Project Ontology

Integrated Model-Centric Engineering
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1 Introduction

The Project Ontology defines concepts and properties for describing a project in terms of its stakeholders, concerns, work breakdown, and deliverables. It provides a basis for specialization by domain experts.
2 Imported Ontologies

- http://imce.jpl.nasa.gov/foundation/analysis/analysis
- http://imce.jpl.nasa.gov/discipline/mechanical/mechanical
2 IMPORTED ONTOLOGIES
3 Namespaces


**PrimitiveTypes**  http://imce.jpl.nasa.gov/www.omg.org/spec/PrimitiveTypes/20110701/PrimitiveTypes#

**PrimitiveTypes-backbone**  http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/www.omg.org/spec/PrimitiveTypes/20110701/PrimitiveTypes#

**PrimitiveTypes-metamodel**  http://imce.jpl.nasa.gov/www.omg.org/spec/PrimitiveTypes/20110701/PrimitiveTypes-metamodel#


data-view http://www.w3.org/2003/g/data-view#

dc http://purl.org/dc/elements/1.1/
dc-backbone http://imce.jpl.nasa.gov/backbone/purl.org/dc/elements/1.1#
mechanical http://imce.jpl.nasa.gov/discipline/mechanical/mechanical#
mechanical-backbone http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/discipline/mechanical/mechanical#
mechanical-embedding http://imce.jpl.nasa.gov/discipline/mechanical/mechanical-embedding#
omf http://imce.jpl.nasa.gov/foundation/omf/omf#
owl http://www.w3.org/2002/07/owl#
owl-backbone http://imce.jpl.nasa.gov/backbone/www.w3.org/2002/07/owl#
owl2-mof2 http://imce.jpl.nasa.gov/foundation/owl2-mof2/owl2-mof2#
owl2-mof2-backbone http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/foundation/owl2-mof2/owl2-mof2#
owl2-mof2-embedding http://imce.jpl.nasa.gov/foundation/owl2-mof2/owl2-mof2-embedding#
project http://imce.jpl.nasa.gov/foundation/project/project#
project-backbone  http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/foundation/project/project#
project-embedding http://imce.jpl.nasa.gov/foundation/project/project-embedding#
project-embedding-backbone  http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/foundation/project/project-embedding#

rdf  http://www.w3.org/1999/02/22-rdf-syntax-ns#
rdf-backbone  http://imce.jpl.nasa.gov/backbone/www.w3.org/1999/02/22-rdf-syntax-ns#
rdfs  http://www.w3.org/2000/01/rdf-schema#
rdfs-backbone  http://imce.jpl.nasa.gov/backbone/www.w3.org/2000/01/rdf-schema#

risk  http://imce.jpl.nasa.gov/discipline/risk/risk#
risk-embedding  http://imce.jpl.nasa.gov/discipline/risk/risk-embedding#

state-analysis  http://imce.jpl.nasa.gov/discipline/state-analysis/state-analysis#
state-analysis-embedding  http://imce.jpl.nasa.gov/discipline/state-analysis/state-analysis-embedding#

swrl  http://www.w3.org/2003/11/swrl#

time  http://imce.jpl.nasa.gov/foundation/time/time#
time-backbone  http://imce.jpl.nasa.gov/backbone/imce.jpl.nasa.gov/foundation/time/time#
time-embedding  http://imce.jpl.nasa.gov/foundation/time/time-embedding#

vandv  http://imce.jpl.nasa.gov/discipline/vandv/vandv#
vandv-embedding  http://imce.jpl.nasa.gov/discipline/vandv/vandv-embedding#

xsd  http://www.w3.org/2001/XMLSchema#
xsd-backbone  http://imce.jpl.nasa.gov/backbone/www.w3.org/2001/XMLSchema#
4 Abstract Class Definitions

4.1 AssignedElement

An AssignedElement is any model element that can have the isAssignedTo relationship with a Role.

Asserted Superclasses: project-backbone:Aspect

Inferred Superclasses: project-backbone:Thing

Asserted Subclasses: Delivers, DevelopedElement, Executes, Process, Receives, ReliesOn, Supplies

Asserted Object Properties: isAssignedTo [0..*] Role

The class definition diagram for AssignedElement is shown in Figure 1.

4.2 DevelopedElement

A DevelopedElement is any model element that manifests DevelopmentStates. Example DevelopedElements include spacecraft, thermal test facility, and requirements document.

Asserted Superclasses: AssignedElement, project-backbone:Aspect

Inferred Superclasses: project-backbone:Thing

Asserted Subclasses: Facility, mission:Component, mission:Interface, Product

Asserted Object Properties: isDescribedBy [0..*] Product

    isReliedOnBy [0..*] Authority

    manifests [0..*] DevelopmentState

Inferred Object Properties: isAssignedTo [0..*] Role

The class definition diagram for DevelopedElement is shown in Figure 2.

4.3 RealizedElement

A RealizedElement is any element that realizes or isRealizedBy another element.

Asserted Superclasses: project-backbone:Aspect

Inferred Superclasses: project-backbone:Thing


Asserted Object Properties: isRealizedBy [0..*] RealizedElement

    realizes [0..*] RealizedElement

The class definition diagram for RealizedElement is shown in Figure 3.
Figure 1: Class definition diagram for AssignedElement.
Figure 2: Class definition diagram for DevelopedElement.
ABSTRACT CLASS DEFINITIONS

Figure 3: Class definition diagram for RealizedElement.
4.4 SuppliedElement

A SuppliedElement is any model element that an Authority properly supplies. Example SuppliedElements include Mission and Component.

**Asserted Superclasses:** project-backbone:Aspect

**Inferred Superclasses:** project-backbone:Thing

**Asserted Subclasses:** mission:Component, mission:Mission, Product

**Asserted Object Properties:** isSuppliedBy [0..1] Authority

The class definition diagram for SuppliedElement is shown in Figure 4.
5 Concrete Class Definitions

5.1 Authority

An Authority is any entity that asserts a fact in a model. Example Authorities include Program, Project, and WorkPackage. (The association of an Authority with its asserted facts requires mechanisms outside the vocabulary of OWL itself, e.g., named graphs. For this reason, there is no object property authorizes. Authorization is conveyed by the organization of statements in a repository.)

Asserted Superclasses: base:Package, project-backbone:Entity


Asserted Subclasses: Program, Project, WorkPackage

Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
    base:hasCanonicalName [0..1] xsd:string
    base:hasDescription [0..1] xsd:string
    base:hasIdentifier [0..*] xsd:string
    base:hasIndexEntry [0..*] xsd:string
    base:hasShortName [0..1] xsd:string
    base:hasSortKey [0..1] xsd:string
    base:hasUuid [0..1] xsd:string

Asserted Object Properties: authorizes [0..*] Authority
    executes [0..*] Process
    isResponsibilityOf [0..1] Organization
    produces [0..*] Product
    reliesOn [0..*] DevelopedElement
    supplies [0..*] SuppliedElement

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
    analysis:isCharacterizedBy [0..*] analysis:Characterization
    analysis:isExplainedBy [0..*] analysis:Explanation
    analysis:isLimitedBy [0..*] analysis:Assumption
    analysis:isValidatedBy [0..*] analysis:Explanation

The class definition diagram for Authority is shown in Figure 5. The class usage diagram for Authority is shown in Figure 6.
Figure 5: Class definition diagram for Authority.
Figure 6: Class usage diagram for Authority.
5.2 Concern

A Concern represents a specific interest that one or more stakeholders have in the successful completion of a Project or Program and its Missions.

**Asserted Superclasses:** analysis:MeasuredElement, base:AggregatedElement, base:IdentifiedElement, project-backbone:Entity

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, base-backbone:Aspect, base-backbone:Thing, project-backbone:Thing

**Asserted Subclasses:** mission:Objective

**Inferred Datatype Properties:**
- base:hasAlternateName [0..*] xsd:string
- base:hasCanonicalName [0..1] xsd:string
- base:hasDescription [0..1] xsd:string
- base:hasIdentifier [0..*] xsd:string
- base:hasIndexEntry [0..*] xsd:string
- base:hasShortName [0..1] xsd:string
- base:hasSortKey [0..1] xsd:string
- base:hasUuid [0..1] xsd:string

**Asserted Object Properties:** isRepresentedBy [0..*] Stakeholder

**Inferred Object Properties:**
- analysis:isAnalyzedBy [0..*] analysis:Explanation
- analysis:isCharacterizedBy [0..*] analysis:Characterization
- analysis:isExplainedBy [0..*] analysis:Explanation
- analysis:isLimitedBy [0..*] analysis:Assumption
- analysis:isMeasuredBy [0..*] analysis:Criterion
- analysis:isValidatedBy [0..*] analysis:Explanation
- base:aggregates [0..*] Concern
- base:isAggregatedIn [0..*] Concern

The class definition diagram for Concern is shown in Figure 7. The class usage diagram for Concern is shown in Figure 8.

5.3 Deliverable

A Deliverable is the result of successful execution of a Process. It may be an input to or prerequisite for another Process.

**Asserted Superclasses:** base:IdentifiedElement, project-backbone:Entity

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, base-backbone:Aspect, base-backbone:Thing, project-backbone:Thing

**Asserted Subclasses:** DevelopmentState
5.3 Deliverable

Figure 7: Class definition diagram for Concern.

