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Use Cases for the Management and Maintenance of Multi-Domain AP 210 Component Models

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1. Introduction

This document provides use cases for the management and maintenance of multi-domain component models using ISO 10303-210:2010 (AP 210) as a computer-interpretable representation. The use cases are the result of conversations with stakeholders and potential end-users. This document identifies the concepts and relationships needed to support configuration control and dependency management among the core elements of the component model including the schematic symbol, functional (netlist) model, footprint, package and part-level models.

2. Scope

The domains considered in this document include electrical engineering, mechanical engineering, materials and process engineering, and component application engineering. Successful application of a component by a manufacturer requires effective communication among these domains. The relationship between component supplier and the manufacturer's internal departments is important and is assumed for the purposes of this document to be coordinated by the component application engineering department. The traditional arrangement of component model elements is illustrated in Figure 1, with the inclusion of supplier and parametric data elements. This document will provide details of the additional relationships necessary to manage and maintain the system level integrity of the component model.

3. Domain Responsibilities for defining product data

Effective communication is defined to occur when and only when there are process guarantees in place to ensure that the detailed properties embodied in the different models that relate to the shared aspect of the real component are coherent. In many organizations the detail operational activities are carried out by technicians trained as CAD librarians, many of whom are fluent in script development and macro programming. The CAD librarian in a Printed Circuit Design (PCD) department will be representing both the electrical engineering discipline and the materials and process engineering discipline. If the PCD department is also responsible for assembly drawings, the CAD librarian will be responsible for a 2D symbol representing the component on the assembly drawing. Technicians in the Mechanical Design department will represent the mechanical engineering discipline. For the purposes of this document the following domain responsibilities will be assumed, recognizing that the assignment of responsibility for

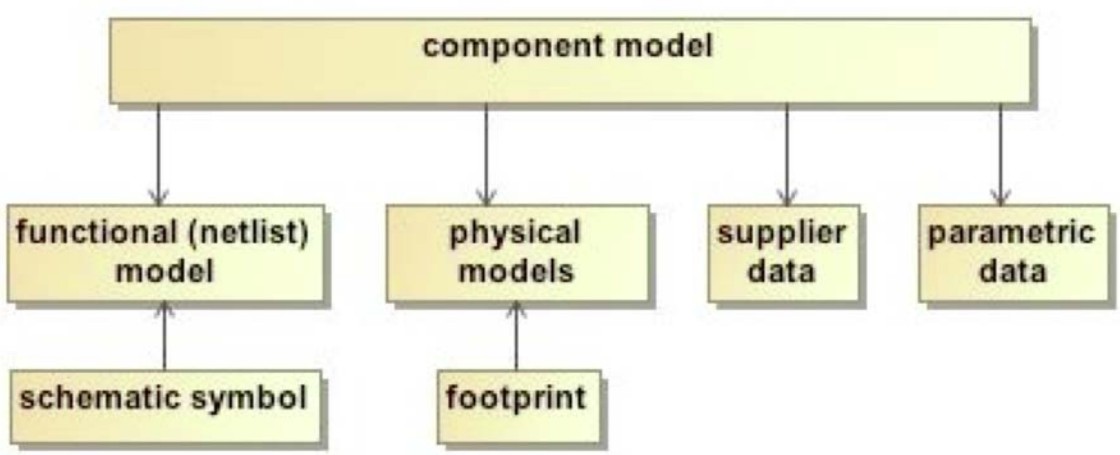

Figure 1. Component model elements

physical and part level models is arbitrary. Each domain is responsible for reviewing and approving proposed changes that impact their models.

3.1 Electrical engineering responsibilities

Electrical engineering is responsible for

- defining the functional (netlist) model,
- defining the functional connector model,
- defining the schematic symbol,
- defining the mapping of the schematic symbol onto the functional (netlist) model,
- defining the mapping of the schematic symbol onto the functional connector model,
- defining the mapping relating the functional (netlist) model to the part level model,
- defining the mapping relating the functional connector model to the part level model,
- defining the composition of the functional (netlist) model and physical models into the part level model,
- defining the mapping relating the schematic symbol to the part level model,
- validating the consistency of the multi-domain model with respect to signal coherency between the schematic symbol, functional (netlist) model, footprint, reference physical model, and part level model.

3.2 Mechanical engineering

Mechanical engineering is responsible for

- defining the physical model required for mechanical design,
- defining the reference physical model required for footprint definition,
- defining the mapping of critical characteristics between the physical model required for mechanical design and the reference physical model required for footprint definition,
- defining the critical characteristics of the part level model,
- defining the mapping between critical characteristics of the reference physical model and critical characteristics of the part level model.

3.3 Materials and process engineering

Materials and process engineering is responsible for

- defining the footprint,
- approving the mapping relating the footprint to the reference physical model provided by mechanical engineering,
- defining manufacturing features.

3.4 Component applications engineering

Component applications engineering is responsible for

- defining the parametric database entry for each component,
- defining the obsolescence status for each component,
- defining the superseded information for each obsolete component.

Example:

The connector pins in a shape model created for fit evaluation are geometrically congruent with a subset of the pins of the reference physical model for the footprint. Because of the congruency, replacement of the reference model with the fit evaluation model will not affect the accuracy of the mating properties of the assembly model.

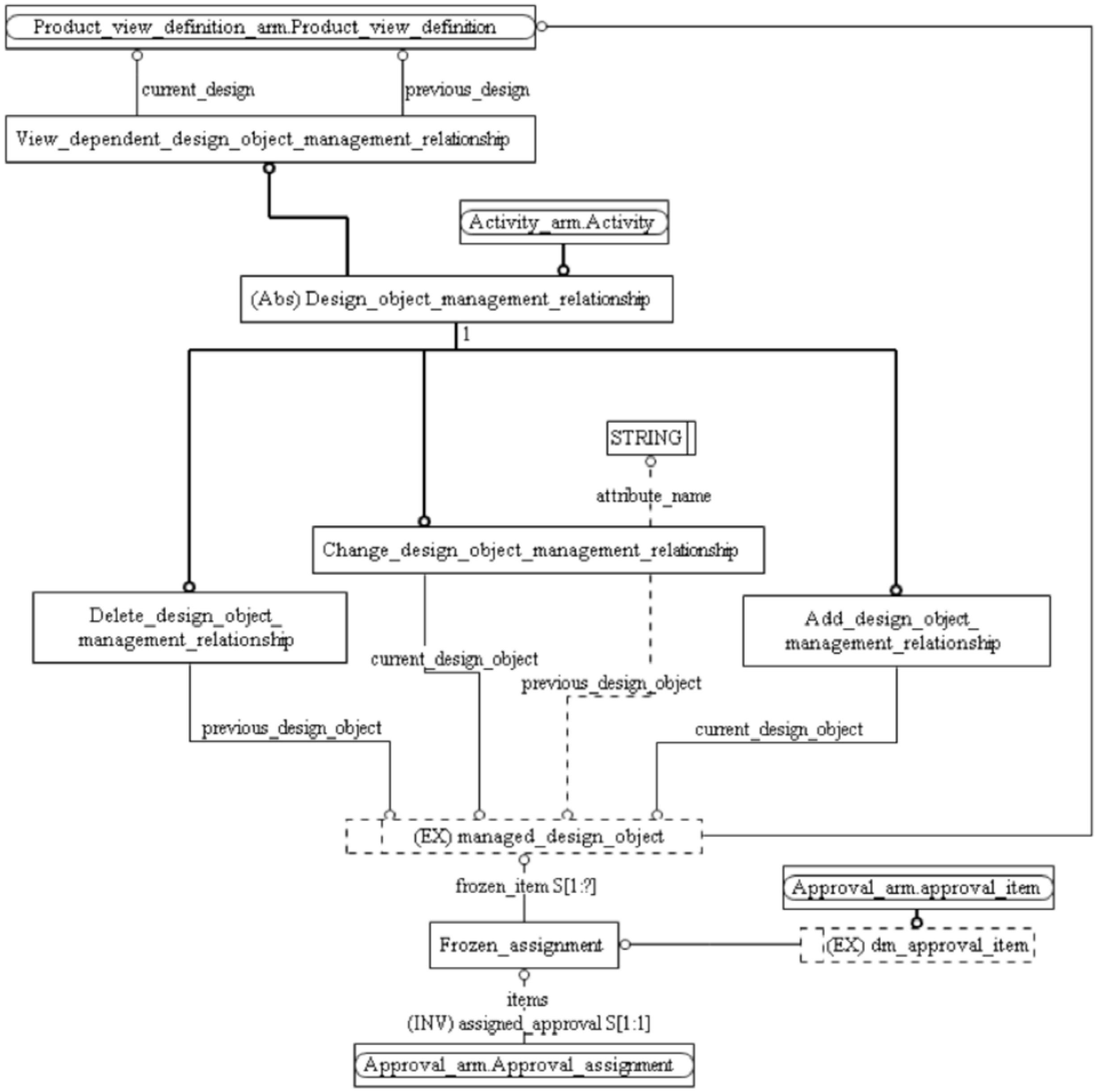

Figure 2. Application Reference Model diagram from design management module showing the role of managed_design_object as the focal point for change tracking [Source: ISO/TS 10303-1661 Design management]

4. Relevant AP 210 content

Ensuring that the population of the detailed relationships between the several models in engineering libraries is valid is impossible without automation. A significant expense of automation is developing and maintaining a canonical model of the information stored in the libraries and of the required mappings between models. AP 210 provides such a canonical model upon which can be built a process model to ensure consistency across the domain models.

