Mission Ontology
Integrated Model-Centric Engineering
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1 Introduction

The Mission Ontology defines concepts and properties for describing missions in terms of their objectives, their constituent components, the functions those components perform, and the requirements that specify them.
2 Imported Ontologies

3 Namespaces


PrimitiveTypes  http://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#


**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#

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

**vandv**  http://imce.jpl.nasa.gov/discipline/vandv/vandv#

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

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

**vandv-embedding-backbone**  http://imce.jpl.nasa.gov/backbone/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 Item

An Item is a discrete unit of material or information exchanged between two Functions.

**Asserted Superclasses:** base:ContainedElement, base:Container, base:IdentifiedElement, mission-backbone:Entity, TraverseElement

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Aspect, mission-backbone:Thing

**Asserted Subclasses:** [MaterialItem] [Message]

**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string
   base:hasCanonicalName [0..1] xsd:string
   base:hasContainmentIndex [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:** isReceivedBy [0..*] InterchangePoint
   isSentBy [0..1] InterchangePoint

**Inferred Object Properties:** base:contains [0..*] Item
   base:isContainedIn [0..1] Item
   participatesIn [0..*] Interchange
   traverses [0..*] Junction

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

4.2 PerformingElement

A PerformingElement is an object that performs one or more Functions.

**Asserted Superclasses:** mission-backbone:Aspect

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Subclasses:** [Component] [Mission]

**Asserted Object Properties:** performs [0..*] Function

The class definition diagram for PerformingElement is shown in Figure 2.
Figure 1: Class definition diagram for Item.
4.3 PresentingElement

A PresentingElement presents zero or more Interfaces that define its connections to the outside world.

**Asserted Superclasses:** mission-backbone:Aspect

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Subclasses:** Component Interface Mission

**Asserted Object Properties:** presents [0..*] Interface

The class definition diagram for PresentingElement is shown in Figure 3.

4.4 SpecifiedElement

**Asserted Superclasses:** mission-backbone:Aspect

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Subclasses:** Component Mission Performs Presents TransfersIn TransfersOut

**Asserted Object Properties:** isSpecifiedBy [0..*] Requirement

The class definition diagram for SpecifiedElement is shown in Figure 4.

4.5 TraversingElement

A TraversingElement is any model element that traverses an Interface.

**Asserted Superclasses:** mission-backbone:Aspect

**Inferred Superclasses:** mission-backbone:Thing
Figure 3: Class definition diagram for PresentingElement.

Figure 4: Class definition diagram for SpecifiedElement.
4.5 TraversingElement

Figure 5: Class definition diagram for TraversingElement.

**Asserted Subclasses:** Flow, Item

**Asserted Object Properties:** participatesIn [0..*] Interchange
traverses [0..*] Junction

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

5.1 Component

A Component is a PerformingElement that is not a Mission. Example Components include launch vehicle, spacecraft, telecommunication subsystem, flight software, attitude control software, and mission operations team.


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
  base:hasCanonicalName [0..1] xsd:string
  base:hasContainmentIndex [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: induces [0..*] Environment
  isDeployedBy [0..*] Mission
  isInfluencedBy [0..*] Environment

Inferred Object Properties: base:contains [0..*] Component
  base:isContainedIn [0..1] Component
  isSpecifiedBy [0..*] Requirement
  performs [0..*] Function
  presents [0..*] Interface

The class definition diagram for Component is shown in Figure 6. The class usage diagram for Component is shown in Figure 7.

5.2 Environment

An Environment corresponds to a set of conditions in which a Component must perform its Functions. Example environments include low earth orbit, trans-Jupiter cruise, and Martian north polar surface.


Inferred Superclasses: base-backbone:Aspect, base-backbone:Thing, mission-backbone:Thing

Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
Figure 6: Class definition diagram for Component.
5.3 Flow

A Flow represents a non-discrete transfer of matter or energy between Functions. Examples of Flow include electrical power, propellant, and heat.

**Asserted Superclasses:** base:ContainedElement, base:Container, base:IdentifiedElement, mission-backbone:Entity, TraversingElement

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Aspect, mission-backbone:Thing

**Inferred Datatype Properties:** base:hasAlternateName [0..*] xsd:string
5  CONCRETE CLASS DEFINITIONS

Figure 8: Class definition diagram for Environment.

Figure 9: Class usage diagram for Environment.

```
base:hasCanonicalName  [0..1] xsd:string
base:hasContainmentIndex   [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:hasUid             [0..1] xsd:string

Asserted Object Properties:  
  isEmittedBy  [0..1] InterchangePoint
  isIngestedBy  [0..1] InterchangePoint

Inferred Object Properties:  
  base:contains  [0..*] Flow
  base:isContainedIn  [0..1] Flow
  participatesIn  [0..*] Interchange
  traverses  [0..*] Junction
```

The class definition diagram for Flow is shown in Figure 10. The class usage diagram for Flow is shown in Figure 11.
Figure 10: Class definition diagram for Flow.
5.4 Function

A Function is an operation or activity performed by a Component in the context of executing a Mission. Every Function is a SpecifiedElement, which implies that a Requirement can specify a Function. Functions, therefore, represent intended Component behavior. Example Functions include search for life on Mars, insert into Martian orbit, and send instrument telemetry packet.

Functions may emit or ingest Flows representing non-discrete exchanges of matter or energy. Functions may send or receive Items representing discrete exchanges of matter or information.

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

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-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:** interchangesThrough [0..*] InterchangePoint
- invokes [0..*] Function
- isInvokedBy [0..*] Function
- isPerformedBy [0..1] PerformingElement

The class definition diagram for Function is shown in Figure 12. The class usage diagram for Function is shown in Figure 13.
Figure 12: Class definition diagram for Function.

