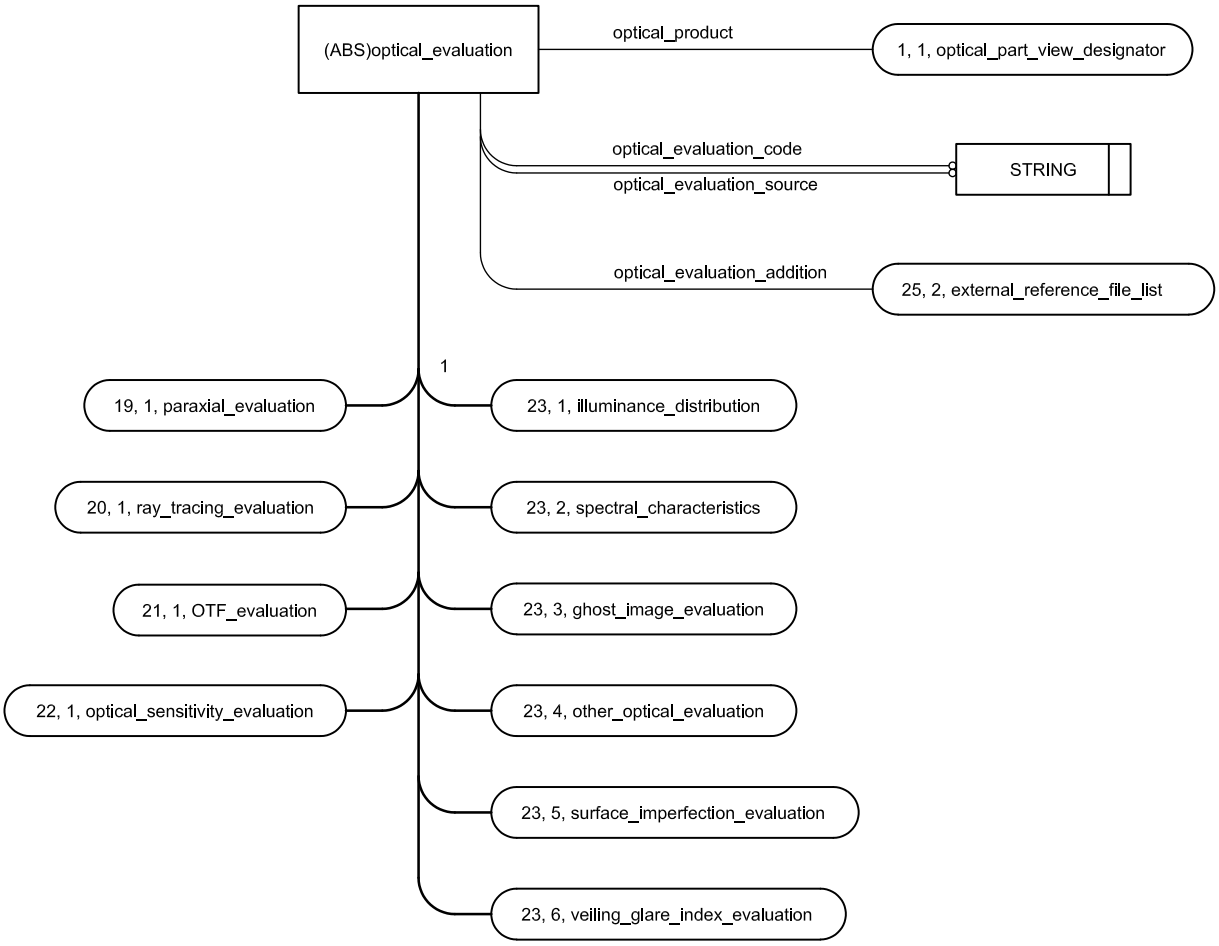


Figure A.18 — NODIF ARM diagram 18 of 25 in EXPRESS-G: optical_evaluation

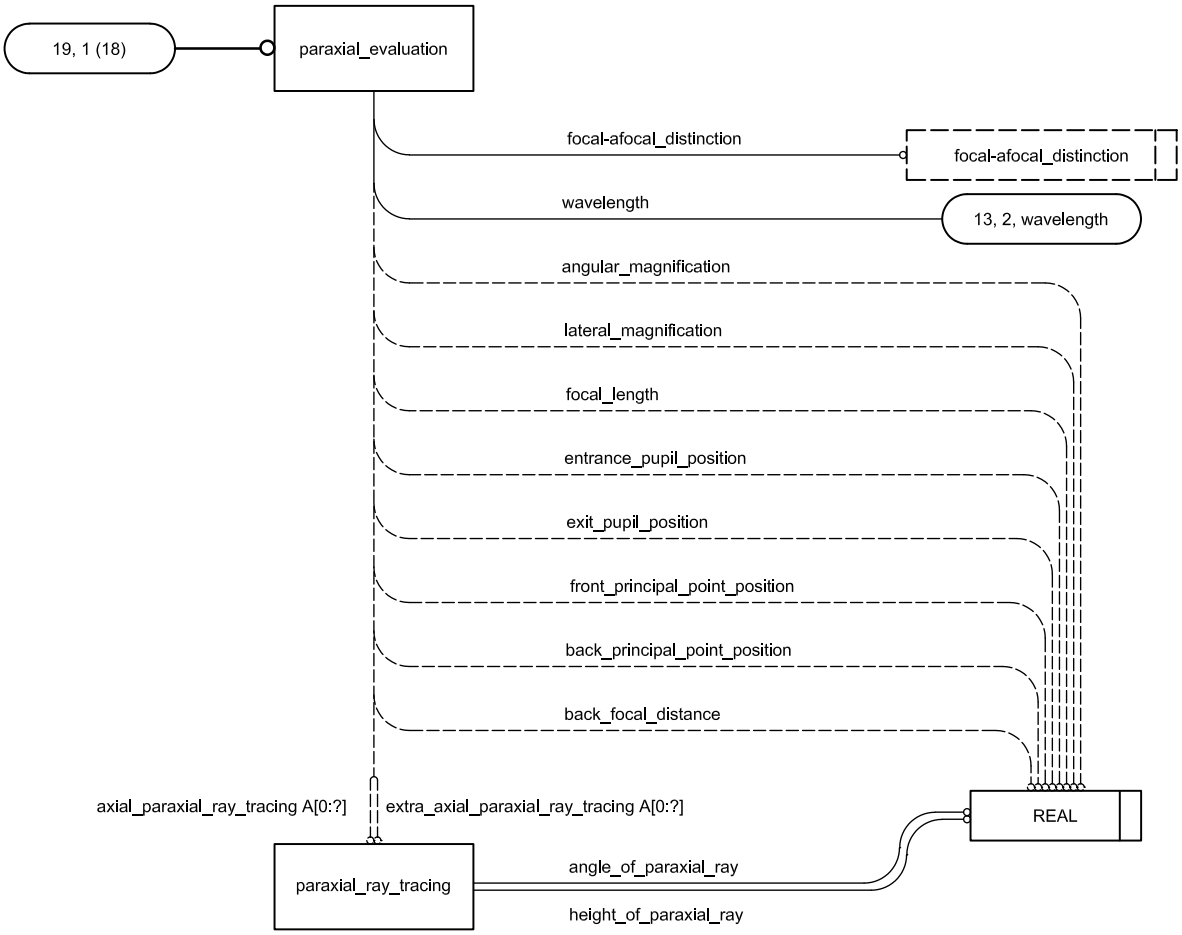


Figure A.19 — NODIF ARM diagram 19 of 25 in EXPRESS-G: paraxial_evaluation

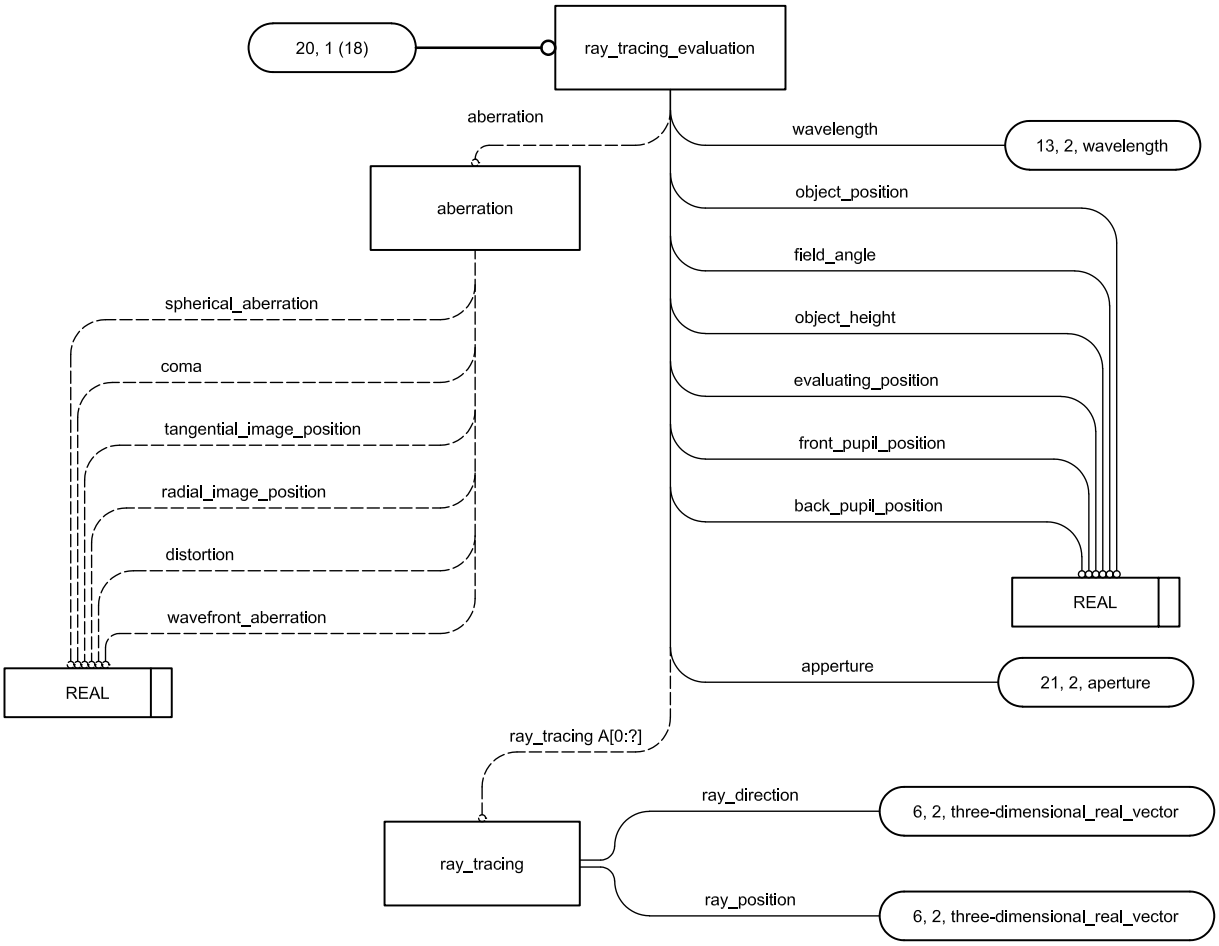


