

Virtual Asset Representation – Manufacturing (VARM)

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Domain & Purpose of the Ontology

- VARM is an ontology from the manufacturing domain. More specifically focused on production and based on the B2MML (Business To Manufacturing Markup Language), an XML implementation of the ANSI/ISA-95
- The aim of the VARM is to provide a flexible knowledge model representing all the required items (i.e. tangible and intangible assets) and their attributes structured in a semantic net of the production process enabling and supporting:
 - a) The control of dynamic real situations in manufacturing shop floors as central information source
 - b) Context aware automation mechanism behaviour adaptation and personalised support (i.e. on the job guidance, decision support) on real time
- Representing the world as a continuum

Ontology Upper Level Concepts I

Class	Description	Data properties
Equipment	Represents the elements of the equipment hierarchy model definition .It may include the definitions of sites, areas, work centres, or Work units.	<ul style="list-style-type: none"> • equipmentId (exactly 1) • description • equipmentName • equipmentLevel (exactly 1)
EquipmentClass	Represents a grouping of equipment with similar characteristics.	<ul style="list-style-type: none"> • equipmentClassID (exactly 1) • description ▲ equipmentLevel (exactly 1)
JobOrder	Represents a job order.	<ul style="list-style-type: none"> • jobOrderId • description • quantityString • unitOfMeasure
MaterialClass	Represents a groupings of material definitions with similar characteristics.	<ul style="list-style-type: none"> • materialClassID (max=1) • description
MaterialDefinition	Represents a material.	<ul style="list-style-type: none"> • materialID (max=1) • description
Person	Represents a specifically identified individual.	<ul style="list-style-type: none"> • personID (exactly 1) • description • personName (exactly 1) • phoneRegId • emailAccount
PersonnelClass	Represents a grouping of persons with similar characteristics.	<ul style="list-style-type: none"> • personnelClassID (exactly 1) • description

Ontology Upper Level Concepts II

Class	Description	Data properties
ProcessSegment	Represents what manufacturing personnel, equipment, or material resources are required for execution of the product segment.	<ul style="list-style-type: none"> • processSegmentID • description • operationType • operationClass • executionType • duration
ProductDefinition	Represents a product.	<ul style="list-style-type: none"> • productID (max=1) • description • version
ProductSegment	Represents the definition of a product segment that is implemented by a process segment.	<ul style="list-style-type: none"> • productSegmentID (exactly 1) • description
TraceProcessSegment	Represent the actual status of a process segment linked to a specific job order	<ul style="list-style-type: none"> • jobOrderId (exactly 1) • processSegmentid _(exactly 1) • equipmentId (exactly 1) • finished (exactly 1) • errorId (max 1) • productSegmentId (max 1) • actualParameterValue (max 1)

VARM: Industrial Use Cases



INDUSTRIAL PILOTS



SCENARIO Complex, manual hydraulic system assembly.

WHAT To optimise hydraulic system assembly through the usage of smart tools and Virtual/Augmented Reality.

WHY To evaluate the impact of an adapted AR HMI in terms of performance and error rate for different skilled groups of people and to enable full quality assurance approach and operators performance thanks to traceability.



SCENARIO Landing gear retraction actuator assembly: Manual deburring operation | Assembly process.

WHAT To incorporate a robot to assist the worker in the deburring operation | To incorporate AR based guidance based on operator's profile as well supporting knowledge sharing.

WHY To increase the quality, efficiency and ergonomics of the deburring process | To reduce operators training time through AR; to reduce time for reviewing documentation; to increase confidence, participation, and internal communication among the personnel.

LAB PILOTS



SCENARIO Collaborative assembly in a fenceless environment.

WHAT To introduce active safety measures supporting Human-Robot collaboration; to support personalized ergonomic adaptation; to provide natural Human-Automation multi-channel interaction; to provide decision support dashboards for quality and maintenance.

WHY To evaluate trust, usability and worker satisfaction (in terms of safety, interaction, ergonomics, assistance).