Figure 8: Class usage diagram for Concern.
**Asserted Datatype Properties:**  
- `isRequiredNotLaterThan: [0..1] xsd:date`

**Inferred Datatype Properties:**  
- `base:hasAlternateName [0..*] xsd:string`
  - `base:hasCanonicalName [0..1] xsd:string`
  - `base:hasDescription [0..1] xsd:string`
  - `base:hasIdentifier [0..*] xsd:string`
  - `base:hasIndexEntry [0..*] xsd:string`
  - `base:hasShortName [0..1] xsd:string`
  - `base:hasSortKey [0..1] xsd:string`
  - `base:hasUuid [0..1] xsd:string`

**Asserted Object Properties:**  
- `isDeliveredBy [0..1] Process`
  - `isReceivedBy [0..*] Process`
  - `participatesIn [0..*] Interchange`

**Inferred Object Properties:**  
- `analysis:isAnalyzedBy [0..*] analysis:Explanation`
  - `analysis:isCharacterizedBy [0..*] analysis:Characterization`
  - `analysis:isExplainedBy [0..*] analysis:Explanation`
  - `analysis:isLimitedBy [0..*] analysis:Assumption`
  - `analysis:isValidatedBy [0..*] analysis:Explanation`

The class definition diagram for Deliverable is shown in Figure 9. The class usage diagram for Deliverable is shown in Figure 10.
5.4 DevelopmentState

A DevelopmentState is a kind of Deliverable that represents a defined condition for a DevelopedElement. DevelopmentStates may be unique to the DevelopedElement; example DevelopmentStates for a Product include Preliminary, Draft, and Final.

**Asserted Superclasses:** Deliverable


**Inferred Datatype Properties:**
- base:hasAlternateName [0..*] xsd:string
- base:hasCanonicalName [0..1] xsd:string
- base:hasDescription [0..1] xsd:string
- base:hasIdentifier [0..*] xsd:string
- base:hasIndexEntry [0..*] xsd:string
- base:hasShortName [0..1] xsd:string
- base:hasSortKey [0..1] xsd:string
- base:hasUuid [0..1] xsd:string
- isRequiredNotLaterThan [0..1] xsd:date

**Asserted Object Properties:** isManifestedBy [0..1] DevelopedElement

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

---

![Diagram of DevelopmentState](image-url)
### 5.5 Facility

A Facility is any asset (e.g., laboratory, assembly facility, test facility, etc.) whose DevelopmentState may be a Deliverable for a project process.

**Asserted Superclasses:** base:IdentifiedElement, DevelopedElement, project-backbone:Entity


**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string

- base:hasCanonicalName [0..1] xsd:string
- base:hasDescription [0..1] xsd:string
- base:hasIdentifier [0..*] xsd:string
- base:hasIndexEntry [0..*] xsd:string
- base:hasShortName [0..1] xsd:string
Figure 12: Class usage diagram for DevelopmentState.
Figure 13: Class definition diagram for Facility.

base:hasSortKey [0..1] xsd:string
base:hasUuid [0..1] xsd:string

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
analysis:isCharacterizedBy [0..*] analysis:Characterization
analysis:isExplainedBy [0..*] analysis:Explanation
analysis:isLimitedBy [0..*] analysis:Assumption
analysis:isValidatedBy [0..*] analysis:Explanation

isAssignedTo [0..*] Role
isDescribedBy [0..*] Product
isReliedOnBy [0..*] Authority
manifests [0..*] DevelopmentState

The class definition diagram for Facility is shown in Figure 13. The class usage diagram for Facility is shown in Figure 14.

5.6 Interchange

An Interchange represents the intended joint behavior of a pair of Processes. It indicates that a Deliverable may be delivered by one Process and received by the other Process.

Asserted Superclasses: base:IdentifiedElement, project-backbone:Entity


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
base:hasCanonicalName [0..1] xsd:string
base:hasDescription [0..1] xsd:string
base:hasIdentifier [0..*] xsd:string
base:hasIndexEntry [0..*] xsd:string
base:hasShortName [0..1] xsd:string
base:hasSortKey [0..1] xsd:string
Figure 14: Class usage diagram for Facility.
5.7 Organization

An Organization is any entity that isResponsibleFor a Authority.

Asserted Superclasses: project-backbone:Entity

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

Asserted Object Properties: hasResponsibilityFor [0..*] Authority

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
analysis:isCharacterizedBy [0..*] analysis:Characterization
analysis:isExplainedBy [0..*] analysis:Explanation
analysis:isLimitedBy [0..*] analysis:Assumption
analysis:isValidatedBy [0..*] analysis:Explanation
The class definition diagram for Organization is shown in Figure 17. The class usage diagram for Organization is shown in Figure 18.

5.8 Person

A Person corresponds to an individual named person. A Person belongsTo zero or more Organizations.

**Asserted Superclasses:** base:IdentifiedElement, project-backbone:Entity

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, base-backbone:Aspect, base-backbone:Thing, project-backbone:Thing

**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string

  base:hasCanonicalName [0..1] xsd:string
  base:hasDescription [0..1] xsd:string
  base:hasIdentifier [0..*] xsd:string
  base:hasIndexEntry [0..*] xsd:string
  base:hasSortKey [0..1] xsd:string
  base:hasUuid [0..1] xsd:string

**Asserted Object Properties:** belongsTo [0..*] Organization
Figure 17: Class definition diagram for Organization.

Figure 18: Class usage diagram for Organization.
5.9 Policy

A Policy represents a specific exercise of authority that binds one or more model elements.

**Asserted Superclasses:** project-backbone:Entity

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Object Properties:** binds [0..*] mission:SpecifiedElement

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

The class definition diagram for Policy is shown in Figure 21. The class usage diagram for Policy is shown in Figure 22.
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Figure 20: Class usage diagram for Person.

Figure 21: Class definition diagram for Policy.
Figure 22: Class usage diagram for Policy.
5.10 Process

A Process is an activity authorized by a WorkPackage in support of delivering a Component or producing a Product. Examples include design trajectory, conduct trade study, and review subsystem design.

Asserted Superclasses: AssignedElement base:IdentifiedElement, project-backbone:Entity, RealizedElement


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
  base:hasCanonicalName [0..1] xsd:string
  base:hasDescription [0..1] xsd:string
  base:hasIdentifier [0..*] xsd:string
  base:hasIndexEntry [0..*] xsd:string
  base:hasShortName [0..1] xsd:string
  base:hasSortKey [0..1] xsd:string
  base:hasUuid [0..1] xsd:string

Asserted Object Properties: delivers [0..*] Deliverable
  invokes [0..*] Process
  isExecutedBy [0..1] Authority
  isInvokedBy [0..*] Process
  isInvolvedIn1 [0..*] Interchange
  isInvolvedIn2 [0..*] Interchange
  receives [0..*] Deliverable

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
  analysis:isCharacterizedBy [0..*] analysis:Characterization
  analysis:isExplainedBy [0..*] analysis:Explanation
  analysis:isLimitedBy [0..*] analysis:Assumption
  analysis:isValidatedBy [0..*] analysis:Explanation
  isAssignedTo [0..*] Role
  isRealizedBy [0..*] Process
  realizes [0..*] Process

The class definition diagram for Process is shown in Figure 23. The class usage diagram for Process is shown in Figure 24.
5.10 Process

Figure 23: Class definition diagram for Process.

Figure 24: Class usage diagram for Process.
5.11 Product

A Product is a document or other artifact supplied by a WorkPackage. Example Products include trade study reports, design documents, and inspection reports.

**Asserted Superclasses:** base:AggregatedElement, base:IdentifiedElement, DevelopedElement, project-backbone:Entity, SuppliedElement

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, AssignedElement, base-backbone:Aspect, base-backbone:Thing

**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string

  base:hasCanonicalName [0..1] xsd:string
  base:hasDescription [0..1] xsd:string
  base:hasIdentifier [0..*] xsd:string
  base:hasIndexEntry [0..*] xsd:string
  base:hasShortName [0..1] xsd:string
  base:hasSortKey [0..1] xsd:string
  base:hasUuid [0..1] xsd:string

**Asserted Object Properties:** describes [0..*] DevelopedElement

  isApprovedBy [0..*] Role
  isConcurredBy [0..*] Role
  isPreparedBy [0..*] Role
  isProducedBy [0..1] Authority

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

  analysis:isCharacterizedBy [0..*] analysis:Characterization
  analysis:isExplainedBy [0..*] analysis:Explanation
  analysis:isLimitedBy [0..*] analysis:Assumption
  analysis:isValidatedBy [0..*] analysis:Explanation

  base:aggregates [0..*] Product
  base:isAggregatedIn [0..*] Product
  isAssignedTo [0..*] Role
  isDescribedBy [0..*] Product
  isReliedOnBy [0..*] Authority
  isSuppliedBy [0..1] Authority
  manifests [0..*] DevelopmentState

The class definition diagram for Product is shown in Figure 25. The class usage diagram for Product is shown in Figure 26.
5.12 Program

Asserted Superclasses: Authority


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string  
base:hasCanonicalName [0..1] xsd:string  
base:hasDescription [0..1] xsd:string  
base:hasIdentifier [0..*] xsd:string  
base:hasIndexEntry [0..*] xsd:string  
base:hasShortName [0..1] xsd:string  
base:hasSortKey [0..1] xsd:string  
base:hasUuid [0..1] xsd:string

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation  
analysis:isCharacterizedBy [0..*] analysis:Characterization  
analysis:isExplainedBy [0..*] analysis:Explanation  
analysis:isLimitedBy [0..*] analysis:Assumption  
analysis:isValidatedBy [0..*] analysis:Explanation  
authorizes [0..*] Authority  
exectes [0..*] Process  
isResponsibilityOf [0..1] Organization  
produces [0..*] Product  
reliesOn [0..*] DevelopedElement

Figure 25: Class definition diagram for Product.
Figure 26: Class usage diagram for Product.
Figure 27: Class definition diagram for Program.

