Vocabulary Management for Multicontext Modelling in UML
Extended MVF- & SKOS-based UML metamodel and profile

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www.coventry.ac.uk/research/areas-of-research/centre-for-future-transport-and-cities/our-research/systems-security/

Overview

Context: Automotive cybersecurity & safety

Research question: enterprise capability

Needs: Expert interview study

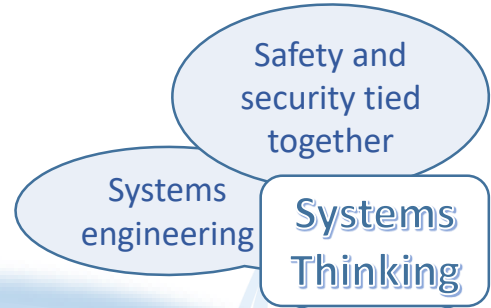Key practices in context

Focus: Standards

Multicontext Modelling

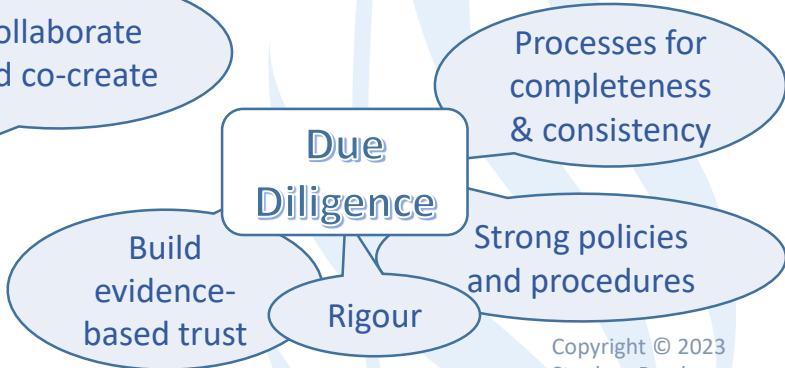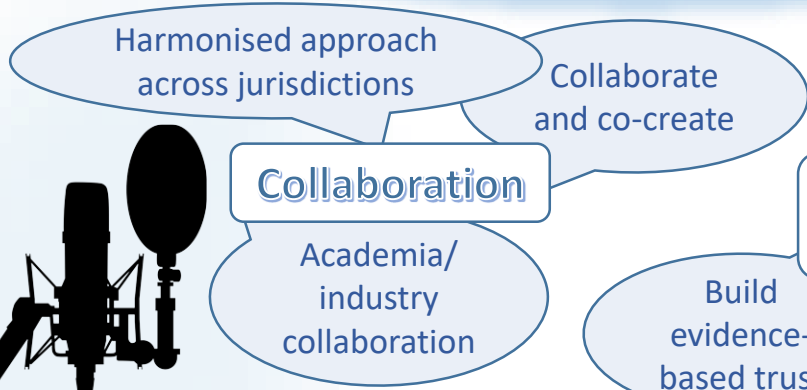Modelling & mapping standards

Concepts and semantic relations

UML metamodel & profile based on MVF

Case study: ISO Harmonization Taskforce

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Focus

Complex systems of systems

- Not business-as-usual
- Unprecedented complexity
- People, vehicles & infrastructure
- Need MBSE **and** semantic capability to handle the complexity
- Integrate engineering models & semantic web

Key standards to harmonise

- ISO/SAE 21434 – Road vehicles – Cybersecurity engineering
- ISO 26262 – Road vehicles – Functional Safety – Part 1: Vocabulary
- ISO 15288 – Systems and software engineering — System life cycle processes
- ASPICE® – Automotive Software Process Improvement & Capability Determination

Rigour
Global
Evidence
Connect
Collaborate
Harmonise
Standards
Safety & Security
Complete
Multidisciplinary
Consistent
Systems Engineering

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Multicontext modelling

Different communities (contexts)…

- … same term to mean different things
- … different terms to mean the same thing
- … different ways of viewing the world and its concepts (worldviews & ontological commitments)

Model-Based Ontology Engineering (MBOE)

To connect contexts, models must accommodate all the above

Lays groundwork for digital transformation initiatives that connect enterprise tool(set)s (engineering & knowledge models)