Figure A.20 — NODIF ARM diagram 20 of 25 in EXPRESS-G: ray_tracing_evaluation

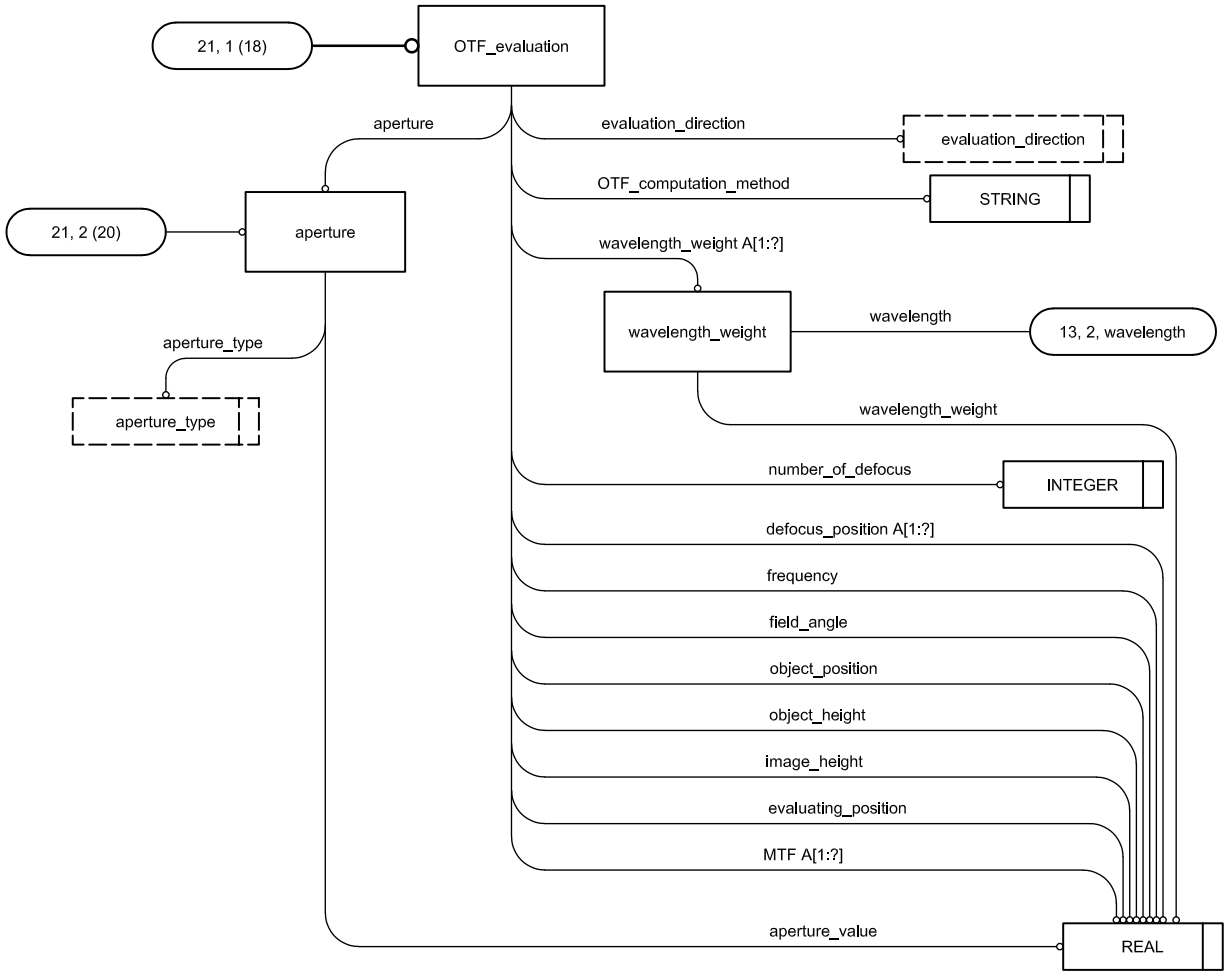


Figure A.21 — NODIF ARM diagram 21 of 25 in EXPRESS-G: OTF_evaluation

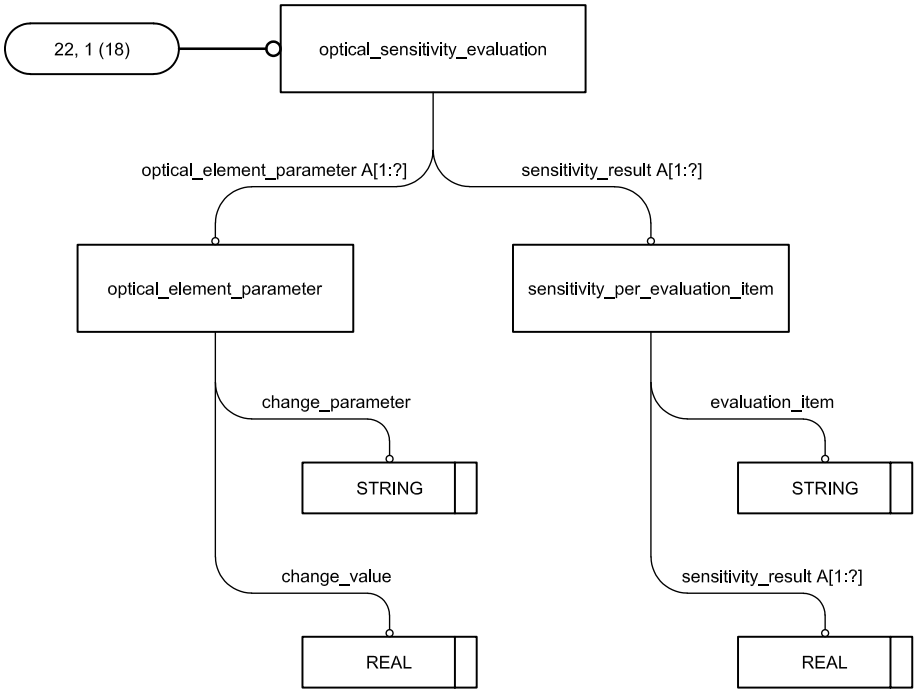


Figure A.22 — NODIF ARM diagram 22 of 25 in EXPRESS-G: optical_sensitivity_evaluation