Figure 13: Class usage diagram for Function.
5.5 Interchange

An Interchange represents the intended joint behavior of a pair of PerformingElements. It indicates that a Flow or Item may be sent or emitted by one PerformingElement and received or ingested by another.

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

Inferred Superclasses: base-backbone:Aspect, base-backbone:Thing, mission-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: hasParticipant [0..*] TraversingElement
- involves1 [0..1] InterchangePoint
- involves2 [0..1] InterchangePoint

The class definition diagram for Interchange is shown in Figure 14. The class usage diagram for Interchange is shown in Figure 15.

5.6 InterchangePoint

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

Inferred Superclasses: base-backbone:Aspect, base-backbone:Thing, mission-backbone:Thing
5.7 Interface

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: 
- emits [0..*] Flow
- ingests [0..*] Flow
- isInterchangePointFor [0..1] Function
- isInInvolvedIn1 [0..*] Interchange
- isInInvolvedIn2 [0..*] Interchange
- receives [0..*] Item
- sends [0..*] Item

The class definition diagram for InterchangePoint is shown in Figure 16. The class usage diagram for InterchangePoint is shown in Figure 17.

5.7 Interface

An Interface represents a set of mechanical, electrical, signal, or other properties that describe some aspect of a Component’s connection to or interaction with another Component.

It is important to distinguish between a Component, which is a discrete thing, and an Interface, which is a collection of properties. In the formulation phase, for example, we might model the launch vehicle and the spacecraft as Components. The properties that describe how the spacecraft is designed to attach to the launch vehicle would be captured in one Interface (and associated with the spacecraft using the presents property).
Figure 16: Class definition diagram for InterchangePoint.

Figure 17: Class usage diagram for InterchangePoint.
The properties that describe how the launch vehicle is designed or configured to attach to the spacecraft would be captured in another Interface. The fact that two (or more) interfaces mate with each other is conveyed the existence of an Junction that joins the Interfaces.

This method of modeling interfaces allows us to capture the asymmetric aspect of producer/consumer relationships, as well as providing a convenient method for associating the sets of properties and characterize the interconnection of any pair of Components so that they can be analyzed for consistency.

**Asserted Superclasses:** base:IdentifiedElement, mission-backbone:Entity, PresentingElement

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Aspect, mission-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:**
- isJoinedIn1 [0..1] Junction
- isJoinedIn2 [0..1] Junction
- isPresentedBy [0..1] PresentingElement
- transfersIn [0..*] TraversingElement
- transfersOut [0..*] TraversingElement

**Inferred Object Properties:**
- presents [0..*] Interface

The class definition diagram for Interface is shown in Figure 18. The class usage diagram for Interface is shown in Figure 19.

### 5.8 Junction

An Junction represents a set of mechanical, electrical, signal, or other properties that are common to a set of mutually connected Interfaces.

**Asserted Superclasses:** base:ContainedElement, base:Container, base:IdentifiedElement, mission-backbone:Entity

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Thing

**Inferred Datatype Properties:**
- base:hasAlternateName [0..*] xsd:string
- base:hasCanonicalName [0..1] xsd:string
- base:hasContainmentIndex [0..1] xsd:string
- base:hasDescription [0..1] xsd:string
- base:hasIdentifier [0..*] xsd:string
5 CONCRETE CLASS DEFINITIONS

Figure 18: Class definition diagram for Interface.

Figure 19: Class usage diagram for Interface.
Figure 20: Class definition diagram for Junction.

asserted: base:hasIndexEntry [0..*] xsd:string
asserted: base:hasShortName [0..1] xsd:string
asserted: base:hasSortKey [0..1] xsd:string
asserted: base:hasUuid [0..1] xsd:string

asserted object properties: isTraversedBy [0..*] TraversingElement
asserted object properties: joins1 [0..1] Interface
asserted object properties: joins2 [0..1] Interface

inferred: base:contains [0..*] Junction
inferred: base:isContainedIn [0..1] Junction

The class definition diagram for Junction is shown in Figure 20. The class usage diagram for Junction is shown in Figure 21.

5.9 MaterialItem

A MaterialItem is a discrete unit of material exchanged between two Functions. Example MaterialItems include rock hammer and soil sample.

asserted superclasses: Item


inferred datatype properties: base:hasAlternateName [0..*] xsd:string
inferred datatype properties: base:hasCanonicalName [0..1] xsd:string
inferred datatype properties: base:hasContainmentIndex [0..1] xsd:string
CONCRETE CLASS DEFINITIONS

Figure 21: Class usage diagram for Junction.

Figure 22: Class definition diagram for MaterialItem.

<table>
<thead>
<tr>
<th>Property</th>
<th>Multiplicity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>base:hasDescription</td>
<td>[0..1]</td>
<td>xsd:string</td>
</tr>
<tr>
<td>base:hasIdentifier</td>
<td>[0..*]</td>
<td>xsd:string</td>
</tr>
<tr>
<td>base:hasIndexEntry</td>
<td>[0..*]</td>
<td>xsd:string</td>
</tr>
<tr>
<td>base:hasShortName</td>
<td>[0..1]</td>
<td>xsd:string</td>
</tr>
<tr>
<td>base:hasSortKey</td>
<td>[0..1]</td>
<td>xsd:string</td>
</tr>
<tr>
<td>base:hasUuid</td>
<td>[0..1]</td>
<td>xsd:string</td>
</tr>
</tbody>
</table>

Inferred Object Properties: base:contains [0..*] Item
  base:isContainedIn [0..1] Item
  isReceivedBy [0..*] InterchangePoint
  isSentBy [0..1] InterchangePoint
  participatesIn [0..*] Interchange
  traverses [0..*] Junction

The class definition diagram for MaterialItem is shown in Figure 22. The class usage diagram for MaterialItem is shown in Figure 23.
5.10 Message

A Message is a discrete unit of information exchanged between two Functions. Example Messages include command, command response, and file contents.