A **Project** is a kind of **Authority** that supplies a related set of **Missions** in pursuit of a set of **Objectives**.

**Asserted Superclasses:** Authority, RealizedElement


**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string

  - base:hasCanonicalName [0..1] xsd:string
  - base:hasDescription [0..1] xsd:string
  - base:hasIdentifier [0..*] xsd:string
  - base:hasIndexEntry [0..*] xsd:string
  - base:hasShortName [0..1] xsd:string
  - base:hasSortKey [0..1] xsd:string
  - base:hasUuid [0..1] xsd:string

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

  - analysis:isCharacterizedBy [0..*] analysis:Characterization
  - analysis:isExplainedBy [0..*] analysis:Explanation
  - analysis:isLimitedBy [0..*] analysis:Assumption
  - analysis:isValidatedBy [0..*] analysis:Explanation

  - authorizes [0..*] Authority
  - executes [0..*] Process
  - isRealizedBy [0..*] Project
Figure 28: Class usage diagram for Program.
Figure 29: Class definition diagram for Project.

The class definition diagram for Project is shown in Figure 29. The class usage diagram for Project is shown in Figure 30.

5.14 Role

A Role corresponds to a set of assignments meant to be filled by a single Person.

Asserted Superclasses: base:IdentifiedElement, project-backbone:Entity


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
  base:hasCanonicalName [0..1] xsd:string
  base:hasDescription [0..1] xsd:string
  base:hasIdentifier [0..*] xsd:string
  base:hasIndexEntry [0..*] xsd:string
  base:hasSortKey [0..1] xsd:string
  base:hasUuid [0..1] xsd:string

Asserted Object Properties: approves [0..*] Product
  concurs [0..*] Product
deglegatesTo [0..*] Role
hasAssignment [0..*] AssignedElement
isDelegateOf [0..1] Role
isRoleOf [0..1] Person
Figure 30: Class usage diagram for Project.
5.15 Stakeholder

A Stakeholder is a person or organization with a recognized interest in the successful completion of a Project or Program. Example Stakeholders include scientists, NASA Directorates, nuclear safety advocates, and the general public.

Asserted Superclasses: base:IdentifiedElement, project-backbone:Entity


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
  base:hasCanonicalName [0..1] xsd:string
  base:hasDescription [0..1] xsd:string
  base:hasIdentifier [0..*] xsd:string
  base:hasIndexEntry [0..*] xsd:string
  base:hasShortName [0..1] xsd:string
Figure 32: Class usage diagram for Role.
5.16 WorkPackage

A WorkPackage represents a discrete unit of Project cost, schedule, and activity. WorkPackages form a hierarchy called the Work Breakdown Structure.

**Asserted Superclasses:** Authority, base:Package, RealizedElement


**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string

Base:hasCanonicalName [0..1] xsd:string

Base:hasDescription [0..1] xsd:string

Base:hasIdentifier [0..*] xsd:string

---

Figure 33: Class definition diagram for Stakeholder.

- **base:hasSortKey** [0..1] xsd:string
- **base:hasUuid** [0..1] xsd:string

**Asserted Object Properties:** represents [0..*] Concern

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

analysis:isCharacterizedBy [0..*] analysis:Characterization

analysis:isExplainedBy [0..*] analysis:Explanation

analysis:isLimitedBy [0..*] analysis:Assumption

analysis:isValidatedBy [0..*] analysis:Explanation

The class definition diagram for Stakeholder is shown in Figure 33. The class usage diagram for Stakeholder is shown in Figure 34.
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Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
analysis:isCharacterizedBy [0..*] analysis:Characterization
analysis:isExplainedBy [0..*] analysis:Explanation
analysis:isLimitedBy [0..*] analysis:Assumption
analysis:isValidatedBy [0..*] analysis:Explanation

authorizes [0..*] Authority
executes [0..*] Process
isRealizedBy [0..*] WorkPackage
isResponsibilityOf [0..1] Organization
produces [0..*] Product
realizes [0..*] WorkPackage
reliesOn [0..*] DevelopedElement
supplies [0..*] mission:Component

The class definition diagram for WorkPackage is shown in Figure 35. The class usage diagram for WorkPackage is shown in Figure 36.

Figure 34: Class usage diagram for Stakeholder.

Figure 35: Class definition diagram for WorkPackage.
Figure 35: Class definition diagram for WorkPackage.

Figure 36: Class usage diagram for WorkPackage.
Figure 37: Class definition diagram for Approves.

6 Object Property Reification Class Definitions

6.1 Approves

Asserted Superclasses: HasAssignment


Asserted Object Properties: hasApprovesSource [0..1] Role
hasApprovesTarget [0..1] Product

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
analysis:isCharacterizedBy [0..*] analysis:Characterization
analysis:isExplainedBy [0..*] analysis:Explanation
analysis:isLimitedBy [0..*] analysis:Assumption
analysis:isValidatedBy [0..*] analysis:Explanation
hasHasAssignmentSource [0..1] Role
hasHasAssignmentTarget [0..1] AssignedElement

Reified Object Properties: approves

The class definition diagram for Approves is shown in Figure 37. The class usage diagram for Approves is shown in Figure 38.

6.2 Authorizes

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing
Figure 38: Class usage diagram for Approves.
Figure 39: Class definition diagram for Authorizes.

Asserted Object Properties: `hasAuthorizesSource` [0..1] Authority
`hasAuthorizesTarget` [0..1] Authority

Inferred Object Properties: `analysis:isAnalyzedBy` [0..*] analysis:Explanation
`analysis:isCharacterizedBy` [0..*] analysis:Characterization
`analysis:isExplainedBy` [0..*] analysis:Explanation
`analysis:isLimitedBy` [0..*] analysis:Assumption
`analysis:isValidatedBy` [0..*] analysis:Explanation

Reified Object Properties: `authorizes`

The class definition diagram for Authorizes is shown in Figure 39. The class usage diagram for Authorizes is shown in Figure 40.

6.3 BelongsTo

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

Asserted Object Properties: `hasBelongsToSource` [0..1] Person
`hasBelongsToTarget` [0..1] Organization

Inferred Object Properties: `analysis:isAnalyzedBy` [0..*] analysis:Explanation
`analysis:isCharacterizedBy` [0..*] analysis:Characterization
`analysis:isExplainedBy` [0..*] analysis:Explanation
`analysis:isLimitedBy` [0..*] analysis:Assumption
`analysis:isValidatedBy` [0..*] analysis:Explanation
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Reified Object Properties: \texttt{belongsTo}

The class definition diagram for BelongsTo is shown in Figure \ref{fig:belongsTo}. The class usage diagram for BelongsTo is shown in Figure \ref{fig:belongsToUsage}.

6.4 Binds

\textbf{Asserted Superclasses:} project-backbone:ReifiedObjectProperty

\textbf{Inferred Superclasses:} analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

\textbf{Asserted Object Properties:} \texttt{hasBindsSource} [0..1] Policy, \texttt{hasBindsTarget} [0..1] mission:SpecifiedElement

\textbf{Inferred Object Properties:} analysis:isAnalyzedBy [0..*] analysis:Explanation, analysis:isCharacterizedBy [0..*] analysis:Characterization, analysis:isExplainedBy [0..*] analysis:Explanation, analysis:isLimitedBy [0..*] analysis:Assumption, analysis:isValidatedBy [0..*] analysis:Explanation

\textbf{Reified Object Properties:} \texttt{binds}

The class definition diagram for Binds is shown in Figure \ref{fig:binds}. The class usage diagram for Binds is shown in Figure \ref{fig:bindsUsage}.

6.5 Concurs

\textbf{Asserted Superclasses:} HasAssignment
Figure 41: Class definition diagram for BelongsTo.

Figure 42: Class usage diagram for BelongsTo.

Asserted Object Properties: \textbf{hasConcursSource} [0..1] \textbf{Role} \\
\textbf{hasConcursTarget} [0..1] \textbf{Product}

Inferred Object Properties: \textbf{analysis:isAnalyzedBy} [0..*] analysis:Explanation \\
\textbf{analysis:isCharacterizedBy} [0..*] analysis:Characterization \\
\textbf{analysis:isExplainedBy} [0..*] analysis:Explanation \\
\textbf{analysis:isLimitedBy} [0..*] analysis:Assumption \\
\textbf{analysis:isValidatedBy} [0..*] analysis:Explanation \\
\textbf{hasHasAssignmentSource} [0..1] \textbf{Role} \\
\textbf{hasHasAssignmentTarget} [0..1] \textbf{AssignedElement}

Reified Object Properties: \textbf{CONCURS}

The class definition diagram for Concurs is shown in Figure 45. The class usage diagram for Concurs is shown in Figure 46.