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Benefits

✓ Resolve issues across different domains

✓ Integrating approach for assessments & audits

✓ Prelude to harmonising primary life cycle processes

✓ Reduce waste, increase reuse
Mappings support collaboration

✓ Connect curated engineering models to mass knowledge
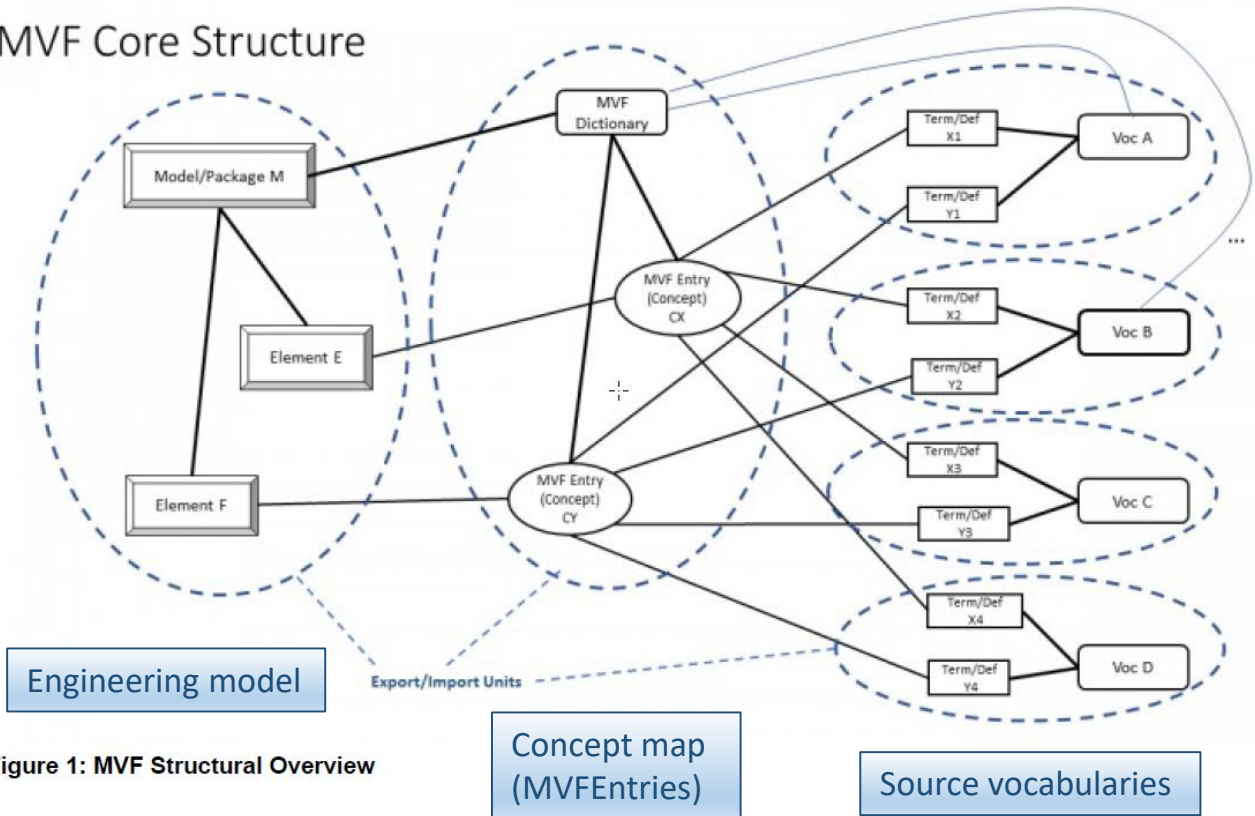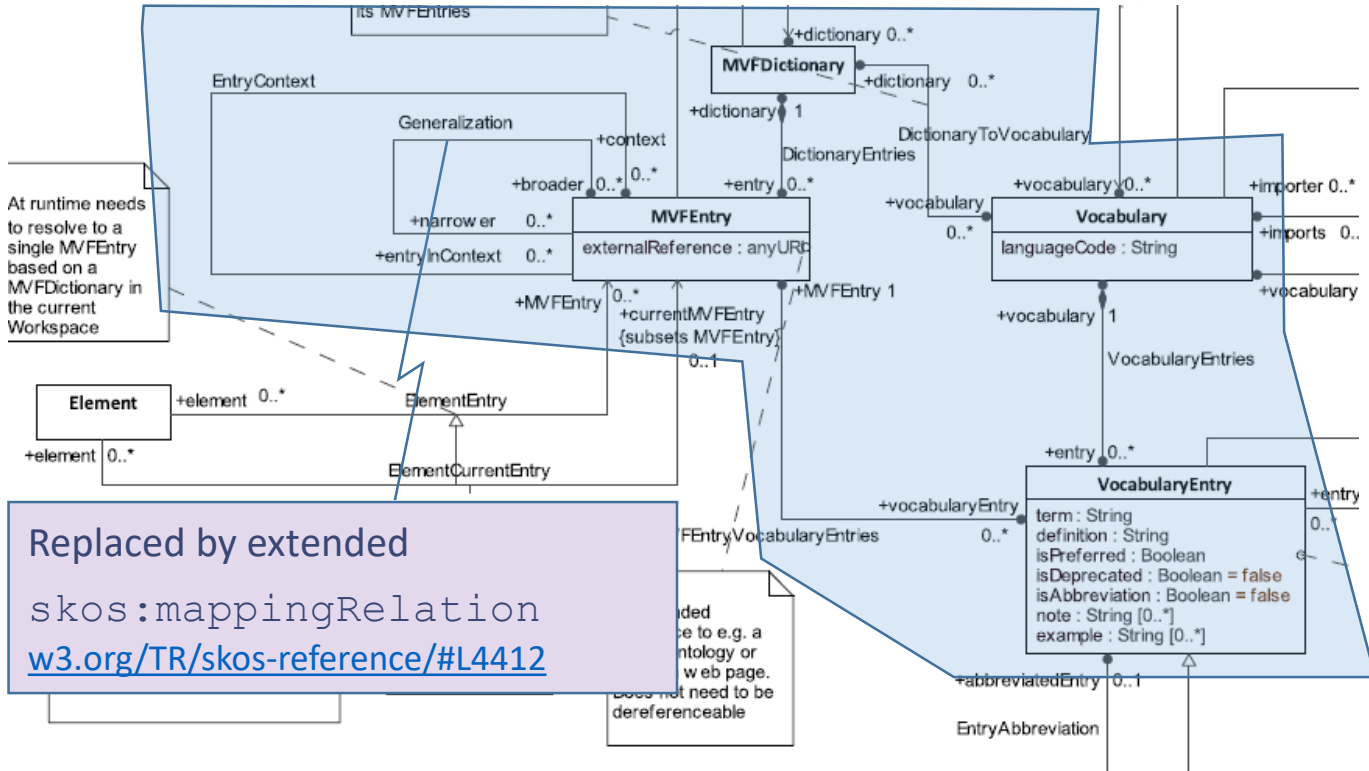Can also guide explainable AI

Model many worlds!

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MVF Core Structure

Model/Package M

Element E

Element F

MVF Dictionary

MVF Entry (Concept) CX

MVF Entry (Concept) CY

Term/Def X1 — Voc A
Term/Def Y1
Term/Def X2 — Voc B
Term/Def Y2
Term/Def X3 — Voc C
Term/Def Y3
Term/Def X4 — Voc D
Term/Def Y4

...

