Putting the O in Model – Ontologies for MBSE

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Safety Critical Systems Club

For Everyone Working in System Safety

Global professional network for sharing knowledge about system safety

Develops and publishes best practice guidance through working groups

Events and publications that advance professional knowledge

scsc.uk/owg

The Ontology Working Group (OWG)...

Develops ontologies to support risk-based decision making and data safety

Champions ontologies to improve how people collaborate, articulate designs and engineer safer systems

Helps bring structure to formal models and documents to reduce ambiguities and inconsistencies

Considers business context where different groups of people collaborate

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What is an ontology?

Why would you want one?

MBSE & architecture description

Ontology stacks

Unified Foundation Ontology

OntoUML

Modelling flights in OntoUML

Final thoughts

Shh, don't mention the 'O' word!

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"An explicit specification of a conceptualization"

Gruber, T.R. (1993)
A translation approach to portable ontology specifications
Knowledge Acquisition, 5(2), pp. 199–220
doi.org/10.1006/knac.1993.1008

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Give structure to concepts and how they are related

Address interoperability challenges

Integrate MBSE with the enterprise knowledge base

Basis for architecture description

Strengthen model foundations

Basis for Domain Specific Languages

Why might you want ontologies?

Improve decision support

Capture different perspectives in models

Shared understanding based on logic

Longer-lived models

Work better together with people and AI

Underpin improvements to artificial intelligence

Rigorous models for high-integrity systems

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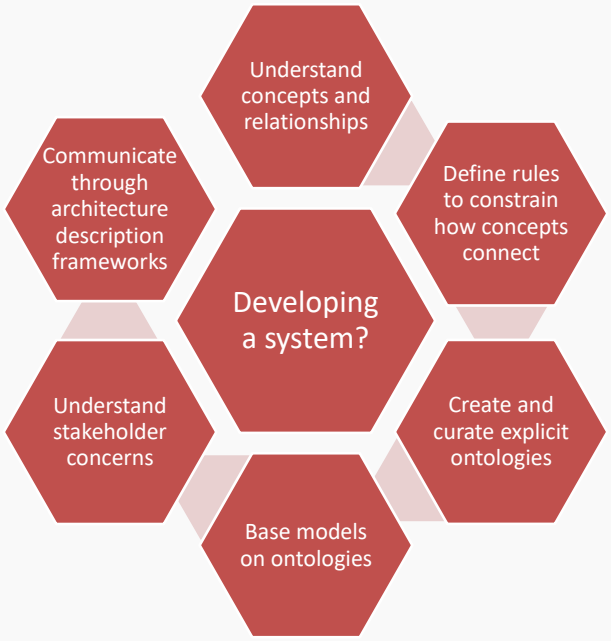
Ontologies, MBSE & architecture description

Treat ontologies as systems for describing systems

Develop with an SE lifecycle

Refine through iteration

Describe the world in terms stakeholders understand



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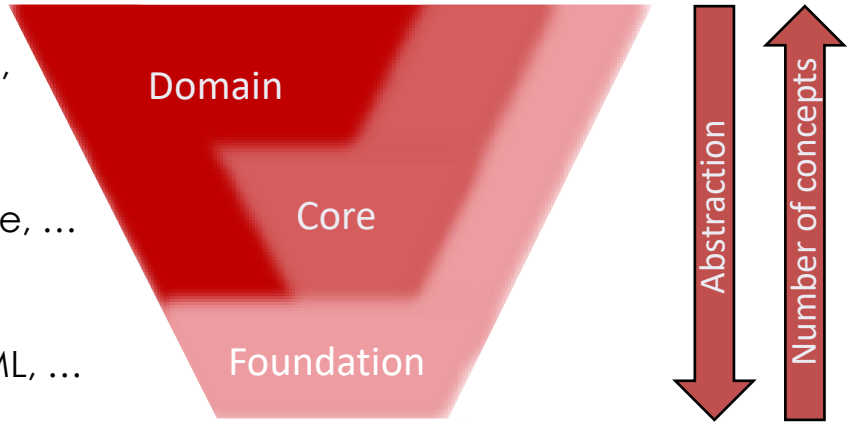
Ontology stacks

Aerospace, medical, automotive, …

CCO, IDEAS, IOF Core, …

BFO, UFO, BORO, OML, …



Adapted from finregont.com/reference-ontologies/ and
Fig. 14 in Scherp, Ansgar et al. 'Designing Core Ontologies'. 2011 : 177 – 221.