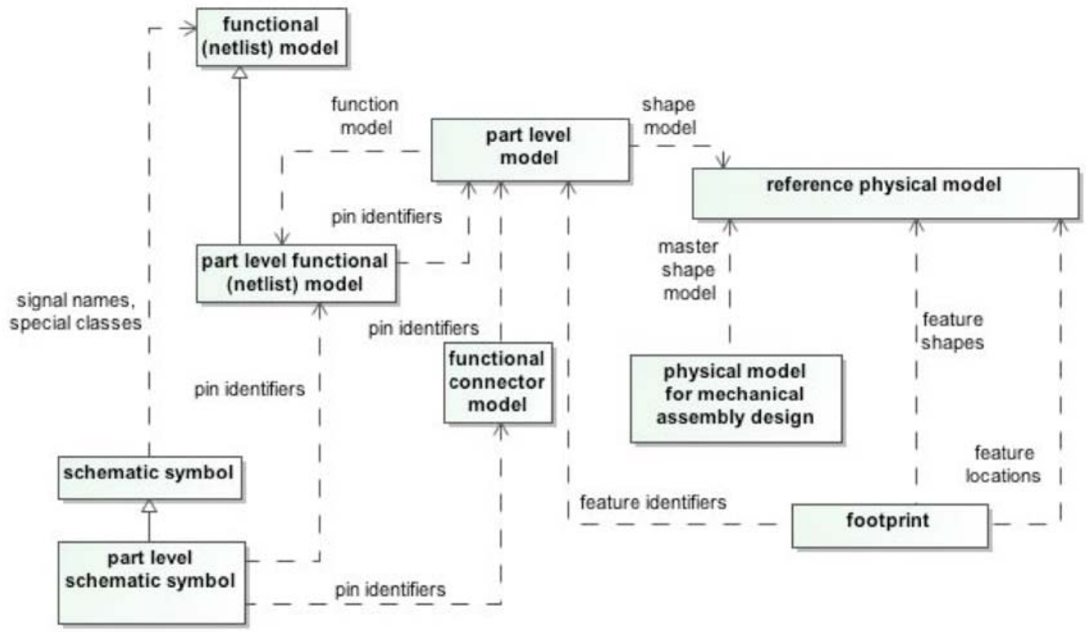

Figure 3. Component model interdependencies present challenging model management issues

Clause 4.1.2.9 of AP 210 is a collection of conformance options[1] that provides comprehensive support for component application data. The subset of conformance options most relevant for this document include:

- approval,
- component black box model,
- component footprint definition,
- component package model,
- component package model in a 2D context,
- component package model in a 3D context,
- part feature grouping,
- predefined part feature functional classification.

Not every Application Object (AO) in the conformance options listed is discussed in this document. The bibliography includes a list of the Application Modules (AM) required to support the AOs mentioned. Schematic symbols and schematic drawings are not yet included in the standard but will be discussed.

4.1 AP 210 specific change management structures

When specific AOs are to be tracked, the design management capability in AP 210 can be used to represent the explicit knowledge of a particular change. Figure 2 illustrates the structure that allows instances in the product data set to be referenced in a change set. The select type managed_design_object is an exhaustive list of types included in AP 210. It is assumed that the relevant instances from the previous model are available for reference. Design_object_management_relationship is an Activity that identifies the current and previous models. The subtypes support actions indicated by their names. Figure 2 illustrates that the activity is directed by a Work_order (discussed in the pdm usage guide) and a

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[1] Conformance options are identified subsets of the standard that an implementer can specify their implementation is compliant with.

member of Affected_item_assignment identifies the Part_version and Package instances that are affected by the change. The specific instance that is operated on by the relevant subtype (in this case Delete_design_object_management_relationship) is not specified by the member of Affected_item_assignment. It is expected that a receiving application would seek further information about the change from the user since deletion of a Package_terminal should cause deletion of all properties that are dependent on the Package_terminal. Detailed recommendations for that user interaction are outside the scope of this document. Note that after the changes have been incorporated into the data set, the data set is still required to be compliant to AP 210, and validating the modified data set will provide structurally relevant information. All AOs identified in this document in the use case scenarios may be referenced by the Design_object_management_relationship AO (or its subtypes Change_design_object_management_relationship, Delete_design_object_management_relationship and Add_design_object_management_relationship) via the managed_design_object because managed_design_object is extensible and is extended in other parts of AP 210.

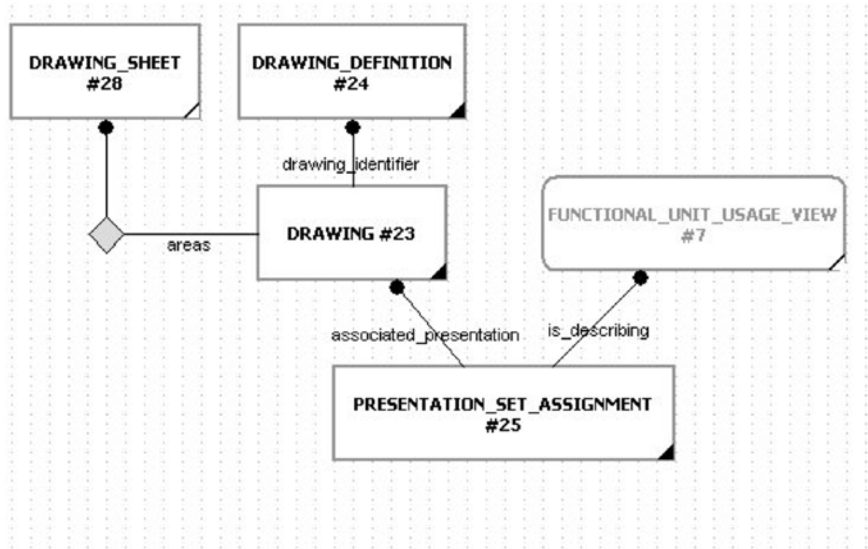


Figure 4. Schematic symbol association to functional model is accomplished through Presentation_set_assignment

5. Use case scenarios

The fundamental model for configuration management recommended is publish/subscribe, that is, that all data are available for review and comment by any discipline. In some cases design systems will be able to support more specific change detection based on journaling technology (also known as history trees), and if that is available, it should be taken advantage of. For complex data manually examining a large data set is unproductive and a stored filter/query mechanism in application software is assumed. Deriving change sets from baseline AP 210 model data is one approach that may be satisfactory for component models as the AP 210 component models are heavily decomposed.

This document does not attempt to address the details of organizational behavior including best practices for product data management.

This document assumes there is in existence a base level product data management system capable of allowing users to establish baseline data sets, identify issues, request work, approve work, etc., and that operates at the part number and version level. There are numerous commercial and open source applications with the base level capability. The product data management and configuration management capability in STEP is focused on the core product model that consists of the following concepts: product,

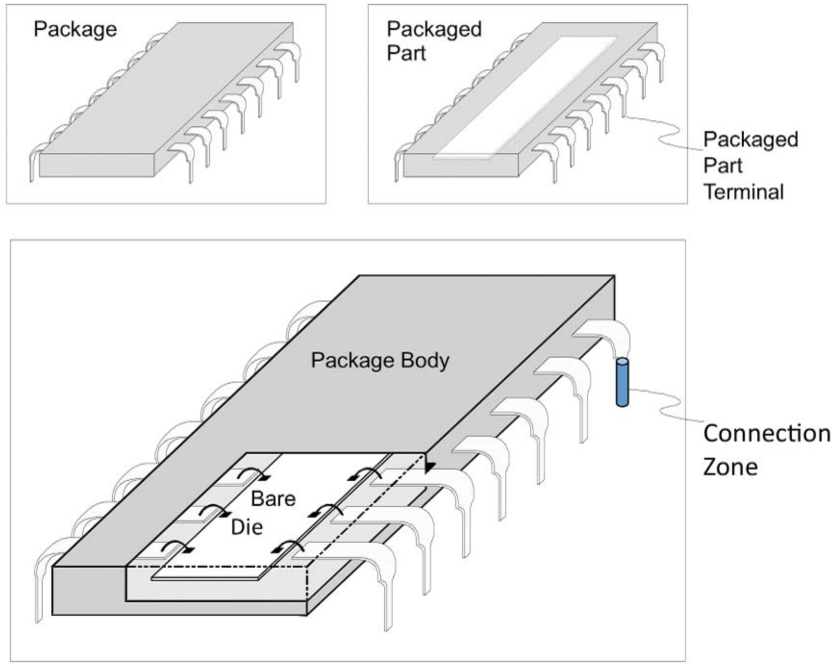


Figure 5. A subset of the data in the AP 210 part level physical model

product_version, and product_definition. The pdm usage guide release 4.3 [2]should be consulted for details related to standard pdm recommendations.