Engineering model

Concept map (MVFEntries)

Source vocabularies

Export/Import Units

Figure 1: MVF Structural Overview

Multiple Vocabulary Facility, v1.0 – beta 1

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omg.org/spec/MVF
opensource.org/license/mit

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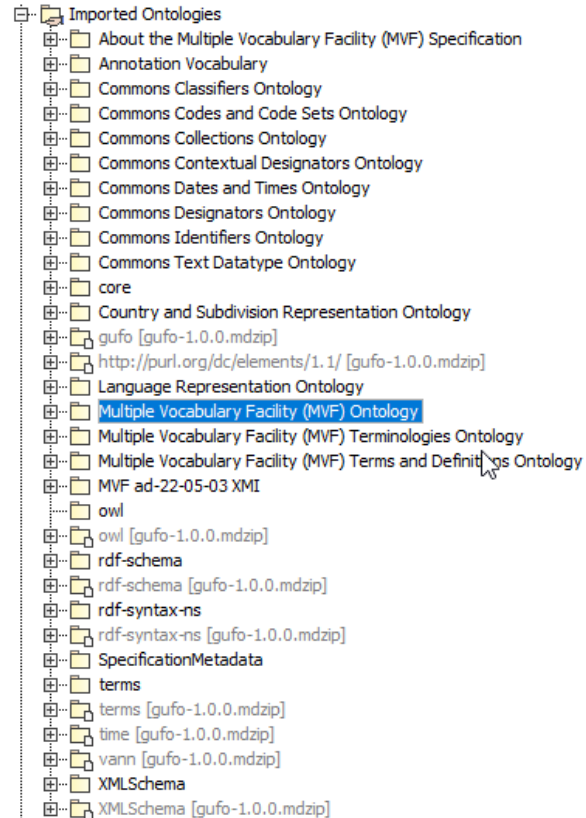Stephen Powley

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MVF (per PDF)

MVF (per PDF, fragment)

ElementEntry diagram including:

- its MVFEntries
- MVFDictionary, +dictionary 0..*, +dictionary 0..*, +dictionary 1
- EntryContext
- Generalization
- DictionaryToVocabulary
- +context
- DictionaryEntries
- +broader 0..* 0..*
- +narrower 0..*
- +entry 0..*
- +entryInContext 0..*
- **MVFEntry** — externalReference : anyURI
- +vocabulary 0..*
- **Vocabulary** — languageCode : String
- +vocabulary 0..*
- +importer 0..*
- +imports 0..
- +vocabulary
- +MVFEntry 0..* / +MVFEntry 1
- +vocabulary 1
- VocabularyEntries
- +currentMVFEntry {subsets MVFEntry} 0..1
- At runtime needs to resolve to a single MVFEntry based on a MVFDictionary in the current Workspace
- **Element**, +element 0..*, +element 0..*
- ElementEntry
- ElementCurrentEntry
- +entry 0..*
- **VocabularyEntry**
  - term : String
  - definition : String
  - isPreferred : Boolean
  - isDeprecated : Boolean = false
  - isAbbreviation : Boolean = false
  - note : String [0..*]
  - example : String [0..*]
- +vocabularyEntry 0..*
- MVFEntryVocabularyEntries
- +abbreviatedEntry 0..1
- EntryAbbreviation
- +entry 0..

Replaced by extended

`skos:mappingRelation`
w3.org/TR/skos-reference/#L4412

Intended reference to e.g. a ontology or web page. Does not need to be dereferenceable

omg.org/spec/MVF opensource.org/license/mit

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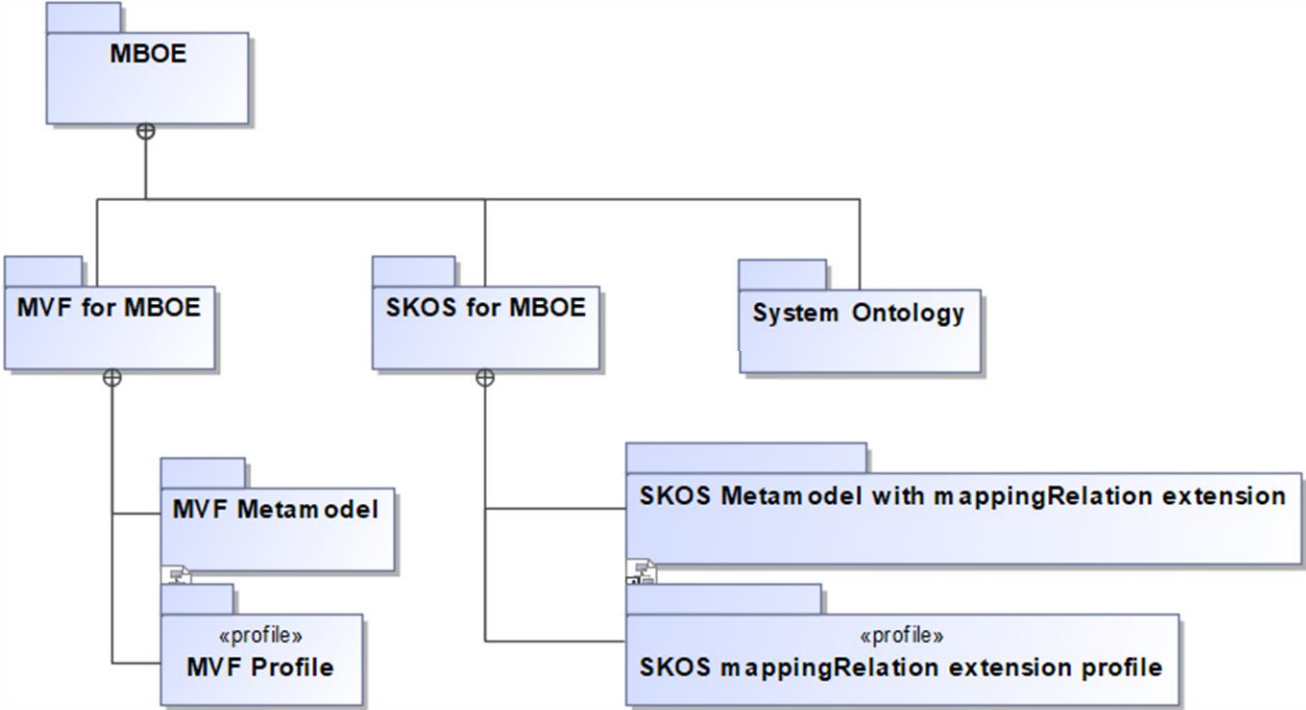# UML Model Mapped to Semantic Web Ontologies