Asserted Superclasses: [Item]


Inferred Datatype Properties: base:hasAlternateName [0..*] xsd:string
- base:hasCanonicalName [0..1] xsd:string
- base:hasContainmentIndex [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:hasUid [0..1] xsd:string

Inferred Object Properties: base:contains [0..*] [Item]
- base:isContainedIn [0..1] [Item]
- isConnectedBy [0..*] [InterchangePoint]
- isSentBy [0..1] [InterchangePoint]
- participatesIn [0..*] [Interchange]
- traverses [0..*] [Junction]

The class definition diagram for Message is shown in Figure 24. The class usage diagram for Message is shown in Figure 25.
5 CONCRETE CLASS DEFINITIONS

Figure 24: Class definition diagram for Message.

Figure 25: Class usage diagram for Message.
5.11 Mission

A Mission is a PerformingElement that pursues Objectives.

A Mission may contain Components, but the preferred relationship is that a Mission deploys its systems (which are Components). This convention allows for a Mission to be associated with shared or external Components that it does not strictly contain.

**Asserted Superclasses:** base:IdentifiedElement, mission-backbone:Entity, PerformingElement

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Aspect, mission-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..1] 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:**
- deploys [0..*] Component
- pursues [0..*] Objective

**Inferred Object Properties:**
- isSpecifiedBy [0..*] Requirement
- performs [0..*] Function
- presents [0..*] Interface

The class definition diagram for Mission is shown in Figure 26. The class usage diagram for Mission is shown in Figure 27.

5.12 Objective

An Objective represents a specific interest that one or more stakeholders have in the successful execution of a mission. Example Objectives include characterize the extent of the Europan ocean and its relation to the deeper interior, characterize the Europan ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange, and determine global Europan surface compositions and chemistry, especially as related to habitability.

Objectives differ from Requirements in that they are not the result of negotiated agreement between customer and supplier, they need not be mutually consistent, and a Mission pursues but need not completely achieve all its Objectives. In a sense, the set of Requirements for a Mission represents the minimum acceptable achievement of Objectives for a given cost, schedule, and risk.

**Asserted Superclasses:** base:AggregatedElement, base:IdentifiedElement, mission-backbone:Entity

**Inferred Superclasses:** base-backbone:Aspect, base-backbone:Thing, mission-backbone:Thing
Figure 26: Class definition diagram for Mission.
5.13 Requirement

A Requirement specifies an assertion about a SpecifiedElement (Component, Function, or Interface) that must be true for every acceptable realization of that element.

By definition, a Requirement that specifies a Function is a functional requirement. A Requirement that specifies an Interface is an interface requirement. A Requirement that specifies a Component is a component requirement.

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

Inferred Superclasses: base-backbone:Aspect, base-backbone:Thing, mission-backbone:Thing

Asserted Datatype Properties: hasRationale [0..1] xsd:string
**Objective**

- base:AggregatedElement
- base:IdentifiedElement
- mission-backbone:Entity

**Mission**

isPursuedBy [0..*]

![Class definition diagram for Objective.](image)

**Objective**

- isPursuedBy [0..*]

**Mission**

![Class usage diagram for Objective.](image)

**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:**
- isRefinedBy [0..*] Requirement
- refines [0..*] Requirement
- specifies [0..1] SpecifiedElement

The class definition diagram for Requirement is shown in Figure 30. The class usage diagram for Requirement is shown in Figure 31.
5.13 Requirement

Figure 30: Class definition diagram for Requirement.

Figure 31: Class usage diagram for Requirement.
6 Object Property Reification Class Definitions

6.1 Deploys

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasDeploysSource [0..1] Mission`
- `hasDeploysTarget [0..1] Component`

**Reified Object Properties:** `deploys`

The class definition diagram for Deploys is shown in Figure 32. The class usage diagram for Deploys is shown in Figure 33.
6.2 Emits

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasEmitsSource` [0..1] InterchangePoint
- `hasEmitsTarget` [0..1] Flow

**Reified Object Properties:** emits

The class definition diagram for Emits is shown in Figure 34. The class usage diagram for Emits is shown in Figure 35.
6.3 HasParticipant

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasHasParticipantSource` [0..1] Interchange
- `hasHasParticipantTarget` [0..1] TraversingElement

**Reified Object Properties:** `hasParticipant`

The class definition diagram for HasParticipant is shown in Figure 36. The class usage diagram for HasParticipant is shown in Figure 37.

6.4 Induces

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasInducesSource` [0..1] Component
- `hasInducesTarget` [0..1] Environment

**Reified Object Properties:** `induces`

The class definition diagram for Induces is shown in Figure 38. The class usage diagram for Induces is shown in Figure 39.

6.5 Influences

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing
Figure 37: Class usage diagram for HasParticipant.

Figure 38: Class definition diagram for Induces.
6.6 Ingests

Figure 39: Class usage diagram for Induces.

Figure 40: Class definition diagram for Influences.

**Asserted Object Properties:**
- `hasInfluencesSource` [0..1] Environment
- `hasInfluencesTarget` [0..1] Component

**Reified Object Properties:**
- `influences`

The class definition diagram for Influences is shown in Figure [40]. The class usage diagram for Influences is shown in Figure [41].

6.6 Ingests

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasIngestsSource` [0..1] InterchangePoint
6.7 InterchangesThrough

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasInterchangesThroughSource` [0..1] `Function`
- `hasInterchangesThroughTarget` [0..1] `InterchangePoint`

Reified Object Properties: `ingests`

The class definition diagram for Ingests is shown in Figure 42. The class usage diagram for Ingests is shown in Figure 43.
6.8 Invokes

**Reified Object Properties:** \texttt{interchangesThrough}

The class definition diagram for InterchangesThrough is shown in Figure 44. The class usage diagram for InterchangesThrough is shown in Figure 45.