6.6 DelegatesTo

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

Asserted Object Properties: \textbf{hasDelegatesToSource} [0..1] \textbf{Role} \\
\textbf{hasDelegatesToTarget} [0..1] \textbf{Role}

Inferred Object Properties: \textbf{analysis:isAnalyzedBy} [0..*] analysis:Explanation
Figure 44: Class usage diagram for Binds.
Figure 45: Class definition diagram for Concurs.

- `analysis:isCharacterizedBy [0..*] analysis:Characterization`
- `analysis:isExplainedBy [0..*] analysis:Explanation`
- `analysis:isLimitedBy [0..*] analysis:Assumption`
- `analysis:isValidatedBy [0..*] analysis:Explanation`

Reified Object Properties: **delegatesTo**

The class definition diagram for DelegatesTo is shown in Figure 47. The class usage diagram for DelegatesTo is shown in Figure 48.

### 6.7 Delivers

**Asserted Superclasses:** `AssignedElement`, `project-backbone:ReifiedObjectProperty`

**Inferred Superclasses:** `analysis-backbone:Aspect`, `analysis-backbone:Thing`, `analysis:AnalyzedElement`, `analysis:CharacterizedElement`, `project-backbone:Aspect`, `project-backbone:Thing`

**Asserted Object Properties:**
- `hasDeliversSource [0..1] Process`
- `hasDeliversTarget [0..1] Deliverable`

**Inferred Object Properties:**
- `analysis:isAnalyzedBy [0..*] analysis:Explanation`
- `analysis:isCharacterizedBy [0..*] analysis:Characterization`
- `analysis:isExplainedBy [0..*] analysis:Explanation`
- `analysis:isLimitedBy [0..*] analysis:Assumption`
- `analysis:isValidatedBy [0..*] analysis:Explanation`
- `isAssignedTo [0..*] Role`

Reified Object Properties: **delivers**

The class definition diagram for Delivers is shown in Figure 49. The class usage diagram for Delivers is shown in Figure 50.
Figure 46: Class usage diagram for Concurs.
DelegatesTo

hasDelegatesToSource [0..1]
hasDelegatesToTarget [0..1]

Role

Figure 47: Class definition diagram for DelegatesTo.

DelegatesTo

hasDelegatesToSource [0..1]
hasDelegatesToTarget [0..1]

Role

Figure 48: Class usage diagram for DelegatesTo.
Figure 49: Class definition diagram for Delivers.

Figure 50: Class usage diagram for Delivers.
6.8 Describes

**Asserted Superclasses:** project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Object Properties:**
- **hasDescribesSource** [0..1] Product
- **hasDescribesTarget** [0..1] DevelopedElement

**Inferred Object Properties:**
- analysis:isAnalyzedBy [0..*] analysis:Explanation
- analysis:isCharacterizedBy [0..*] analysis:Characterization
- analysis:isExplainedBy [0..*] analysis:Explanation
- analysis:isLimitedBy [0..*] analysis:Assumption
- analysis:isValidatedBy [0..*] analysis:Explanation

**Reified Object Properties:** describes

The class definition diagram for Describes is shown in Figure 51. The class usage diagram for Describes is shown in Figure 52.

6.9 Executes

**Asserted Superclasses:** AssignedElement, mission:SpecifiedElement, project-backbone:ReifiedObjectProperty


**Asserted Object Properties:**
- **hasExecutesSource** [0..1] Authority
Figure 52: Class usage diagram for Describes.
Inferred Object Properties: \(\text{analysis:isAnalyzedBy}\) [0..\*] analysis:Explanation
  \(\text{analysis:isCharacterizedBy}\) [0..\*] analysis:Characterization
  \(\text{analysis:isExplainedBy}\) [0..\*] analysis:Explanation
  \(\text{analysis:isLimitedBy}\) [0..\*] analysis:Assumption
  \(\text{analysis:isQuantifiedBy}\) [0..\*] analysis:Quantity
  \(\text{analysis:isValidatedBy}\) [0..\*] analysis:Explanation
  \(\text{isAssignedTo}\) [0..\*] Role
  \(\text{isBoundBy}\) [0..\*] Policy
  \(\text{mission:isSpecifiedBy}\) [0..\*] mission:Requirement

Reified Object Properties: \(\text{executes}\)

The class definition diagram for Executes is shown in Figure 53. The class usage diagram for Executes is shown in Figure 54.

6.10 HasAssignment

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

Asserted Subclasses: Approves, Concurs, Prepares

Asserted Object Properties: \(\text{hasHasAssignmentSource}\) [0..1] Role
  \(\text{hasHasAssignmentTarget}\) [0..1] AssignedElement

Inferred Object Properties: \(\text{analysis:isAnalyzedBy}\) [0..\*] analysis:Explanation
Figure 54: Class usage diagram for Executes.
6.11 HasParticipant

**asserted superclasses:** project-backbone:ReifiedObjectProperty

**inferred superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**asserted object properties:**
- hasHasParticipantSource [0..1] Interchange
- hasHasParticipantTarget [0..1] Deliverable

**inferred object properties:**
- analysis:isAnalyzedBy [0..*] analysis:Explanation
- analysis:isCharacterizedBy [0..*] analysis:Characterization
- analysis:isExplainedBy [0..*] analysis:Explanation
- analysis:isLimitedBy [0..*] analysis:Assumption
- analysis:isValidatedBy [0..*] analysis:Explanation

**reified object properties:** hasParticipant

The class definition diagram for HasParticipant is shown in Figure 57. The class usage diagram for HasParticipant is shown in Figure 58.
Figure 56: Class usage diagram for HasAssignment.
Figure 57: Class definition diagram for HasParticipant.

Figure 58: Class usage diagram for HasParticipant.
6.12 HasResponsibilityFor

**Asserted Superclasses:** project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Object Properties:**
- hasHasResponsibilityForSource [0..1] Organization
- hasHasResponsibilityForTarget [0..1] Authority

**Inferred Object Properties:**
- analysis:isAnalyzedBy [0..*] analysis:Explanation
- analysis:isCharacterizedBy [0..*] analysis:Characterization
- analysis:isExplainedBy [0..*] analysis:Explanation
- analysis:isLimitedBy [0..*] analysis:Assumption
- analysis:isValidatedBy [0..*] analysis:Explanation

**Reified Object Properties:** hasResponsibilityFor

The class definition diagram for HasResponsibilityFor is shown in Figure 59. The class usage diagram for HasResponsibilityFor is shown in Figure 60.

6.13 HasRole

**Asserted Superclasses:** project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Object Properties:**
- hasHasRoleSource [0..1] Person
- hasHasRoleTarget [0..1] Role
Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
   analysis:isCharacterizedBy [0..*] analysis:Characterization
   analysis:isExplainedBy [0..*] analysis:Characterization
   analysis:isLimitedBy [0..*] analysis:Assumption
   analysis:isValidatedBy [0..*] analysis:Explanation

Reified Object Properties: hasRole

The class definition diagram for HasRole is shown in Figure 61. The class usage diagram for HasRole is shown in Figure 62.

6.14 Invokes

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

Asserted Object Properties: hasInvokesSource [0..1] Process
   hasInvokesTarget [0..1] Process

Inferred Object Properties: analysis:isAnalyzedBy [0..*] analysis:Explanation
   analysis:isCharacterizedBy [0..*] analysis:Characterization
6.14 Invokes

Figure 61: Class definition diagram for HasRole.

Figure 62: Class usage diagram for HasRole.
6.15 Involves

**Asserted Superclasses:** project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Subclasses:** Involves1, Involves2

**Asserted Object Properties:**
- `hasInvolvesSource` [0..1] Interchange
- `hasInvolvesTarget` [0..1] Process

**Inferred Object Properties:**
- `analysis:isAnalyzedBy` [0..*] analysis:Explanation
- `analysis:isCharacterizedBy` [0..*] analysis:Characterization
- `analysis:isExplainedBy` [0..*] analysis:Explanation
- `analysis:isLimitedBy` [0..*] analysis:Assumption
- `analysis:isValidatedBy` [0..*] analysis:Explanation

**Reified Object Properties:** involves

The class definition diagram for Involves is shown in Figure 65. The class usage diagram for Involves is shown in Figure 66.
6.15 Involves

Figure 64: Class usage diagram for Invokes.

Figure 65: Class definition diagram for Involves.
6.16 Involves1

**Asserted Superclasses:** Involves

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:ReifiedObjectProperty, project-backbone:Thing

**Asserted Object Properties:**
- `hasInvolves1Source` [0..1] Interchange
- `hasInvolves1Target` [0..1] Process

**Inferred Object Properties:**
- `analysis:isAnalyzedBy` [0..*] analysis:Explanation
- `analysis:isCharacterizedBy` [0..*] analysis:Characterization
- `analysis:isExplainedBy` [0..*] analysis:Explanation
- `analysis:isLimitedBy` [0..*] analysis:Assumption
- `analysis:isValidatedBy` [0..*] analysis:Explanation
- `hasInvolvesSource` [0..1] Interchange
- `hasInvolvesTarget` [0..1] Process

**Reified Object Properties:** involves1

The class definition diagram for Involves1 is shown in Figure 67. The class usage diagram for Involves1 is shown in Figure 68.

6.17 Involves2

**Asserted Superclasses:** Involves
6.17 Involves2

Figure 67: Class definition diagram for Involves1.