MVF
- RDF
- OWL2
- SKOS Core
- Commons Ontology Library
- DC Terms
- MVF Ontology
- MVF Terminologies Ontology (ISO 1087)
- MVF Terms and Definitions Ontology (ISO 1087)
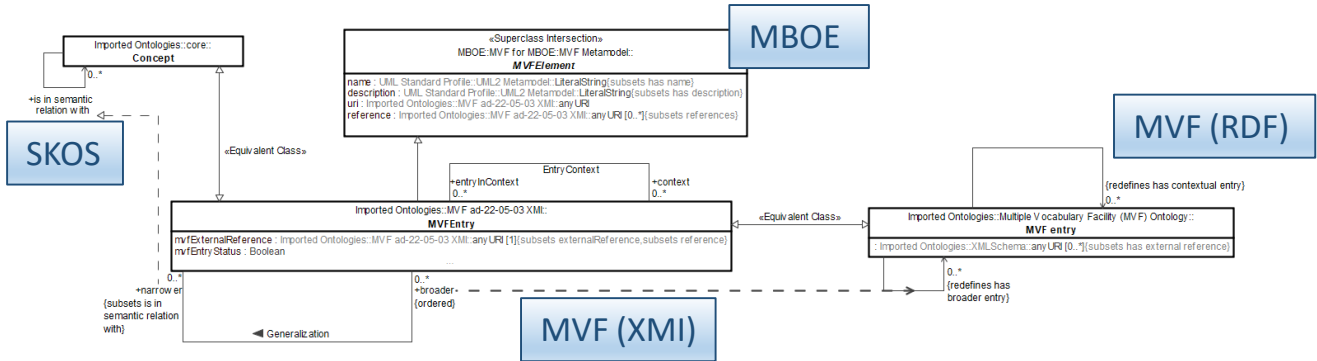
gUFO (gentle Unified Foundation Ontology)
- RDF
- OWL2
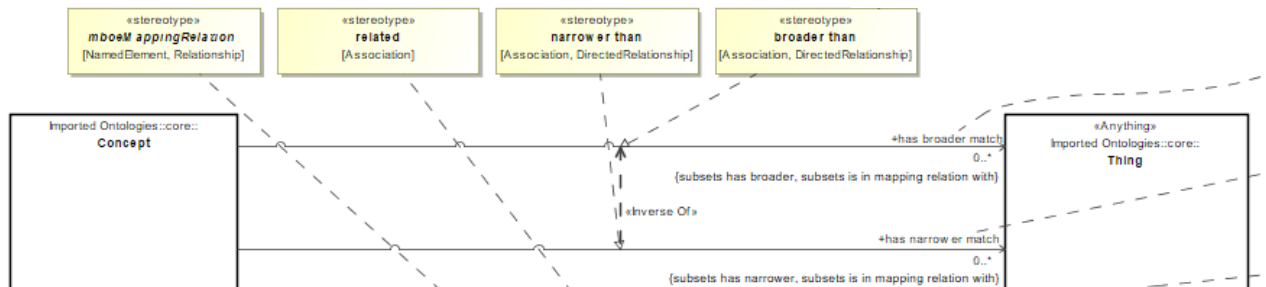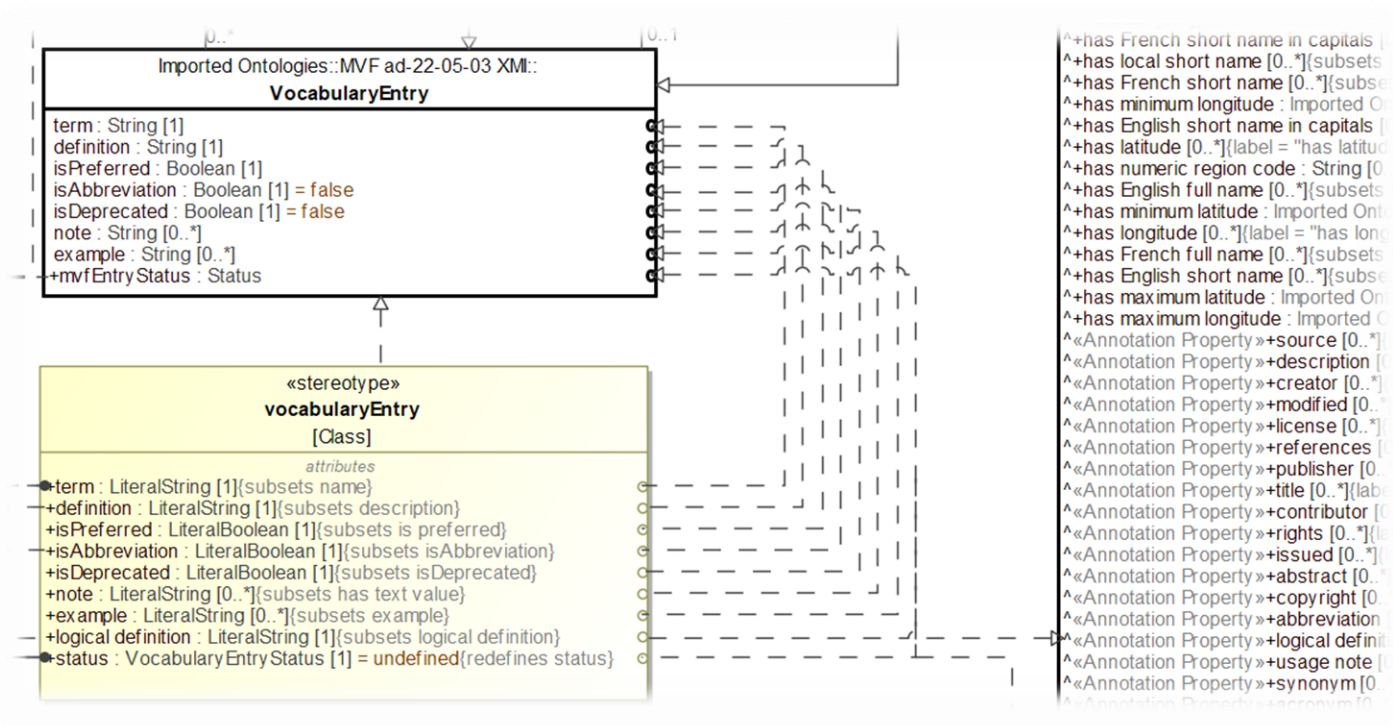- DC Terms
- Time
- Vann (Vocabulary Annotation)