6.8 Invokes

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:** 
- \texttt{hasInvokesSource} \([0..1]\) \texttt{Function}
- \texttt{hasInvokesTarget} \([0..1]\) \texttt{Function}

**Reified Object Properties:** \texttt{invokes}
6.9 Involves

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Subclasses:** Involves1, Involves2

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

**Reified Object Properties:** involves
The class definition diagram for Involves is shown in Figure 48.

6.10 Involves1

**Asserted Superclasses:** Involves

**Inferred Superclasses:** mission-backbone:ReifiedObjectProperty, mission-backbone:Thing

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

**Inferred Object Properties:**
- `hasInvolvesSource` [0..1] Interchange
- `hasInvolvesTarget` [0..1] InterchangePoint

**Reified Object Properties:** involves1

The class definition diagram for Involves1 is shown in Figure 49. The class usage diagram for Involves1 is shown in Figure 50.

6.11 Involves2

**Asserted Superclasses:** Involves

**Inferred Superclasses:** mission-backbone:ReifiedObjectProperty, mission-backbone:Thing
Involves

Figure 49: Class definition diagram for Involves1.

Figure 50: Class usage diagram for Involves1.
The class definition diagram for Involves2 is shown in Figure 51. The class usage diagram for Involves2 is shown in Figure 52.

6.12 Joins

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty
The class definition diagram for Joins is shown in Figure 53.

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Subclasses:** Joins1, Joins2

**Asserted Object Properties:**
- hasJoinsSource: [0..1] Junction
- hasJoinsTarget: [0..1] Interface

**Reified Object Properties:** joins

The class definition diagram for Joins is shown in Figure 53.

6.13 Joins1

**Asserted Superclasses:** Joins

**Inferred Superclasses:** mission-backbone:ReifiedObjectProperty, mission-backbone:Thing

**Asserted Object Properties:**
- hasJoins1Source: [0..1] Junction
- hasJoins1Target: [0..1] Interface

**Inferred Object Properties:**
- hasJoinsSource: [0..1] Junction
- hasJoinsTarget: [0..1] Interface

**Reified Object Properties:** joins1

The class definition diagram for Joins1 is shown in Figure 54. The class usage diagram for Joins1 is shown in Figure 55.
Figure 54: Class definition diagram for Joins1.

Figure 55: Class usage diagram for Joins1.
6.14 Joins2

**Asserted Superclasses:** Joins

**Inferred Superclasses:** mission-backbone:ReifiedObjectProperty, mission-backbone:Thing

**Asserted Object Properties:** hasJoins2Source [0..1] Junction
                                hasJoins2Target [0..1] Interface

**Inferred Object Properties:** hasJoinsSource [0..1] Junction
                                hasJoinsTarget [0..1] Interface

**Reified Object Properties:** joins2

The class definition diagram for Joins2 is shown in Figure 56. The class usage diagram for Joins2 is shown in Figure 57.

6.15 Performs

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

**Inferred Superclasses:** mission-backbone:Aspect, mission-backbone:Thing

**Asserted Object Properties:** hasPerformsSource [0..1] PerformingElement
                                hasPerformsTarget [0..1] Function

**Inferred Object Properties:** isSpecifiedBy [0..*] Requirement

**Reified Object Properties:** performs

The class definition diagram for Performs is shown in Figure 58. The class usage diagram for Performs is shown in Figure 59.
Figure 57: Class usage diagram for Joins2.

Figure 58: Class definition diagram for Performs.
6.16 Presents

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

**Inferred Superclasses:** mission-backbone:Aspect, mission-backbone:Thing

**Asserted Object Properties:**
- hasPresentsSource [0..1] PresentingElement
- hasPresentsTarget [0..1] Interface

**Inferred Object Properties:**
- isSpecifiedBy [0..*] Requirement

**Reified Object Properties:** presents

The class definition diagram for Presents is shown in Figure 60. The class usage diagram for Presents is shown in Figure 61.

6.17 Pursues

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- hasPursuesSource [0..1] Mission
- hasPursuesTarget [0..1] Objective

**Reified Object Properties:** pursues

The class definition diagram for Pursues is shown in Figure 62. The class usage diagram for Pursues is shown in Figure 63.

Figure 59: Class usage diagram for Performs.
6.17 Pursues

Figure 60: Class definition diagram for Presents.

Figure 61: Class usage diagram for Presents.
Pursues\textsuperscript{\textregistered}\textemdash\textsuperscript{\textregistered}Mission
\hspace{1cm}\textsuperscript{\textregistered}Objective

Figure 62: Class definition diagram for Pursues.

Figure 63: Class usage diagram for Pursues.
6.18 Receives

Asserted Superclasses: mission-backbone:ReifiedObjectProperty

Inferred Superclasses: mission-backbone:Thing

Asserted Object Properties: hasReceivesSource [0..1] InterchangePoint
hasReceivesTarget [0..1] Item

Reified Object Properties: receives

The class definition diagram for Receives is shown in Figure 64. The class usage diagram for Receives is shown in Figure 65.

6.19 Refines

Asserted Superclasses: mission-backbone:ReifiedObjectProperty

Inferred Superclasses: mission-backbone:Thing

Asserted Object Properties: hasRefinesSource [0..1] Requirement
hasRefinesTarget [0..1] Requirement

Reified Object Properties: refines

The class definition diagram for Refines is shown in Figure 66. The class usage diagram for Refines is shown in Figure 67.

6.19.1 Comments

6.20 Sends

Asserted Superclasses: mission-backbone:ReifiedObjectProperty
**Figure 65:** Class usage diagram for Receives.