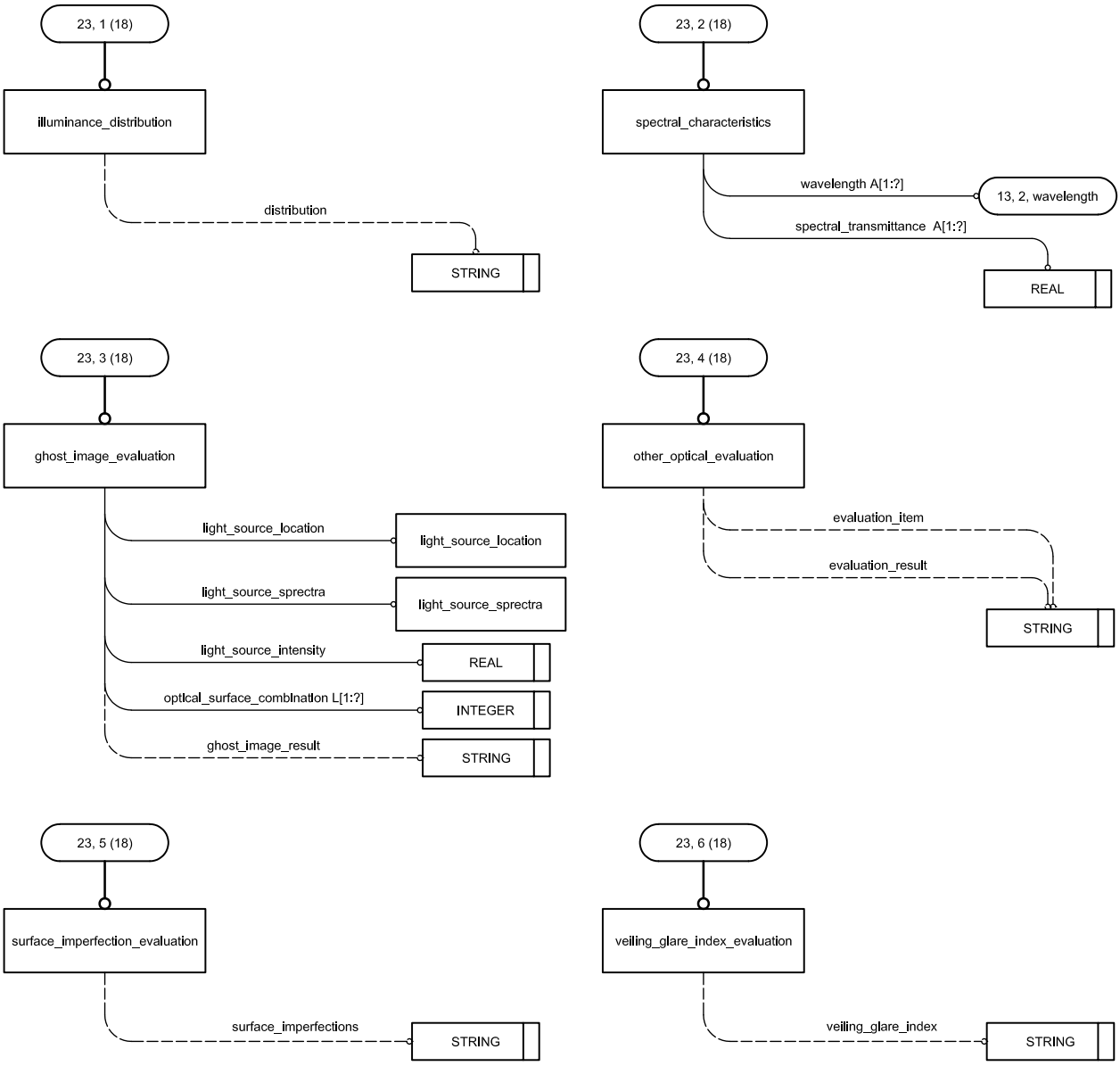


Figure A.23 — NODIF ARM diagram 23 of 25 in EXPRESS-G: other_optical_evaluations

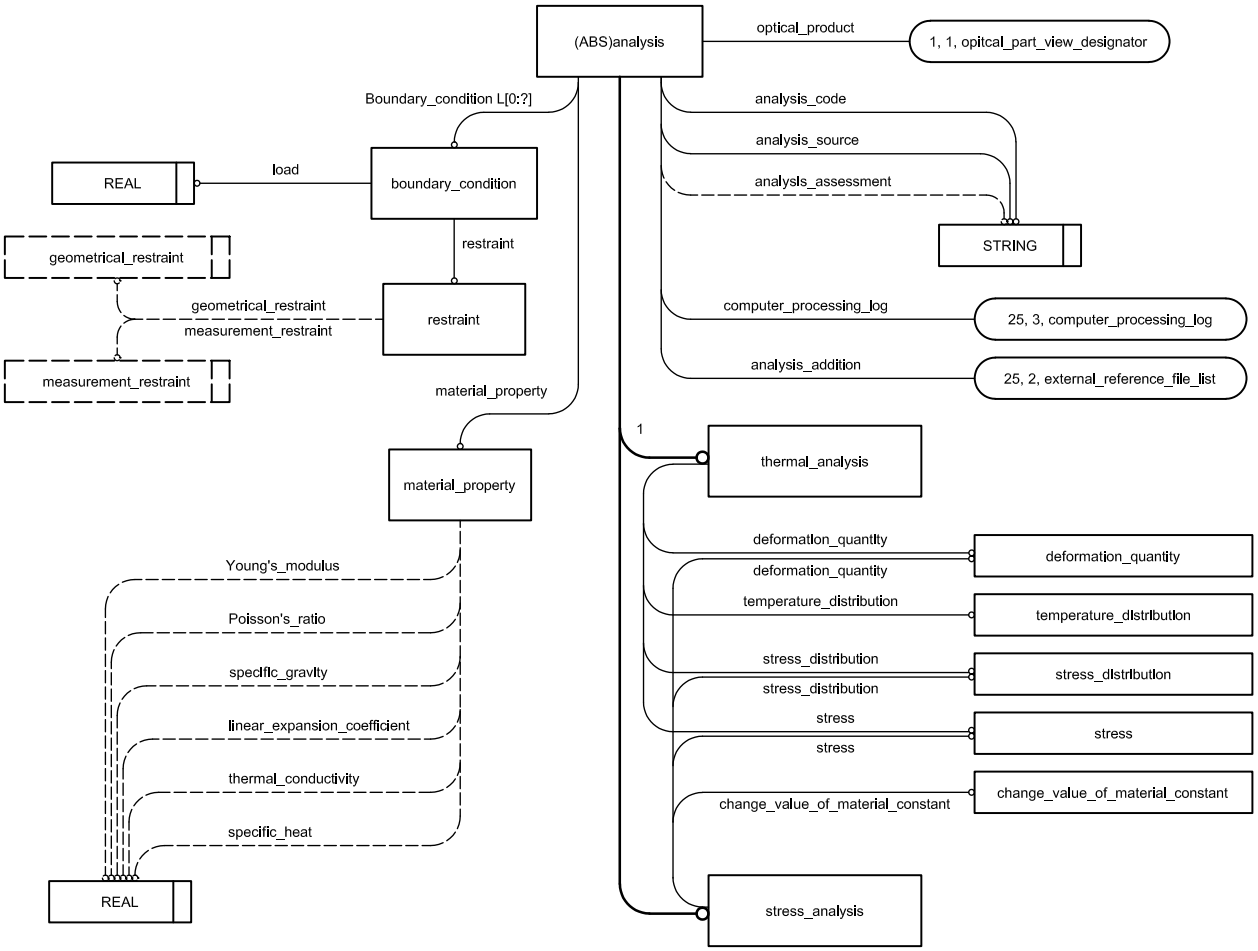


Figure A.24 — NODIF ARM diagram 24 of 25 in EXPRESS-G: analysis

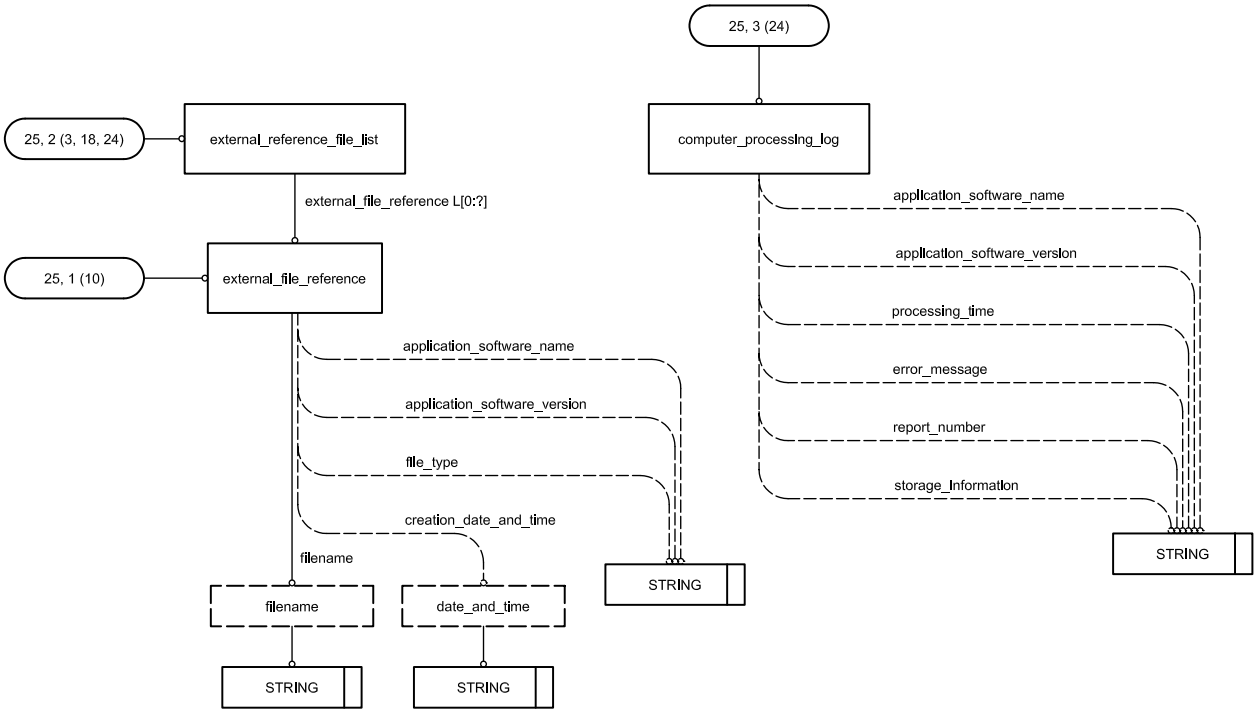
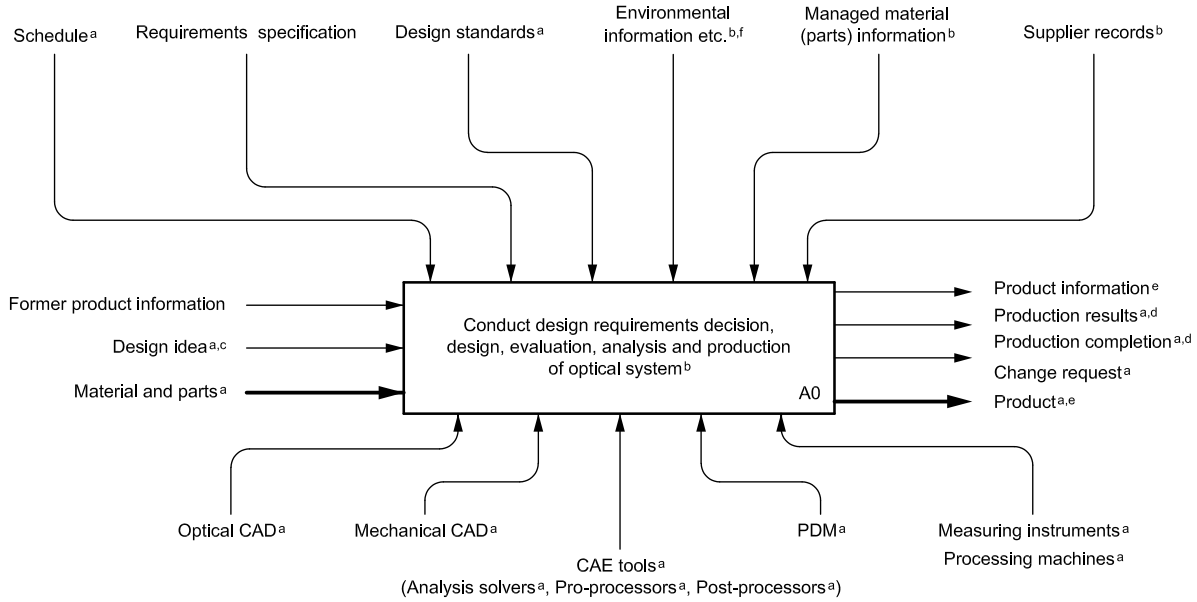


Figure A.25 — NODIF ARM diagram 25 of 25 in EXPRESS-G: miscellaneous_types_and_entities

Annex B
(informative)

NODIF application activity model (AAM)



a Out of scope.

b Partly out of scope.