Imported Ontologies
- About the Multiple Vocabulary Facility (MVF) Specification
- Annotation Vocabulary
- Commons Classifiers Ontology
- Commons Codes and Code Sets Ontology
- Commons Collections Ontology
- Commons Contextual Designators Ontology
- Commons Dates and Times Ontology
- Commons Designators Ontology
- Commons Identifiers Ontology
- Commons Text Datatype Ontology
- core
- Country and Subdivision Representation Ontology
- gufo [gufo-1.0.0.mdzip]
- http://purl.org/dc/elements/1.1/ [gufo-1.0.0.mdzip]
- Language Representation Ontology
- Multiple Vocabulary Facility (MVF) Ontology
- Multiple Vocabulary Facility (MVF) Terminologies Ontology
- Multiple Vocabulary Facility (MVF) Terms and Definitions Ontology
- MVF ad-22-05-03 XMI
- owl
- owl [gufo-1.0.0.mdzip]
- rdf-schema
- rdf-schema [gufo-1.0.0.mdzip]
- rdf-syntax-ns
- rdf-syntax-ns [gufo-1.0.0.mdzip]
- SpecificationMetadata
- terms
- terms [gufo-1.0.0.mdzip]
- time [gufo-1.0.0.mdzip]
- vann [gufo-1.0.0.mdzip]
- XMLSchema
- XMLSchema [gufo-1.0.0.mdzip]

UML model structure

Equivalency & superclass assertions

SKOS

MBOE

MVF (RDF)

MVF (XMI)

RDF to UML profile mapping

Tagged value definition stereotypes

Imported Ontologies::MVF ad-22-05-03 XMI::
VocabularyEntry

term : String [1]
definition : String [1]
isPreferred : Boolean [1]
isAbbreviation : Boolean [1] = false
isDeprecated : Boolean [1] = false
note : String [0..*]
example : String [0..*]
+mvfEntryStatus : Status

«stereotype»
vocabularyEntry
[Class]

attributes
+term : LiteralString [1]{subsets name}
+definition : LiteralString [1]{subsets description}
+isPreferred : LiteralBoolean [1]{subsets is preferred}
+isAbbreviation : LiteralBoolean [1]{subsets isAbbreviation}
+isDeprecated : LiteralBoolean [1]{subsets isDeprecated}
+note : LiteralString [0..*]{subsets has text value}
+example : LiteralString [0..*]{subsets example}
+logical definition : LiteralString [1]{subsets logical definition}
+status : VocabularyEntryStatus [1] = undefined{redefines status}

^+has French short name in capitals [
^+has local short name [0..*]{subsets
^+has French short name [0..*]{subse
^+has minimum longitude : Imported O
^+has English short name in capitals [
^+has latitude [0..*]{label = "has latitud
^+has numeric region code : String [0
^+has English full name [0..*]{subsets
^+has minimum latitude : Imported Ont
^+has longitude [0..*]{label = "has long
^+has French full name [0..*]{subsets
^+has English short name [0..*]{subse
^+has maximum latitude : Imported On
^+has maximum longitude : Imported O
^«Annotation Property»+source [0..*]
^«Annotation Property»+description [
^«Annotation Property»+creator [0..*]
^«Annotation Property»+modified [0..
^«Annotation Property»+license [0..*]
^«Annotation Property»+references [
^«Annotation Property»+publisher [0.
^«Annotation Property»+title [0..*]{lab
^«Annotation Property»+contributor [
^«Annotation Property»+rights [0..*]{
^«Annotation Property»+issued [0..*]
^«Annotation Property»+abstract [0..
^«Annotation Property»+copyright [0.
^«Annotation Property»+abbreviation
^«Annotation Property»+logical defini
^«Annotation Property»+usage note [
^«Annotation Property»+synonym [0.

MVF profile (fragment for classes)

```
skos:semanticRelation
 |
 +- skos:related
 |   |
 |   +- skos:relatedMatch
 |
 +- skos:broaderTransitive
 |   |
 |   +- skos:broader
 |       |
 |       +- skos:broadMatch
 |
 +- skos:narrowerTransitive
 |   |
 |   +- skos:narrower
 |       |
 |       +- skos:narrowMatch
 |
 +- skos:mappingRelation
     |
     +- skos:closeMatch
     |   |
     |   +- skos:exactMatch
     |
     +- skos:relatedMatch
     |
     +- skos:broadMatch
     |
     +- skos:narrowMatch
```