**Figure 66:** Class definition diagram for Refines.

**Figure 67:** Class usage diagram for Refines.
6.21 Specifies

Inferred Superclasses: mission-backbone:Thing

Asserted Object Properties: hasSpecifiesSource [0..1] Requirement
hasSpecifiesTarget [0..1] SpecifiedElement

Reified Object Properties: specifies

The class definition diagram for Specifies is shown in Figure 68. The class usage diagram for Specifies is shown in Figure 69.

6.22 Transfers

Asserted Superclasses: mission-backbone:ReifiedObjectProperty

Inferred Superclasses: mission-backbone:Thing

Asserted Subclasses: TransfersIn, TransfersOut

Asserted Object Properties: hasTransfersSource [0..1] Interface
Figure 69: Class usage diagram for Sends.

Figure 70: Class definition diagram for Specifies.
6.23 TransfersIn

The class definition diagram for TransfersIn is shown in Figure 73. The class usage diagram for TransfersIn is shown in Figure 74.
Figure 72: Class definition diagram for Transfers.

Figure 73: Class definition diagram for TransfersIn.
6.25 Traverses

**Inferred Superclasses:** mission-backbone:Aspect, mission-backbone:ReifiedObjectProperty, mission-backbone:Thing

**Asserted Object Properties:**
- `hasTransfersOutSource` [0..1] Interface
- `hasTransfersOutTarget` [0..1] TraversingElement

**Inferred Object Properties:**
- `hasTransfersSource` [0..1] Interface
- `hasTransfersTarget` [0..1] TraversingElement
- `isSpecifiedBy` [0..*] Requirement

**Reified Object Properties:** transfersOut

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

6.25 Traverses

**Asserted Superclasses:** mission-backbone:ReifiedObjectProperty

**Inferred Superclasses:** mission-backbone:Thing

**Asserted Object Properties:**
- `hasIsTraversedBySource` [0..1] Junction
- `hasIsTraversedByTarget` [0..1] TraversingElement

**Reified Object Properties:** isTraversedBy

The class definition diagram for Traverses is shown in Figure 77. The class usage diagram for Traverses is shown in Figure 78.
Figure 75: Class definition diagram for TransfersOut.

Figure 76: Class usage diagram for TransfersOut.
6.25 Traverses

Figure 77: Class definition diagram for Traverses.

Figure 78: Class usage diagram for Traverses.
7 Concrete Datatype Property Definitions

7.1 hasRationale

A rationale explains why a Requirement exists and why it specifies what it does.

**Asserted Superproperties:** base-backbone:topDataProperty, mission-backbone:topDataProperty

**Domain:** Requirement

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

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

8.1 involves
An Interaction $i$ involves a pair of Functions $\{f_1\}$ and $\{f_2\}$ if and only if $\{f_1\}$ emits a Flow or sends an Item that $\{f_2\}$ ingests or receives.

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

**Range:** $[0..\ast]$ InterchangePoint

**Inverse:** isInvolvedIn

**Derived:** false

**Reification Class:** Involves

**Reification Property Chain:** $\text{hasInvolvesSource}^{-1} \circ \text{hasInvolvesTarget}

8.2 isInvolvedIn

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

**Range:** $[0..\ast]$ Interchange

**Inverse:** involves

**Derived:** true

8.3 isJoinedIn

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

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

**Inverse:** joins

**Derived:** true

8.4 joins

A Junction $j$ joins a pair of Interfaces $\{i_1\}$ and $\{i_2\}$ if and only if the set $\{i_k\}$ share some type of connection and $j$ represents properties common to all Interfaces in $\{i_k\}$ pertinent to that connection.

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

**Range:** $[0..\ast]$ Interface

**Inverse:** isJoinedIn
Derived: false

Reification Class: Joins

Reification Property Chain: hasJoinsSource \overset{\sim}{\circ} hasJoinsTarget

8.5 transfers

An Interface \( i \) transfers a TraversingElement \( e \) if and only if \( i \) is the access point by which \( e \) enters or leaves a Component that presents \( i \).

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

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

Derived: false

Reification Class: Transfers

Reification Property Chain: hasTransfersSource \overset{\sim}{\circ} hasTransfersTarget
9 Concrete Object Property Definitions

9.1 deploys

A a Mission \( m \) deploys Component \( c \) if and only if \( m \) exploits or utilizes \( c \) in pursuit of Objectives. Note that a given Mission may not own all the Components it deploys; some Components (e.g., ground system assets) may be shared with multiple missions.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Mission

**Range:** [0..*] Component

**Inverse:** isDeployedBy

**Derived:** false

**Reification Class:** Deploys

**Reification Property Chain:** \( \text{hasDeploysSource}^{-1} \circ \text{hasDeploysTarget} \)

The property usage diagram for deploys is shown in Figure 79.

9.2 emits

A Function \( F \) emits a Flow \( f \) if and only if \( F \) is the source of \( f \).

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** InterchangePoint

**Range:** [0..*] Flow

**Inverse:** isEmittedBy

**Derived:** false

**Reification Class:** Emits

**Reification Property Chain:** \( \text{hasEmitsSource}^{-1} \circ \text{hasEmitsTarget} \)

The property usage diagram for emits is shown in Figure 80.
Figure 80: Property usage diagram for emits.

Figure 81: Property usage diagram for hasParticipant.

9.3 hasParticipant

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Interchange

Range: [0..*] TraversingElement

Inverse: participatesIn

Derived: false

Reification Class: HasParticipant

Reification Property Chain: hasHasParticipantSource⁻¹ ∘ hasHasParticipantTarget

The property usage diagram for hasParticipant is shown in Figure 81.

9.4 induces

A Component c induces an Environment e if and only if c generates or contributes to the conditions described in e.

