ISO 10303-209
(AP209)
Application Reference Model
(ARM) Overview

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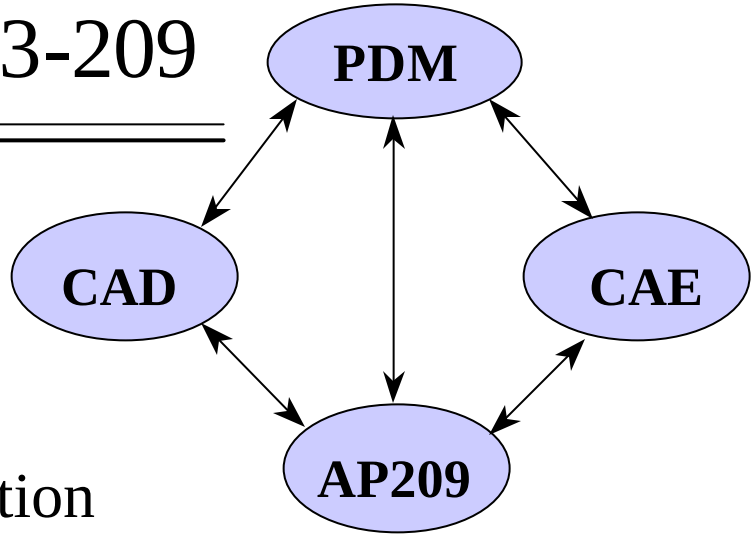
Enterprise Design and Analysis Information Integration with ISO 10303-209



- Enables sharing of PDM controlled composite and metallic design, analysis, material properties/specs information
- Enables automated, electronic feedback of product shape, performance, and property analyses to CAD with respect to PDM product structure and versioning
- Platform to extend engineering analysis STEP coverage into other analysis disciplines such as Fluid Dynamics
- Provides a long term, potentially growing, repository crucial to many industries and vendors
  - Neutral format for PDM/CAD/CAE

AP209: Composite & Metallic Structural Analysis & Related Design

Analysis Discipline Product Definitions

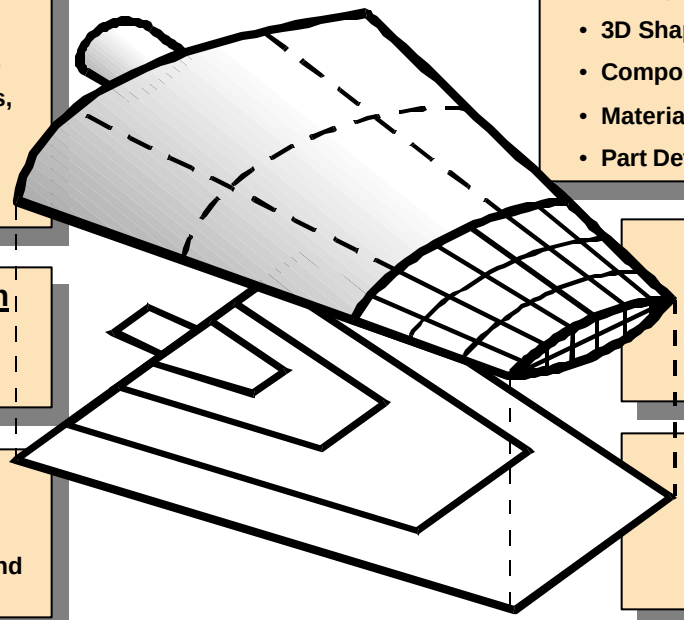
- Finite Element Analysis
  - –Model (Nodes, Elements, Properties,...)
  - –Controls (Loads, Boundary Constraints, Number of Modes,...)
  - –Results (Displacements, Stresses,...)
- Analysis Report

Design Discipline Product Definition

- Shape Representations
- Assemblies

Configuration Control, Approvals

- Part, product definitions
- Finite element analysis model, controls, and results



Information Shared Between Analysis & Design

- 3D Shape Representations
- Composite Constituents
- Material Specifications & Properties
- Part Definitions

Composite Constituents

- Ply Boundaries, Surfaces
- Laminate Stacking Tables
- Reinforcement Orientation

Material Specifications & Properties

- Composites
- Homogeneous (metallics)

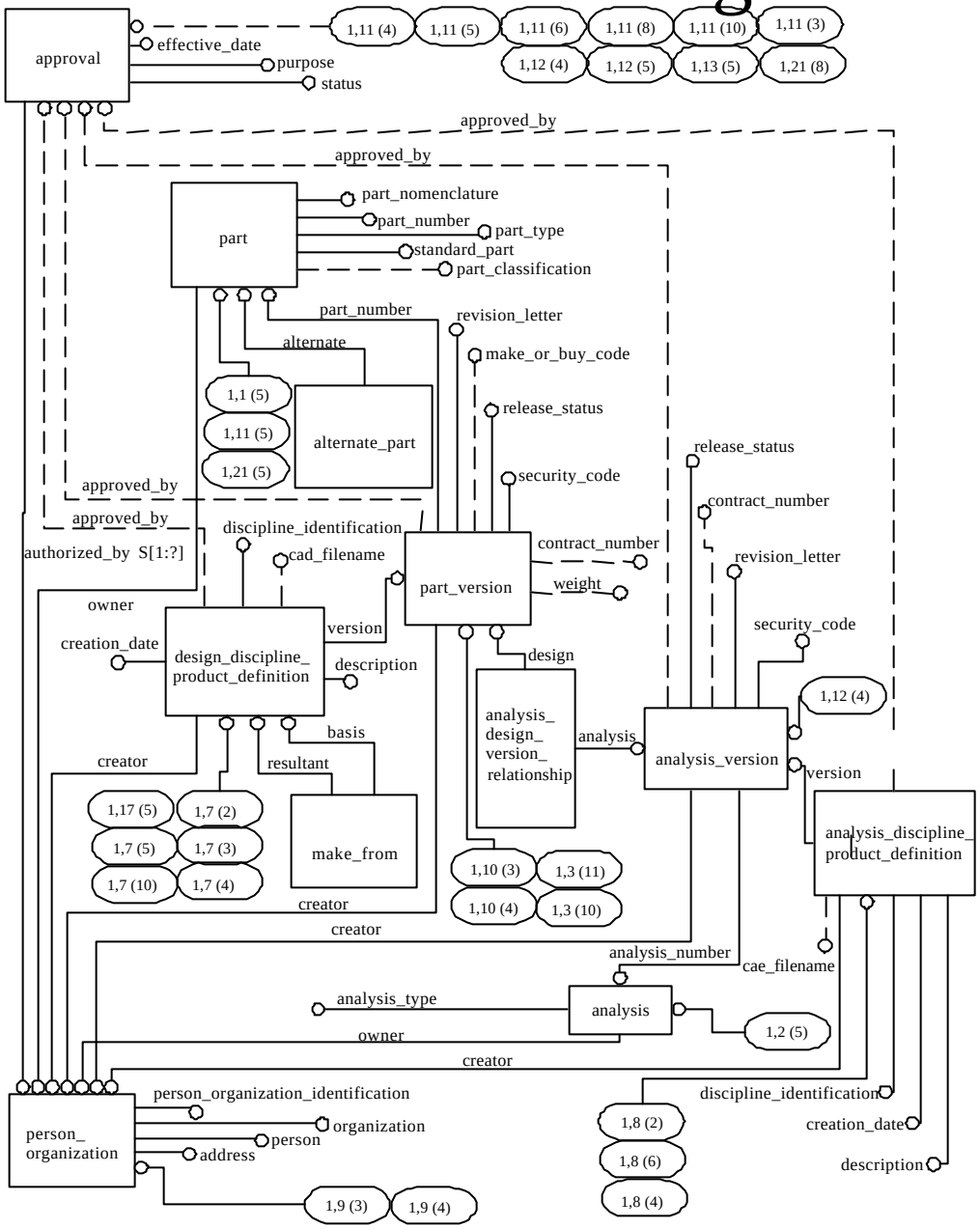
3D Shape Representation

- AP202/203 Commonality Plus Composite Specific 3D Shapes
  - – Advanced B-Representation
  - – Faceted B-Representation
  - – Manifold Surfaces With Topology
  - – Wireframe & Surface without Topology
  - – Wireframe Geometry with Topology
  - – Composite Constituent Shape Representation

