The Simulation Scenario Definition Language, towards simulator independent experiment definition

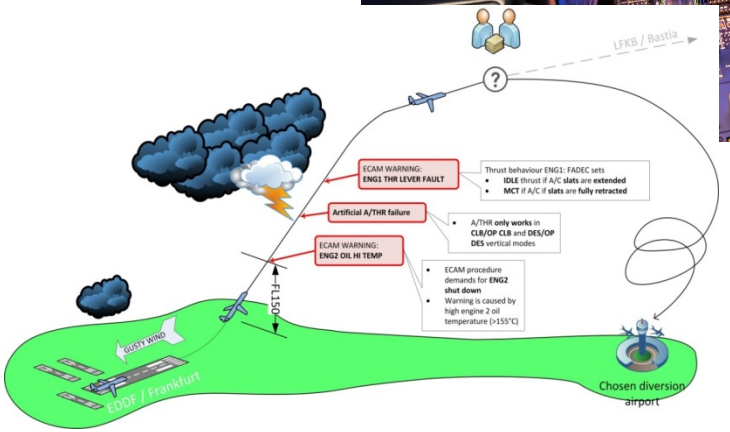
Torsten Gerlach, Dr. Umut Durak

DLR (German Aerospace Center)
Institute of Flight Systems

Spring Flight Simulation Conference 2017

Motivation

While any simulation study in a research simulator starts with a scenario, the scenario development is usually conducted in an unstructured and ad-hoc manner.



How to streamline scenario development?

Air Vehicle Simulator – AVES

Air Vehicle Simulator – AVES

EC135 ACT/FHS

A320 ATRA

Typical Operational Scenario

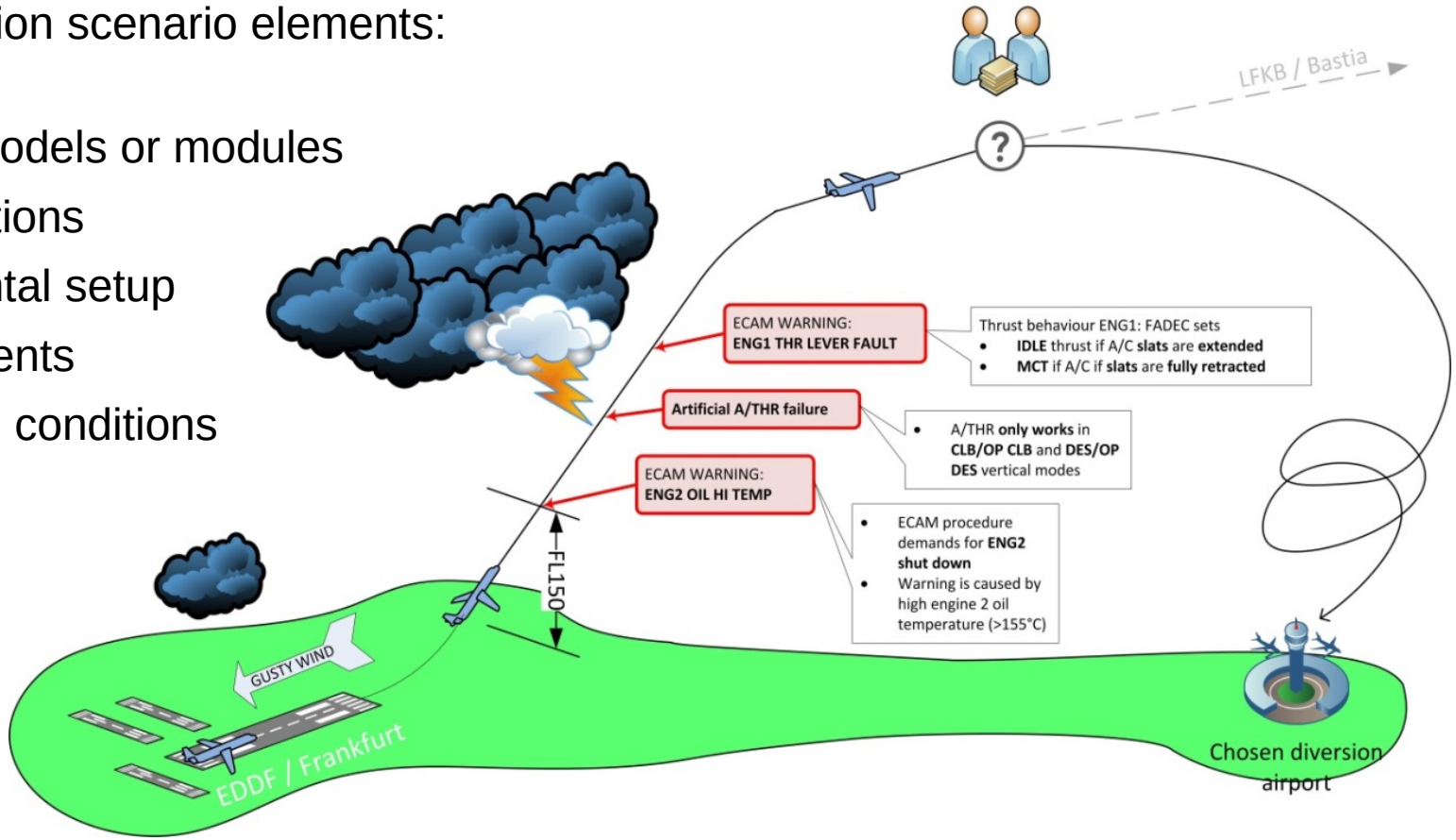
“Aircraft D-ATRA stands in front of its hangar at DLR in Braunschweig. Pilots ask the tower for taxi clearance. The tower provides taxi instructions towards RWY 08. The Pilots start taxiing according to instructions. Then the tower provides information about the departure like weather, VRB05KT, R08/2800FT, overcast sky. Then the pilot asks for a departure clearance and tower grants the departure.”