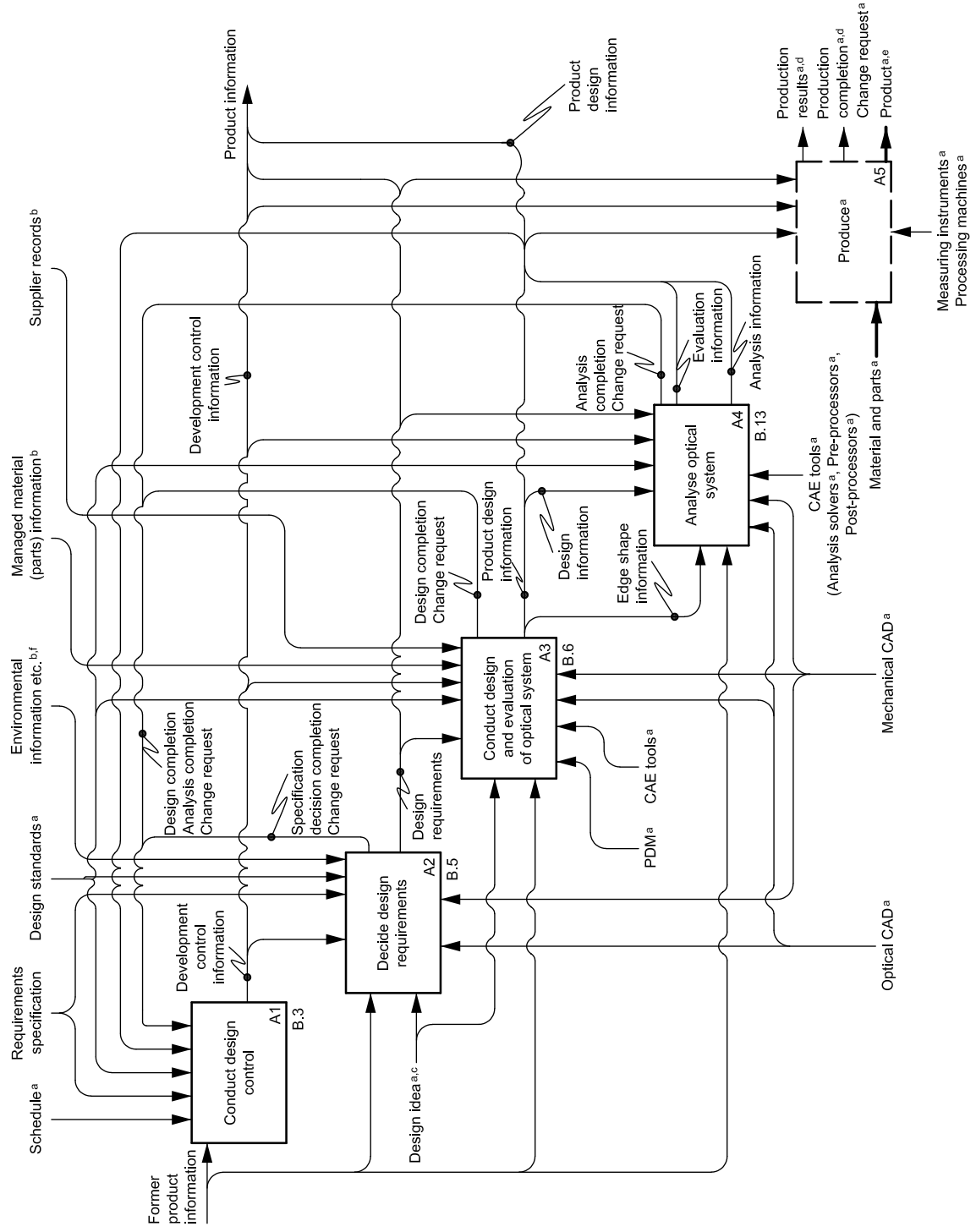
c For design idea, refer to ISO 10303-203.

d Production includes trial production.

e Product includes trial product.

f Environmental information, etc. includes environment information (partly out of scope), information on recycling (out of scope), regulations (out of scope) and patent information (out of scope).

Figure B.1 — NODIF AAM 1 of 16 — NODIF AAM (node A-0)



a Out of scope.

b Partly out of scope.

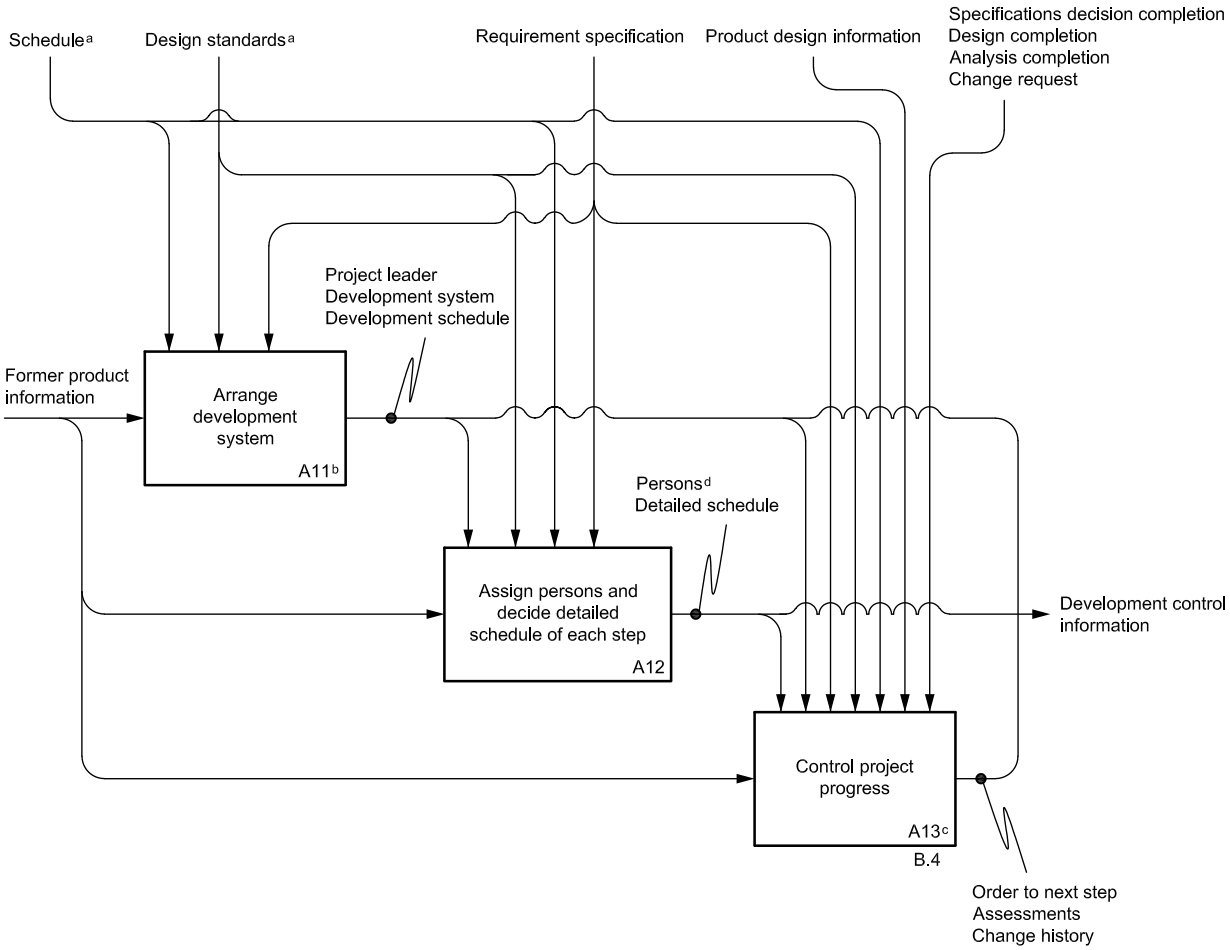
c For design idea, refer to ISO 10303-203.

d Production includes trial production.

e Product includes trial product.

f Environmental information, etc. includes environment information (partly out of scope), information on recycling (out of scope), regulations (out of scope) and patent information (out of scope).

Figure B.2 — NODIF AAM 2 of 16 — Conduct design requirements decision, design, evaluation, analysis and production of optical system (node A0)



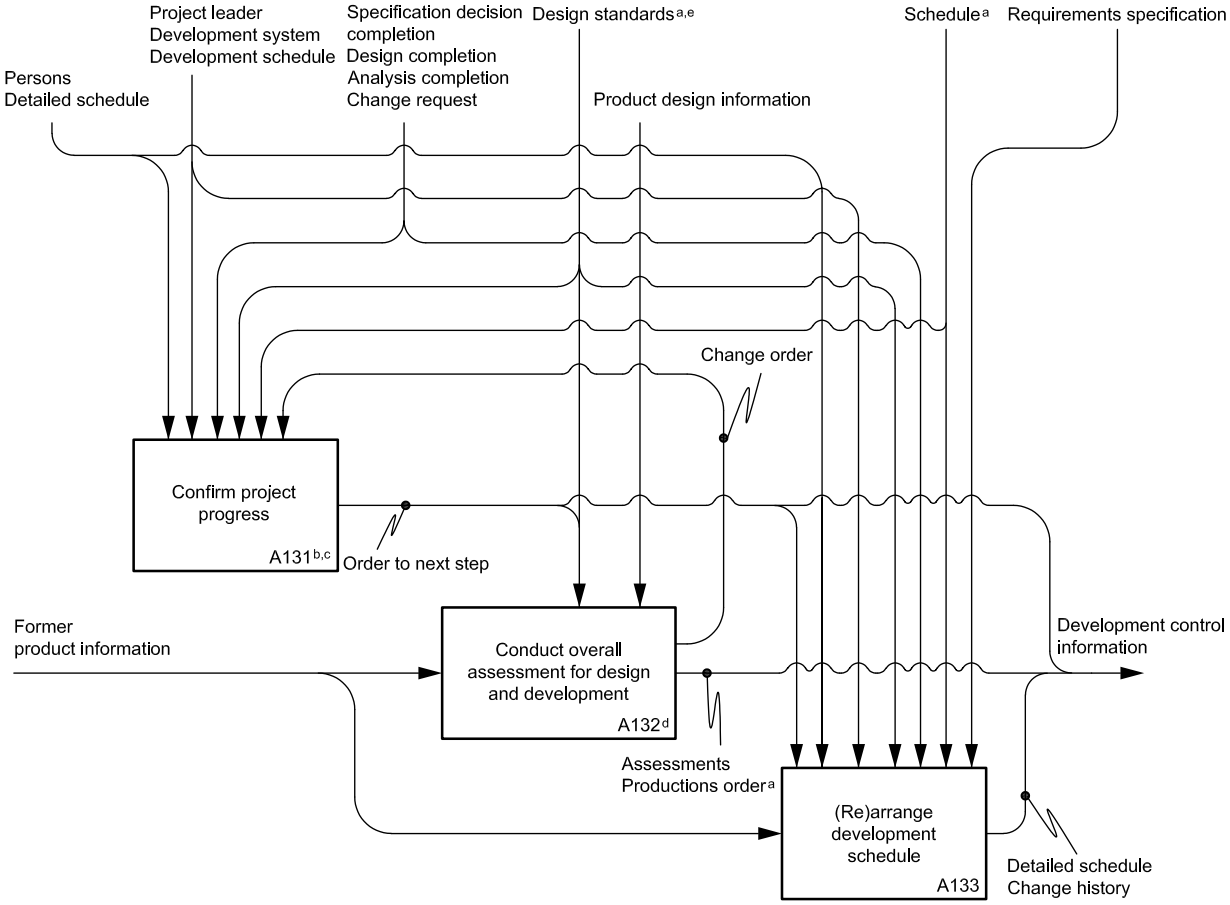
a Out of scope.

b A11 is conducted first and only once.

c A13 is conducted at a completion or a change request.

d Persons are arranged according to difficulty of requirements specification.

Figure B.3 — NODIF AAM 3 of 16 — Conduct design control (node A1)



a Out of scope.