Product Structure for Design and Analysis

- Harmonized with AP203, AP214, and PDM Schema
  - AP209 is a superset of AP203 requirements
- Critical concept is the two types of discipline product definitions
  - Design Discipline Product Definition (DDPD)
  - Analysis Discipline Product Definition (ADPD)
- The relationship between the Analysis Version and the Design version allows the Analysis to be revised independently of the Design Version
  - Approach harmonized with AP214
  - Analysis Version is always with respect to Design Version
- Many types of analyses may attach to the ADPD

Product Structure for Design and Analysis

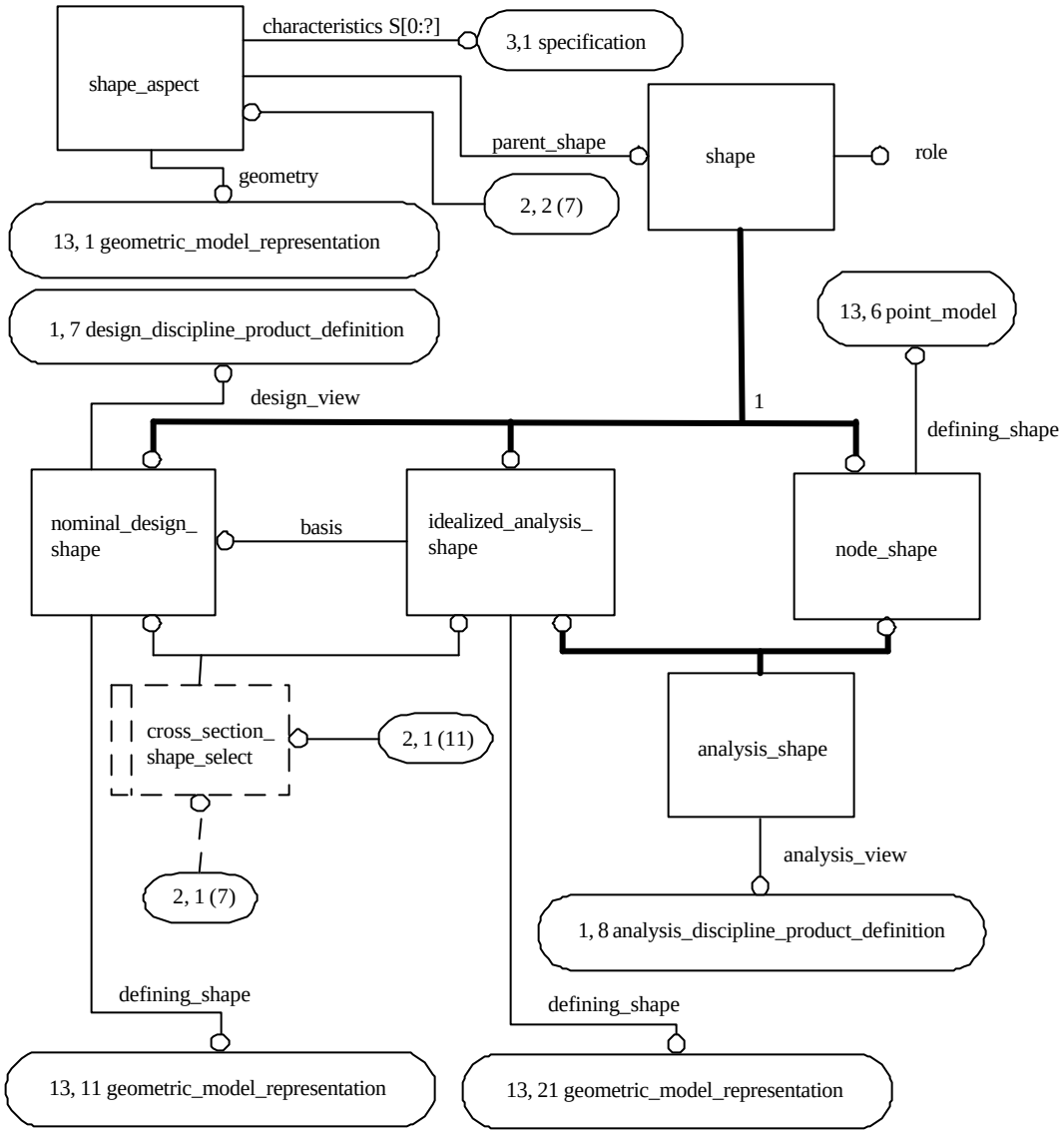


ARM Diagram 1

AP209 Shapes Add Crucial Capabilities

- AP203 shape is purely the Nominal Design Shape (NDS)
  - NDS Only belongs to the Design in AP209
  - Shape Aspect is harmonized with AP203
- AP209 has the new concepts of Idealized Analysis Shape (IAS) and Node Shape (NS)
  - IAS and NS can only belong to Analysis in AP209
  - The NDS forms a basis for the IAS
  - The Node Shape is only for Finite Element Models to allow geometric founding for nodes

AP209 Shapes Add Crucial Capabilities

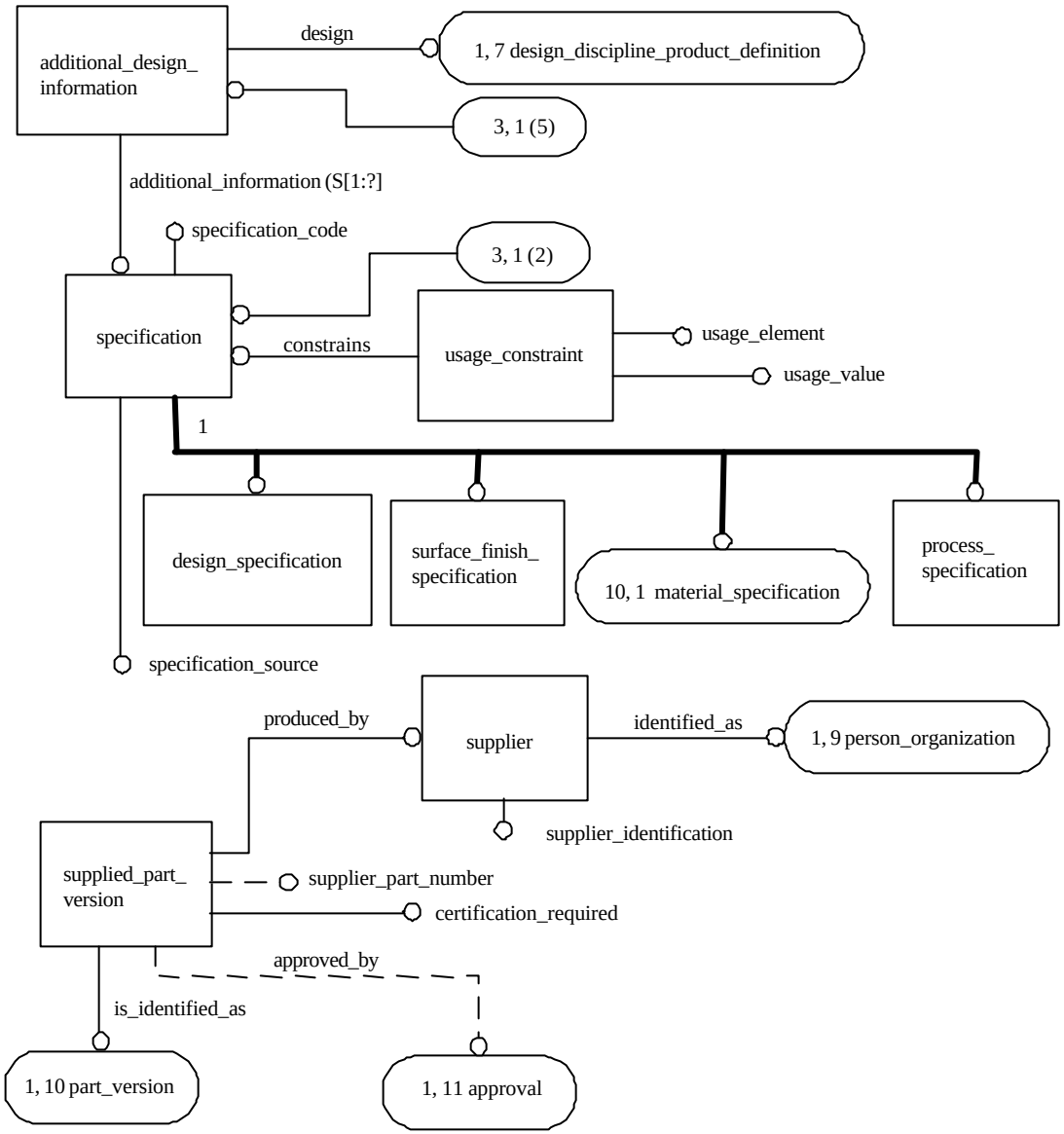


ARM Diagram 2

AP209 Adds Enhanced Material Specification

- Specification applied to the DDPD as in AP203
  - Additional Design Information relationship
- AP209 adds capability to the Material Specification
  - Much detail on composites
  - Not as much on metallics
  - Properties may be related to specification to allow Engineering Analysis material properties to be associated to a design
- The design specification can be used to communicate design intent