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Component

Range: [0..*] Environment
9.5 influences

An Environment $e$ influences a Component $c$ if and only if $c$ is subject to the conditions that define $e$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Environment

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

**Inverse:** isInducedBy

**Derived:** false

**Reification Class:** Induces

**Reification Property Chain:** hasInducesSource $\rightarrow$ hasInducesTarget

The property usage diagram for induces is shown in Figure 82.

9.6 ingests

An Function $F$ ingests a Flow $f$ if and only if $F$ consumes or is otherwise the recipient of $f$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** InterchangePoint
9.7 interchangesThrough

A PerformingElement $p$ interchangesThrough an InterchangePoint $i$ if and only if $p$ has as a consequence of execution an interchange of matter or information with some other PerformingElement via $i$. Exactly one PerformingElement interchangesThrough each InterchangePoint.

**Asserted Superproperties**: mission-backbone:topReifiedObjectProperty

**Inferred Superproperties**: mission-backbone:topObjectProperty

**Domain**: Function

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

**Inverse**: isInterchangePointFor

**Derived**: false

**Reification Class**: InterchangesThrough

**Reification Property Chain**: $\text{hasInterchangesThroughSource}^{-1} \circ \text{hasInterchangesThroughTarget}$

The property usage diagram for interchangesThrough is shown in Figure 85.
9.8 invokes

A Function $f_1$ invokes a Function $f_2$ if and only if execution of $f_1$ may directly cause execution of $f_2$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Function

**Range:** [0..*] Function

**Inverse:** isInvokedBy

**Derived:** false

**Reification Class:** Invokes

**Reification Property Chain:** hasInvokesSource $^{-1} \circ$ hasInvokesTarget

The property usage diagram for invokes is shown in Figure 86.

9.9 involves1

**Asserted Superproperties:** involves

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

**Domain:** Interchange

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

**Inverse:** isInvolvedIn1

**Derived:** false

**Reification Class:** Involves1

**Reification Property Chain:** hasInvolves1Source $^{-1} \circ$ hasInvolves1Target

The property usage diagram for involves1 is shown in Figure 87.
9.10 involves2

Asserted Superproperties: involves

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

Domain: Interchange

Range: [0..1] InterchangePoint

Inverse: isInvolvedIn2

Derived: false

Reification Class: Involves2

Reification Property Chain: hasInvolves2Source \(\circ\) hasInvolves2Target

The property usage diagram for involves2 is shown in Figure 88.

9.11 isDeployedBy

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Component

Range: [0..*] Mission

Inverse: deploys

Derived: true

The property usage diagram for isDeployedBy is shown in Figure 89.
9.12  isEmittedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Flow

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

**Inverse:** emits

**Derived:** true

The property usage diagram for isEmittedBy is shown in Figure 90.

9.13  isInducedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Environment

**Range:** [0..*] Component

**Inverse:** induces

**Derived:** true

The property usage diagram for isInducedBy is shown in Figure 91.
9.14 isInfluencedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Component

**Range:** [0..*] Environment

**Inverse:** influences

**Derived:** true

The property usage diagram for isInfluencedBy is shown in Figure 92.

9.15 isIngestedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Flow

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

**Inverse:** ingests

**Derived:** true

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

9.16 isInterchangePointFor

See interchangesThrough.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** InterchangePoint
Figure 94: Property usage diagram for isInterchangePointFor.

Figure 95: Property usage diagram for isInvokedBy.

Range: [0..1] Function
Inverse: interchangesThrough
Derived: true

The property usage diagram for isInterchangePointFor is shown in Figure 94.

9.17  isInvokedBy

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Function
Range: [0..*] Function
Inverse: invokes
Derived: true

The property usage diagram for isInvokedBy is shown in Figure 95.

9.18  isInvolvedIn1

Asserted Superproperties: isInvolvedIn

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

Domain: InterchangePoint
Range: [0..*] Interchange
Inverse: involves1
Derived: true

The property usage diagram for isInvolvedIn1 is shown in Figure 96.
9.19 isInvolvedIn2

**Asserted Superproperties:** isInvolvedIn

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

**Domain:** InterchangePoint

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

**Inverse:** involves2

**Derived:** true

The property usage diagram for isInvolvedIn2 is shown in Figure 97.

9.20 isJoinedIn1

**Asserted Superproperties:** isJoinedIn

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

**Domain:** Interface

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

**Inverse:** joins1

**Derived:** true

The property usage diagram for isJoinedIn1 is shown in Figure 98.

9.21 isJoinedIn2

**Asserted Superproperties:** isJoinedIn

**Inferred Superproperties:** mission-backbone:topObjectProperty,
mission-backbone:topReifiedObjectProperty
9.22 isPerformedBy

![Diagram](image1)

Figure 98: Property usage diagram for isJoinedIn1.

![Diagram](image2)

Figure 99: Property usage diagram for isJoinedIn2.

**Domain:** Interface

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

**Inverse:** joins2

**Derived:** true

The property usage diagram for isJoinedIn2 is shown in Figure 99.

9.22 isPerformedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Function

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

**Inverse:** performs

**Derived:** true

The property usage diagram for isPerformedBy is shown in Figure 100.

![Diagram](image3)

Figure 100: Property usage diagram for isPerformedBy.
9.23 isPresentedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Interface

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

**Inverse:** presents

**Derived:** true

The property usage diagram for isPresentedBy is shown in Figure 101.

9.24 isPursuedBy

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Objective

**Range:** [0..*] Mission

**Inverse:** pursues

**Derived:** true

The property usage diagram for isPursuedBy is shown in Figure 102.
9.25 isReceivedBy

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Item

Range: [0..*] InterchangePoint

Inverse: receives

Derived: true

The property usage diagram for isReceivedBy is shown in Figure 103.