SCENARIO Final assembly of electric vehicles.

WHAT To incorporate AR based guidance based on operator's profile and to provide the tools required for the assembly by means of an automated tool trolley.

WHY To improve worker satisfaction; to reduce training time; to improve process efficiency; to improve ergonomics; to validate a tool to determine the optimal degree of automation.

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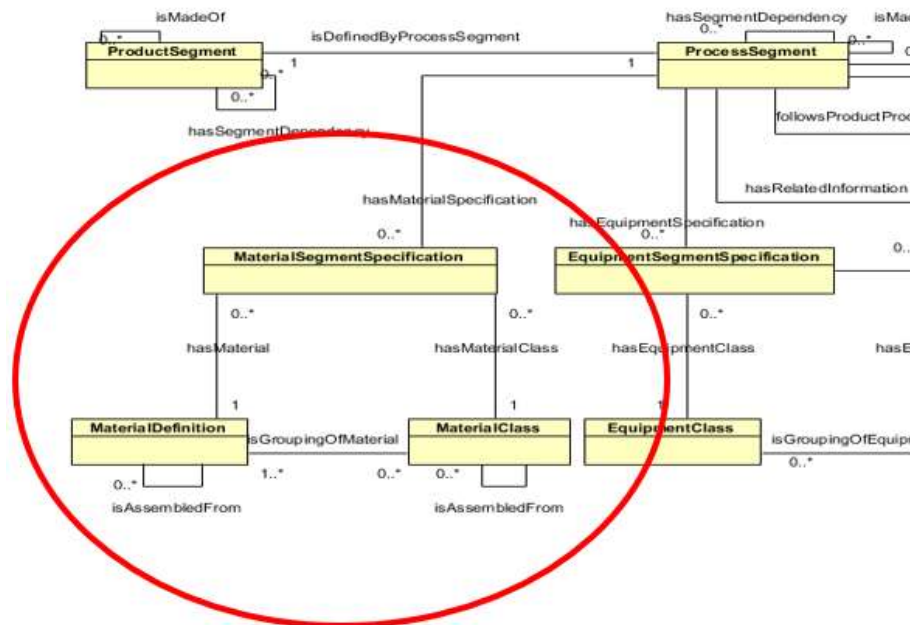
VARM: Industrial Use Cases

- VARM in the presented scenarios enables
 - Data exchange from and to diverse shop floor components, as well as external sources (e.g. legacy systems such as Manufacturing Execution Systems):
 - The ontology is instantiated manually with all the operations needed for each production scenario as well as with all the work centres in each shop floor.
 - All the components (automatisms, legacy systems, interaction devices) involved in the scenario use the same data format described in the ontology to exchange information related to the elements described in it.
 - Automatisms plug and produce approach
 - Each time an automatism is plugged in any of the work centres of the scenarios it publish its capabilities using a RDF file in the ontology, and based on its IP it is related automatically to a work centre in the ontology.
 - Traceability and dynamic status control
 - All the components in the work centres report their status and actions related to the operations and they are stored in the ontology, having a real time information in it.
 - Adaptability to operators
 - Consuming real situation information in the ontology, operations can be personalized to the operators: ie. the presentation of a piece to an operator for its assembly is adjusted considering the height of the current operator.
 - Natural interaction
 - The way to naturally refer to relevant actions in the scenarios are included in the ontology, leading to a natural interpreter to ensure that natural requests are feasible in the current context (i.e: if an operation is stopped or waiting for a collaboration and the operator send a resume action by natural speaking, consuming the ontology information we can know that it is a feasible action, and so trigger the corresponding actions.
 - Personalized assistance in training/on the job guidance and decision making
 - Consuming the current status in terms of production from the ontology, as well as the operator performing the operations, the ontology provides the assistance level required for such a operator for the given process.
 - Notification
 - Considering the current context in the ontology, when necessary a notification is triggered for the target person in the required interaction channel