Figure 68: Class usage diagram for Involves1.
Involves

Involves2

Interchange

Process

\(\text{hasInvolvesSource} \ [0..1] \ \text{Interchange}\)
\(\text{hasInvolvesTarget} \ [0..1] \ \text{Process}\)

Figure 69: Class definition diagram for Involves2.

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:ReifiedObjectProperty, project-backbone:Thing

**Asserted Object Properties:**
\(\text{hasInvolvesSource} \ [0..1] \ \text{Interchange}\)
\(\text{hasInvolvesTarget} \ [0..1] \ \text{Process}\)

**Inferred Object Properties:**
analysis:isAnalyzedBy \ [0..*] analysis:Explanation
analysis:isCharacterizedBy \ [0..*] analysis:Characterization
analysis:isExplainedBy \ [0..*] analysis:Explanation
analysis:isLimitedBy \ [0..*] analysis:Assumption
analysis:isValidatedBy \ [0..*] analysis:Explanation
\(\text{hasInvolvesSource} \ [0..1] \ \text{Interchange}\)
\(\text{hasInvolvesTarget} \ [0..1] \ \text{Process}\)

**Reified Object Properties:** involves2

The class definition diagram for Involves2 is shown in Figure 69. The class usage diagram for Involves2 is shown in Figure 70.

6.18 Manifests

**Asserted Superclasses:** project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Thing

**Asserted Object Properties:**
\(\text{hasManifestsSource} \ [0..1] \ \text{DevelopedElement}\)
\(\text{hasManifestsTarget} \ [0..1] \ \text{DevelopmentState}\)

**Inferred Object Properties:**
analysis:isAnalyzedBy \ [0..*] analysis:Explanation
6.19  Prepares

Figure 70: Class usage diagram for Involves2.

\[
\text{analysis:isCharacterizedBy} \ [0..*] \ \text{analysis:Characterization}
\]

\[
\text{analysis:isExplainedBy} \ [0..*] \ \text{analysis:Explanation}
\]

\[
\text{analysis:isLimitedBy} \ [0..*] \ \text{analysis:Assumption}
\]

\[
\text{analysis:isValidatedBy} \ [0..*] \ \text{analysis:Explanation}
\]

Reified Object Properties: \text{manifests}

The class definition diagram for Manifests is shown in Figure 71. The class usage diagram for Manifests is shown in Figure 72.

6.19  Prepares

Asserted Superclasses: \text{HasAssignment}


Asserted Object Properties: \text{hasPreparesSource} \ [0..1] \ \text{Role}
\text{hasPreparesTarget} \ [0..1] \ \text{Product}

Inferred Object Properties: \text{analysis:isAnalyzedBy} \ [0..*] \ \text{analysis:Explanation}
\text{analysis:isCharacterizedBy} \ [0..*] \ \text{analysis:Characterization}
\text{analysis:isExplainedBy} \ [0..*] \ \text{analysis:Explanation}
\text{analysis:isLimitedBy} \ [0..*] \ \text{analysis:Assumption}
\text{analysis:isValidatedBy} \ [0..*] \ \text{analysis:Explanation}
Figure 71: Class definition diagram for Manifests.

Figure 72: Class usage diagram for Manifests.
6.20 Produces

**asserted superclasses**: `Supplies`


**asserted object properties**: `hasProducesSource` [0..1] Authority

`hasProducesTarget` [0..1] Product

**inferred object properties**: analysis:isAnalyzedBy [0..*] analysis:Explanation

analysis:isCharacterizedBy [0..*] analysis:Characterization

analysis:isExplainedBy [0..*] analysis:Explanation

analysis:isLimitedBy [0..*] analysis:Assumption

analysis:isValidatedBy [0..*] analysis:Explanation

`hasSuppliesSource` [0..1] Authority

`hasSuppliesTarget` [0..1] SuppliedElement

`isAssignedTo` [0..*] Role

**reified object properties**: produces

The class definition diagram for Produces is shown in Figure 75. The class usage diagram for Produces is shown in Figure 76.

---

6.20 Produces

**asserted superclasses**: `Supplies`


**asserted object properties**: `hasHasAssignmentSource` [0..1] Role

`hasHasAssignmentTarget` [0..1] AssignedElement

**reified object properties**: prepares

The class definition diagram for Prepares is shown in Figure 73. The class usage diagram for Prepares is shown in Figure 74.

---

**asserted superclasses**: `Supplies`


**asserted object properties**: `hasProducesSource` [0..1] Authority

`hasProducesTarget` [0..1] Product

**inferred object properties**: analysis:isAnalyzedBy [0..*] analysis:Explanation

analysis:isCharacterizedBy [0..*] analysis:Characterization

analysis:isExplainedBy [0..*] analysis:Explanation

analysis:isLimitedBy [0..*] analysis:Assumption

analysis:isValidatedBy [0..*] analysis:Explanation

`hasSuppliesSource` [0..1] Authority

`hasSuppliesTarget` [0..1] SuppliedElement

`isAssignedTo` [0..*] Role

**reified object properties**: produces

The class definition diagram for Produces is shown in Figure 75. The class usage diagram for Produces is shown in Figure 76.
Figure 74: Class usage diagram for Prepares.
Figure 75: Class definition diagram for Produces.

Figure 76: Class usage diagram for Produces.
6.21 Realizes

Asserted Superclasses: project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement,
analysis:CharacterizedElement, project-backbone:Thing

Asserted Object Properties: 
- hasRealizesSource [0..1] RealizedElement
- hasRealizesTarget [0..1] RealizedElement

Inferred Object Properties: 
- analysis:isAnalyzedBy [0..*] analysis:Explanation
- analysis:isCharacterizedBy [0..*] analysis:Characterization
- analysis:isExplainedBy [0..*] analysis:Explanation
- analysis:isLimitedBy [0..*] analysis:Assumption
- analysis:isValidatedBy [0..*] analysis:Explanation

Reified Object Properties: realizes

The class definition diagram for Realizes is shown in Figure 77. The class usage diagram for Realizes is shown in Figure 78.

6.22 Receives

Asserted Superclasses: AssignedElement project-backbone:ReifiedObjectProperty

Inferred Superclasses: analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement,
analysis:CharacterizedElement, project-backbone:Aspect, project-backbone:Thing

Asserted Object Properties: 
- hasReceivesSource [0..1] Process
- hasReceivesTarget [0..1] Deliverable
Figure 78: Class usage diagram for Realizes.
Inferred Object Properties: \textit{analysis:isAnalyzedBy} \([0..*]\) \textit{analysis:Explanation} \\
\textit{analysis:isCharacterizedBy} \([0..*]\) \textit{analysis:Characterization} \\
\textit{analysis:isExplainedBy} \([0..*]\) \textit{analysis:Explanation} \\
\textit{analysis:isLimitedBy} \([0..*]\) \textit{analysis:Assumption} \\
\textit{analysis:isValidatedBy} \([0..*]\) \textit{analysis:Explanation} \\
isAssignedTo \([0..*]\) \textit{Role}

Reified Object Properties: \textit{receives}

The class definition diagram for Receives is shown in Figure 79. The class usage diagram for Receives is shown in Figure 80.

6.23 ReliesOn

Asserted Superclasses: \textit{AssignedElement} \textit{project-backbone:ReifiedObjectProperty}


Asserted Object Properties: \textit{hasReliesOnSource} \([0..1]\) \textit{Authority} \\
\textit{hasReliesOnTarget} \([0..1]\) \textit{DevelopedElement}

Inferred Object Properties: \textit{analysis:isAnalyzedBy} \([0..*]\) \textit{analysis:Explanation} \\
\textit{analysis:isCharacterizedBy} \([0..*]\) \textit{analysis:Characterization} \\
\textit{analysis:isExplainedBy} \([0..*]\) \textit{analysis:Explanation} \\
\textit{analysis:isLimitedBy} \([0..*]\) \textit{analysis:Assumption} \\
\textit{analysis:isValidatedBy} \([0..*]\) \textit{analysis:Explanation} \\
isAssignedTo \([0..*]\) \textit{Role}
6.24 Represents

**Reified Object Properties:** `reliesOn`

The class definition diagram for ReliesOn is shown in Figure 81. The class usage diagram for ReliesOn is shown in Figure 82.

### 6.24 Represents

**Asserted Superclasses:** `project-backbone:ReifiedObjectProperty`

**Inferred Superclasses:** `analysis-backbone:Aspect`, `analysis-backbone:Thing`, `analysis:AnalyzedElement`, `analysis:CharacterizedElement`, `project-backbone:Thing`

**Asserted Object Properties:**
- `hasRepresentsSource` [0..1] `Stakeholder`
- `hasRepresentsTarget` [0..1] `Concern`

**Inferred Object Properties:**
- `analysis:isAnalyzedBy` [0..*] `analysis:Explanation`
- `analysis:isCharacterizedBy` [0..*] `analysis:Characterization`
- `analysis:isExplainedBy` [0..*] `analysis:Explanation`
- `analysis:isLimitedBy` [0..*] `analysis:Assumption`
- `analysis:isValidatedBy` [0..*] `analysis:Explanation`

**Reified Object Properties:** `represents`

The class definition diagram for Represents is shown in Figure 83. The class usage diagram for Represents is shown in Figure 84.
Figure 81: Class definition diagram for ReliesOn.

Figure 82: Class usage diagram for ReliesOn.
Figure 83: Class definition diagram for Represents.