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Unified Foundation Ontology (UFO)

'O', that looks scary

Don't panic! We just need some of the leaves

OntoUML

Guizzardi et al, 2022
doi.org/10.3233/AO-210256

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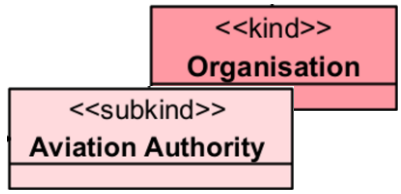
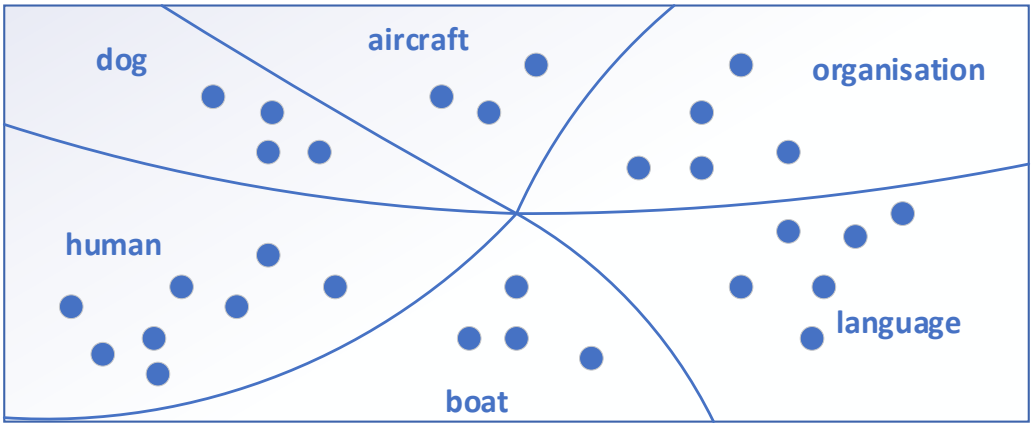
Ontological UML (OntoUML)

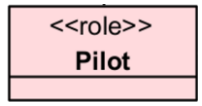
Diagram inspired by [Guizzardi 2021]
Introduction to the OntoUML Approach
youtube.com/watch?v=ENGEIhbnAx4