skos:semanticRelation
w3.org/TR/skos-reference/#L4160

skos:mappingRelation
w3.org/TR/skos-reference/#L4412

Extended SKOS Mapping Relations
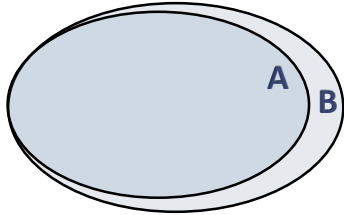
A close match narrower than B
B close match broader than A
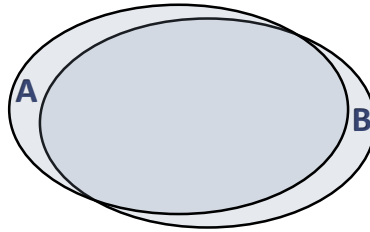
A close match overlaps B
B close match overlaps A
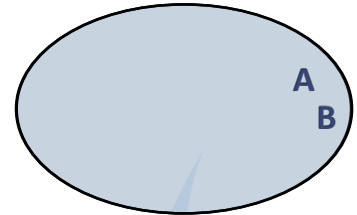
A exact match B
B exact match A
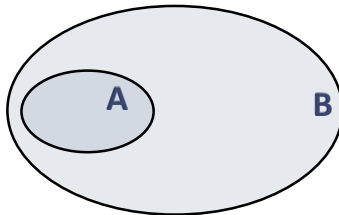
A loose match narrower than B
B narrow match broader than A
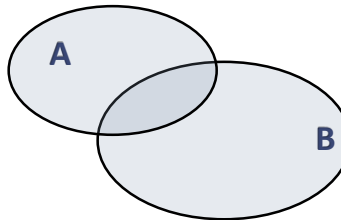
A loose match overlaps B
B loose match overlaps A
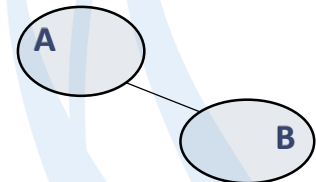
A related to B
(specify nature of relation)

close =
high degree of confidence defined terms could
be used interchangeably in most contexts

loose =
slightly similar, could be considered
similar in limited contexts

Extended mapping relations profile

This diagram is incomplete.
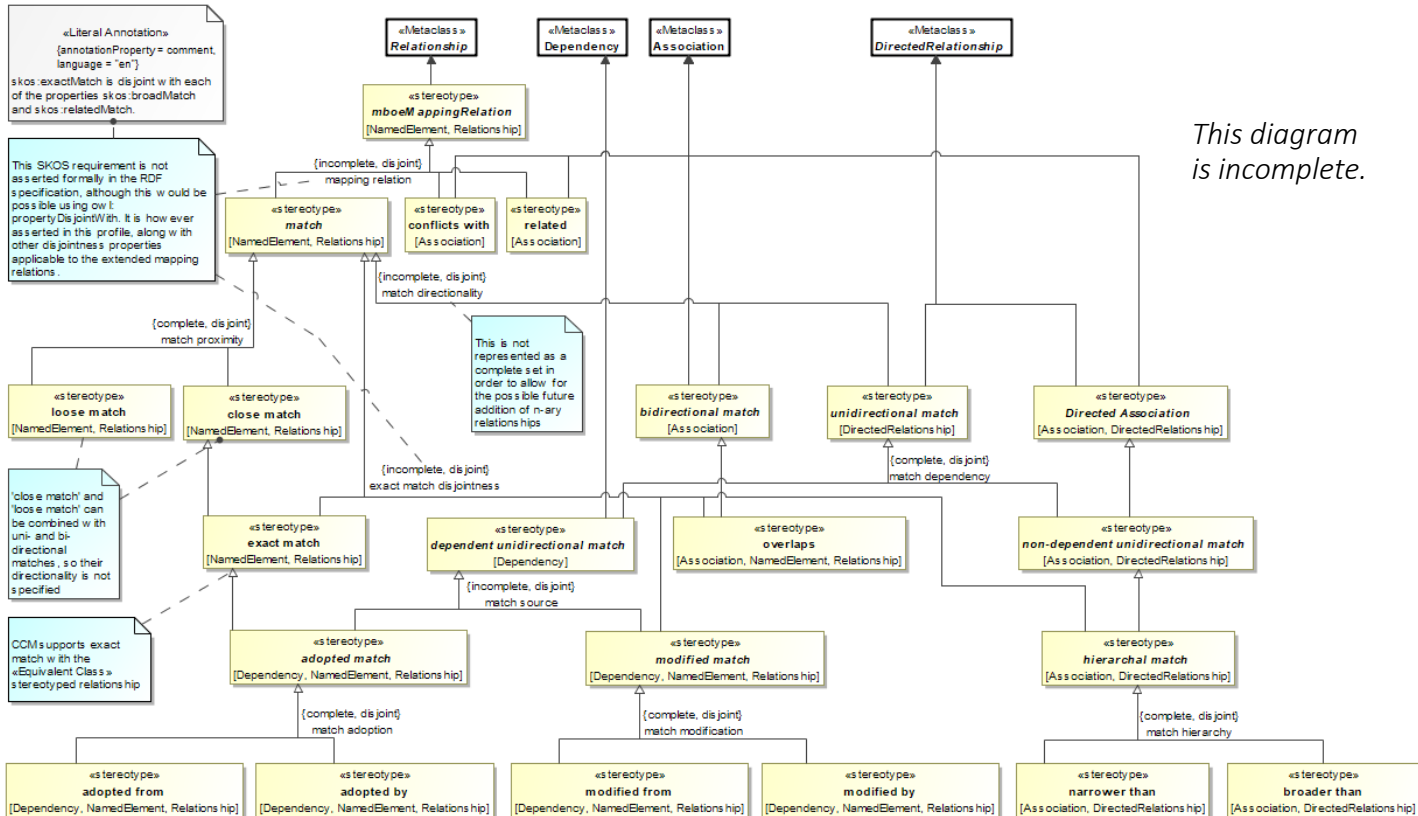
Vocabulary mapping: ISO domain standards

Important to get involved
- Not as difficult as you might think to participate, but time consuming

Don't underestimate value of access to experts
- Those involved in authoring the standards understand intent

Ambiguity might be deliberate
- Can provide an alternative to consensus making

Consistency, adequacy & completeness of definitions not required
- Tendency to rely on 'dictionary definitions' as much as possible, but five different dictionaries permitted and not always checked

Conceptual models very useful to address the above
- **Sound logical basis for amendments, not easily dismissed**

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Concepts

ISO/SAE 21434:2021

component

part that is logically and technically separable

ISO 15288:2015

system element

member of a set of elements that constitutes a system

EXAMPLE Hardware, software, data, humans, processes, procedures, facilities, materials, and naturally occurring entities or any combination.