Figure 84: Class usage diagram for Represents.
6.25 Supplies

**Asserted Superclasses:** [AssignedElement] project-backbone:ReifiedObjectProperty

**Inferred Superclasses:** analysis-backbone:Aspect, analysis-backbone:Thing, analysis:AnalyzedElement, analysis:CharacterizedElement, project-backbone:Aspect, project-backbone:Thing

**Asserted Subclasses:** [Produces]

**Asserted Object Properties:** hasSuppliesSource [0..1] Authority

| hasSuppliesTarget [0..1] SuppliedElement |

**Inferred Object Properties:** analysis:isAnalyzedBy [0..*] analysis:Explanation

| analysis:isCharacterizedBy [0..*] analysis:Characterization |

| analysis:isExplainedBy [0..*] analysis:Explanation |

| analysis:isLimitedBy [0..*] analysis:Assumption |

| analysis:isValidatedBy [0..*] analysis:Explanation |

| isAssignedTo [0..*] Role |

**Reified Object Properties:** supplies

The class definition diagram for Supplies is shown in Figure 85. The class usage diagram for Supplies is shown in Figure 86.

![Class Definition Diagram for Supplies](image-url)
Figure 86: Class usage diagram for Supplies.
7 Concrete Datatype Property Definitions

7.1 isRequiredNotLaterThan

A ScheduledElement $e$ isRequiredNotLaterThan $d$ if and only if $e$ must be completed or achieved no later than $d$.

**Asserted Superproperties:** project-backbone:topDataProperty

**Domain:** Deliverable

**Range:** [0..1] xsd:date

**Derived:** false
8 Abstract Object Property Definitions

8.1 involves

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

Range: [0..*] Process

Inverse: isInvolvedIn

Derived: false

Reification Class: Involves

Reification Property Chain: hasInvolvesSource⁻¹ o hasInvolvesTarget

8.2 isInvolvedIn

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

Range: [0..*] Interchange

Inverse: involves

Derived: true
9 Concrete Object Property Definitions

9.1 approves

Asserted Superproperties: hasAssignment

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

Domain: Role

Range: [0..*] Product

Inverse: isApprovedBy

Derived: false

Reification Class: Approves

Reification Property Chain: hasApprovesSource \(^{-1}\) \(\circ\) hasApprovesTarget

The property usage diagram for approves is shown in Figure 87.

9.2 authorizes

Asserted Superproperties: project-backbone:topReifiedObjectProperty

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Authority

Range: [0..*] Authority

Derived: false

Reification Class: Authorizes

Reification Property Chain: hasAuthorizesSource \(^{-1}\) \(\circ\) hasAuthorizesTarget

The property usage diagram for authorizes is shown in Figure 88.

9.3 belongsTo

A Person belongsTo zero or more Organizations.

Asserted Superproperties: project-backbone:topReifiedObjectProperty

Inferred Superproperties: project-backbone:topObjectProperty
Figure 88: Property usage diagram for authorizes.

Figure 89: Property usage diagram for belongsTo.

Domain: **Person**  
Range: [0..*] **Organization**  
Derived: false  
Reification Class: **BelongsTo**  
Reification Property Chain: hasBelongsToSource\(^{-1}\) \circ hasBelongsToTarget

The property usage diagram for belongsTo is shown in Figure 89

9.4 binds

A *Policy* \(p\) binds a *SpecifiedElement* \(e\) if and only if the course of action embodied in \(p\) governs the design, analysis, implementation, operation, or other applicable aspects of \(e\).

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty  
**Inferred Superproperties:** project-backbone:topObjectProperty  
Domain: **Policy**  
Range: [0..*] mission:SpecifiedElement  
Inverse: isBoundBy  
Derived: false  
Reification Class: **Binds**  
Reification Property Chain: hasBindsSource\(^{-1}\) \circ hasBindsTarget

The property usage diagram for binds is shown in Figure 90
Figure 90: Property usage diagram for binds.
9.5 concurs

**Asserted Superproperties:** hasAssignment

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Role

**Range:** [0..*] Product

**Inverse:** isConcurredBy

**Derived:** false

**Reification Class:** Concurs

**Reification Property Chain:** hasConcursSource\(^{-1} \circ\) hasConcursTarget

The property usage diagram for concurs is shown in Figure 91.

9.6 delegatesTo

A Role \( r_1 \) delegatesTo a Role \( r_2 \) if and only if \( r_1 \) gives direction or otherwise exercises authority over \( r_2 \).

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Role

**Range:** [0..*] Role

**Inverse:** isDelegateOf

**Derived:** false

**Reification Class:** DelegatesTo

**Reification Property Chain:** hasDelegatesToSource\(^{-1} \circ\) hasDelegatesToTarget

The property usage diagram for delegatesTo is shown in Figure 92.
9.7 delivers

A Process $p$ delivers a Deliverable $r$ if and only if the successful execution of $p$ results in availability of $r$.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Process

**Range:** [0..*] Deliverable

**Inverse:** isDeliveredBy

**Derived:** false

**Reification Class:** Delivers

**Reification Property Chain:** hasDeliversSource $^{-1}$ hasDeliversTarget

The property usage diagram for delivers is shown in Figure 93.

9.8 describes

A Product $p$ describes a DevelopmentElement $e$ if and only if $p$ contains design, analysis, operations, or other information about $e$.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Product

**Range:** [0..*] DevelopedElement

**Inverse:** isDescribedBy

**Derived:** false
9.9 executes

An Authority $a$ executes a Process $p$ if and only if $a$ carries out any actions required for successful completion of $p$.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Authority

**Range:** [0..*] Process

**Inverse:** isExecutedBy

**Derived:** false

**Reification Class:** Executes

**Reification Property Chain:** hasExecutesSource $^{-1} \circ$ hasExecutesTarget

The property usage diagram for executes is shown in Figure 95.
9.10 hasAssignment

A Role \( r \) hasAssignment some AssignedElement \( e \) if and only if \( r \) has specific cognizance and/or responsibility for \( e \).

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Role

**Range:** \([0..*]\) AssignedElement

**Inverse:** isAssignedTo

**Derived:** false

**Reification Class:** HasAssignment

**Reification Property Chain:** \( \text{hasHasAssignmentSource}^{-1} \circ \text{hasHasAssignmentTarget} \)

The property usage diagram for hasAssignment is shown in Figure 96.

9.11 hasParticipant

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Interchange

**Range:** \([0..*]\) Deliverable

**Inverse:** participatesIn

**Derived:** false

**Reification Class:** HasParticipant

**Reification Property Chain:** \( \text{hasHasParticipantSource}^{-1} \circ \text{hasHasParticipantTarget} \)

The property usage diagram for hasParticipant is shown in Figure 97.

9.12 hasResponsibilityFor

An Organization \( o \) hasResponsibilityFor some Authority \( a \) if and only if \( o \) provides the actual workforce and execution of the work embodied in \( a \). An example is the relation between a “doing” Organization and a Work-Package.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Organization
Figure 96: Property usage diagram for hasAssignment.

Figure 97: Property usage diagram for hasParticipant.
9.13 hasRole

A Person \( p \) hasRole Role \( r \) if and only if \( p \) acts to execute the assignments of \( r \).

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Person

**Range:** \([0..*]\) Role

**Inverse:** isRoleOf

**Derived:** false

**Reification Class:** HasRole

**Reification Property Chain:** \( \text{hasHasRoleSource}^{-1} \circ \text{hasHasRoleTarget} \)

The property usage diagram for hasRole is shown in Figure 99.

9.14 invokes

A PerformedElement \( p \) invokes a PerformedElement \( c \) if and only if the execution of \( c \) may be triggered or caused by and within the execution of \( p \).

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty
9.15 involves1

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Interchange

**Range:** [0..1] Process

**Inverse:** isInvolvesIn1

**Derived:** false

**Reification Class:** Involves1

**Reification Property Chain:** hasInvolves1Source \( \circ \) hasInvolves1Target

The property usage diagram for involves1 is shown in Figure [101](#).
9.16 involves2

**Asserted Superproperties:** involves

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Interchange

**Range:** [0..1] Process

**Inverse:** isInvolvedIn2

**Derived:** false

**Reification Class:** Involves2

**Reification Property Chain:** hasInvolves2Source\(^{-1}\) o hasInvolves2Target

The property usage diagram for involves2 is shown in Figure 102.

9.17 isApprovedBy

**Asserted Superproperties:** isAssignedTo

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Product

**Range:** [0..*] Role

**Inverse:** approves

**Derived:** true

The property usage diagram for isApprovedBy is shown in Figure 103.
9.18 isAssignedTo

See hasAssignment.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** AssignedElement

**Range:** [0..*] Role

**Inverse:** hasAssignment

**Derived:** true

The property usage diagram for isAssignedTo is shown in Figure 104.

9.19 isBoundBy

See binds.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** mission:SpecifiedElement

**Range:** [0..*] Policy

**Inverse:** binds

**Derived:** true

The property usage diagram for isBoundBy is shown in Figure 105.

9.20 isConcurredBy

**Asserted Superproperties:** isAssignedTo

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Product

**Range:** [0..*] Role

**Inverse:** concurs

**Derived:** true

The property usage diagram for isConcurredBy is shown in Figure 106.
Figure 104: Property usage diagram for isAssignedTo.
CONCRETE OBJECT PROPERTY DEFINITIONS

Figure 105: Property usage diagram for isBoundBy.