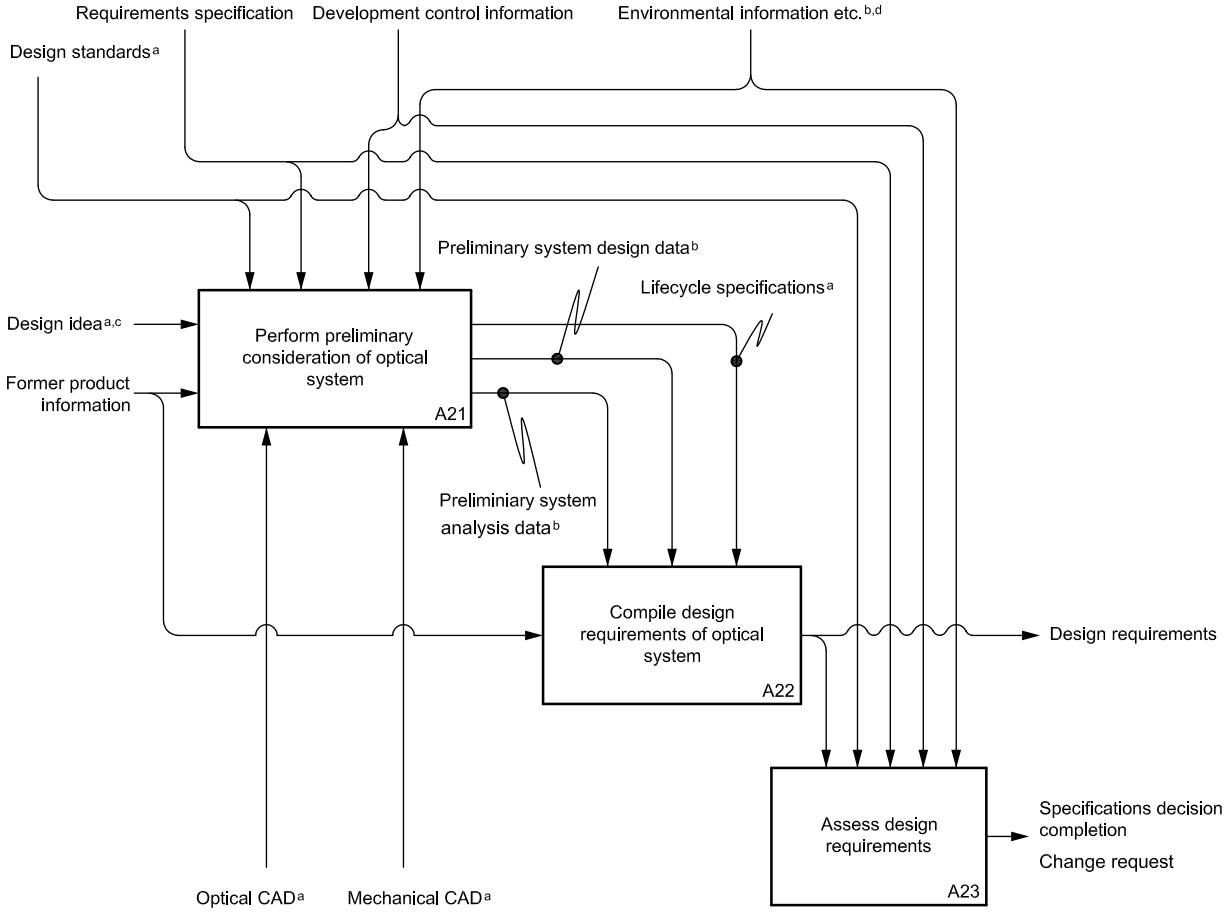
b A131 is conducted according to a change request.

c A131 controls to return to any process at a change request.

d A132 is conducted after completion of design and evaluation.

e Design standards include criteria.

Figure B.4 — NODIF AAM 4 of 16 — Control project progress (node A13)



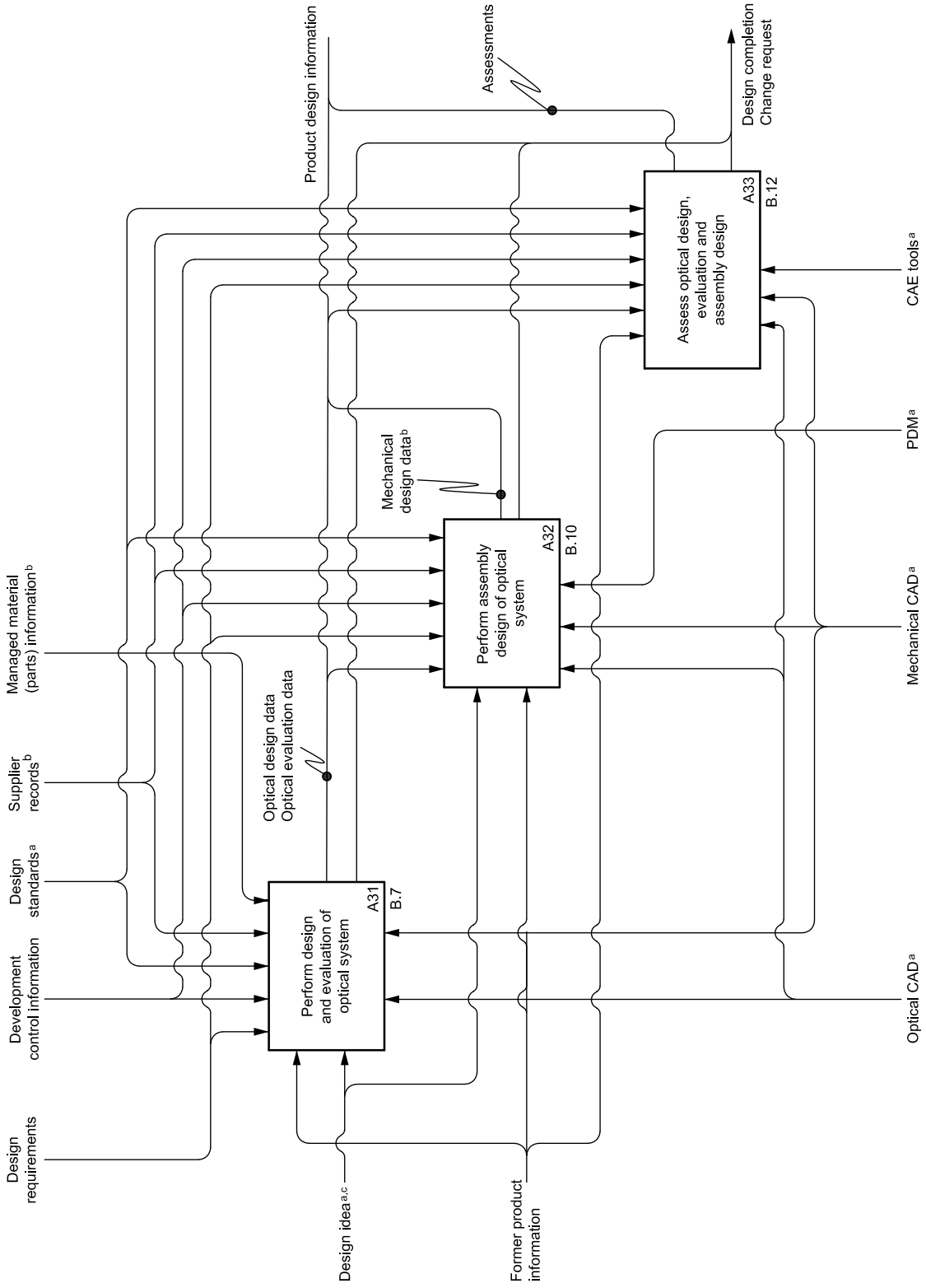
a Out of scope.

b Partly out of scope.

c For design idea, refer to ISO 10303-203.

d Environmental information, etc. includes environment information (partly out of scope), information on recycling (out of scope), regulations (out of scope) and patent information (out of scope).

Figure B.5 — NODIF AAM 5 of 16 — Decide design requirements (node A2)

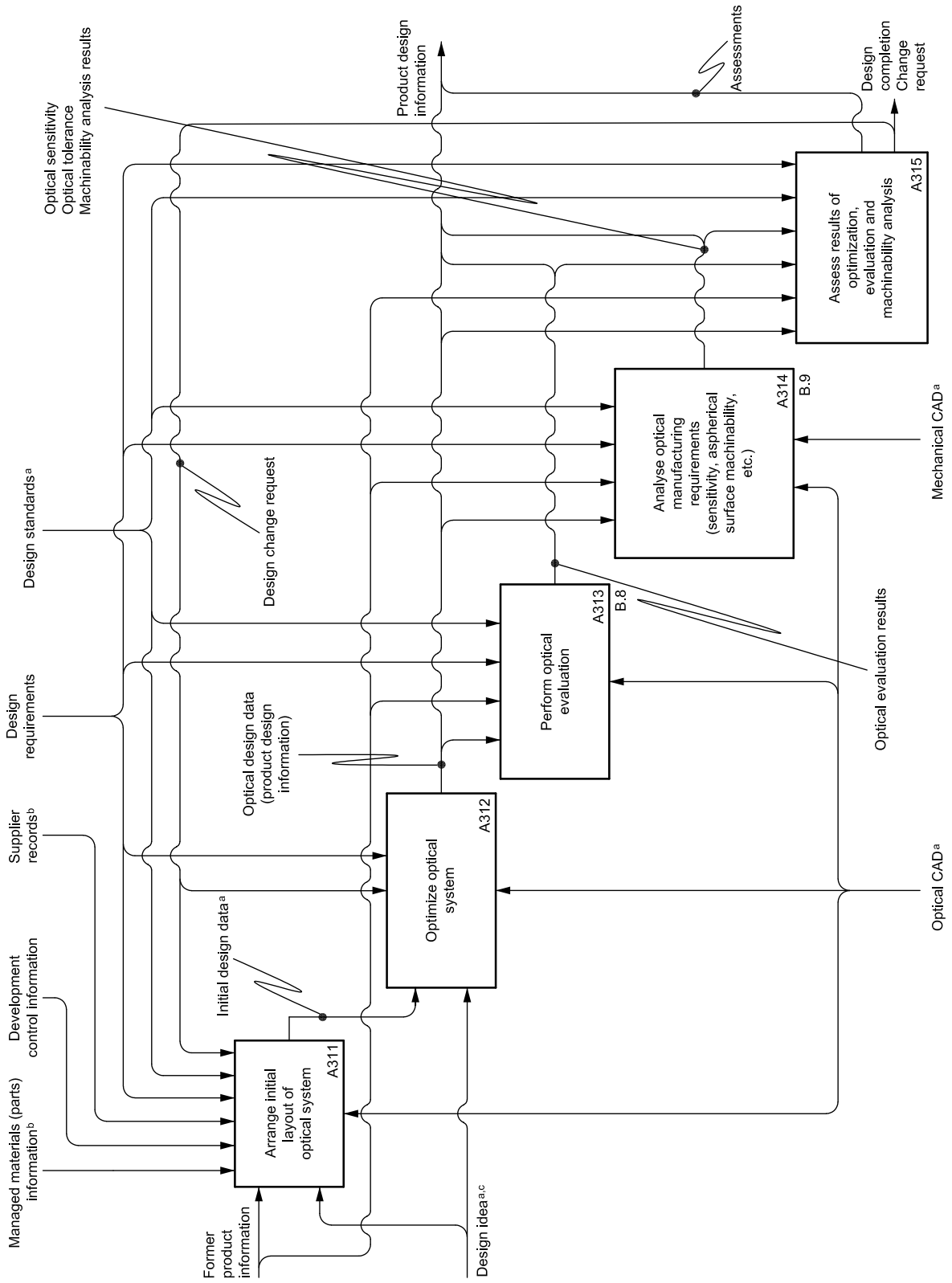


[a] Out of scope.