Figure 3 illustrates specific dependencies between discipline models that were derived from review of the use cases and from the AP 210 model structure.[3] The part level functional (netlist) model binds the signal names of a component to the component pin identifiers. The part level model binds the component feature identifiers to the relevant physical model features. A separate functional model for connectors is provided because in electronic design automation tools, connectors are considered to be purely mechanical components.

Review of Figure 3 indicates that the electrical domain needs to subscribe to the reference physical model for pin-out information changes; the material and process domain needs to subscribe to the reference physical model for feature identifier, feature shape and feature location changes. Omitted from Figure 3 for clarity is the dependency on part version identification. The detailed use cases provide recommendations for part version management. All domains need to subscribe to part level model revision activity.

Each use case scenario is derived from one or more of the domain responsibilities and includes discussion of the relevant AP 210 content and recommendations for management methods for the use case scenario. This document makes recommendations for communicating changes to model users based on structural/topological dependencies for cases where model incompatibilities would require updates. An

[2] http://www.wikistep.org/index.php/PDM_Usage_Guide

[3] The subclass symbol from UML is used in Figure 3. The arrowhead on the dashed lines indicates the more independent model. For example, the footprint is dependent on the reference physical model.

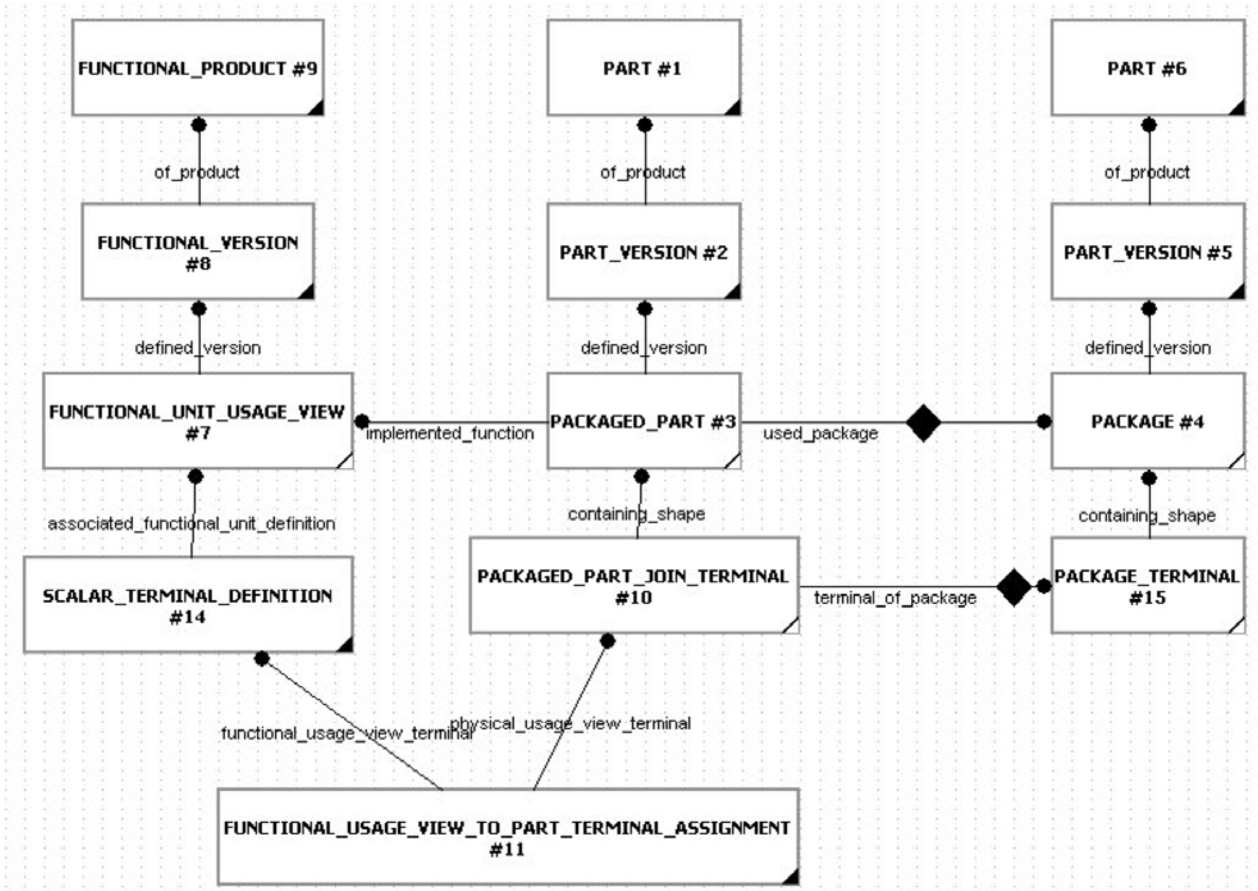


Figure 6. Illustration of typical structure needed for part-level multi-domain model

example of a structural or topological case is the quantity of terminals on a package. Specific AO recommendations will be noted in the detailed use case scenarios.

5.1 Defining the schematic symbol

A Schematic symbol presents the graphical image representing a functional model. A schematic symbol contains elements that are explicitly dependent on the functional model (i.e., an instance of a Scalar_terminal_definition in the functional model is represented by an instance of Schematic_symbol_callout). A schematic symbol in AP 210 will be shown on a Drawing_sheet. A Drawing_sheet is controlled by a Drawing, which contains identification and revision information. As illustrated in Figure 4, the drawing identification information is located in the Drawing_definition AO. Figure 4 illustrates the top-level association of a Drawing_sheet to the functional model for configuration management traceability purposes through the Presentation_set_assignment AO. By populating the Presentation_set_assignment a pre-processor asserts that all the Schematic_symbol_callout included in the schematic symbol will be associated with the relevant Functional_unit_usage_view, simplifying change management.

There are no critical properties of the schematic symbol for multi-domain communication because the schematic symbol only exists in the electrical design flow.