Flight Simulation Scenarios

A scenario is the description of initial conditions and the timeline of significant events. (IEEE, 1993)

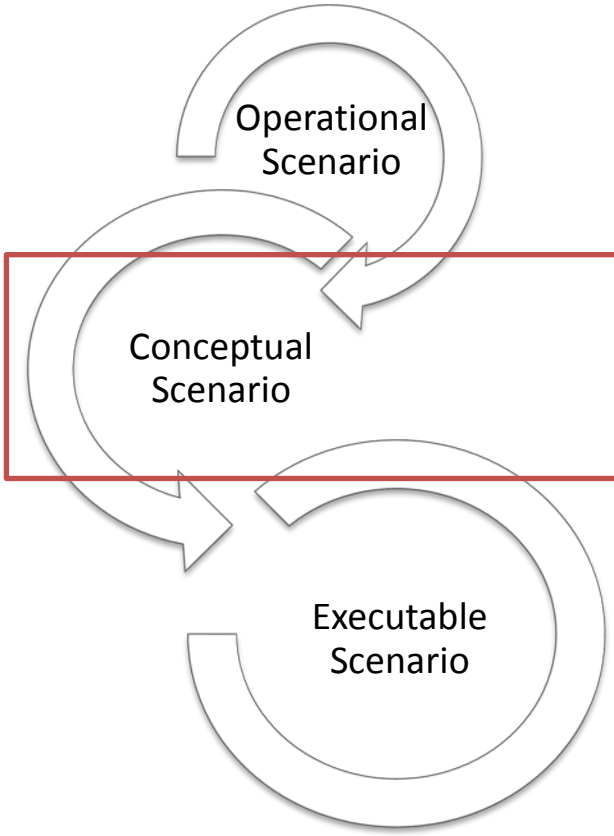
Flight simulation scenario elements:

- Systems, models or modules
- Initial conditions
- Environmental setup
- Discrete events
- Termination conditions



Structuring Scenario Development

Hard to structure!



mostly defined in a natural language
- Not complete
- Mostly not consistent
- From domain experts

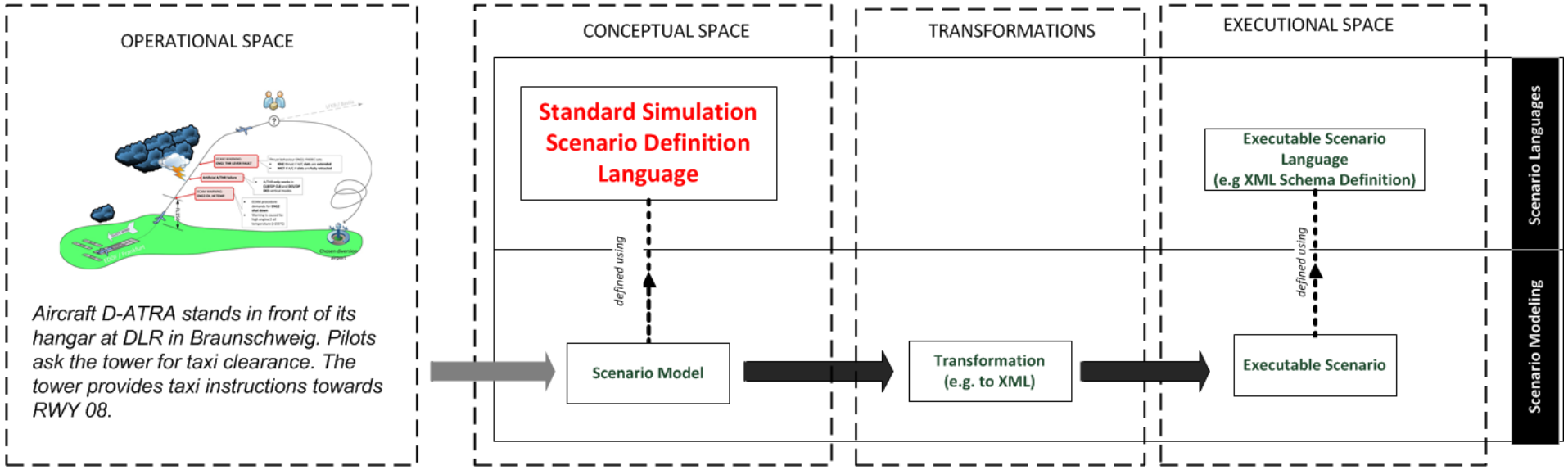
mostly prepared as data tables
- Complete
- Consistent