[b] Partly out of scope.

[c] For design idea, refer to ISO 10303-203.

Figure B.6 — NODIF AAM 6 of 16 — Conduct design and evaluation of optical system (node A3)

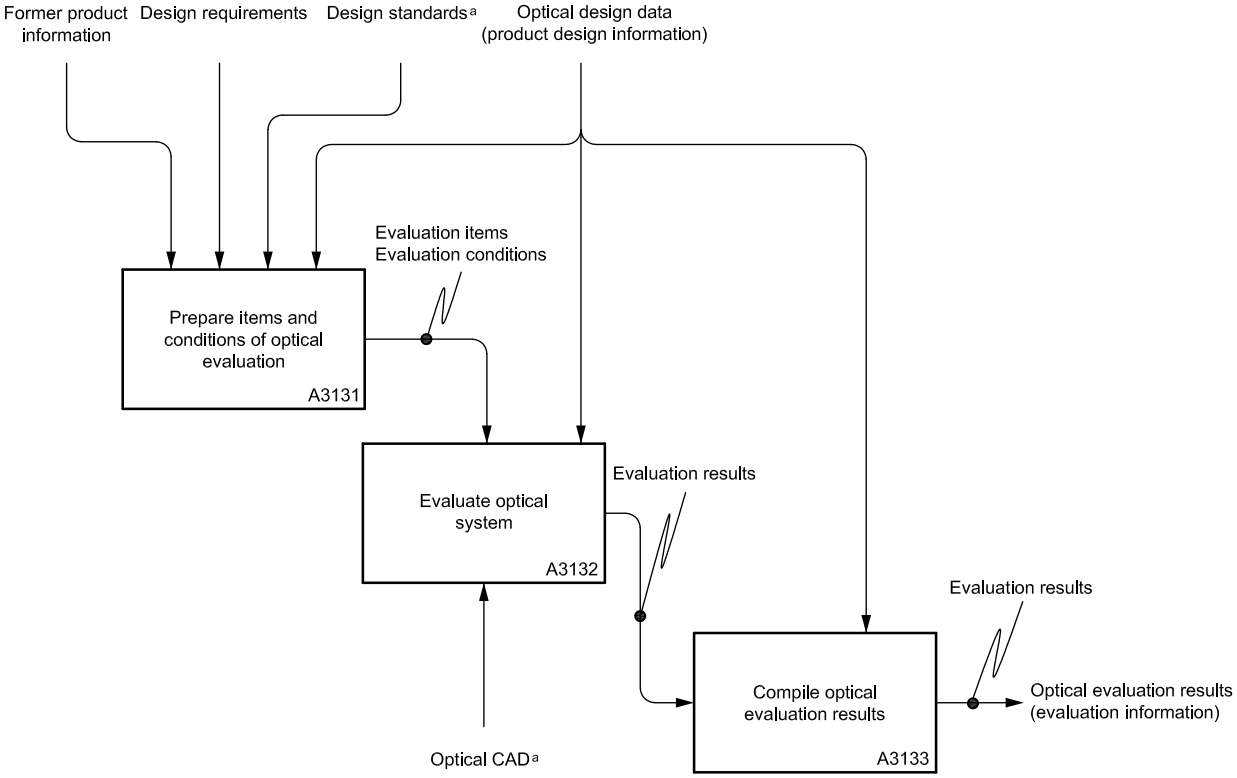


a Out of scope.

b Partly out of scope.

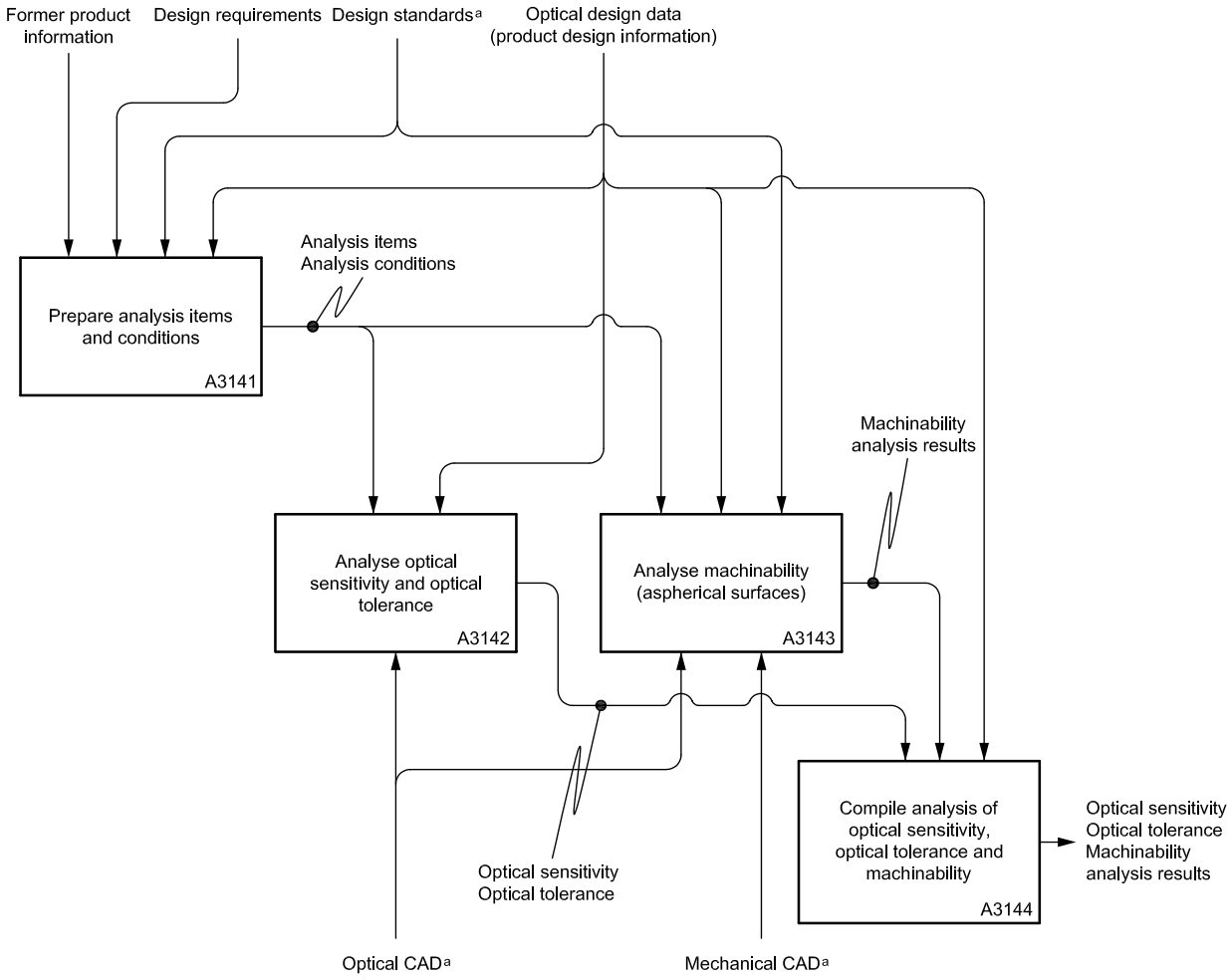
c For design idea, refer to ISO 10303-203.

Figure B.7 — NODIF AAM 7 of 16 — Perform design and evaluation of optical system (node A31)



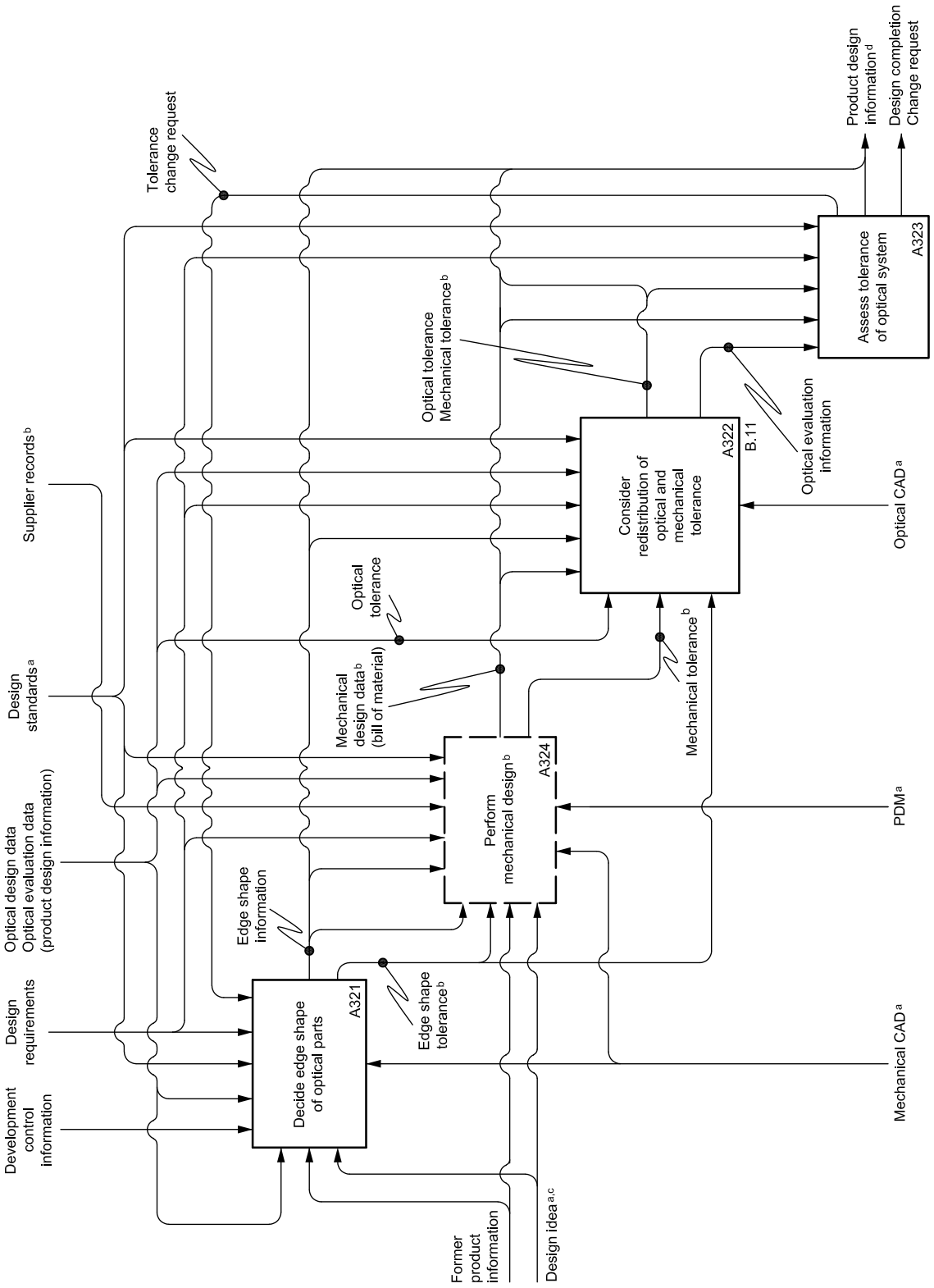
[a] Out of scope.