5.2 Composing the part level model

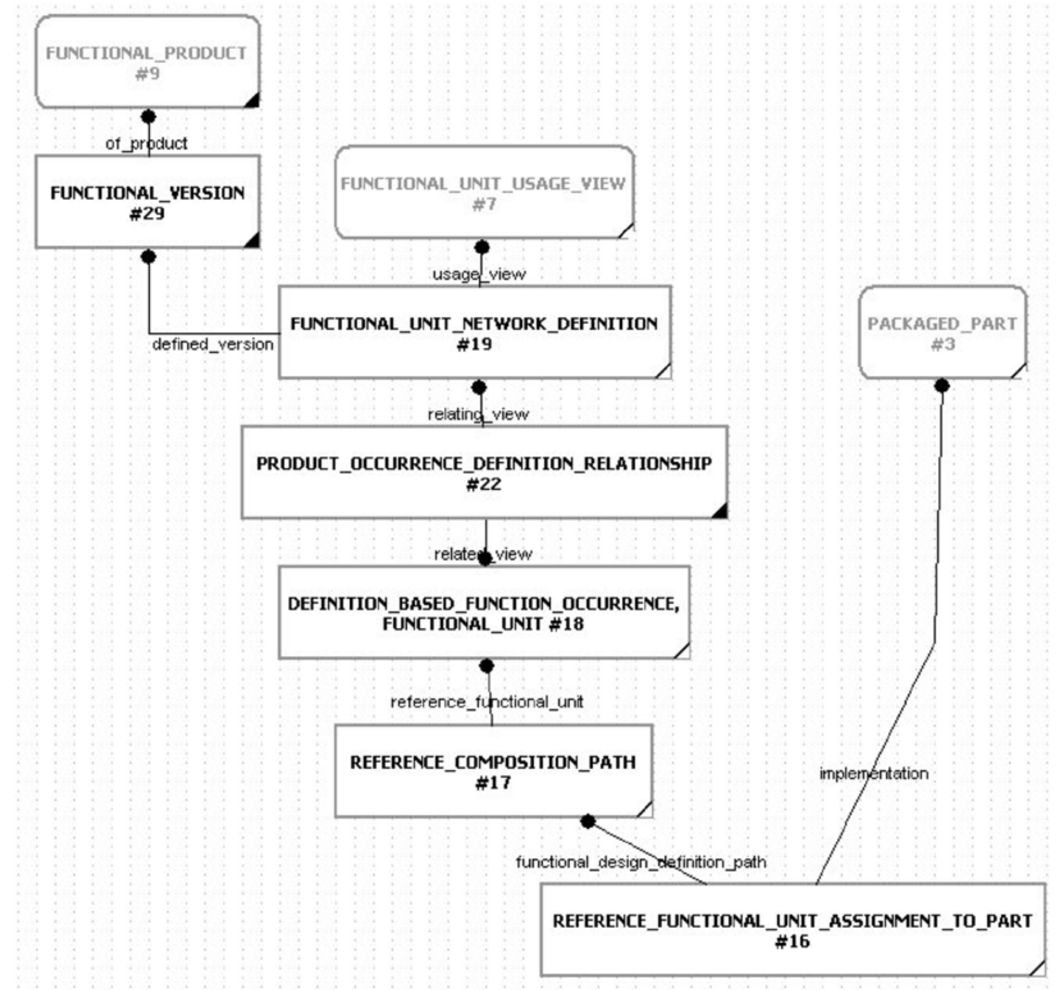
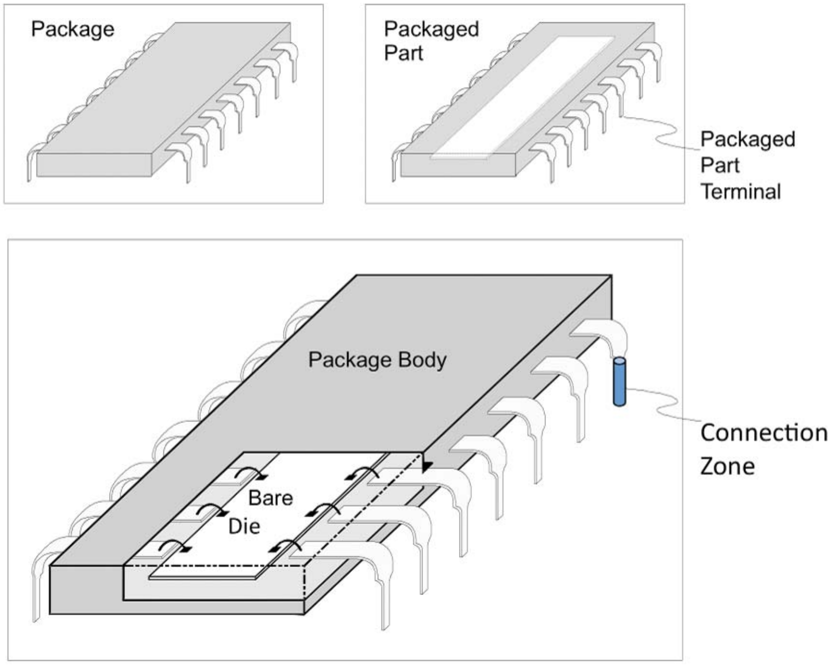


Figure 7. Decomposition of functional (netlist) model for part level model

A graphical representation of the concepts present in the AP 210 component part-level model is



shown in
Figure 5.[4]

The data required to populate a multi-domain part level model includes

- Functional_product,
- Functional_version,
- Functional_unit_usage_view,
- Scalar_terminal_definition,
- Part,
- Part_version,

[4] Figure 5 illustrates a lower level concept that is sometimes critical, a connection area or zone. The model in AP 210 permits the specification of e.g., an area on a feature that is the specific region for energy or material transport through the surface of the feature.

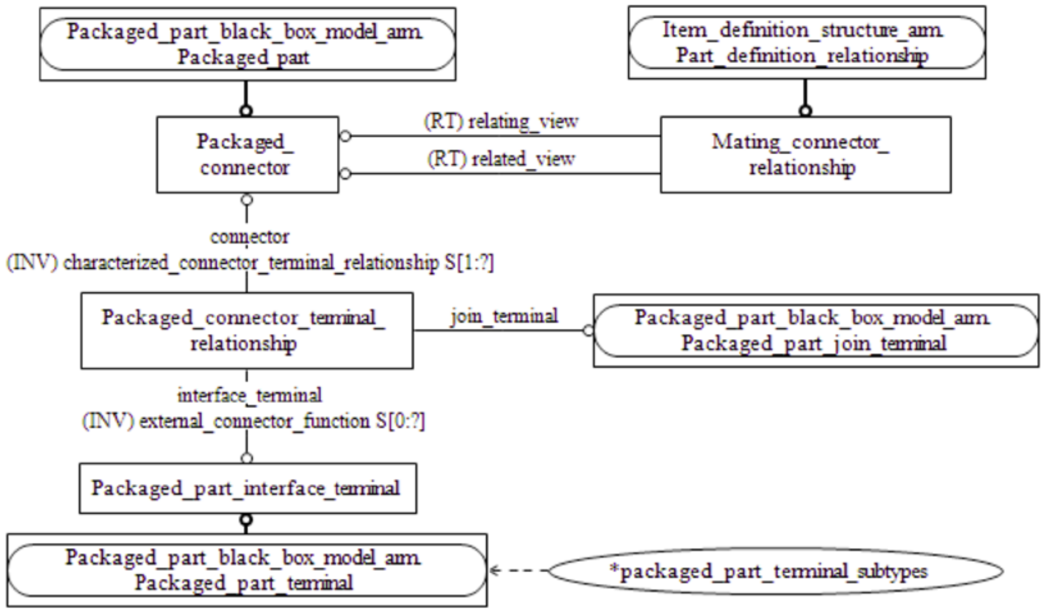


Figure 8. A subset of the data in the AP 210 connector model. Join terminals mate with some interconnecting materials in a design. [Source: ISO/TS 10303-1708 Packaged connector model]

- Packaged_part,
- Packaged_part_join_terminal,
- Functional_usage_view_to_part_terminal_assignment,
- Package,
- Package_terminal,
- Management related AOs (approval, date…).

Figure 6 illustrates the critical data relationships. Change management will be placed on all AOs in that diagram as each AO type and each attribute represented on the figure is critical for correct synchronization between the functional and physical models. Packaged_part.used_package specifies a set of Package but the Package of interest in this case is the base package.[5] Packaged_part_join_terminal.terminal_of_package specifies a set of Package_terminal but the Package_terminal of interest in this case is a Package_terminal for the Package that is the base package.

[5] Two-dimensional CAD library applications traditionally allow alternate symbols for the package. The support for that is provided by the aggregate used_package and the aggregate terminal_of_package. Detailed discussion of the application of alternate symbols is outside the scope of this document. The package that is the base package is the master model, which is the use case pertinent to this document.