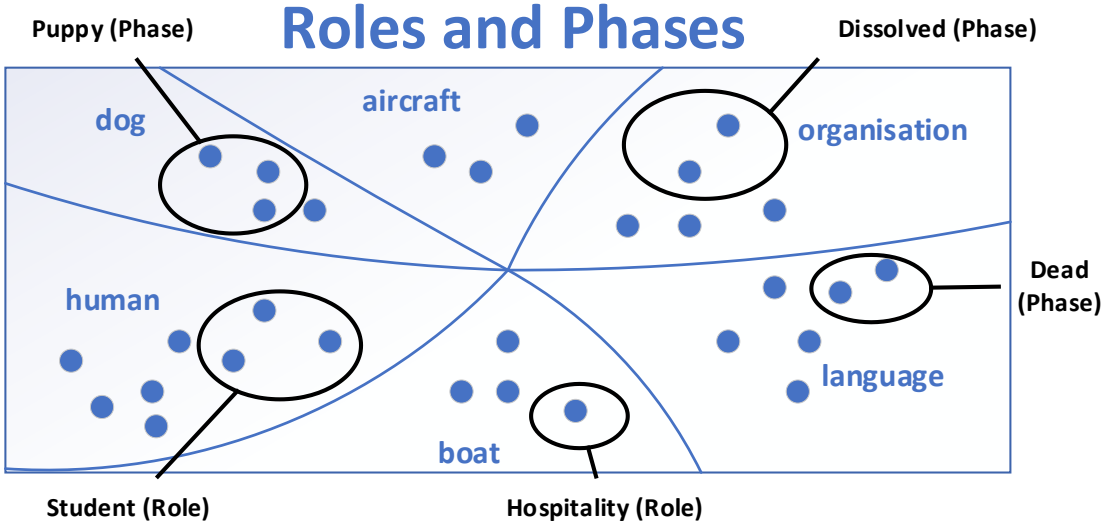
Kinds



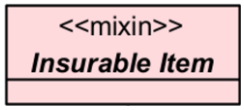
OntoUML

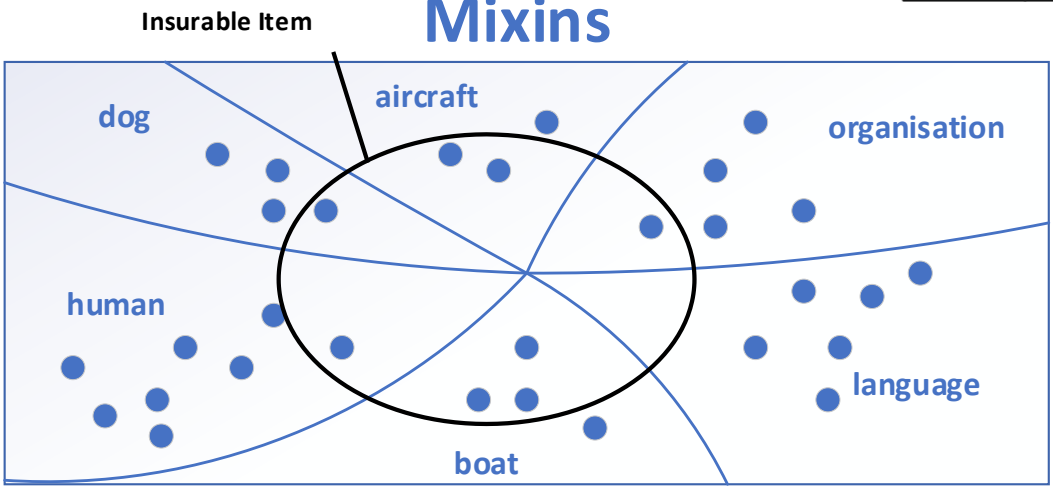


Roles and Phases



OntoUML





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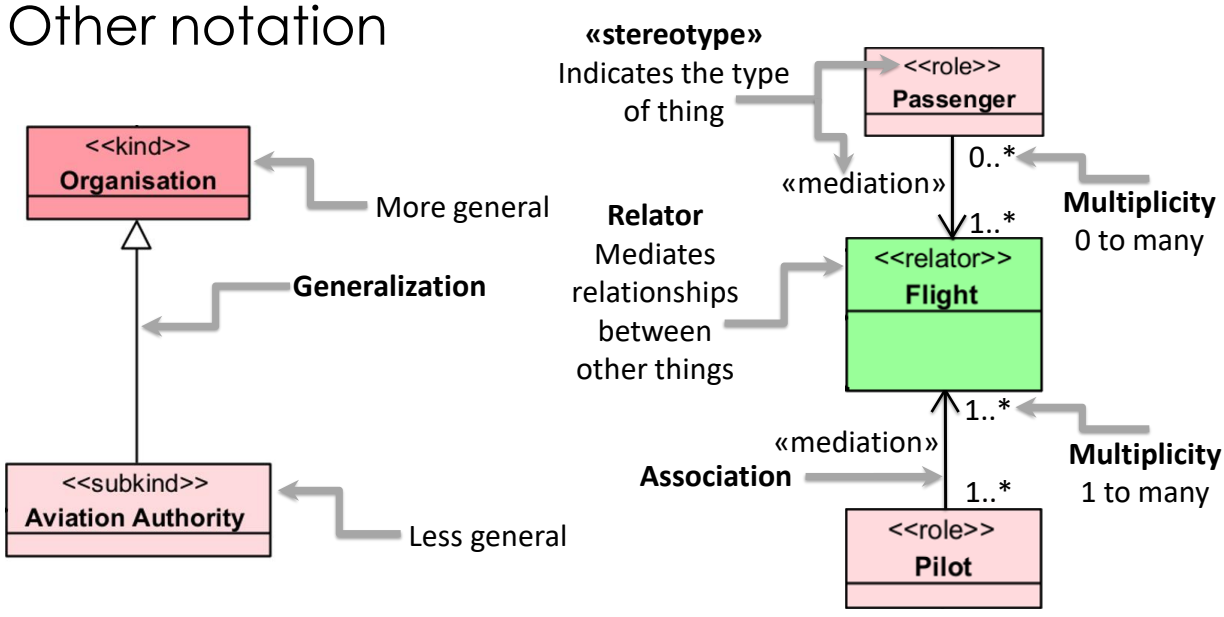
Other notation