Overlaps with other ontologies I

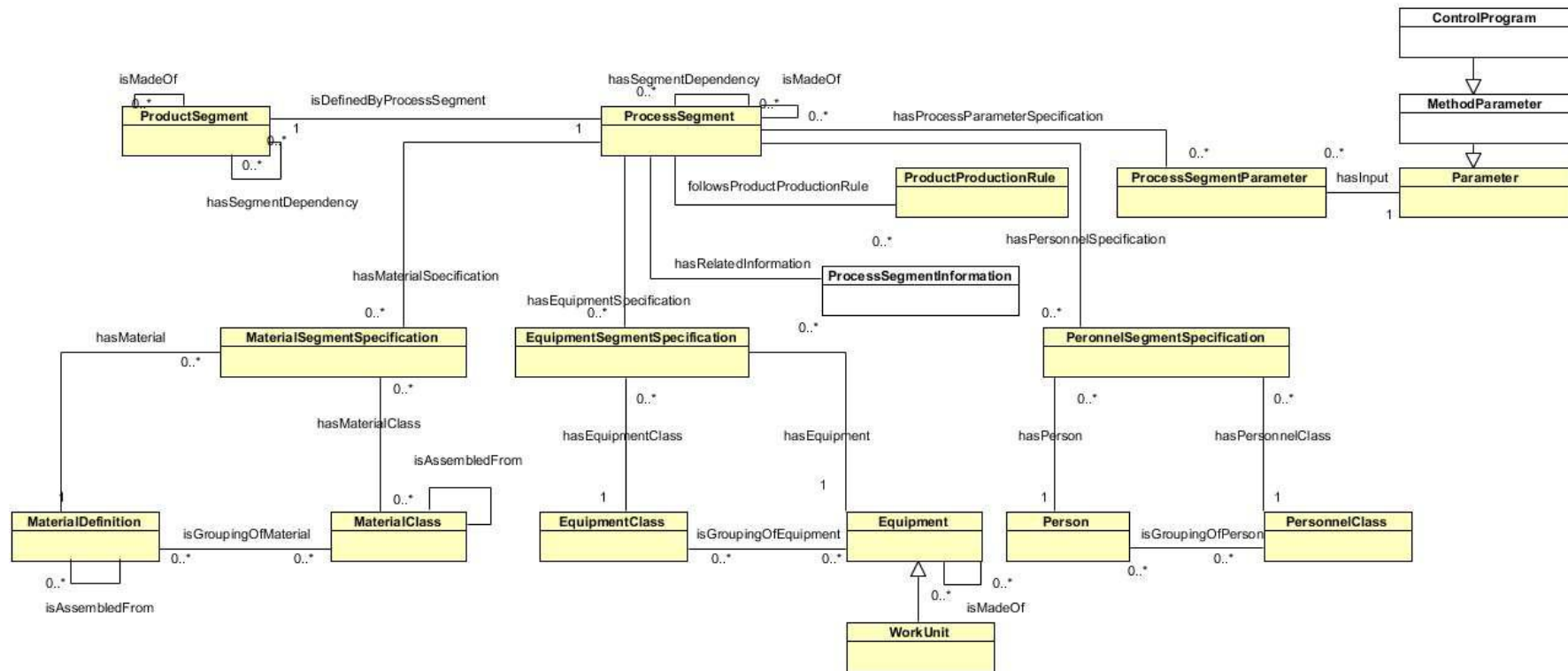
- Ontologies
 - MASON
 - Manufacturing-Marketplaces-Ontology
- Shared concepts
 - machines, tools, materials etc