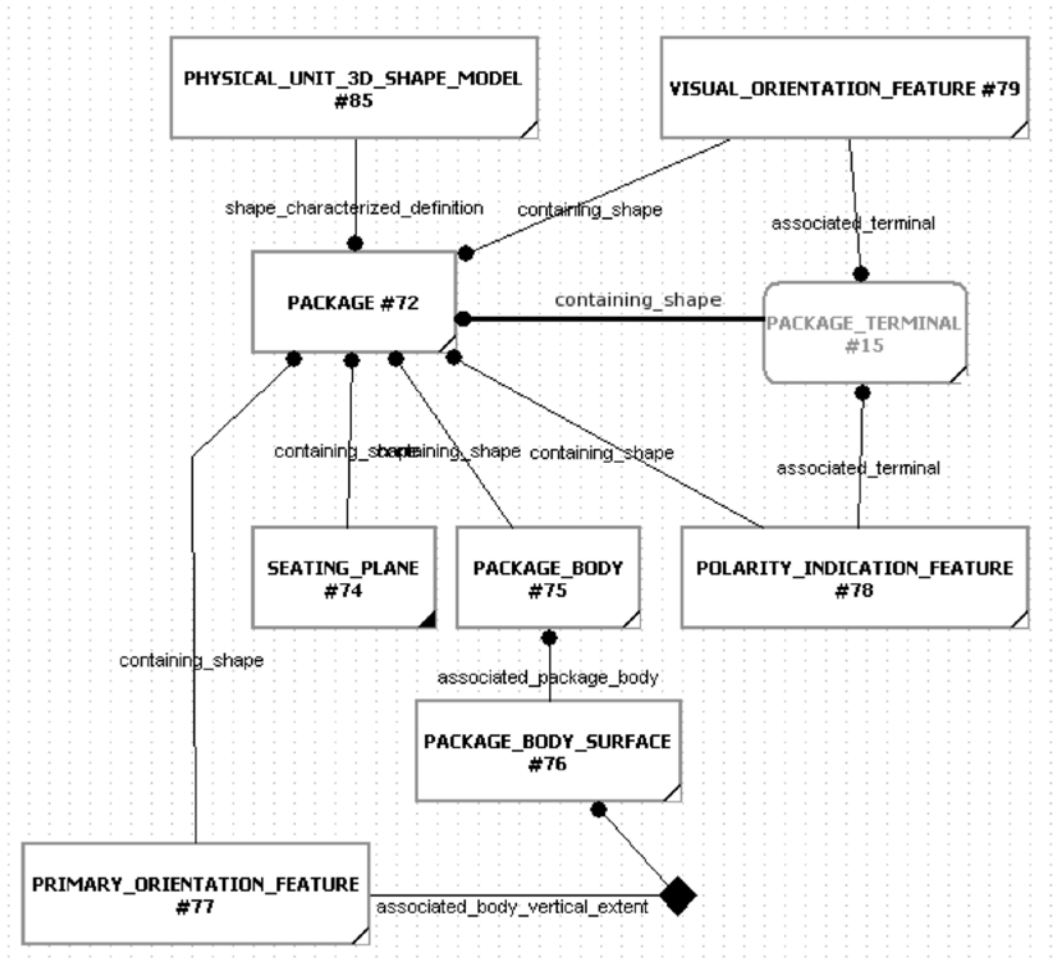


Figure 9. A subset of the data in the Package AO

When the functional (netlist) model includes decomposition, the following additional data is required

- Functional_unit_network_definition,
- Product_occurrence_definition_relationship,
- Functional_unit,
- Reference_composition_path,
- Reference_functional_unit_assignment_to_part.

Figure 7 illustrates the additional data relationships. The decomposition is via a member of Functional_unit_network_definition that references the Functional_unit_usage_view. This relationship is critical because it establishes the link between the details and the interface. The Functional_unit_network_definition may specify a different version than the Functional_unit_usage_view specifies but the Functional_product specified by the two versions shall be the same Functional_product. Although there is a direct reference to Packaged_part from the functional model via Reference_functional_unit_assignment_to_part, because there is already a strong binding of the Packaged_part to the Functional_unit_usage_view, it is not critical to monitor that additional data.

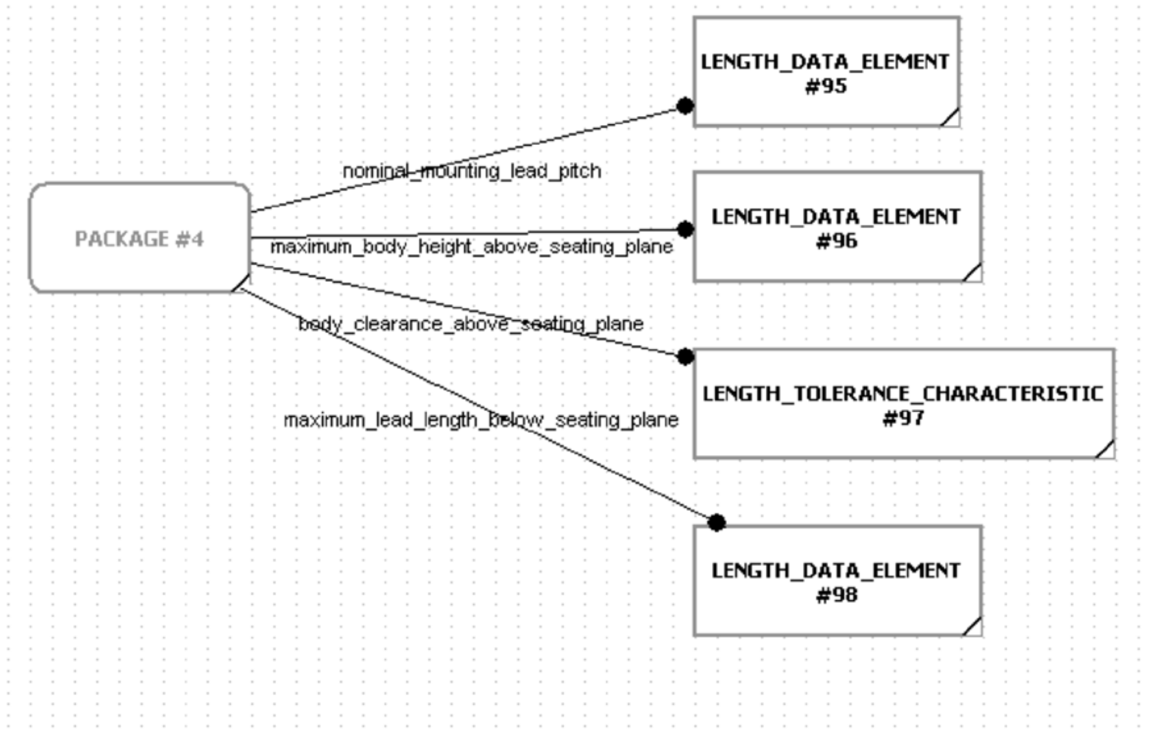


Figure 10. Parametric properties of concern to materials and process engineers

5.3 Defining the connector model

Connectors are included as a separate product type of component specification in order to identify their critical role in product interfacing and in order to assign related properties in support of that role.

A connector is modeled in AP 210 as a Packaged_connector, a subtype of Packaged_part. The AMs representing functional properties of connectors include Packaged_connector_model and Packaged_part_black_box_model. The critical additional properties over those of Package for multi-domain communication include AOs:

- Packaged_part_interface_terminal,
- Packaged_part_join_terminal,
- Packaged_connector,
- Packaged_connector_terminal_relationship.

A Packaged_connector_terminal_relationship specifies the functional short that exists between the interface and join terminals but is not critical.

5.4 Mapping the schematic symbol to part level model

When a part level schematic symbol is provided, each part level pin identifier string will be referenced by a schematic text variable to make the component pin identifier text available on the top-level schematic symbol. Members of Packaged_part_terminal are referenced by the schematic text variable for this