AP209 Adds Enhanced Material Specification

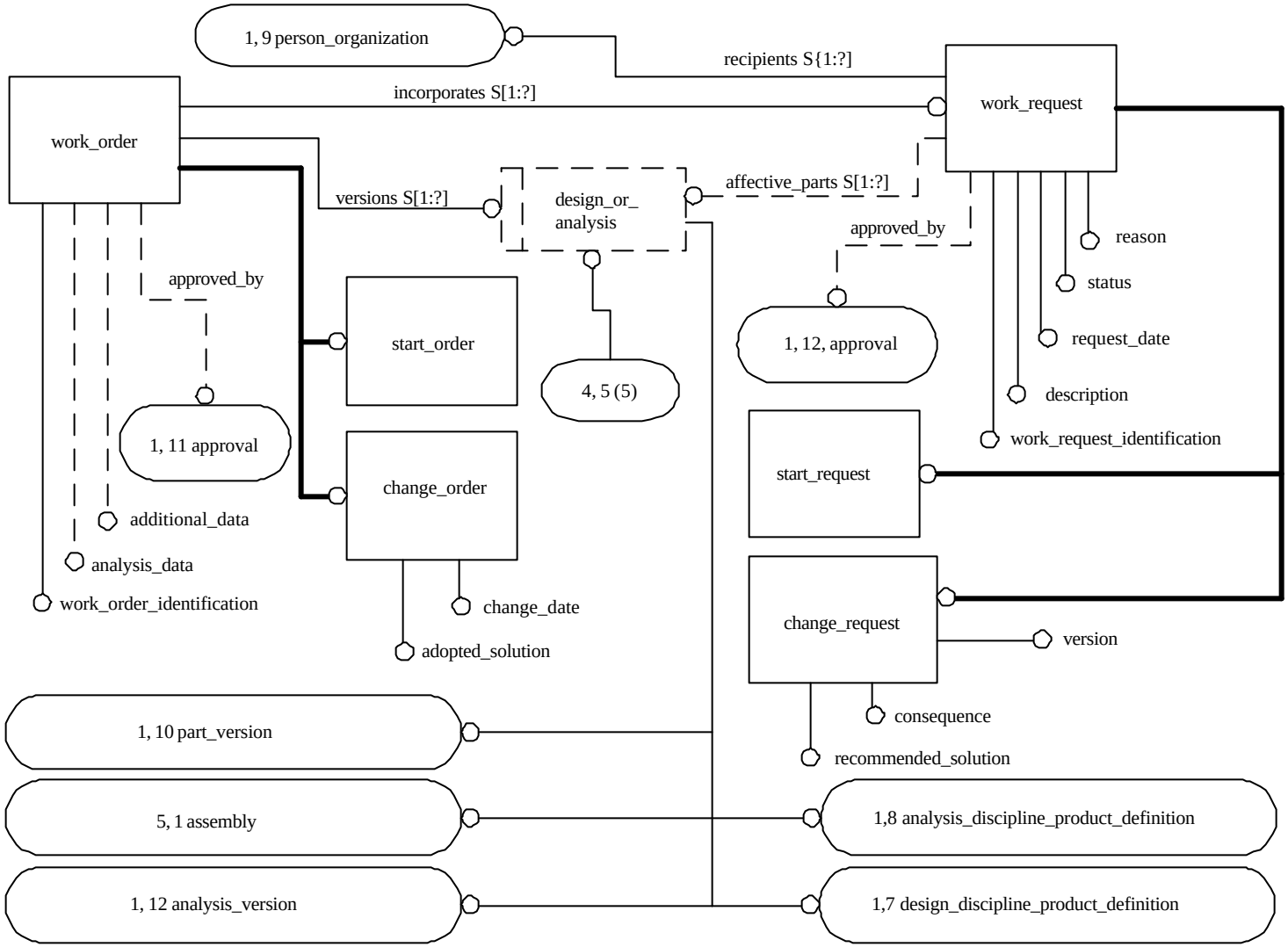


ARM Diagram 3

Activity Control Extended in AP209

- Designs and Analysis activities may be independently controlled
  - Important requirement as in many enterprises the two organizations are independent
- AP209 added activity control to more than the Product definition level (DDPD, ADPD)
  - Versions
  - Assemblies
- Note that this concept also applies to Approval
  - Approval primarily on ARM Diagram 1
  - Approvals are all optional to accommodate many industrial practices