Overlaps with other ontologies II

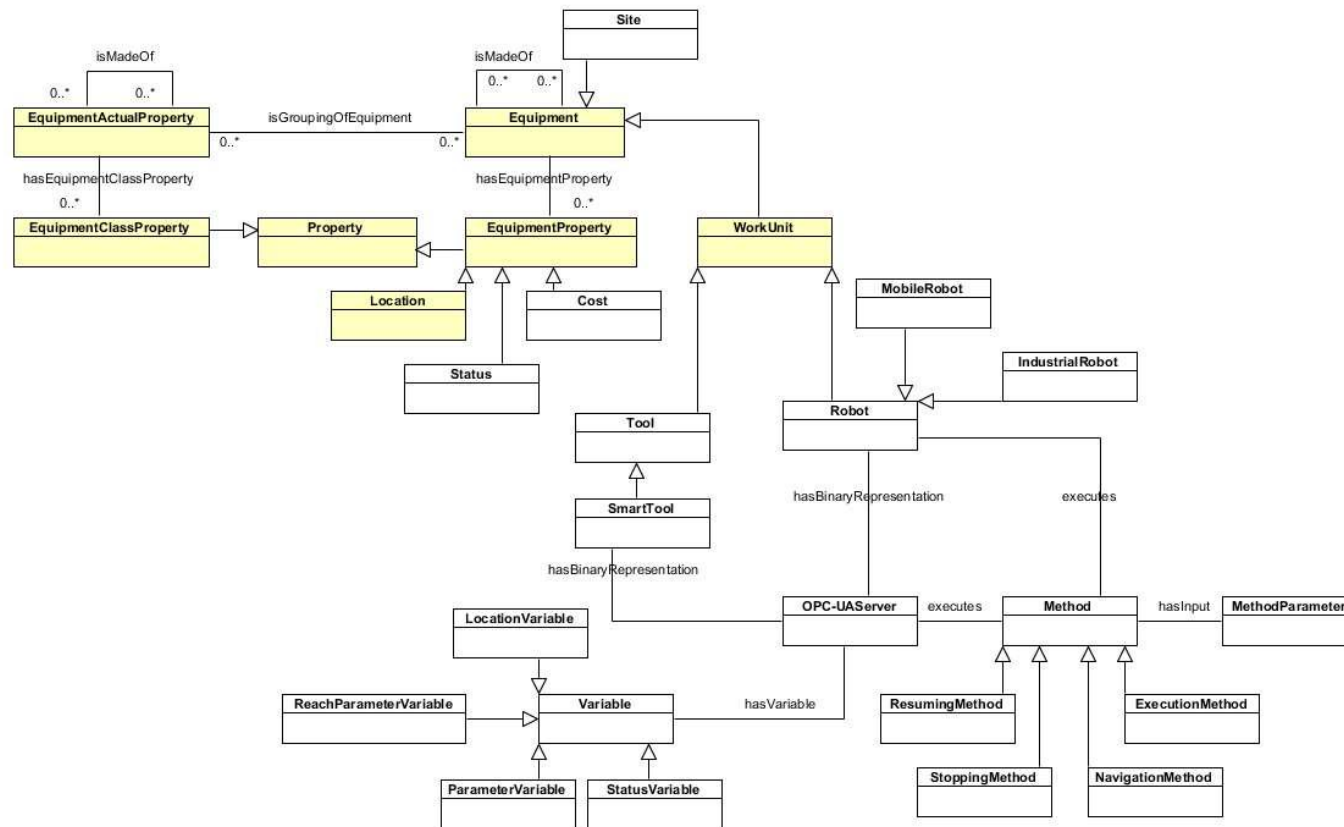


Potential connection