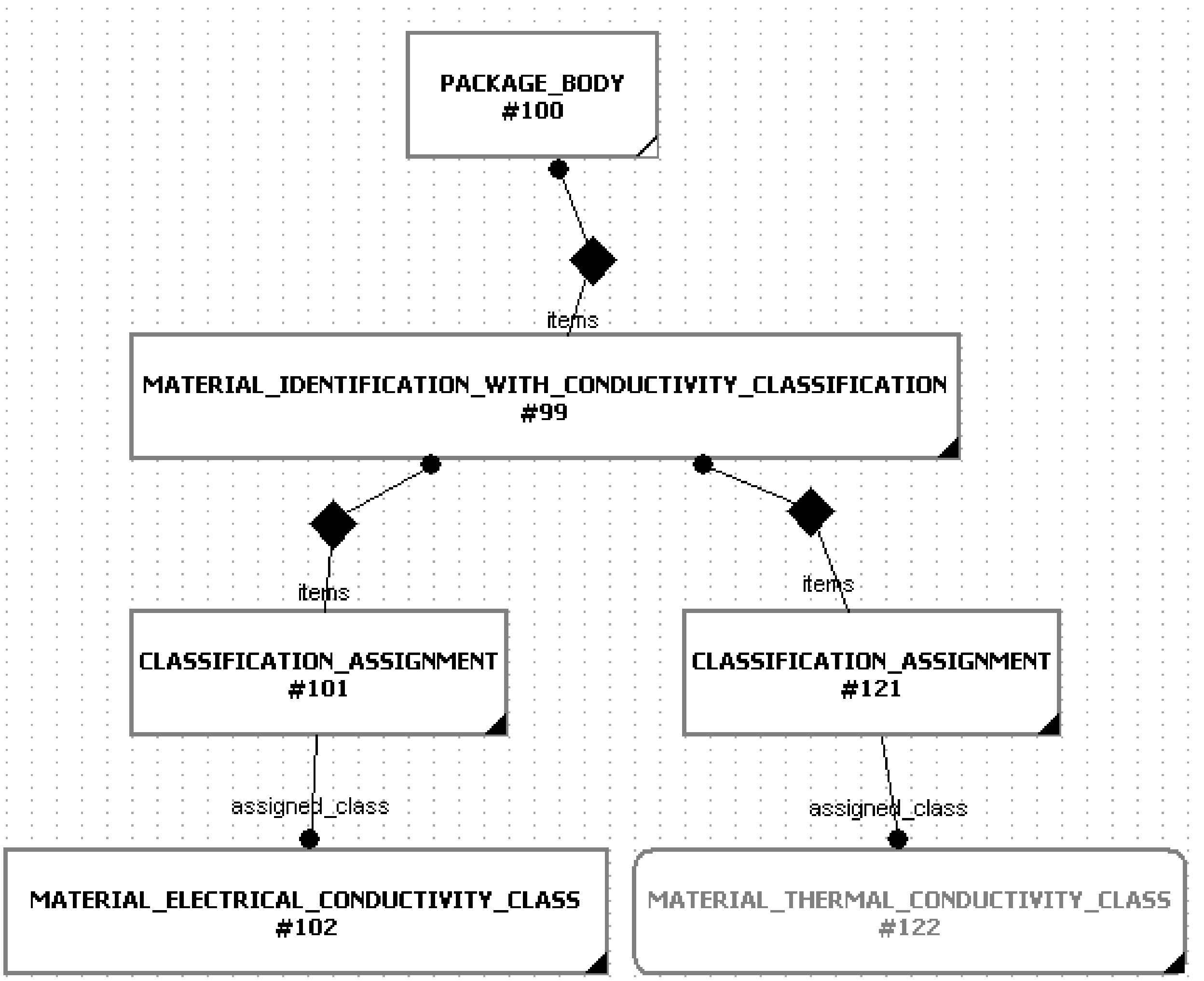


Figure 11. Two material property classification assignments are applied to a Package_body. The class type indicates the domain and the class name attribute provides the conductivity value.

purpose.[6] Because the references to the part level pin identifiers are through variables, there are no critical items for other domains in the schematic symbol to part level model mapping.

5.5 Defining the physical shape model for mechanical design

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[6] This approach results in redundant information paths between the schematic symbol and the part level model. One path is through the part level functional (netlist) model and the other is direct. The AOs involved in the path through the part level functional (netlist) model are Part_connected_terminals_definition and Functional_usage_view_to_part_terminal_assignment. Because the schematic symbol model is currently under development, the redundancy will be addressed as part of that development effort.

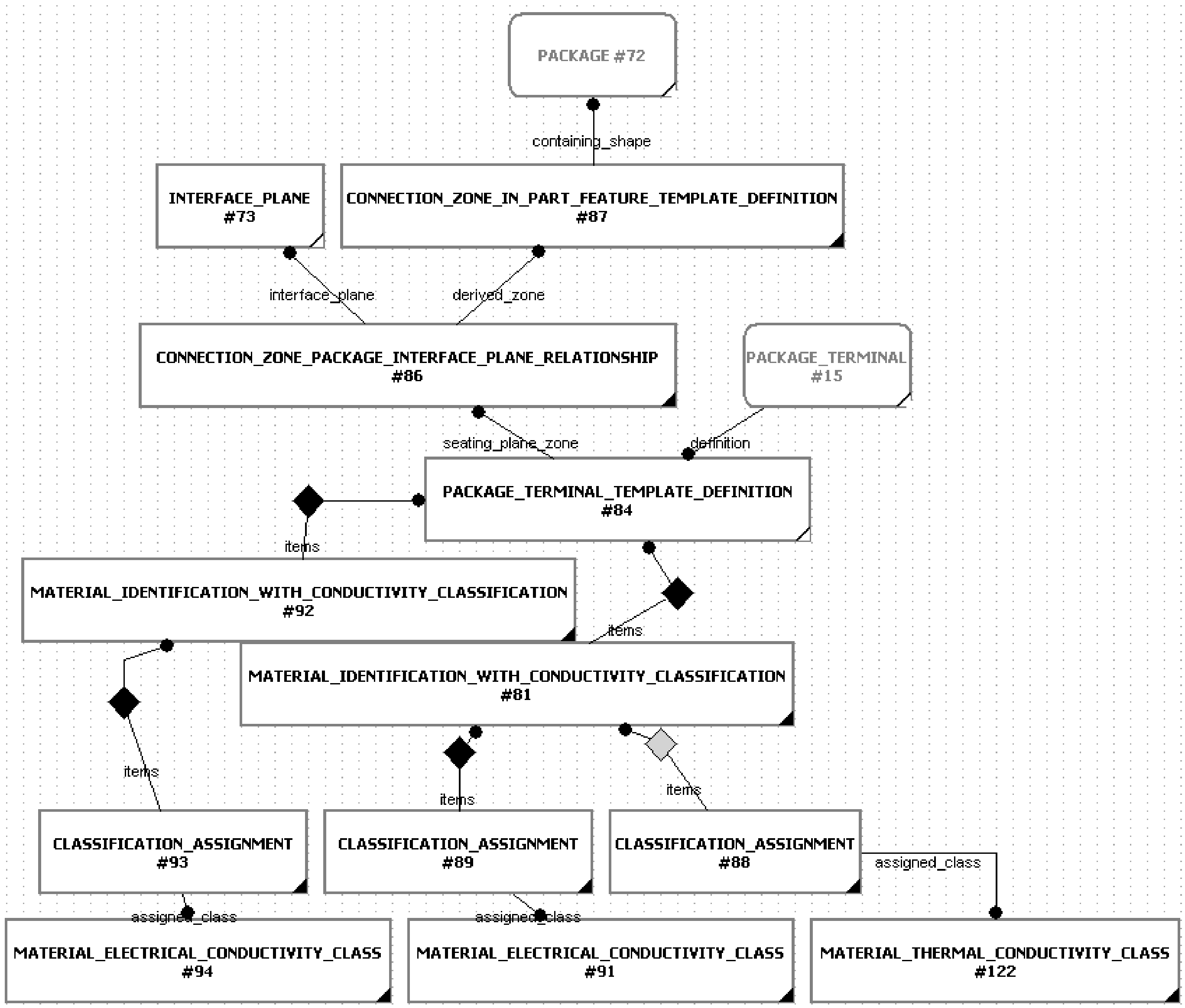

Figure 12. Assigning a material property classification to Package_terminal (#15) requires assignment to the terminal definition, a Package_terminal_template_definition (#84). This figure illustrates assignment of more than one conductivity property.

The shape models in AP 210 are a complete shape of the product. They may be composed of other shapes or may be one shape, depending on the application details. Two-dimensional and three dimensional models are supported, with the added capability to specify the context for the model shape. The models recommended are 2D wireframe, 2D csg, and 3D advanced brep.

There are multiple purposes for shapes that are supported:

- analysis input;
- analysis output;

- shock analysis input;
- shock analysis output;
- design;
- vibration analysis input;
- vibration analysis output;
- electromagnetic compatibility analysis input;
- electromagnetic compatibility analysis output;
- thermal analysis input;
- thermal analysis output.

The GD&T defined material condition may be specified (i.e., least, nominal, maximum material condition).. The application environment for the shape may be specified (i.e., manufacturing environment, end-user). The detail level of the shape is up to the implementation but explicit support for terminals is provided to enable hierarchical extraction of continuity for validation.

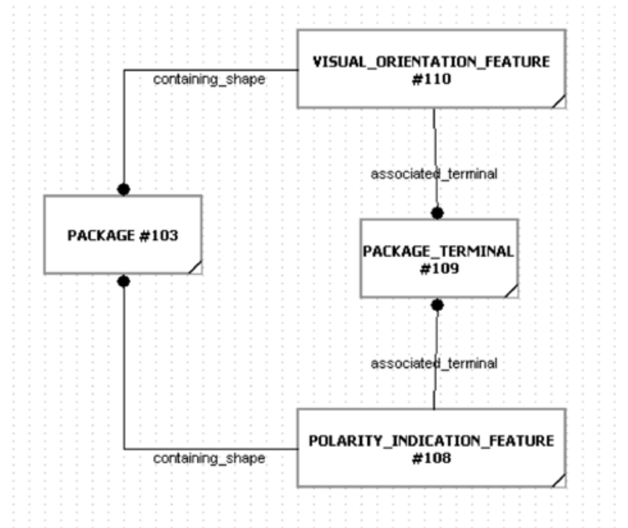

Figure 13. Package model features of special interest to manufacturing and process engineers

The class of 3D shape may be specified as:

- extrusion,
- manhattan_block,
- other,
- is_unknown.