Figure B.8 — NODIF AAM 8 of 16 — Perform optical evaluation (node A313)



[a] Out of scope.

Figure B.9 — NODIF AAM 9 of 16 — Analyse optical manufacturing requirements (sensitivity, aspherical surface machinability, etc., node A314)



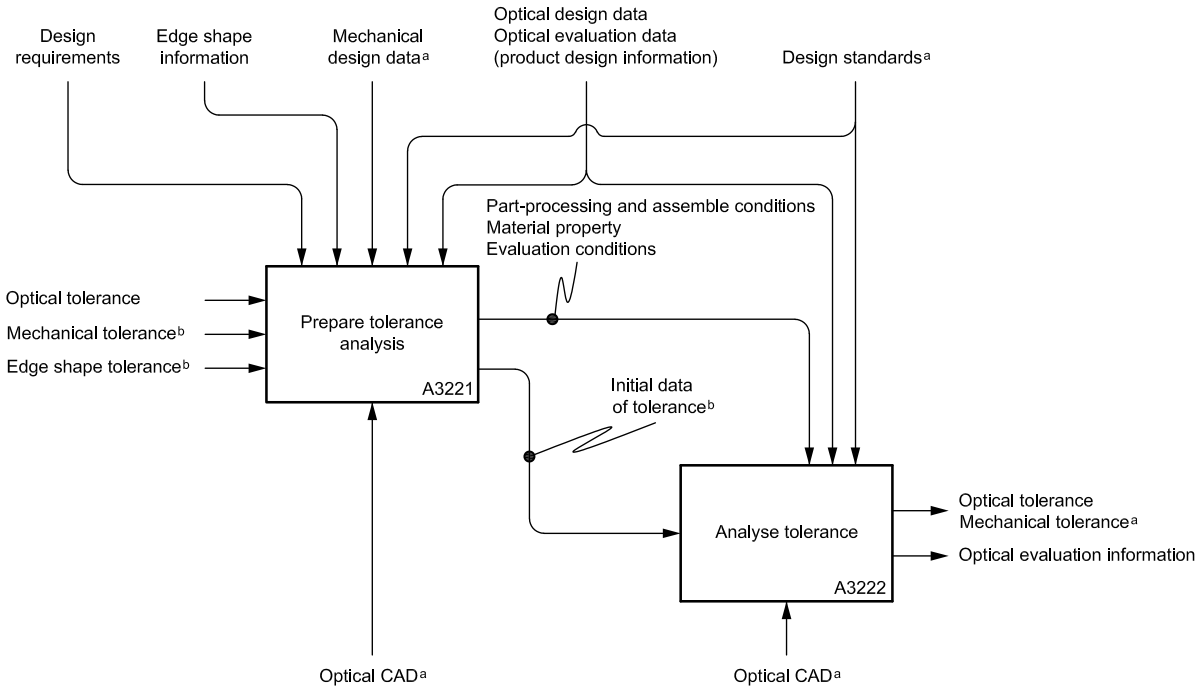
[a] Out of scope.

[b] Partly out of scope.

[c] For design idea, refer to ISO 10303-203.

[d] Product includes trial product.

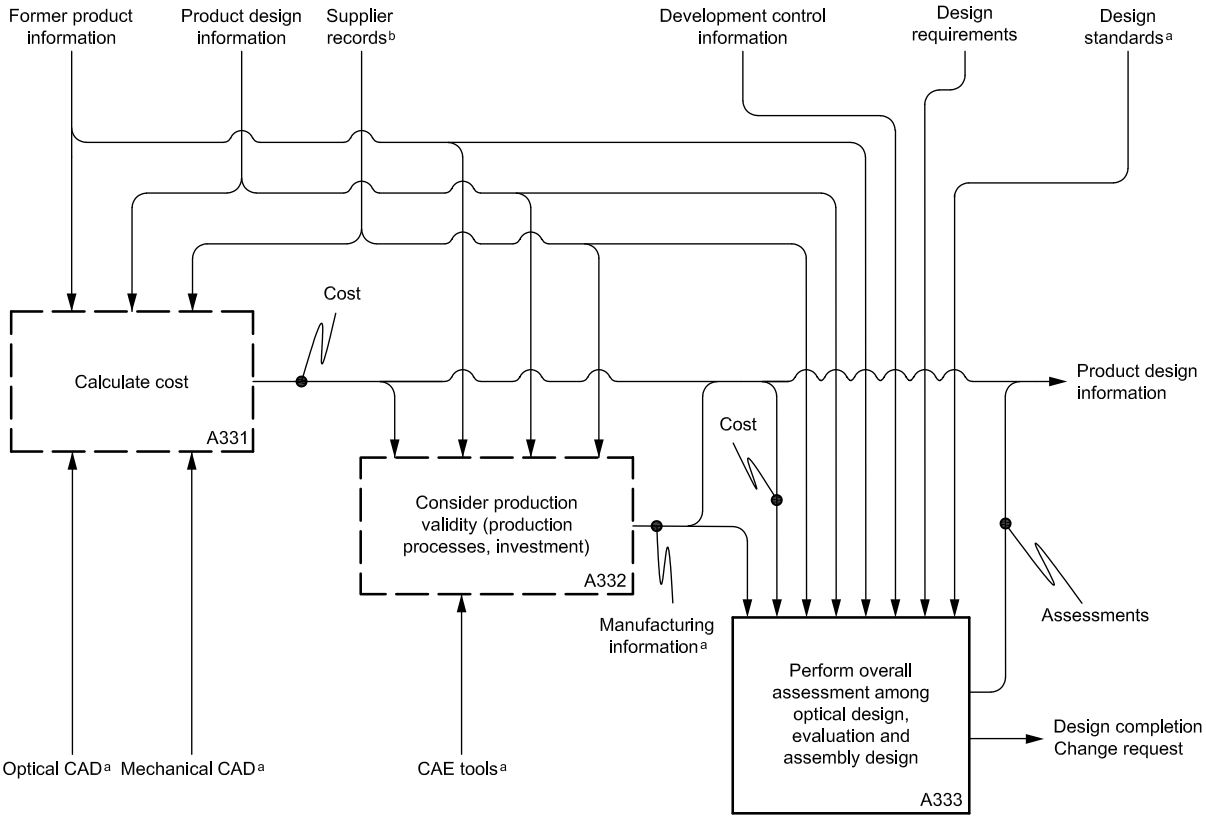
Figure B.10 — NODIF AAM 10 of 16 — Perform assembly design of optical system (node A32)



[a] Out of scope.

[b] Partly out of scope.

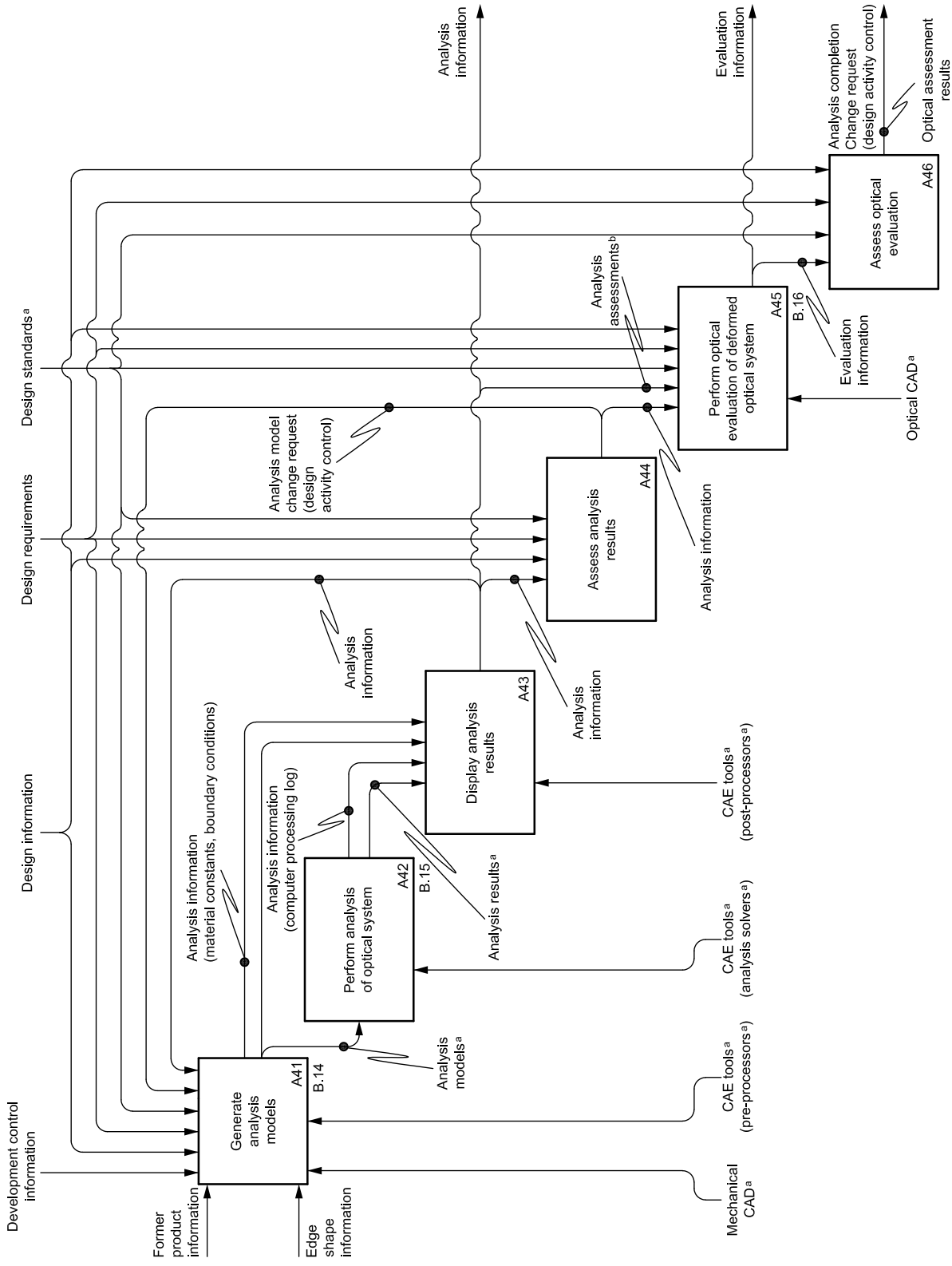
Figure B.11 — NODIF AAM 11 of 16 — Consider redistribution of optical and mechanical tolerance (node A322)



[a] Out of scope.