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Air Traffic Control

Flight plan with waypoints

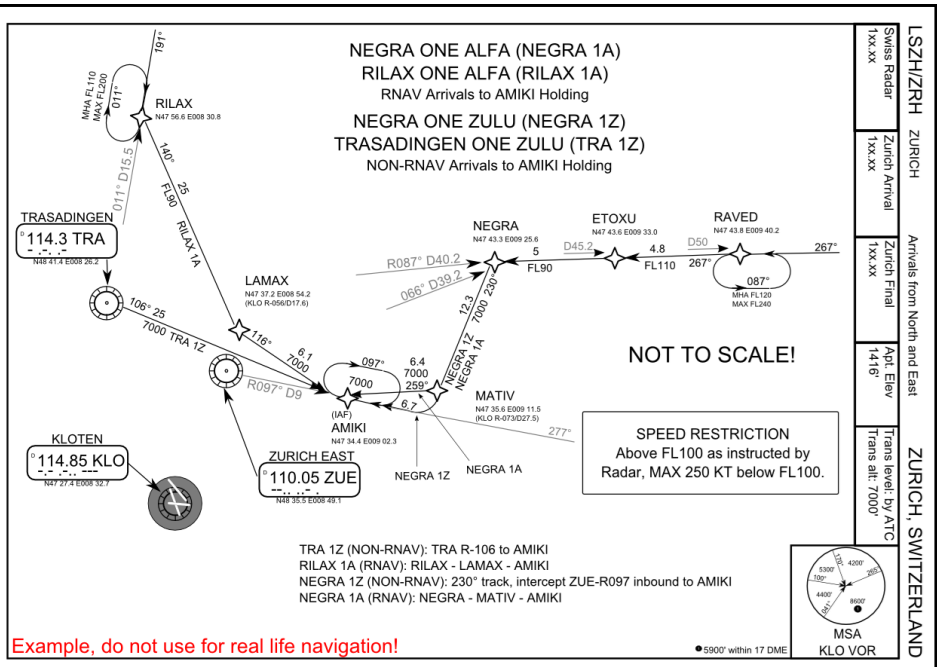

Image by El-major, 2009
CC BY-SA 3.0

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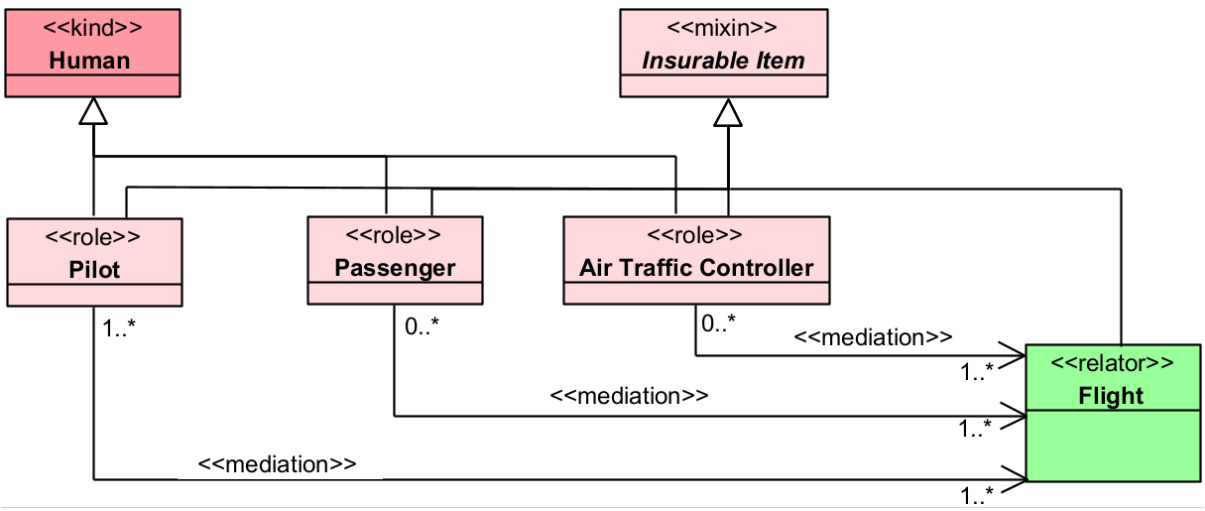
UFO model – aviation system of systems using OntoUML



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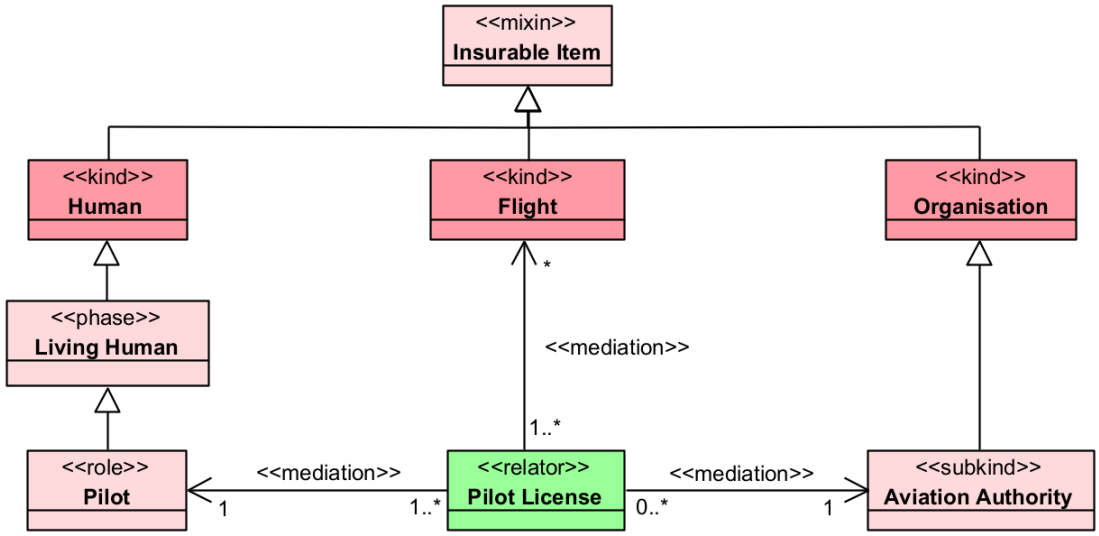
A different perspective on an aviation system of systems



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Same thing? Different perspectives?

© Peter Hermes Furian

Is it the same thing?

Appearances can be deceptive…

Things that seem the same can be different in important ways:

Flight (waypoints) Flight (kind) Flight (relator)

Sometimes things look different, but are the same

Ontology-based modelling can reveal hidden nuances

Bonus

Models grounded on logical axioms amenable to reasoning ⇨ model checking

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Final thoughts

Concepts, relationships and rules for using them are fundamental to any SE activity

Inconsistency and ambiguity breeds vulnerability

Develop explicit conceptualisations that are shared and understood by all stakeholders

Great benefits for systems engineers adopting more formal approaches to ontologies

Emerging technological paradigms defy traditional analysis – how can we trust AI?

SCSC formalising the language of risk as applied to risk-based decision making in engineering

Engage with the SCSC community

scsc.uk/working-groups

Connect with Stephen

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