point with EMMO

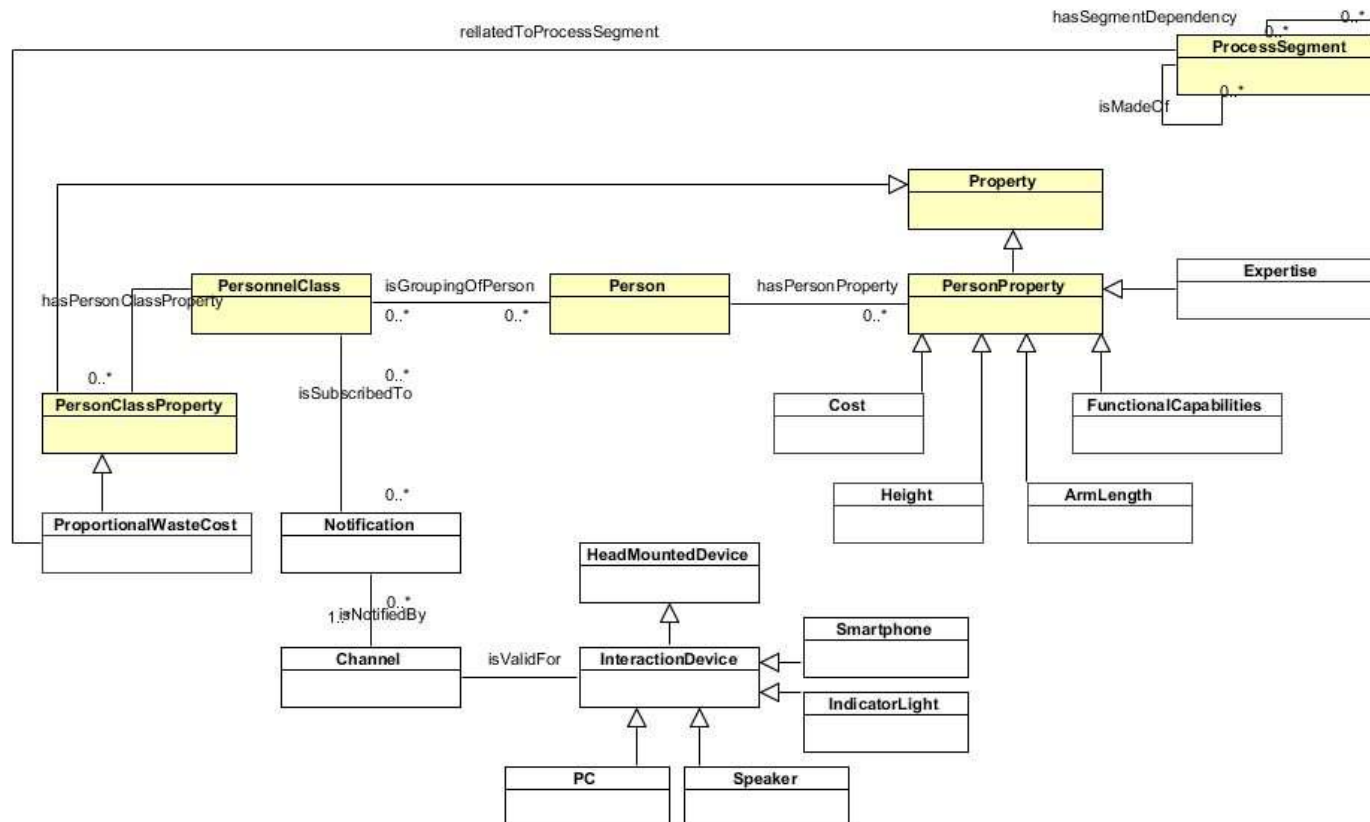
Ontology Main Relations – Process Segment