[b] Partly out of scope.

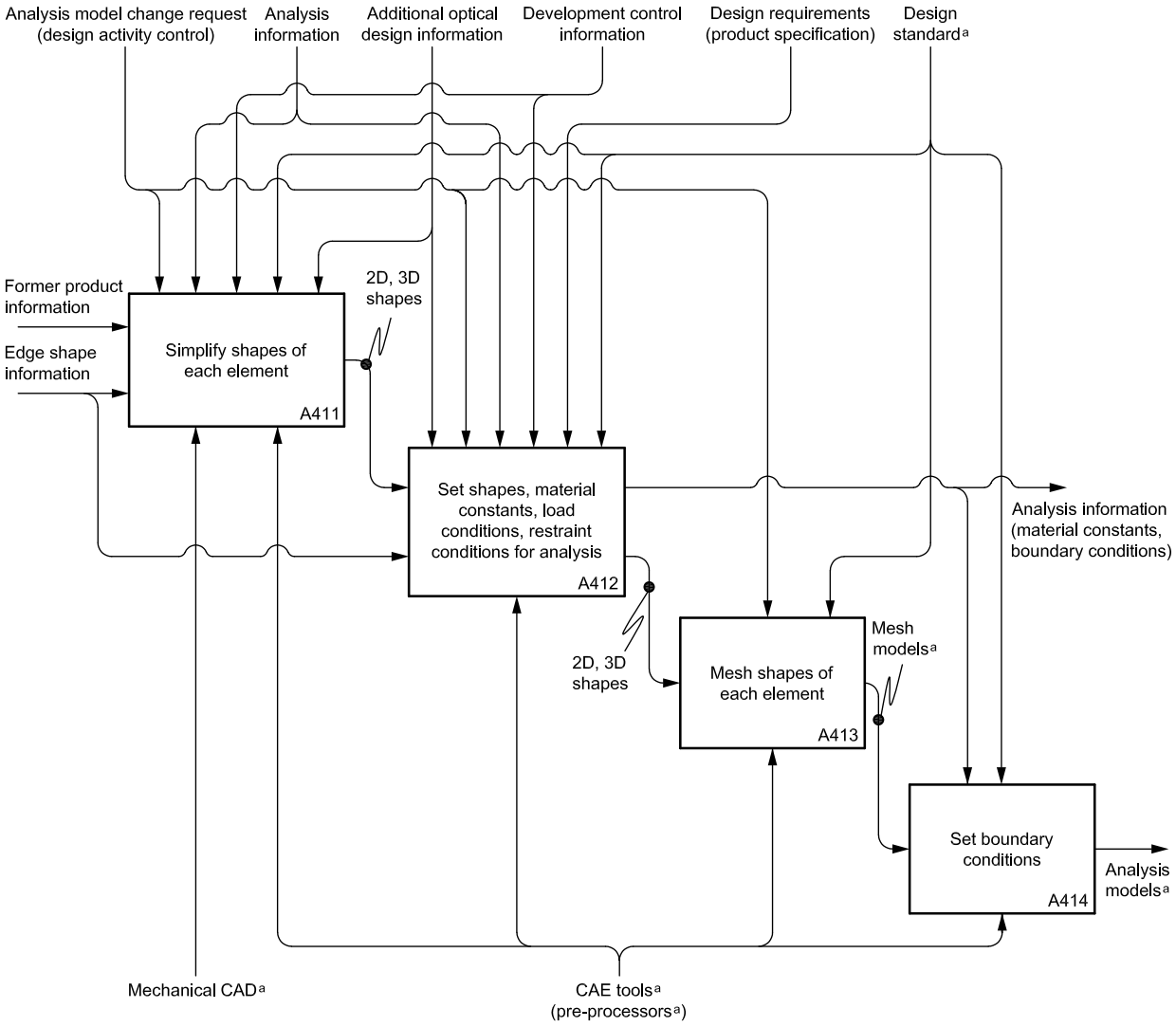
Figure B.12 — NODIF AAM 12 of 16 — Assess optical design, evaluation and assembly design (node A33)



[a] Out of scope.

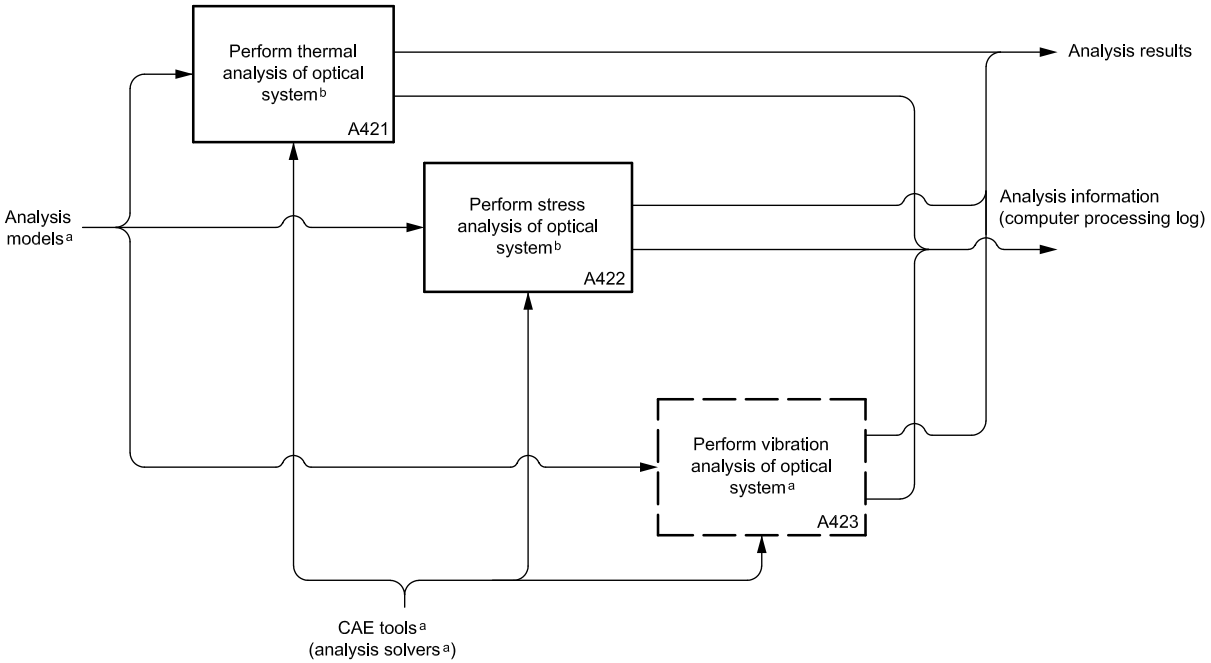
[b] Partly out of scope.

Figure B.13 — NODIF AAM 13 of 16 — Analyse optical system (node A4)



[a] Out of scope.

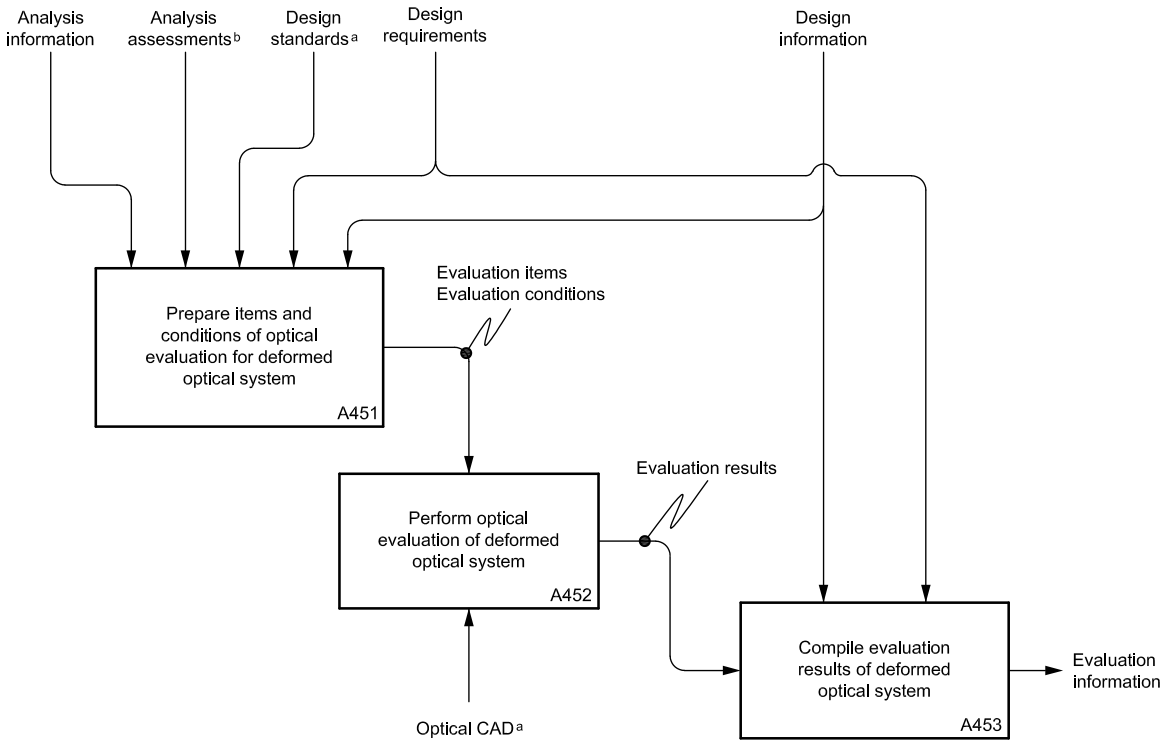
Figure B.14 — NODIF AAM 14 of 16 — Generate analysis models (node A41)



a Out of scope.

b Partly out of scope.

Figure B.15 — NODIF AAM 15 of 16 — Perform analysis of optical system (node A42)



a Out of scope.

b Partly out of scope.

Figure B.16 — NODIF AAM 16 of 16 — Perform optical evaluation of deformed optical system (node A45)

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[1] ISO 10110-9, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 9: Surface treatment and coating*

[2] ISO 10110-10, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 10: Table representing data of optical elements and cemented assemblies*

[3] ISO 10110-11, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 11: Non-toleranced data*

[4] ISO 10110-14, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 14: Wavefront deformation tolerance*

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

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