Note 1 to entry: A system element is a discrete part of a system that can be implemented to fulfil specified requirements.

ISO 26262:2018

component

non-system level element that is logically or technically separable and is comprised of more than one hardware part or one or more software units

EXAMPLE A microcontroller.

Note 1 to entry: A component is a part of a system.
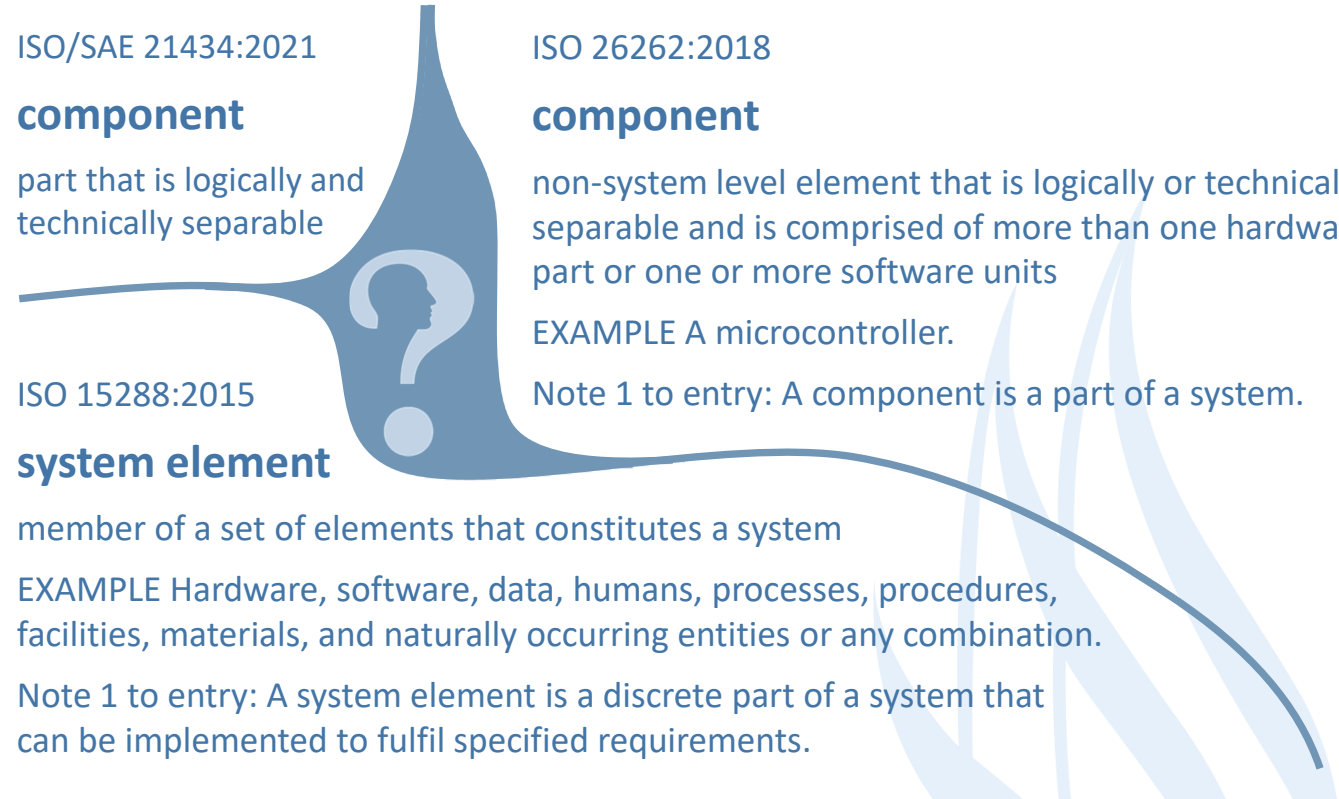
Excel tool to build mappings

- Interface for non-UML users

- Guided process

- Automatically populates terms and descriptions (3 standards)