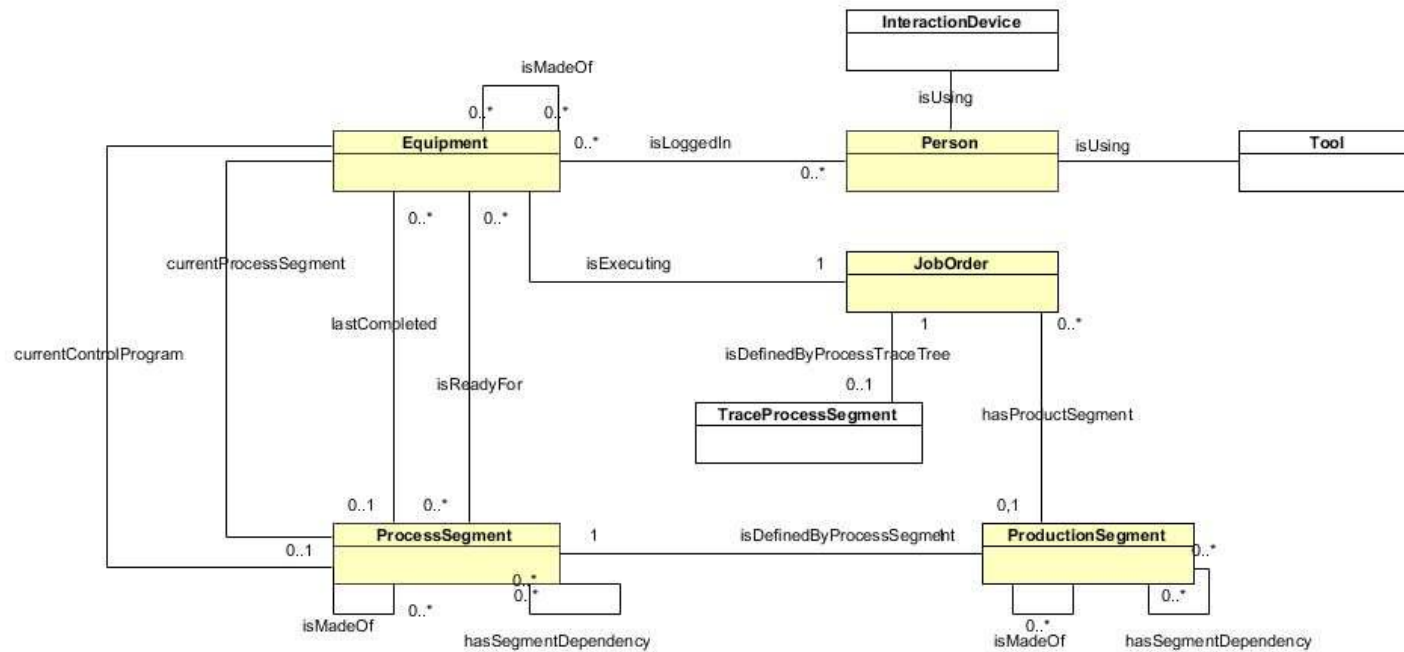
Ontology Main Relations - Equipment



Ontology Main Relations - Personnel



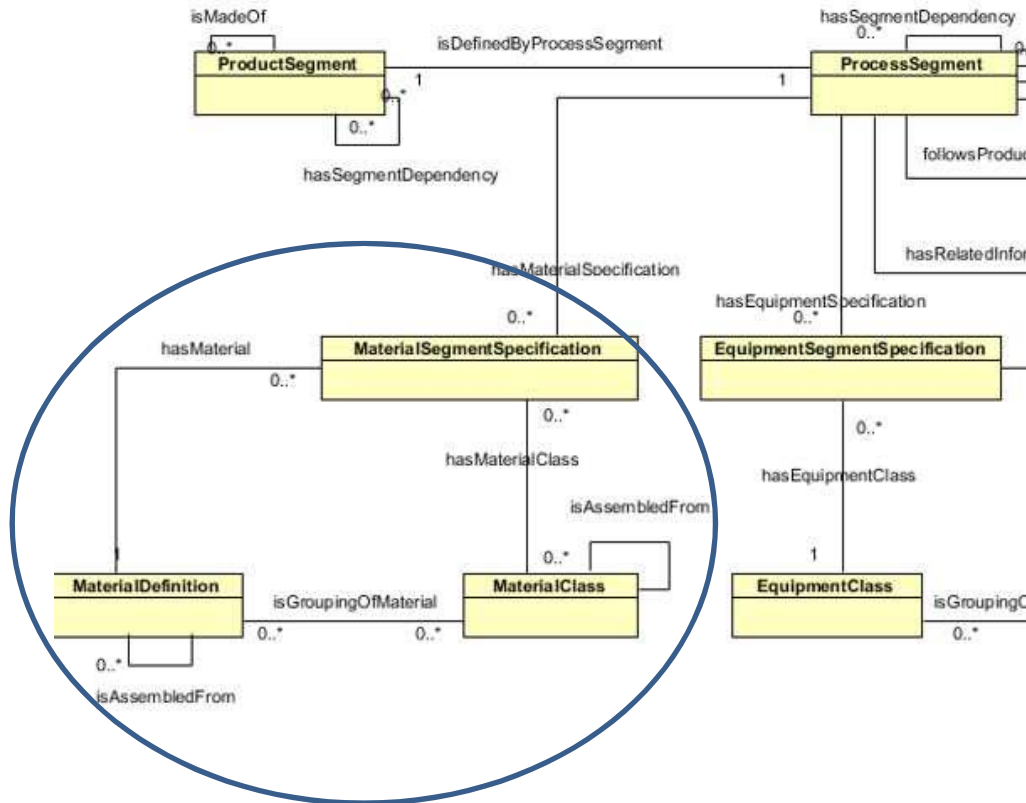
Ontology Main Relations – Dynamic status & Traceability