Activity Control Extended in AP209

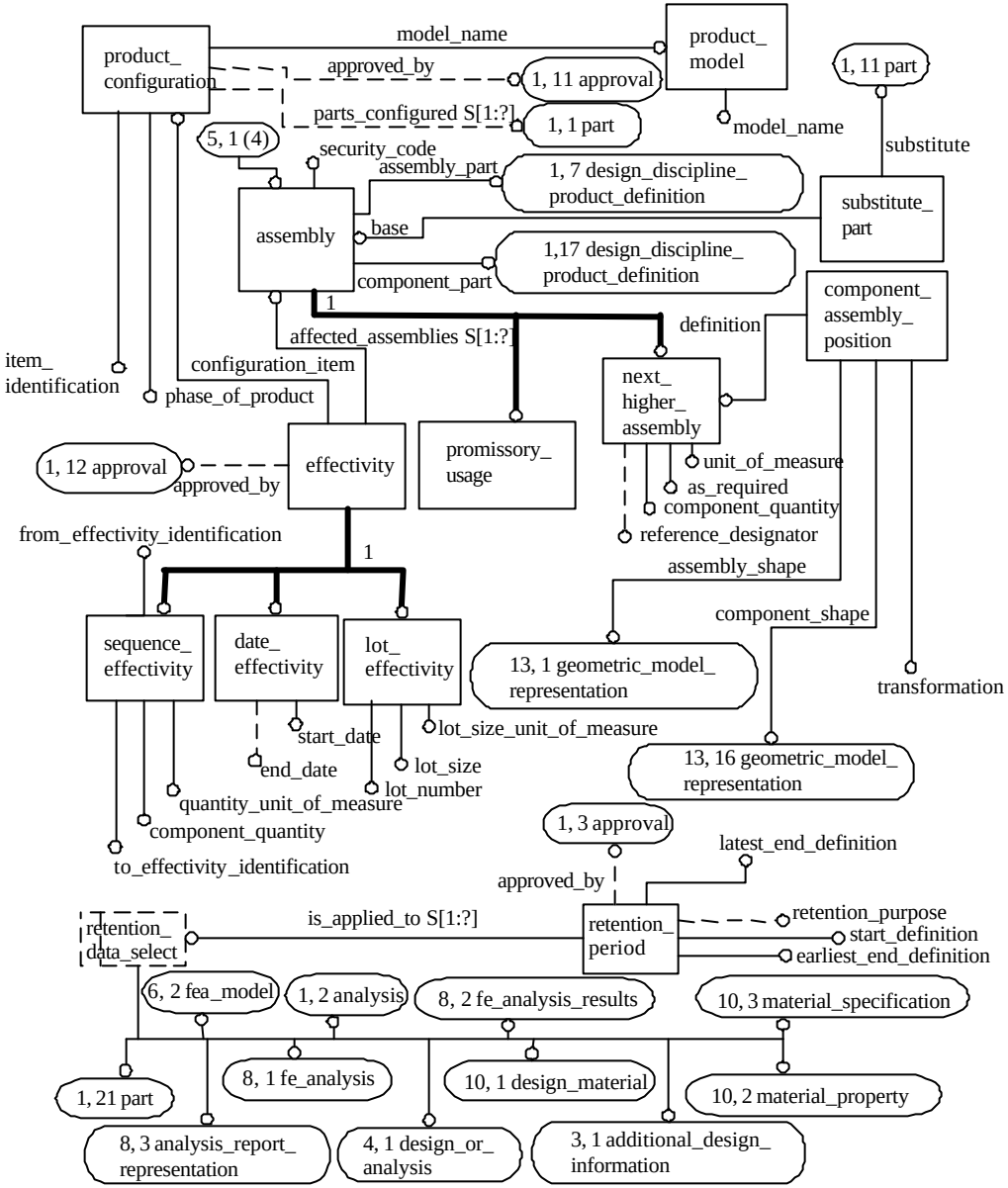


ARM Diagram 4

End Items, Assemblies, and Retention

- End Item identification and Assemblies apply only to the Design Discipline Product Definition (DDPD)
  - Consistent with AP203
  - Follows the philosophy of partitioning Analysis and Design responsibilities
  - Assembly NOT hooked into FEM Substructuring - there is a coordinated list between the Assembly components and the FEM components inside the Finite Element Model
- Retention Period has been added and harmonized with AP214

End Items, Assemblies, and Retention

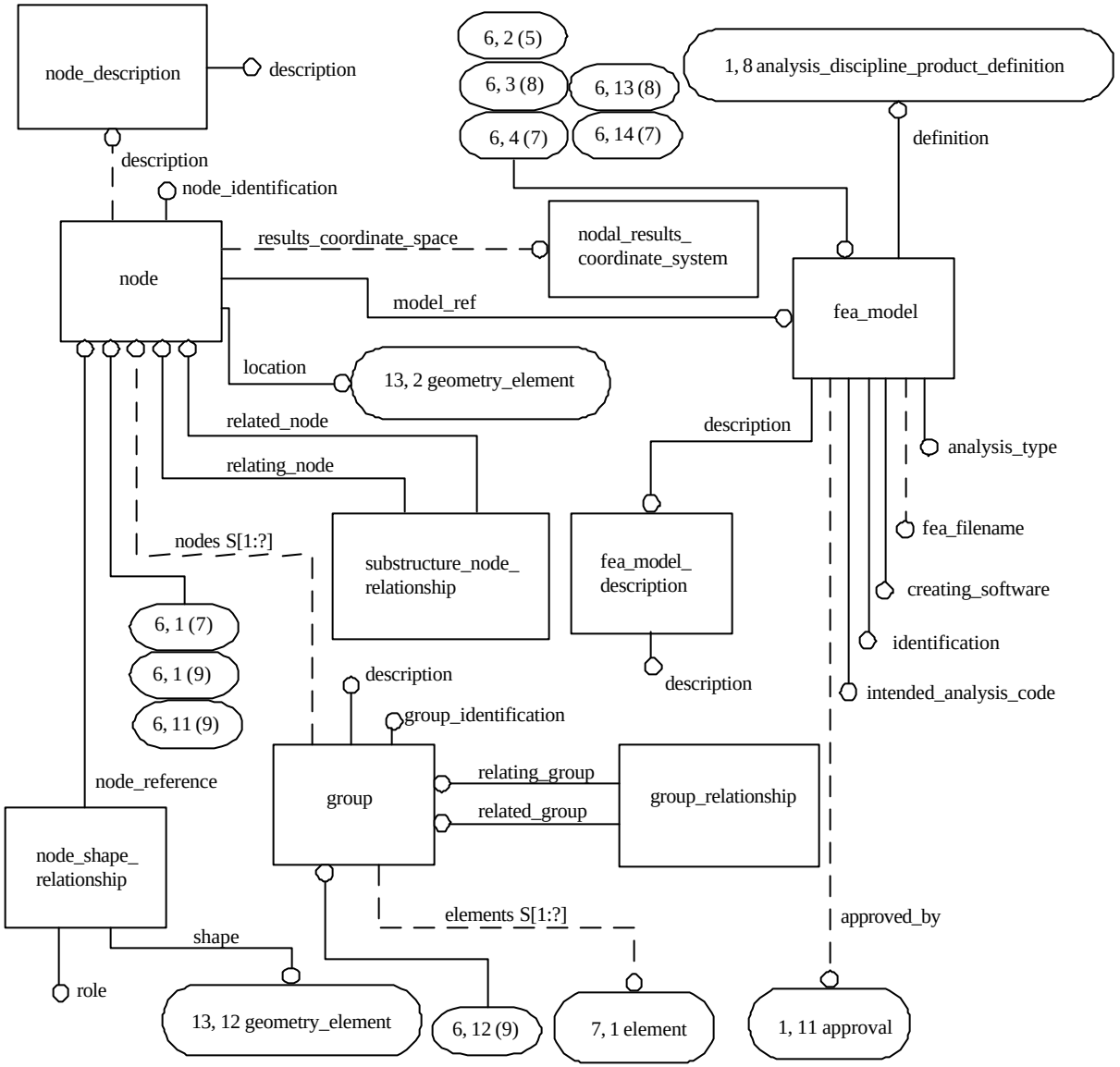


ARM Diagram 5

Finite Element Models, Groups, and Nodes

- The Finite Element Model is the ‘root node’ of a model (and any attached loads, bc’s, and analyses)
  - Must be connected to an ADPD and a model description (provides Definitional STEP capabilities)
  - Optionally may be approved
- Groups may aggregate nodes, elements, and groups
- Nodes must be defined by a geometry element
  - Cartesian, cylindrical, spherical, parametric (on a shape)
- Node may be related to a geometric element of a shape
  - Supports associativity such as node/curve for meshing