Figure 106: Property usage diagram for isConcurredBy.
9.21 isDelegateOf

See delegatesTo.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Role

**Range:** $[0..1]$ Role

**Inverse:** delegatesTo

**Derived:** true

The property usage diagram for isDelegateOf is shown in Figure 107.

9.22 isDeliveredBy

See delivers.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Deliverable

**Range:** $[0..1]$ Process

**Inverse:** delivers

**Derived:** true

The property usage diagram for isDeliveredBy is shown in Figure 108.
9.23 isDescribedBy

See describes.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DevelopedElement

**Range:** [0..*] Product

**Inverse:** describes

**Derived:** true

The property usage diagram for isDescribedBy is shown in Figure 109.

9.24 isExecutedBy

See executes.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Process

**Range:** [0..1] Authority

**Inverse:** executes

**Derived:** true

The property usage diagram for isExecutedBy is shown in Figure 110.
9.25  isInvokedBy

See invokes.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Process

**Range:** [0..*] Process

**Inverse:** involves

**Derived:** true

The property usage diagram for isInvokedBy is shown in Figure 111.

9.26  isInvolvedIn1

**Asserted Superproperties:** isInvolvedIn

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Process

**Range:** [0..*] Interchange

**Inverse:** involves1

**Derived:** true

The property usage diagram for isInvolvedIn1 is shown in Figure 112.
9.27 isInvolvedIn2

**Asserted Superproperties:** isInvolvedIn

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Process

**Range:** [0..*] Interchange

**Inverse:** involves2

**Derived:** true

The property usage diagram for isInvolvedIn2 is shown in Figure 113.

9.28 isManfestedBy

**See manifests.**

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DevelopmentState

**Range:** [0..1] DevelopedElement

**Inverse:** manifests

**Derived:** true

The property usage diagram for isManfestedBy is shown in Figure 114.

9.29 isPreparedBy

**Asserted Superproperties:** isAssignedTo

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Product
9.30  *isProducedBy*

See *produces*.

**Asserted Superproperties:** *isSuppliedBy*

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Product

**Range:** [0..1] Authority

**Inverse:** produces

**Derived:** true

The property usage diagram for *isProducedBy* is shown in Figure 116.
9.30.1 Comments

9.31 isRealizedBy

See realizes.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** RealizedElement

**Range:** [0..*] RealizedElement

**Inverse:** realizes

**Derived:** true

The property usage diagram for isRealizedBy is shown in Figure 117.

9.32 isReceivedBy

See receives.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Deliverable

**Range:** [0..*] Process

**Inverse:** receives

**Derived:** true

The property usage diagram for isReceivedBy is shown in Figure 118.

9.33 isReliedOnBy

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DevelopedElement

**Range:** [0..*] Authority

**Inverse:** reliesOn

**Derived:** true

The property usage diagram for isReliedOnBy is shown in Figure 119.
Figure 117: Property usage diagram for isRealizedBy.
9.34 isRepresentedBy

See represents.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Concern

**Range:** [0..*] Stakeholder

**Inverse:** represents

**Derived:** true

The property usage diagram for isRepresentedBy is shown in Figure 120.
9.35  isResponsibilityOf
See hasResponsibilityFor.

**Asserted Superproperties:**  project-backbone:topReifiedObjectProperty

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Authority

**Range:**  [0..1] Organization

**Inverse:**  hasResponsibilityFor

**Derived:**  true

The property usage diagram for isResponsibilityOf is shown in Figure 121.

9.36  isRoleOf
See hasRole.

**Asserted Superproperties:**  project-backbone:topReifiedObjectProperty

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Role

**Range:**  [0..1] Person

**Inverse:**  hasRole

**Derived:**  true

The property usage diagram for isRoleOf is shown in Figure 122.
9.37 isSuppliedBy

See supplies.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** SuppliedElement

**Range:** [0..1] Authority

**Inverse:** supplies

**Derived:** true

The property usage diagram for isSuppliedBy is shown in Figure 123.

9.38 manifests

A DevelopmentalElement e has manifests a DevelopmentState s if and only if e attains s during its development process.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DevelopedElement

**Range:** [0..*] DevelopmentState

**Inverse:** isManifestedBy

**Derived:** false

**Reification Class:** Manifests

**Reification Property Chain:** hasManifestsSource \(\sim\) \(\circ\) hasManifestsTarget

The property usage diagram for manifests is shown in Figure 124.
9.39 participatesIn

Asserted Superproperties: project-backbone:topReifiedObjectProperty

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Deliverable

Range: [0..*] Interchange

Inverse: has Participant

Derived: true

The property usage diagram for participatesIn is shown in Figure 125.

9.40 prepares

Asserted Superproperties: hasAssignment

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

Domain: Role

Range: [0..*] Product

Inverse: isPreparedBy
9.41 produces

A WorkPackage $w$ produces a Product $p$ if and only if $w$ is responsible for creation and development of $p$.

**Asserted Superproperties:** supplies

**Inferred Superproperties:** project-backbone:topObjectProperty, project-backbone:topReifiedObjectProperty

**Domain:** Authority

**Range:** $[0..*]$ Product

**Inverse:** isProducedBy

**Derived:** false

**Reification Class:** Prepares

**Reification Property Chain:** hasPreparesSource$^{-1}$ ◦ hasPreparesTarget

The property usage diagram for produces is shown in Figure 127.

9.41.1 Comments

9.42 realizes

A SpecifiedElement $c_1$ realizes a SpecifiedElement $c_2$ if and only if $c_1$ is proffered by a supplier as a specification-compliant implementation of $c_2$.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty
9.43 **receives**

A Process $p$ receives a Deliverable $r$ if and only if the successful execution of $p$ is contingent on the receipt of $r$.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Process

**Range:** [0..*] Deliverable

**Inverse:** isReceivedBy

**Derived:** false

**Reification Class:** Receives

**Reification Property Chain:** $\text{hasReceivesSource}^{-1} \circ \text{hasReceivesTarget}$

The property usage diagram for receives is shown in Figure 129.

9.44 **reliesOn**

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Authority

**Range:** [0..*] DevelopedElement

**Inverse:** isReliedOnBy

**Derived:** false

**Reification Class:** ReliesOn

**Reification Property Chain:** $\text{hasReliesOnSource}^{-1} \circ \text{hasReliesOnTarget}$

The property usage diagram for reliesOn is shown in Figure 130.
Figure 128: Property usage diagram for realizes.

Figure 129: Property usage diagram for receives.
9.45 represents

A Stakeholder $s$ represents Concern $c$ if and only if $s$ has a direct, legitimate, and recognized interest in $c$ as it relates to a particular Project or Program.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [Stakeholder](#)

**Range:** [0, *] Concern

**Inverse:** isRepresentedBy

**Derived:** false

**Reification Class:** [Represents](#)

**Reification Property Chain:** hasRepresentsSource\(^{-1}\) $\circ$ hasRepresentsTarget

The property usage diagram for represents is shown in Figure [131](#).

9.46 supplies

A WorkPackage $w$ supplies a Component $c$ if and only if $w$ is responsible for the acquisition and delivery of $c$. 
The property usage diagram for supplies is shown in Figure 132.

**Asserted Superproperties:** project-backbone:topReifiedObjectProperty

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Authority

**Range:** [0..*] SuppliedElement

**Inverse:** isSuppliedBy

**Derived:** false

**Reification Class:** Supplies

**Reification Property Chain:** hasSuppliesSource\(^{-1}\) \(\circ\) hasSuppliesTarget

The property usage diagram for supplies is shown in Figure 132.
10 Object Property Reification Source/Target Object Property Definitions

10.1 hasApprovesSource

Asserted Superproperties: hasHasAssignmentSource

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectPropertySource

Domain: Approves
Range: [0..1] Role
Derived: false

10.2 hasApprovesTarget

Asserted Superproperties: hasHasAssignmentTarget

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectPropertyTarget

Domain: Approves
Range: [0..1] Product
Derived: false

10.3 hasAuthorizesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Authorizes
Range: [0..1] Authority
Derived: false

10.4 hasAuthorizesTarget

Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Authorizes
Range: [0..1] Authority
Derived: false
10.5 hasBelongsToSource
Asserted Superproperties: project-backbone:topReifiedObjectPropertySource
Inferred Superproperties: project-backbone:topObjectProperty
Domain: BelongsTo
Range: [0..1] Person
Derived: false

10.6 hasBelongsToTarget
Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget
Inferred Superproperties: project-backbone:topObjectProperty
Domain: BelongsTo
Range: [0..1] Organization
Derived: false

10.7 hasBindsSource
Asserted Superproperties: project-backbone:topReifiedObjectPropertySource
Inferred Superproperties: project-backbone:topObjectProperty
Domain: Binds
Range: [0..1] Policy
Derived: false

10.8 hasBindsTarget
Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget
Inferred Superproperties: project-backbone:topObjectProperty
Domain: Binds
Range: [0..1] mission:SpecifiedElement
Derived: false
10.9 hasConcursSource