A 3D shape extent property is provided for application to components targeted to be attached to layered interconnect: an overall shape including terminals with minimal details;

- a shape that includes only the body and not terminals;
- a shape that includes the shape of the mating lands;
- a shape that includes the lands and the associated breakout pattern.

A 3D shape approximation level is provided for classification of shape model fidelity to actual product shape (i.e., coarse, detailed or unknown may be indicated). This is primarily used when the centroid is provided. In the case where there are several shapes provided, one shape shall be designated as the master shape representation.

Critical capabilities supported include the ability to synchronize coordinate systems between 2D and 3D representations. The AO that provides this support is Coordinated_geometric_relationship_with_2d_3d_placement_transformation (found in AM Geometric model 2D 3D relationship).

One application example is that the contact areas on the part features match the relevant contact areas on the footprint.

Another application example is that a two-dimensional assembly symbol in an ECAD library matches the outline of a three-dimensional reference model in a MCAD library.

5.6 Defining the mechanical engineering feature functions

The AOs of interest in the AM Part feature function are Part_mating_feature and Part_mounting_feature. Part_mating_feature identifies a feature on the part used for alignment when two parts are mated.

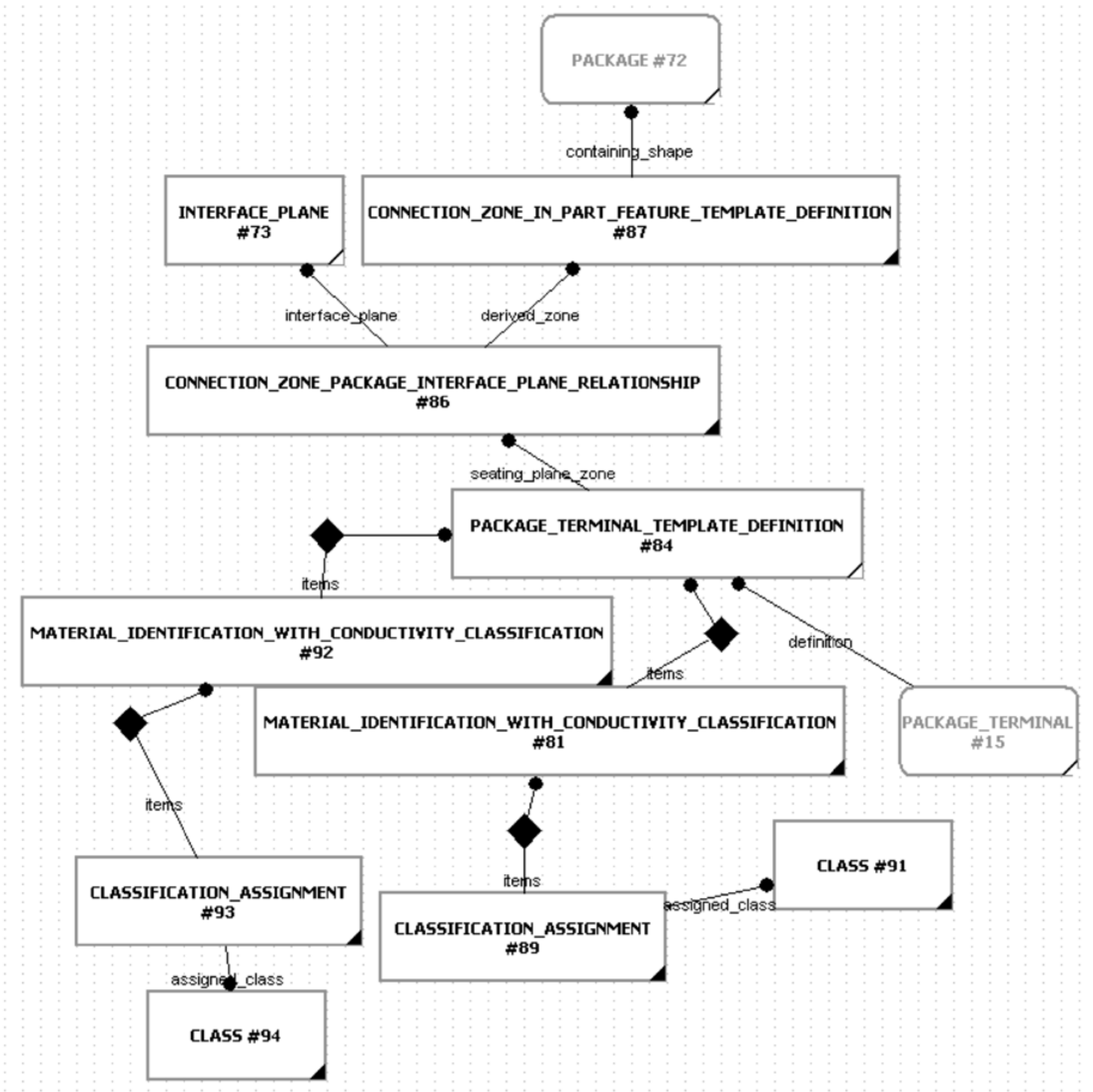

Figure 14. Assigning material conductivity classification to a Package_terminal (#15) requires assignment to the terminal definition which is a Package_terminal_template_definition (#84).

Electrical functionality (e.g., pins) is specifically excluded from the domain of Part_mating_feature. Part_mounting_feature indicates a feature on a part that may be used to constrain an occurrence of the part in the context of another component in an assembly context (e.g., a plastic pin that mates with a hole). Neither of these AOs are critical with respect to other domains in the multi-domain model.

The AOs of interest in the AM Package are Interface_plane, Visual_orientation_feature and Polarity_indication_feature. While Interface_plane is critical for mating connectors in an assembly, it is not directly critical with respect to other domains in the multi-domain model. Visual_orientation_feature and Polarity_indication_feature are of primary concern to material and process engineers so should be included in the list of items available for multi-domain communication.

5.7 Defining the mechanical engineering package

The structure representing the physical shape model for a part is contained within the AM package. Because the package model formalizes domain knowledge related to automated assembly and to component placement onto interconnect substrates, the concept of seating plane was included. Because there are cases where there are only 2D shape models available, alternative structures are provided to define orientation and cross section shape.[7]

Mechanical engineering, component application engineering, and materials and process engineering collaborate closely to develop the model for a package. The following AOs, when provided, are considered relevant for multi-domain modeling for the package:

- Connection_zone_in_part_feature_template_definition,
- Package,
- Seating_plane,
- Interface_plane,
- Package_body,
- Package_body_surface,
- Package_body_bottom_surface,
- Package_body_top_surface,
- Package_terminal,
- Package_terminal_surface_constituent_relationship,
- Package_terminal_template_definition,
- Polarity_indication_feature,
- Primary_orientation_feature,
- Secondary_orientation_feature,
- Tertiary_orientation_feature.

Other AOs may be important for specific applications and the application recommendations applied to AOs in the list would apply. The following list of types are considered relevant for multi-domain modeling for the package in particular in collaboration between mechanical engineering, component application engineering, and materials and process engineering:

- mounting_technology_type,
- pa_material_item_select,
- predefined_lead_form,
- seating_plane_intersection_type.

5.8 Defining the material and process engineering footprint

AP 210 provides capability to exchange and share footprint definitions that are either generic or that are based on specific interconnect substrate technology. Breakout patterns are also supported. Experimental results may be captured. This capability extends the ability of organizations to relate their land patterns to substrate and assembly technology. AP 210 provides capability to exchange and share definition of land template parameters including the explicit geometry of the template, as well as what electrical and thermal requirements the land template satisfies.

The following AOs that support footprint definition are considered critical in this document:

- Footprint_definition,
- Footprint_definition_shape_model,
- Part_feature_based_template_location,

[7] Package_body_top_surface and Package_body_bottom_surface provide the ability to parameterize height data using the seating plane as a reference in a 2D shape representation.

- Part_template_shape_model (inherited from ISO/TS 10303-1720, Part template shape with parameters),
- Template_location_in_structured_template (inherited from ISO/TS 10303-1720, Layered interconnect complex template),
- Template_location_in_structured_template_transform (inherited from ISO/TS 10303-1720, Layered interconnect complex template),
- Geometric_template (inherited from ISO/TS 10303-1720, Part template shape with parameters),
- Template_version (inherited from ISO/TS 10303-1722, Part template),
- Template (inherited from ISO/TS 10303-1722,Part template),
- Thermal_isolation_removal_template (inherited from ISO/TS 10303-1720, Layered interconnect complex template),
- Electrical_isolation_removal_template (inherited from ISO/TS 10303-1718, Layered interconnect simple template),
- Package_footprint_relationship_definition.