Finite Element Models, Groups, and Nodes

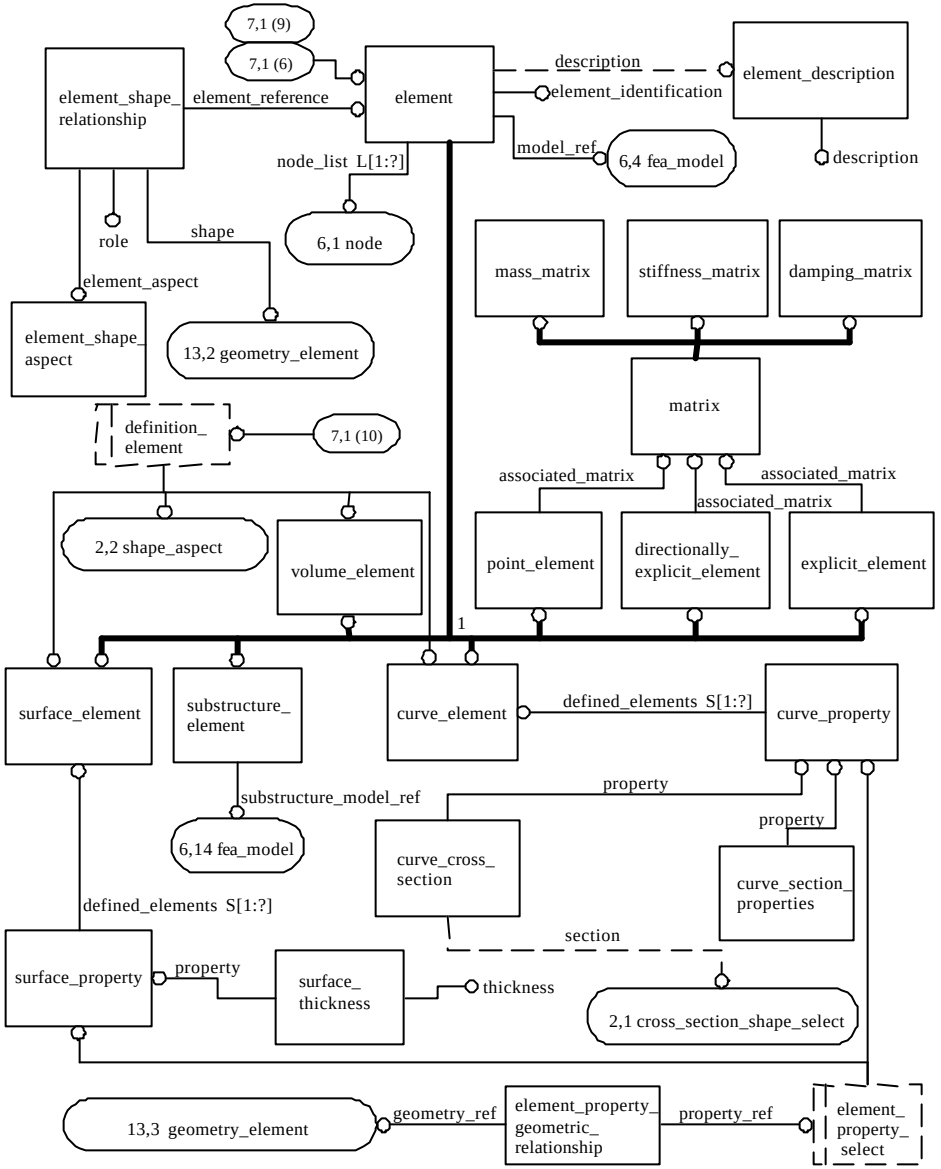


ARM Diagram 6

Elements, Properties, and Substructuring

- Elements types include: implicit (curve, surface, volume) and explicit (direct matrix definition)
- Aspects of an element (edge, surface, volume) may be associated to geometric elements of the same type
- Curve (beam) elements may have an associated geometric representation of cross-section
- Materials may be metallic or composite
  - Composites may have shape and structure defined
- Substructuring defined for elements and nodes (diagrams 6 & 7)

Elements, Properties, and Substructuring

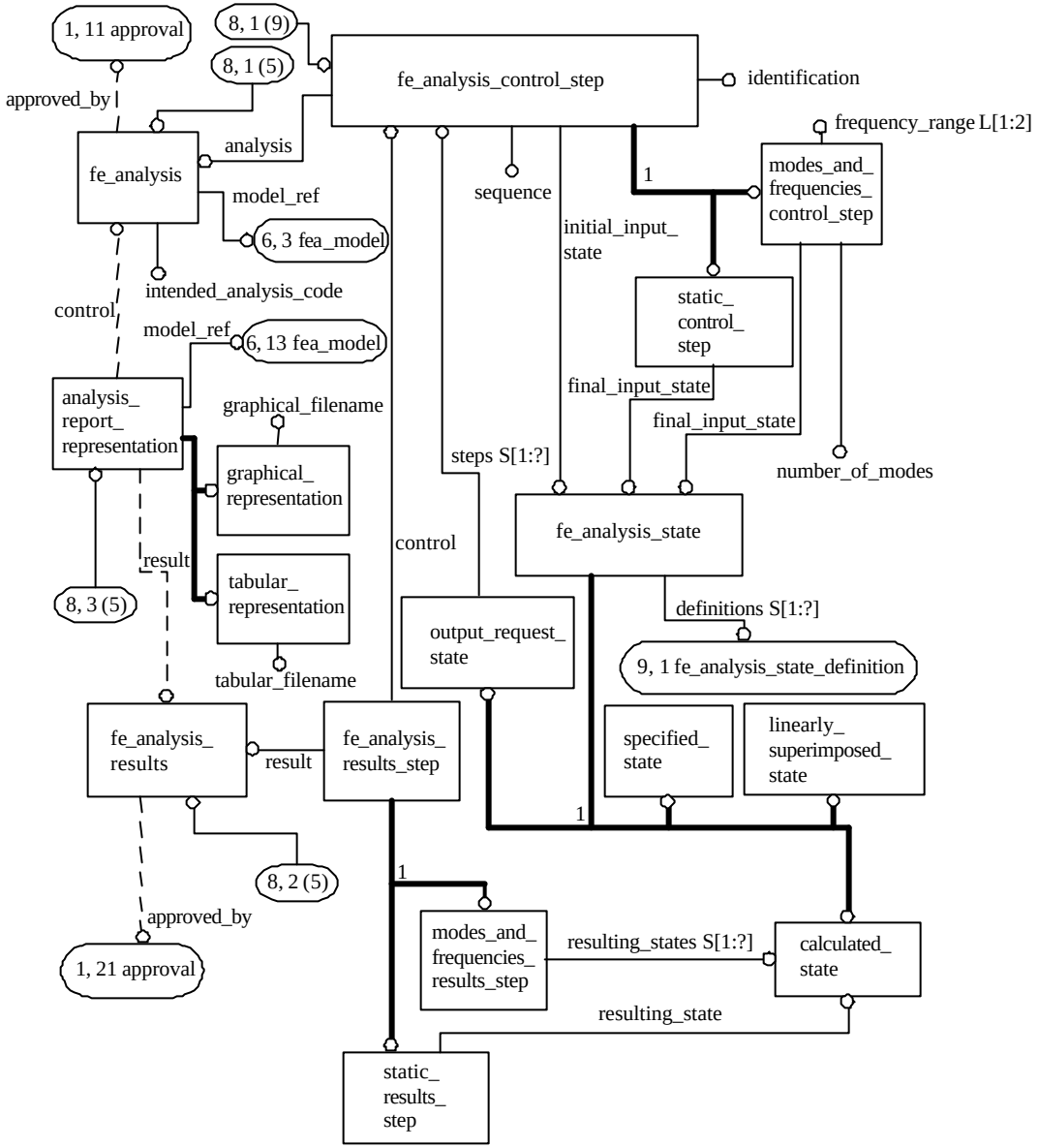


ARM Diagram 7

Static and Dynamic Analysis Control

- Analyses consist of one or many Steps
  - Initial conditions for a Step may be specified, previously computed, or a linear combination of those
  - The structure of analysis control was developed specifically to accommodate nonlinear analyses as well
- State definition entities are used to represent output requests, specified and calculated states
- Analysis report allows the documentation of analysis and design decisions and post processing assumptions - not just output summaries