9.26 isRefinedBy

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Requirement

Range: [0..*] Requirement

Inverse: refines

Derived: true

The property usage diagram for isRefinedBy is shown in Figure 104.
9.27 isSentBy

**Asserted Superproperties**: mission-backbone:topReifiedObjectProperty

**Inferred Superproperties**: mission-backbone:topObjectProperty

**Domain**: Item

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

**Inverse**: sends

**Derived**: true

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

9.28 isSpecifiedBy

**Asserted Superproperties**: mission-backbone:topReifiedObjectProperty

**Inferred Superproperties**: mission-backbone:topObjectProperty

**Domain**: SpecifiedElement

**Range**: [0..*] Requirement

**Inverse**: specifies

**Derived**: true

The property usage diagram for isSpecifiedBy is shown in Figure 106.

9.29 isTraversedBy

**Asserted Superproperties**: mission-backbone:topReifiedObjectProperty

**Inferred Superproperties**: mission-backbone:topObjectProperty

**Domain**: Junction

**Range**: [0..*] TraversingElement

**Inverse**: traverses
Figure 106: Property usage diagram for isSpecifiedBy.


9.30 joins1

**Derived:** false

**Reification Class:** Joins1

**Reification Property Chain:** \[\text{hasJoins1Source}^{-1} \circ \text{hasJoins1Target}\]

The property usage diagram for joins1 is shown in Figure 108.

---

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

**Derived:** false

**Reification Class:** Traverses

**Reification Property Chain:** \[\text{hasIsTraversedBySource}^{-1} \circ \text{hasIsTraversedByTarget}\]

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

---

**Assorted Superproperties:** joins

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

**Domain:** Junction

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

**Inverse:** isJoinedIn1

**Derived:** false

**Reification Class:** Joins1

**Reification Property Chain:** \[\text{hasJoins1Source}^{-1} \circ \text{hasJoins1Target}\]

The property usage diagram for joins1 is shown in Figure 108.
9.31 joins2

**Asserted Superproperties:** \( \text{joins} \)

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

**Domain:** Junction

**Range:** \([0..1] \) Interface

**Inverse:** isJoinedIn2

**Derived:** false

**Reification Class:** Joins2

**Reification Property Chain:** \( \text{hasJoins2Source}^{-1} \circ \text{hasJoins2Target} \)

The property usage diagram for joins2 is shown in Figure 109.

---

9.32 participatesIn

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** TraversingElement

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

**Inverse:** hasParticipant

**Derived:** true

The property usage diagram for participatesIn is shown in Figure 110.

---

9.33 performs

A Component \( c \) performs a Function \( f \) if and only if \( c \) has the sole responsibility for execution of \( f \).

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** PerformingElement

**Range:** \([0..*] \) Function
9.34 presents

A Component $c$ presents an Interface $i$ if and only if $c$ has a direct electrical, mechanical, or logical connection to the outside via $i$. Exactly one Component presents each Interface.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** PresentingElement

**Range:** [0..*] Interface

**Inverse:** isPresentedBy

**Derived:** false
9.35 pursues

A Mission m pursues an Objective o if and only if the successful execution of m results in at least partial achievement of o.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Mission

**Range:** \([0..\star]\) Objective

**Inverse:** isPursuedBy

**Derived:** false

**Reification Class:** Pursues

**Reification Property Chain:**

\[
\text{hasPursuesSource}^{-1} \circ \text{hasPursuesTarget}
\]

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

9.36 receives

A Function F receives an Item i if and only if F consumes i.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty
9.37 refines

A Requirement $l$ refines a Requirement $h$ if and only if satisfaction of $l$ implies partial satisfaction of $h$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

9.38 sends

A Function $F$ sends an Item $i$ if and only if $F$ is the source for $i$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty
9.39 specifies

A Requirement $r$ specifies a element $e$ if and only if the properties of $e$ are bound by $r$.

Asserted Superproperties: mission-backbone:topReifiedObjectProperty

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: Requirement

Range: $[0..1]$ SpecifiedElement

Inverse: isSpecifiedBy

Derived: false

Reification Class: Specifies

Reification Property Chain: \texttt{hasSpecifiesSource}^{-1} \circ \texttt{hasSpecifiesTarget}

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

---

Figure 115: Property usage diagram for refines.

Figure 116: Property usage diagram for sends.
Figure 117: Property usage diagram for specifies.
9.40 transfersIn

An Interface \( i \) transfersOut a TraversingElement \( e \) if and only if \( i \) is the access point by which \( e \) leaves a Component that presents \( i \).

Asserted Superproperties: \[\text{transfers}\]

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

Domain: Interface

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

Derived: false

Reification Class: TransfersIn

Reification Property Chain: \(\text{hasTransfersInSource}^{-1} \circ \text{hasTransfersInTarget}\)

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

9.41 transfersOut

An Interface \( i \) transfersOut a TraversingElement \( e \) if and only if \( i \) is the access point by which \( e \) leaves a Component that presents \( i \).

Asserted Superproperties: \[\text{transfers}\]

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

Domain: Interface

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

Derived: false
Reification Class: **TransfersOut**

Reification Property Chain: $\text{hasTransfersOutSource}^{-1} \circ \text{hasTransfersOutTarget}$

The property usage diagram for transfersOut is shown in Figure 119.

9.42 **traverses**

A TraversingElement $e$ traverses an Junction $j$ if and only if $j$ provides a medium or channel for the transfer of $e$.