**Asserted Superproperties:** hasHasAssignmentSource

**Inferred Superproperties:**
- project-backbone:topObjectProperty
- project-backbone:topReifiedObjectPropertySource

**Domain:** Concurs
**Range:** [0..1] Role
**Derived:** false

10.10 hasConcursTarget

**Asserted Superproperties:** hasHasAssignmentTarget

**Inferred Superproperties:**
- project-backbone:topObjectProperty
- project-backbone:topReifiedObjectPropertyTarget

**Domain:** Concurs
**Range:** [0..1] Product
**Derived:** false

10.11 hasDelegatesToSource

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DelegatesTo
**Range:** [0..1] Role
**Derived:** false

10.12 hasDelegatesToTarget

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** DelegatesTo
**Range:** [0..1] Role
**Derived:** false
10.13 hasDeliversSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: [Delivers]

Range: [0..1][Process]

Derived: false

10.14 hasDeliversTarget

Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: project-backbone:topObjectProperty

Domain: [Delivers]

Range: [0..1][Deliverable]

Derived: false

10.15 hasDescribesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: [Describes]

Range: [0..1][Product]

Derived: false

10.16 hasDescribesTarget

Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: project-backbone:topObjectProperty

Domain: [Describes]

Range: [0..1][DevelopedElement]

Derived: false

10.17 hasExecutesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: [Executes]

Range: [0..1][Authority]

Derived: false
10.18 hasExecutesTarget

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [Executes](#)

**Range:** [0..1] [Process](#)

**Derived:** false

10.19 hasHasAssignmentSource

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [HasAssignment](#)

**Range:** [0..1] [Role](#)

**Derived:** false

10.20 hasHasAssignmentTarget

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [HasAssignment](#)

**Range:** [0..1] [AssignedElement](#)

**Derived:** false

10.21 hasHasParticipantSource

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [HasParticipant](#)

**Range:** [0..1] [Interchange](#)

**Derived:** false

10.22 hasHasParticipantTarget

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** [HasParticipant](#)

**Range:** [0..1] [Deliverable](#)

**Derived:** false
10.23 **hasHasResponsibilityForSource**

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** HasResponsibilityFor

**Range:** [0..1] Organization

**Derived:** false

### 10.24 **hasHasResponsibilityForTarget**

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** HasResponsibilityFor

**Range:** [0..1] Authority

**Derived:** false

### 10.25 **hasHasRoleSource**

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** HasRole

**Range:** [0..1] Person

**Derived:** false

### 10.26 **hasHasRoleTarget**

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** HasRole

**Range:** [0..1] Role

**Derived:** false

### 10.27 **hasInvokesSource**

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Invokes

**Range:** [0..1] Process

**Derived:** false
10.28  hasInvokesTarget

Asserted Superproperties:  project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties:  project-backbone:topObjectProperty

Domain:  Invokes

Range:  [0..1] Process

Derived:  false

10.29  hasInvolves1Source

Asserted Superproperties:  hasInvolvesSource

Inferred Superproperties:  project-backbone:topObjectProperty,  project-backbone:topReifiedObjectPropertySource

Domain:  Involves1

Range:  [0..1] Interchange

Derived:  false

10.30  hasInvolves1Target

Asserted Superproperties:  hasInvolvesTarget

Inferred Superproperties:  project-backbone:topObjectProperty,  project-backbone:topReifiedObjectPropertyTarget

Domain:  Involves1

Range:  [0..1] Process

Derived:  false

10.31  hasInvolves2Source

Asserted Superproperties:  hasInvolvesSource

Inferred Superproperties:  project-backbone:topObjectProperty,  project-backbone:topReifiedObjectPropertySource

Domain:  Involves2

Range:  [0..1] Interchange

Derived:  false
10.32  hasInvolves2Target

Asserted Superproperties: hasInvolvesTarget

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectPropertyTarget

Domain: Involves2
Range: [0..1] Process
Derived: false

10.33  hasInvolvesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Involves
Range: [0..1] Interchange
Derived: false

10.34  hasInvolvesTarget

Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Involves
Range: [0..1] Process
Derived: false

10.35  hasManifestsSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Manifests
Range: [0..1] DevelopedElement
Derived: false
10.36  **hasManifestsTarget**

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Manifests

**Range:**  [0..1] DevelopmentState

**Derived:**  false

10.37  **hasPreparesSource**

**Asserted Superproperties:**  hasHasAssignmentSource

**Inferred Superproperties:**  project-backbone:topObjectProperty,
                             project-backbone:topReifiedObjectPropertySource

**Domain:**  Prepares

**Range:**  [0..1] Role

**Derived:**  false

10.38  **hasPreparesTarget**

**Asserted Superproperties:**  hasHasAssignmentTarget

**Inferred Superproperties:**  project-backbone:topObjectProperty,
                             project-backbone:topReifiedObjectPropertyTarget

**Domain:**  Prepares

**Range:**  [0..1] Product

**Derived:**  false

10.39  **hasProducesSource**

**Asserted Superproperties:**  hasSuppliesSource

**Inferred Superproperties:**  project-backbone:topObjectProperty,
                             project-backbone:topReifiedObjectPropertySource

**Domain:**  Produces

**Range:**  [0..1] Authority

**Derived:**  false
10.40  hasProducesTarget

Asserted Superproperties: hasSuppliesTarget

Inferred Superproperties: project-backbone:topObjectProperty, project-backbone:topReifiedObjectPropertyTarget

Domain: Produces
Range: [0..1] Product
Derived: false

10.41  hasRealizesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Realizes
Range: [0..1] RealizedElement
Derived: false

10.42  hasRealizesTarget

Asserted Superproperties: project-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Realizes
Range: [0..1] RealizedElement
Derived: false

10.43  hasReceivesSource

Asserted Superproperties: project-backbone:topReifiedObjectPropertySource

Inferred Superproperties: project-backbone:topObjectProperty

Domain: Receives
Range: [0..1] Process
Derived: false
10.44  hasReceivesTarget

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Receives

**Range:**  [0..1] Deliverable

**Derived:**  false

10.45  hasReliesOnSource

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  ReliesOn

**Range:**  [0..1] Authority

**Derived:**  false

10.46  hasReliesOnTarget

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  ReliesOn

**Range:**  [0..1] DevelopedElement

**Derived:**  false

10.47  hasRepresentsSource

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Represents

**Range:**  [0..1] Stakeholder

**Derived:**  false

10.48  hasRepresentsTarget

**Asserted Superproperties:**  project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:**  project-backbone:topObjectProperty

**Domain:**  Represents

**Range:**  [0..1] Concern

**Derived:**  false
10.49 hasSuppliesSource

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Supplies

**Range:** [0..1] Authority

**Derived:** false

10.50 hasSuppliesTarget

**Asserted Superproperties:** project-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** project-backbone:topObjectProperty

**Domain:** Supplies

**Range:** [0..1] SuppliedElement

**Derived:** false
## A UML/SysML Embedding

### Table 1: Class UML/SysML Embedding

<table>
<thead>
<tr>
<th>AssignedElement</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concern</td>
<td></td>
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<tr>
<td>Deliverable</td>
<td></td>
</tr>
<tr>
<td>DevelopedElement</td>
<td></td>
</tr>
<tr>
<td>DevelopmentState</td>
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<tr>
<td>Facility</td>
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<tr>
<td>Interchange</td>
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<td>Organization</td>
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<td>Person</td>
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<td>Policy</td>
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<td>Process</td>
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<td>Product</td>
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<td>Program</td>
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<td>Project</td>
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<tr>
<td>RealizedElement</td>
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<td>Role</td>
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<tr>
<td>Stakeholder</td>
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<tr>
<td>SuppliedElement</td>
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<tr>
<td>WorkPackage</td>
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</tr>
<tr>
<td>Class Type</td>
<td>OWL2-MOF2 Embedding</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>owl2-mof2:BinaryAssociationEndType</td>
<td>owl2-mof2:BinaryDependencyEndType</td>
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<tr>
<td>owl2-mof2:BinaryAssociationEndType</td>
<td>owl2-mof2:BinaryDependencyEndType</td>
</tr>
<tr>
<td>owl2-mof2:ObjectPropertyDependentRangeType</td>
<td>owl2-mof2:StructuralFlowPropertyType</td>
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</table>

<table>
<thead>
<tr>
<th>Class Name</th>
<th>OWL2-MOF2 Embedding</th>
</tr>
</thead>
<tbody>
<tr>
<td>AssignedElement</td>
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<tr>
<td>Authority</td>
<td>●</td>
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<tr>
<td>Concern</td>
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<td>Deliverable</td>
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<td>DevelopedElement</td>
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<td>DevelopmentState</td>
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<td>Facility</td>
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<td>Stakeholder</td>
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<td>SuppliedElement</td>
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<tr>
<td>WorkPackage</td>
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</tbody>
</table>
Table 3: Object Property Reification Class OWL2-MOF2 Embedding

| Approves | • | • |
| Authorizes | • | • |
| BelongsTo | • | • |
| Binds | • | • |
| Concurs | • | • |
| DelegatesTo | • | • |
| Delivers | • | • |
| Describes | • | • |
| Executes | • | • |
| HasAssignment | • | • |
| HasParticipant | • | • |
| HasResponsibilityFor | • | • |
| HasRole | • | • |
| Invokes | • | • |
| Involves | • | • |
| Involves1 | • | • |
| Involves2 | • | • |
| Manifests | • | • |
| Prepares | • | • |
| Produces | • | • |
| Realizes | • | • |
| Receives | • | • |
| ReliesOn | • | • |
| Represents | • | • |
| Supplies | • | • |
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