Static and Dynamic Analysis Control

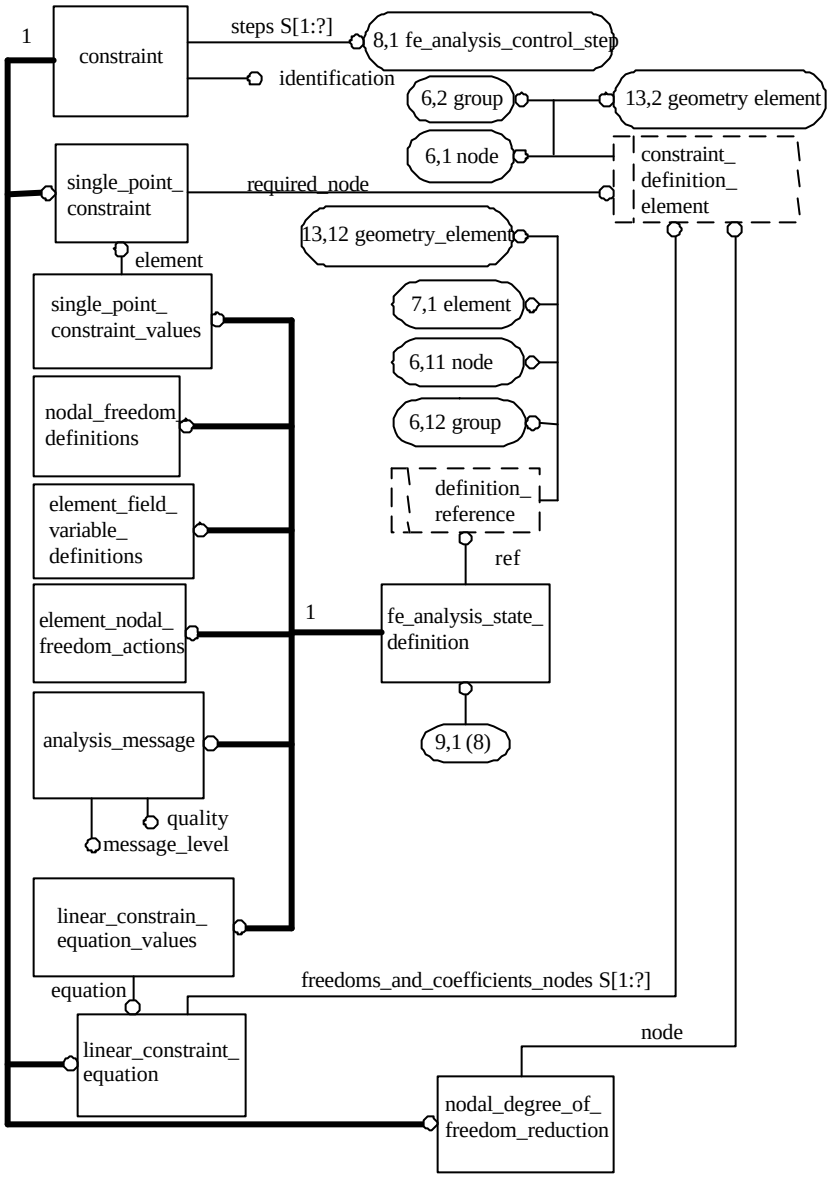


ARM Diagram 8

State and Constraint Definitions

- State Definitions specify:
  - Element fields such as stress and strain
  - Element nodal freedom actions for reaction forces
  - Nodal freedom definitions such as displacement, force
  - Constraint equation values
- Constraints may be applied to one or many nodes
  - Constraints are applied to one or many Steps
- State Definitions and Constraints may be applied to Nodes/Elements, Groups or Geometry Elements
  - All FEM entities associated to a Geometry Element will have the Constraints or Definitions applied to them

State and Constraint Definitions

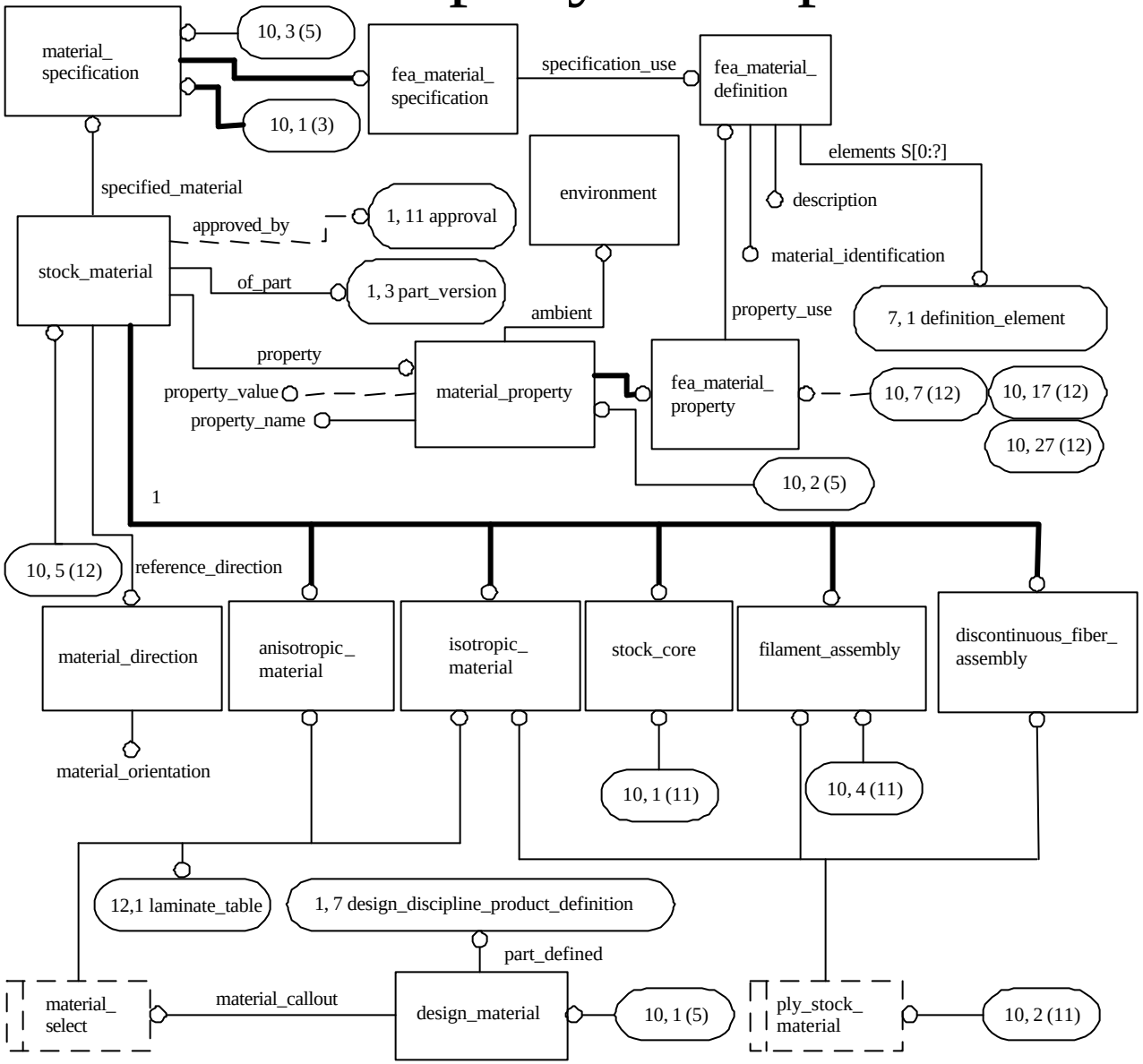


ARM Diagram 9

Stock Material Property and Specification

- A Stock Material has both a Specification and a Property
  - Both may also be specialized FEA information that is applied to an Element
  - Properties are defined with respect to an environment
- Stock material has a Part/Version/Approval and may be:
  - Isotropic/Anisotropic for metals and other non-structured materials
  - Filament/Core/Discontinuous Fiber for structured materials (Composites)
  - Applied to a Design Discipline Product Definition