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Concepts mapped between contexts
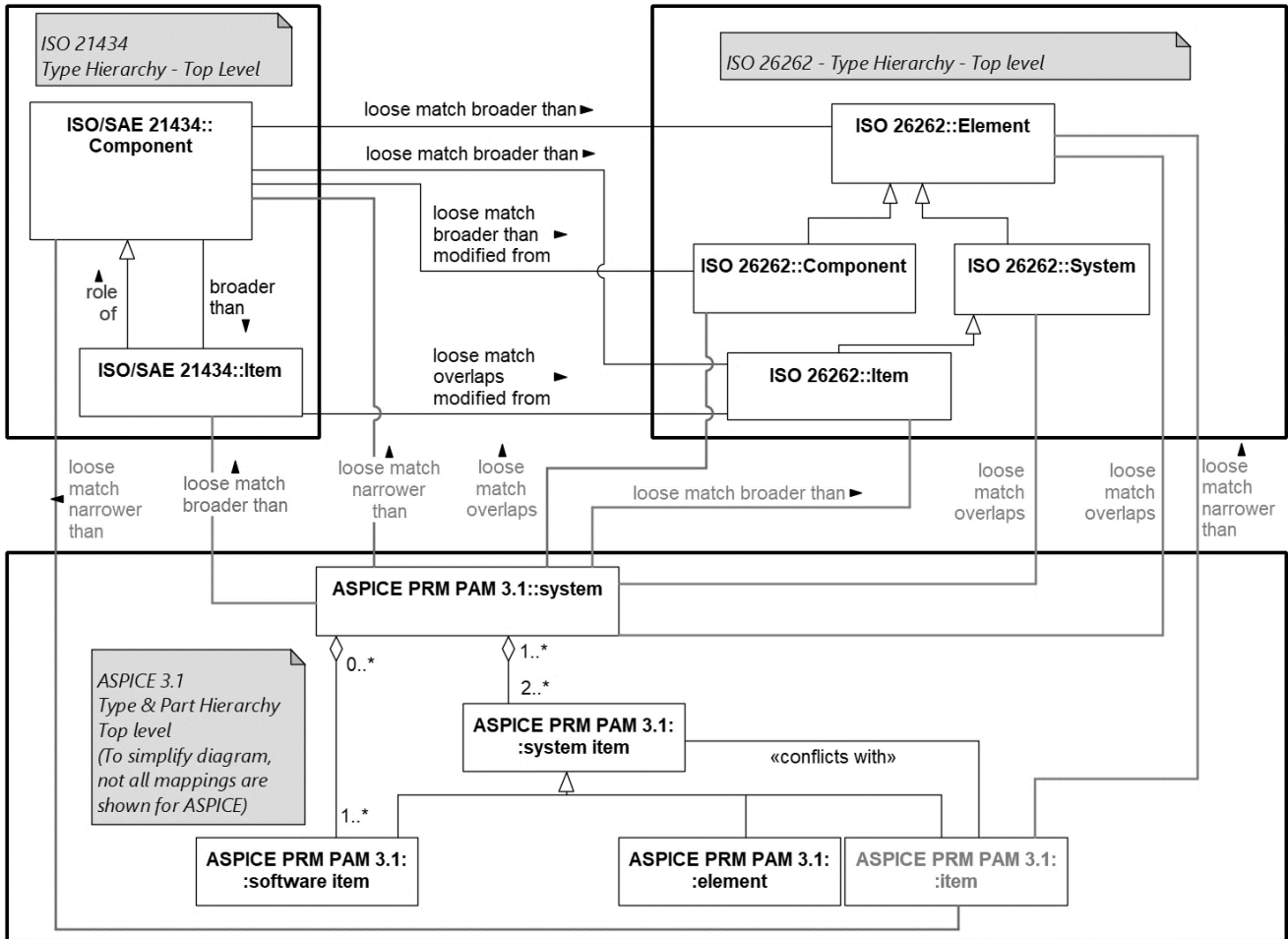
From mapping to harmonisation

- Little direct alignment between concepts, so must find 'common ancestors' (root concepts)

  - Makes the harmonisation task harder because who 'owns' the root term?

  - Scope exceeds remit of a single organisation

- Root concepts for only three standards is limiting

  Beware:
  So many standards we need a new standard to rule them all?
  That's just one more standard!

- So develop a common core for a whole suite of standards?

  - Huge modelling and organisational challenges

THE CHALLENGE OF HARMONIZATION

> " *If one is interested in the relations between fields which,*
>
> *according to customary academic divisions,*
>
> *belong to different departments,*
>
> *then he will not be welcomed as a builder of bridges,*
>
> *as he might have expected,*
>
> *but will rather be <u>regarded by both sides as an outsider and troublesome intruder</u>.* "

Carnap, Rudolf
(in The Philosophy of Rudolf Carnap, Schilpp, 1963)
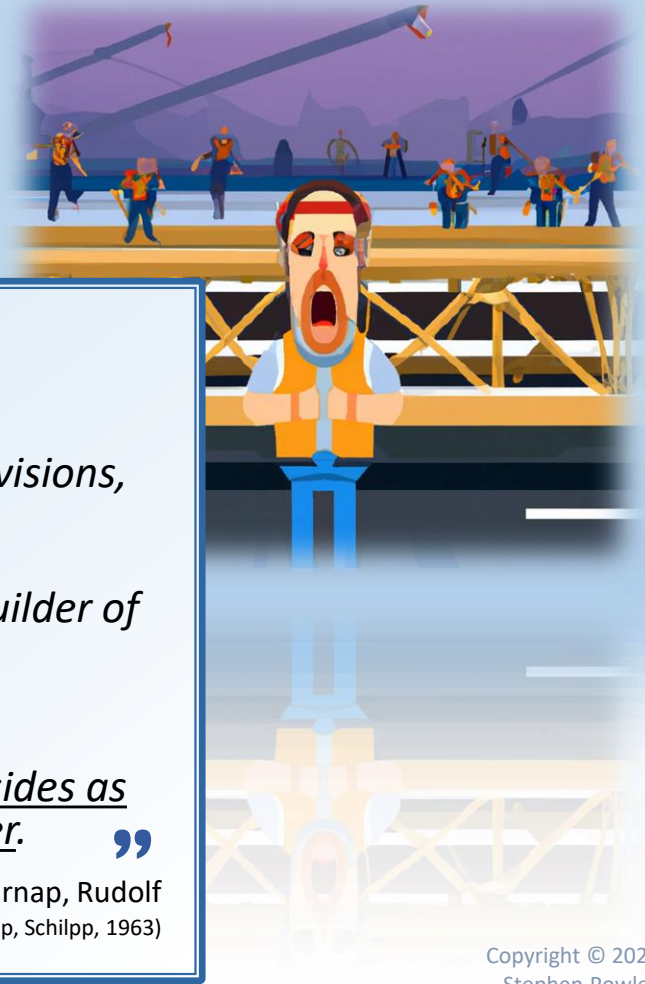
SUMMARY

❑ Context: language, industry, time, location, team, … (who, where, what, why, when, how)

❑ Listen to stakeholders

❑ Collaborate, participate & develop talent

❑ Semantic web-compatible engineering models

❑ Add value with transdisciplinary approach

❑ Use MBSE and model multiple contexts

❑ Case studies to demonstrate value of methods

❑ Influence global standards

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