5.9 Defining the material and process engineering package

The following examples of parametric properties of the physical model that are of concern to material and process engineers are included:

- lead pitch,
- maximum body height above seating plane,
- body clearance above seating plane,
- maximum lead length below seating plane.

Figure 10 illustrates the details of the property value assignment for those items. Note that in the case of body clearance the standard does not predefine a maximum or minimum value and leaves it up to the implementation based on the sending system's capabilities.

Materials data support in AP 210 allows the exchange of several types of conductivity classification for a material:

- electrical conductivity,
- thermal conductivity,
- magnetic permeability,
- optical_insertion_loss,
- dielectric_permittivity.

The following enumerations of electrical and thermal conductivity are provided in the standard: 'conductive', 'semi-conductive', 'resistive', 'non-conductive'.

The following enumerations of relative permeability are provided in the standard: 'free space permeabilty', 'low permeability', 'medium permeability', 'highly permeable'.

The following enumerations of relative optical_insertion_loss are provided in the standard: 'vacuum', 'very low loss', 'low loss', 'medium loss', 'high loss'.

The following enumerations of relative dielectric_permitivity are provided in the standard: 'vacuum permittivity', 'low permittivity', 'medium permittivity', 'high permittivity'.

Material conductivity properties of the package body that are of concern to material and process engineers are illustrated in

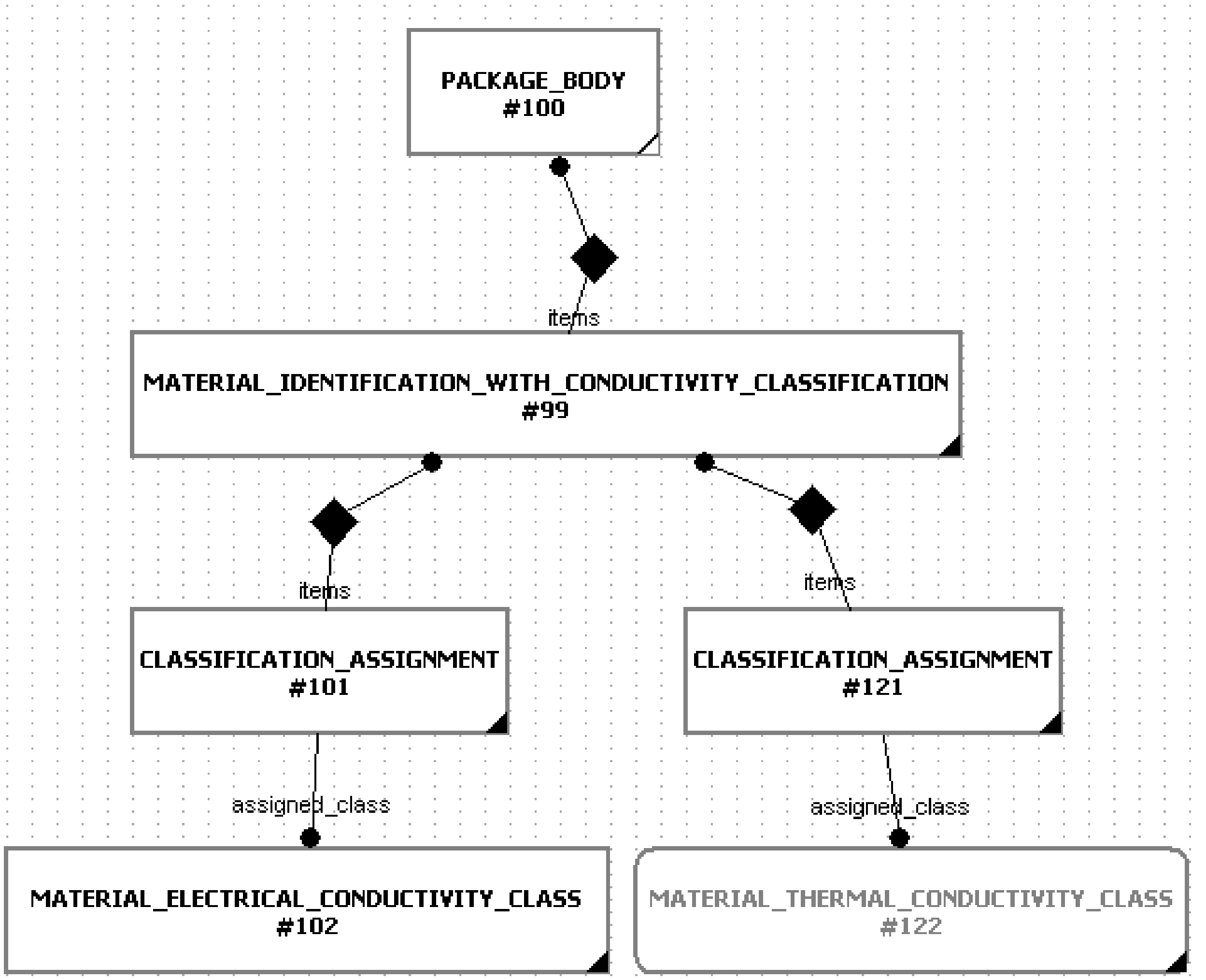

Figure 11. Examples of material properties of concern to material and process engineers that are illustrated in Figure 12 include terminal surface and core material conductivity properties.

Manufacturing specific feature classes of concern to material and process engineers are illustrated in Figure 13 that are included include Visual_orientation_feature and Polarity_indication_feature.

When other engineering domains populate the items, the material and process engineers will at least maintain subscription access to the data.

5.10 Component application engineering interaction

Interaction with component application engineering is assumed to be on a request-response basis either from the internal perspective or from the external perspective. From the internal perspective, requests for new components arise from electrical engineering domain. Component application engineering determines suitable suppliers, populates parametric datasets and supports access to supplier component application engineering data, either in model form or in graphic, e.g., PDF. Examples of application data include material properties of package bodies, package terminals. From the external perspective, component application engineering receives updates regarding material obsolescence and works with suppliers and design engineering to qualify replacement components. Component application engineering then updates the internal component database for part obsolescence and superseded information. From a modeling perspective, the component application engineering domain will generate a work request for design engineering upon determination that design engineering needs to become involved in a component issue.

6. Future work

Simulation models and requirements are obvious examples of extensions, as are investigations into the material stackup models provided by interconnect fabrication suppliers, and a truly behavioral model of the footprint.

7. Bibliography

ISO/TS 10303-1010 Product data representation and exchange: Application module: Date time

ISO/TS 10303-1011 Product data representation and exchange: Application module: Person organization

ISO/TS 10303-1012 Product data representation and exchange: Application module: Approval

ISO/TS 10303-1013 Product data representation and exchange: Application module: Person organization assignment

ISO/TS 10303-1014 Product data representation and exchange: Application module: Date time assignment

ISO/TS 10303-1022 Product data representation and exchange: Application module: Part and version identification

ISO/TS 10303-1042 Product data representation and exchange: Application module: Work request

ISO/TS 10303-1043 Product data representation and exchange: Application module: Work order

ISO/TS 10303-1404 Product data representation and exchange: Application module: Geometric model 2D 3D relationship

ISO/TS 10303-1646 Product data representation and exchange: Application module: Footprint definition

ISO/TS 10303-1661 Product data representation and exchange: Application module: Design management

ISO/TS 10303-1674 Product data representation and exchange: Application module: Functional assignment to part

ISO/TS 10303-1756 Product data representation and exchange: Application module: Conductivity material aspects

ISO/TS 10303-1760 Product data representation and exchange: Application module: Pre defined product data management specializations

ISO/TS 10303-1704 Product data representation and exchange: Application module: Network functional design view

ISO/TS 10303-1705 Product data representation and exchange: Application module: Functional usage view

ISO/TS 10303-1707 Product data representation and exchange: Application module: Package

ISO/TS 10303-1708 Packaged connector model

ISO/TS 10303-1710 Product data representation and exchange: Application module: Packaged part black box model

ISO/TS 10303-1712 Product data representation and exchange: Application module: Part feature function

ISO/TS 10303-1726 Product data representation and exchange: Application module: Physical unit 2D shape

ISO/TS 10303-1727 Product data representation and exchange: Application module: Physical unit 3D shape

ISO/TS 10303-1732 Product data representation and exchange: Application module: Physical unit usage view

ISO/TS 10303-1738 Product data representation and exchange: Application module: Product identification extension

PDM usage guide release 4.3.Available from the World Wide Web:<http://www.wikistep.org/index.php/PDM_Usage_Guide>

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