Stock Material Property and Specification

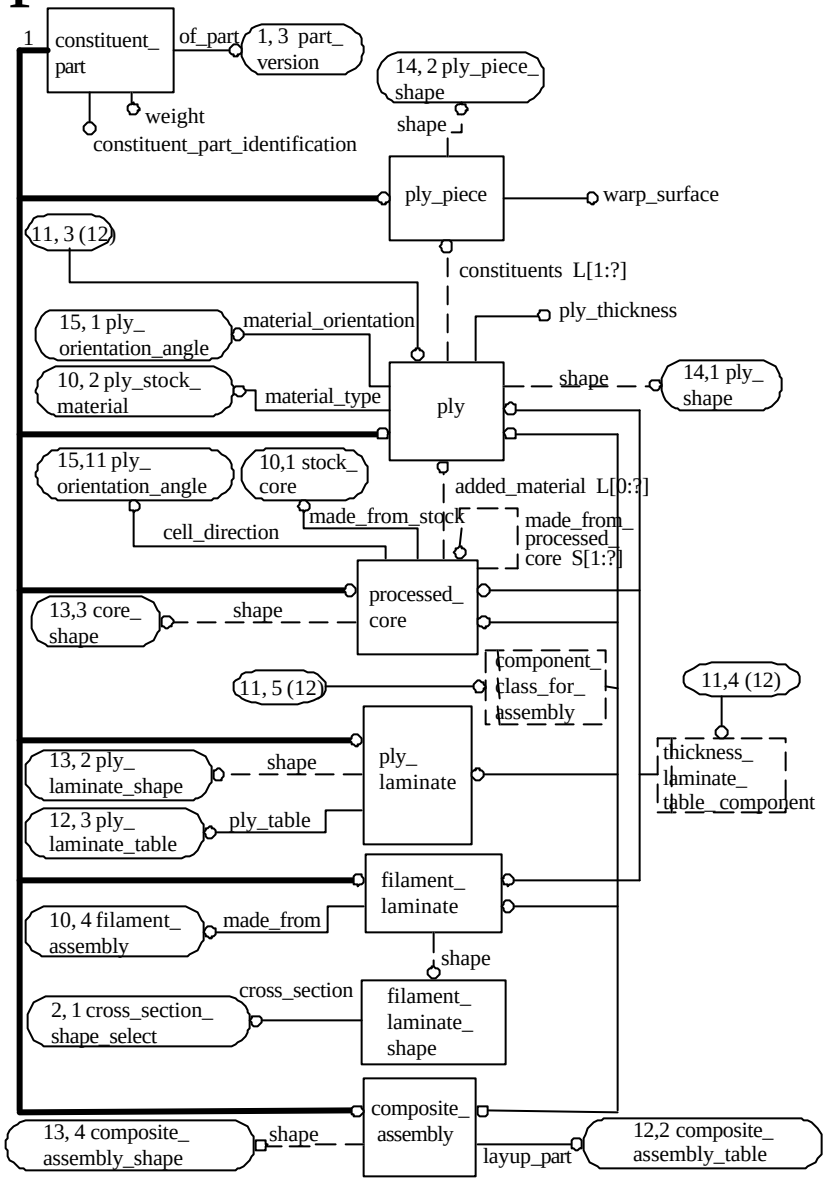


ARM Diagram 10

Composite Constituent Definition

- Composite Constituents have a Part/Version
  - Plies may be made up of Ply Pieces
  - Core may be made up of Core pieces
  - Ply laminates provide a ply structure within a structure capability
  - Filament laminates provide curvilinear constituents such as tows and ‘noodles’ in Tees or Hats
  - Composite Assemblies provide a general structure within a structure capability
  - All have an associated orientation, shape representation, and Stock Material

Composite Constituent Definition

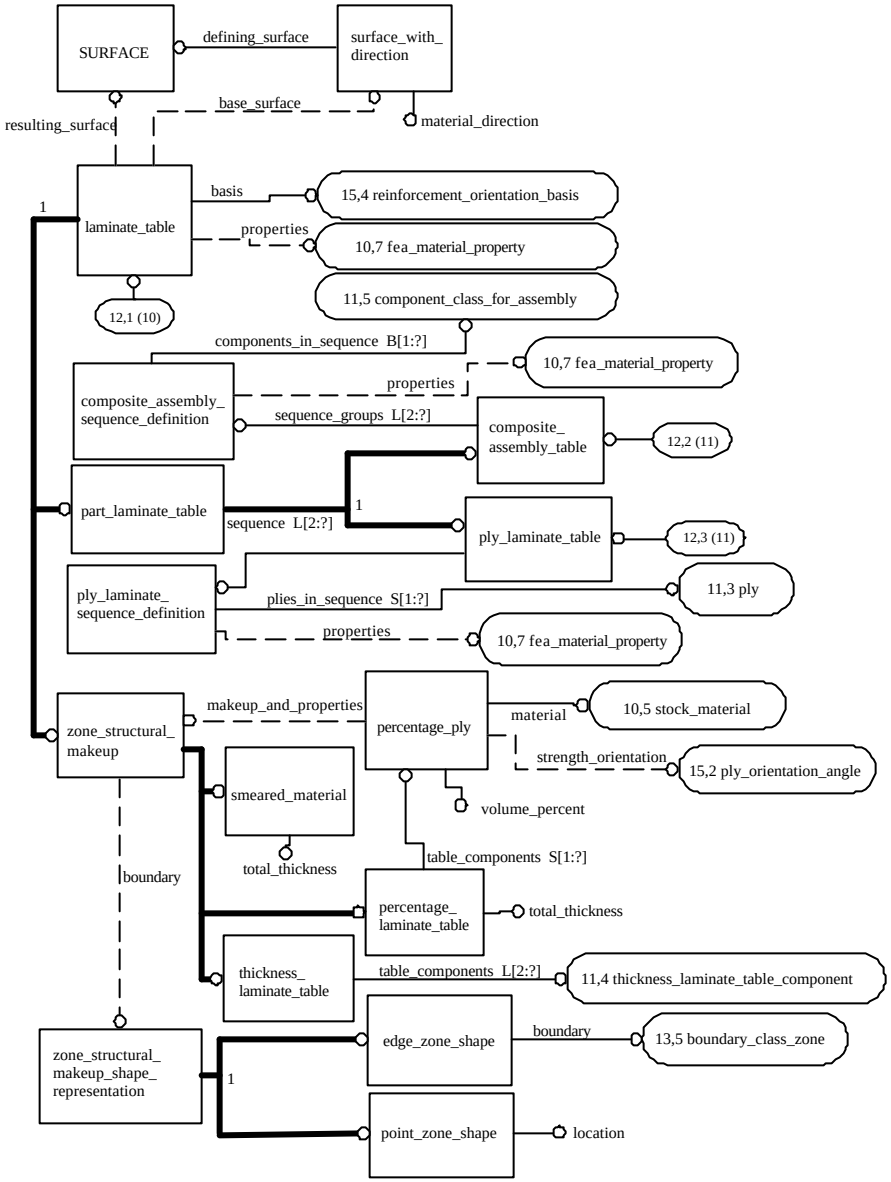


ARM Diagram 11

Part and Zone Laminate Tables

- AP209 specifies two types of Laminate Tables
  - Part Laminate Tables define material structure in a layer by layer fashion, where the layers do not have to cover the entire part
  - Zone Laminate Tables are points or areas of constant laminate thickness
- Laminate Tables have a basis (tool) surface with associated orientation
  - Optionally may specify a resulting surface
- FEA material properties may be defined at the Laminate or sub-Laminate level

Part and Zone Laminate Tables

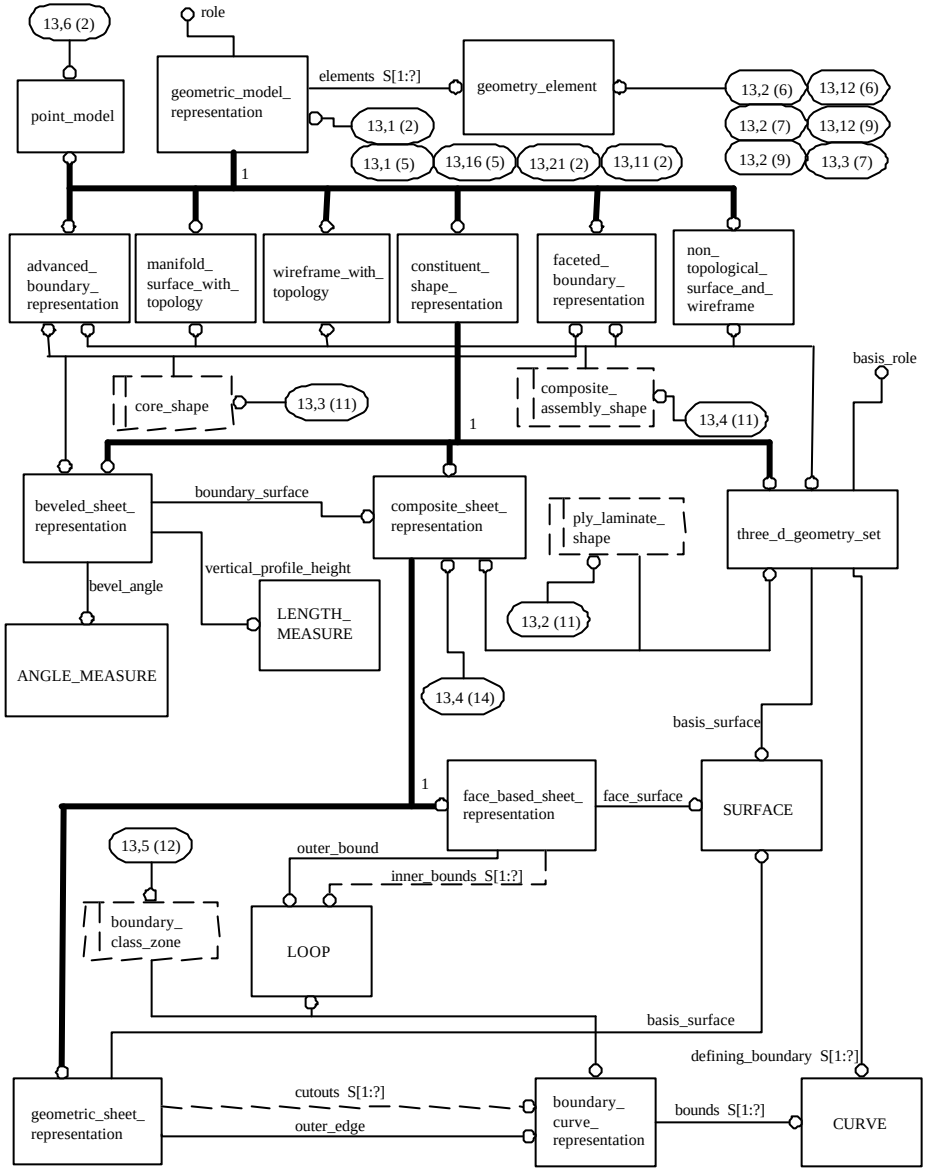


ARM Diagram 12

AP209 Shape Representation Extends AP203

- The standard five Shape AIC's are used in AP209
  - Advanced, faceted BREPs
  - Manifold Surface with Topology
  - Wireframe with Topology
  - Non-Topological Surface and Wireframe
- AP209 adds Constituent Shape Representation (CCR) to describe Composite Constituents
  - CCR Representations vary from a simple bag of geometry to topological surfaces with holes
- AP209 also adds the Point Model to geometrically found Finite Element Models Part and Zone Laminate Tables