Knowledge

- The VARM represents all the key assets (tangible and intangible) for a pragmatic description of the real situation in manufacturing scenarios.
 - Tangible and intangible assets: Product, Equipment, Person, Process, Materials, Information, Interaction Devices, Notifications, Annotations
 - The relations between them: i.e which processes and type of automatisms are necessary to produce a product
 - As well as the current status in the shop floor: who is logged where, which operation is running in each automatism and in which status it is,...
 - Leading to infer in real time which is the next operation to perform, to whom a notification must be sent, whose intervention is required...

Materials



Potential connection
with EMMO

Class	Description	Data properties
MaterialClass	Represents a groupings of material definitions with similar characteristics.	<ul style="list-style-type: none"> materialClassID (max=1) description model
MaterialDefinition	Represents a material.	<ul style="list-style-type: none"> materialID (max=1) description model maker
MaterialSegmentSpecification	Represents the material resources required for a process segment.	<ul style="list-style-type: none"> description quantityString dateType

i-Tribomat: represent the material not only as itself but as the evolution of it (properties, etc.) after a process

Addressed Process Types

- Current version supports manufacturing processes such as
 - Production
 - Assembly
 - Logistics
 - Inspection
 - Maintenance

Class	Description	Data properties
ProcessSegment	Represents what manufacturing personnel, equipment, or material resources are required for execution of the product segment.	<ul style="list-style-type: none">• processSegmentID• description• operationType• operationClass• executionType• duration

How does your ontology represent manufacturing

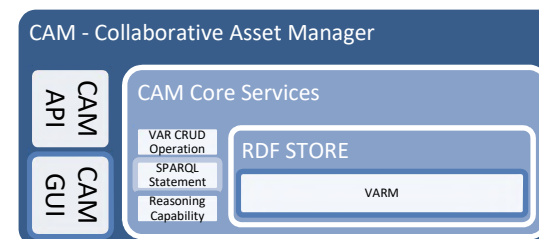
- The ontology defines Products
 - That are defined by / produced by a main processes
 - Main process are composed by more specific processes with their own specifications in terms of parameters, personnel, equipment, material, ...
- The manufacturing of those products are represented in the ontology by the JobOrder class
 - That has assigned a product

Circular connection between physical properties, materials models and measurement

- Currently the ontology does not cover this aspects.
- It is intended to approach it in i-Tribomat project

Implementation

- Language: OWL + SWRL
- Reasoner: Pellet
- Tools
 - Implementation & Static Instantiations: Protegé
 - Dynamic Instantiation & Exploitation:
 - Stardog (reasoning level: DL)
 - CAM (rdf4j + pellet) (Engineering)



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