**Asserted Superproperties:** mission-backbone:topReifiedObjectProperty

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** **TraversingElement**

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

**Inverse:** **isTraversedBy**

**Derived:** true

The property usage diagram for traverses is shown in Figure 120.
Figure 120: Property usage diagram for traverses.
10 Object Property Reification Source/Target Object Property Definitions

10.1 hasDeploysSource

Asserted Superproperties: mission-backbone:topReifiedObjectPropertySource

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: [Deploys]

Range: [0..1] [Mission]

Derived: false

10.2 hasDeploysTarget

Asserted Superproperties: mission-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: [Deploys]

Range: [0..1] [Component]

Derived: false

10.3 hasEmitsSource

Asserted Superproperties: mission-backbone:topReifiedObjectPropertySource

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: [Emits]

Range: [0..1] [InterchangePoint]

Derived: false

10.4 hasEmitsTarget

Asserted Superproperties: mission-backbone:topReifiedObjectPropertyTarget

Inferred Superproperties: mission-backbone:topObjectProperty

Domain: [Emits]

Range: [0..1] [Flow]

Derived: false
10.5 hasHasParticipantSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** HasParticipant

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

**Derived:** false

10.6 hasHasParticipantTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** HasParticipant

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

**Derived:** false

10.7 hasInducesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Induces

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

**Derived:** false

10.8 hasInducesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Induces

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

**Derived:** false

10.9 hasInfluencesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Influences

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

**Derived:** false
10.10 hasInfluencesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Influences

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

**Derived:** false

10.11 hasIngestsSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Ingests

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

**Derived:** false

10.12 hasIngestsTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Ingests

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

**Derived:** false

10.13 hasInterchangesThroughSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** InterchangesThrough

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

**Derived:** false

10.14 hasInterchangesThroughTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** InterchangesThrough

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

**Derived:** false
10.15 hasInvokesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Invokes

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

**Derived:** false

10.16 hasInvokesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Invokes

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

**Derived:** false

10.17 hasInvolves1Source

**Asserted Superproperties:** hasInvolvesSource

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

**Domain:** Involves1

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

**Derived:** false

10.18 hasInvolves1Target

**Asserted Superproperties:** hasInvolvesTarget

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

**Domain:** Involves1

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

**Derived:** false
10.19  hasInvolves2Source

**Asserted Superproperties:** hasInvolvesSource

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

**Domain:** Involves2

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

**Derived:** false

10.20  hasInvolves2Target

**Asserted Superproperties:** hasInvolvesTarget

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

**Domain:** Involves2

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

**Derived:** false

10.21  hasInvolvesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Involves

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

**Derived:** false

10.22  hasInvolvesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Involves

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

**Derived:** false
10.23 hasIsTraversedBySource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Traverses

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

**Derived:** false

10.24 hasIsTraversedByTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Traverses

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

**Derived:** false

10.25 hasJoins1Source

**Asserted Superproperties:** hasJoinsSource

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

**Domain:** Joins1

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

**Derived:** false

10.26 hasJoins1Target

**Asserted Superproperties:** hasJoinsTarget

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

**Domain:** Joins1

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

**Derived:** false
10.27 hasJoins2Source

**Asserted Superproperties:** hasJoinsSource

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

**Domain:** Joins2

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

**Derived:** false

10.28 hasJoins2Target

**Asserted Superproperties:** hasJoinsTarget

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

**Domain:** Joins2

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

**Derived:** false

10.29 hasJoinsSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Joins

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

**Derived:** false

10.30 hasJoinsTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Joins

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

**Derived:** false
10.31 hasPerformsSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Performs

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

**Derived:** false

10.32 hasPerformsTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Performs

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

**Derived:** false

10.33 hasPresentsSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Presents

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

**Derived:** false

10.34 hasPresentsTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Presents

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

**Derived:** false

10.35 hasPursuesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Pursues

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

**Derived:** false
10.36  hasPursuesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Pursues

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

**Derived:** false

10.37  hasReceivesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Receives

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

**Derived:** false

10.38  hasReceivesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Receives

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

**Derived:** false

10.39  hasRefinesSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Refines

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

**Derived:** false

10.40  hasRefinesTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Refines

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

**Derived:** false
10.41 hasSendsSource
Asserted Superproperties: mission-backbone:topReifiedObjectPropertySource
Inferred Superproperties: mission-backbone:topObjectProperty
Domain: Sends
Range: \([0..1]\) InterchangePoint
Derived: false

10.42 hasSendsTarget
Asserted Superproperties: mission-backbone:topReifiedObjectPropertyTarget
Inferred Superproperties: mission-backbone:topObjectProperty
Domain: Sends
Range: \([0..1]\) Item
Derived: false

10.43 hasSpecifiesSource
Asserted Superproperties: mission-backbone:topReifiedObjectPropertySource
Inferred Superproperties: mission-backbone:topObjectProperty
Domain: Specifies
Range: \([0..1]\) Requirement
Derived: false

10.44 hasSpecifiesTarget
Asserted Superproperties: mission-backbone:topReifiedObjectPropertyTarget
Inferred Superproperties: mission-backbone:topObjectProperty
Domain: Specifies
Range: \([0..1]\) SpecifiedElement
Derived: false
10.45 hasTransfersInSource

Asserted Superproperties: hasTransfersSource


Domain: TransfersIn

Range: [0..1] Interface

Derived: false

10.46 hasTransfersInTarget

Asserted Superproperties: hasTransfersTarget

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

Domain: TransfersIn

Range: [0..1] TraversingElement

Derived: false

10.47 hasTransfersOutSource

Asserted Superproperties: hasTransfersSource


Domain: TransfersOut

Range: [0..1] Interface

Derived: false

10.48 hasTransfersOutTarget

Asserted Superproperties: hasTransfersTarget

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

Domain: TransfersOut

Range: [0..1] TraversingElement

Derived: false
10.49 hasTransfersSource

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertySource

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Transfers

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

**Derived:** false

10.50 hasTransfersTarget

**Asserted Superproperties:** mission-backbone:topReifiedObjectPropertyTarget

**Inferred Superproperties:** mission-backbone:topObjectProperty

**Domain:** Transfers

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

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

Table 1: Class UML/SysML Embedding

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