AP209 Shape Representation Extends AP203

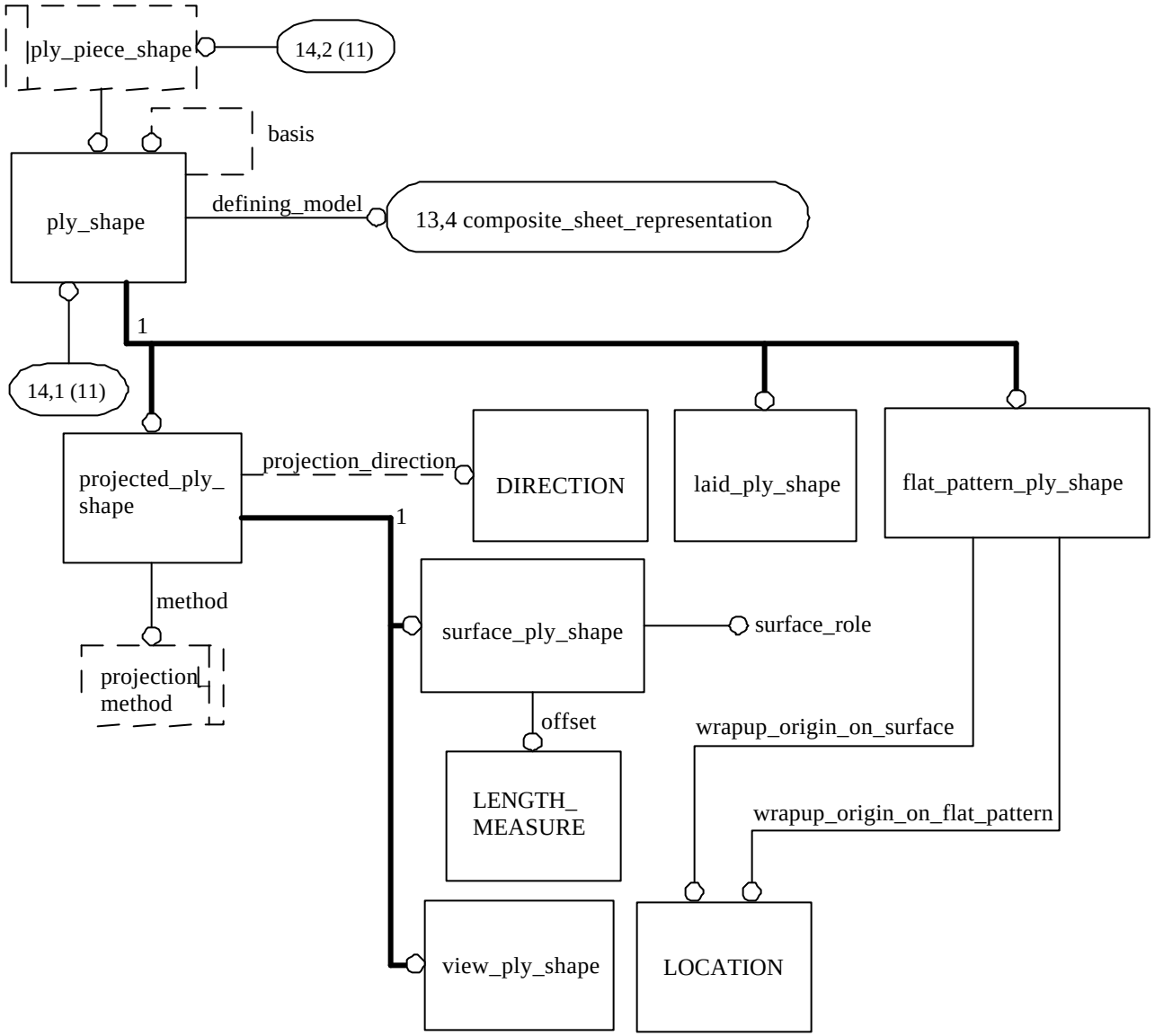


ARM Diagram 13

Ply Shape Definition

- Ply Shapes may be defined as:
  - Projected onto a surface
  - Projected onto a viewing plane
  - Laid in three-dimensional space
  - A flat pattern of a three-dimensional as-laid ply
- Ply Shape definitions have an associated shape representation

Ply Shape Definition

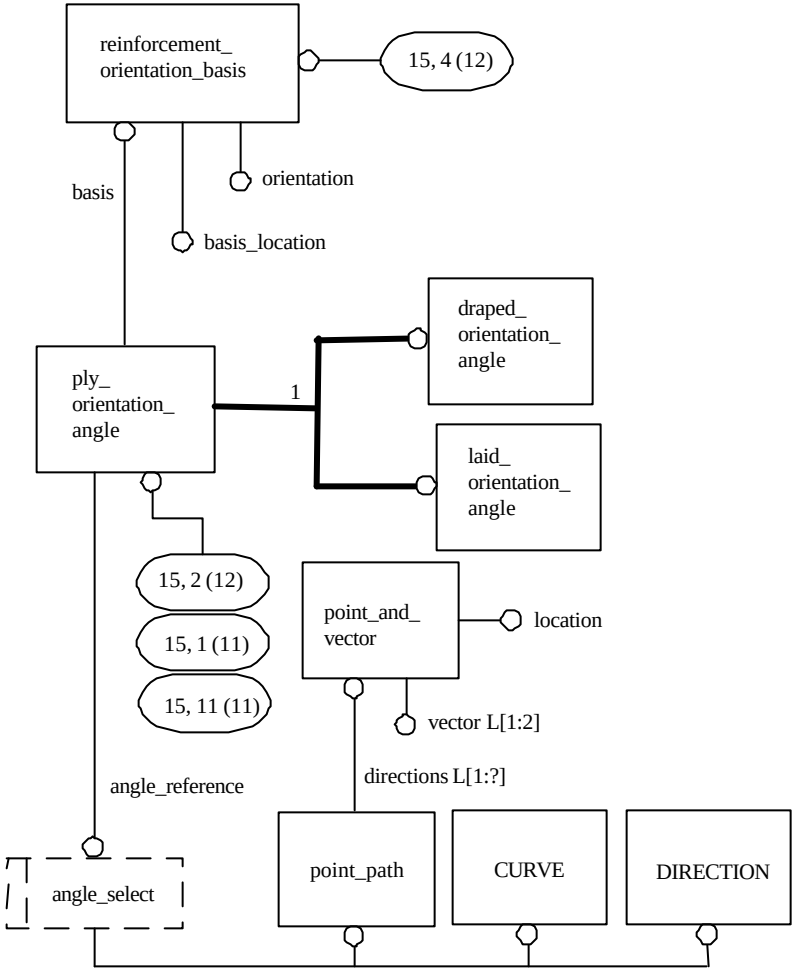


ARM Diagram 14

Ply Orientation Specification

- Plies may be oriented with respect to a reinforcement basis (typically called a rosette)
- The orientation angle is either:
  - A draped definition in which case it specifies a start position and direction
  - An as-laid definition
- The ply orientation angle may be specified by a:
  - Direction (which may be processed to an angle)
  - A spine curve (as is common in fiber placement)
  - A series of point/vector pair in a path (as is a common output from draping tools)

Ply Orientation Specification



ARM Diagram 15