standardized **Scenario Definition Language**

using specific scenario definition language
- XML or binary
- Mostly using a tool
- From simulation experts

Simulator specific!

The Vision



A scenario definition language shall …

- be **simple** and **natural** to the user
- handle **complexity** and **variability** of heterogenous systems
- enable **transformations** to different languages, e.g. simulator configuration

The Benefits

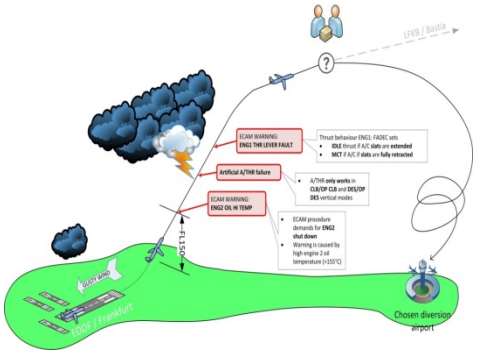
With a **standardized** scenario definition language

- Standardization in tools and workflows
  - Off-the-shelf tools for scenario development
- Scenario sharing
  - Ability to run the same scenario in different simulators

With a **formal** scenario definition language

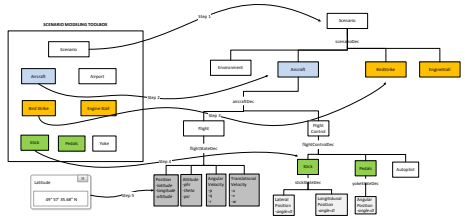
- Scenario Validation
  - Completeness and consistency checking
- Scenario Generation
  - Automated scenario generation for particular purposes
- Scenario Assessment
  - Assessment of a scenario for “fit for purpose“
- Simulation/Simulator Assessment
  - Assessment of a simulation/simulator facility for a scenario

Possible Workflow



SSDL

Scenario Builder



Specific Scenario

AVES Simulation Scenario

XXX Simulation Scenario

AVES Simulation Execution

Project Partner Simulation Execution

AIAA Working Group: Aviation Simulation Scenario Development

American Institute of Aeronautics and Astronautics

- Historical
  - Since 2014 several publications on first approaches and concepts
  - 2015 collaborating with *Embry Riddle Aeronautical University*
  - 2017 AIAA Scitech: Working Group officially confirmed
- Objectives
  - sharing scenario definitions across various facilities and experts
  - boosting interoperability of scenario definition tools and execution infrastructures
  - increasing the quality of scenarios by formal completeness and consistency checking approaches
  - enable automated scenario generation using language constructs

Organization

Chair : Umut DURAK — *German Aerospace Center (DLR)*
Co-Chair : Shafagh JAFER — *Embry Riddle Aeronautical University*

Interested Parties

USA
NASA AMES, Embry Riddle Aeronautical University, National Transport Safety Board, CAE, Lockheed Martin, FAA, MITRE

Europe
DLR, NLR, ONERA, Clausthal University of Technology, Wismar University, University of Antwerp , University of Dresden

Working Group Website: *Aviation Simulation Scenario Development*

https://info.aiaa.org/tac/ASG/MSTC/default.aspx

Concepts

Ontology-driven domain modeling is an effective mechanism in developing domain-specific languages (DSL).

Ontology is an explicit specification of a shared conceptualization. (Gruber)

*O*ntology provides a quick and simplified description of a DSL, abstracting language's technical details.

Two alternative approaches

Aviation Scenario Development Language (ASDL) Ontology to capture the terms, concepts and their relations in aviation to support a simulation scenario definition language meta-model which is based on Base Object Model (BOM)

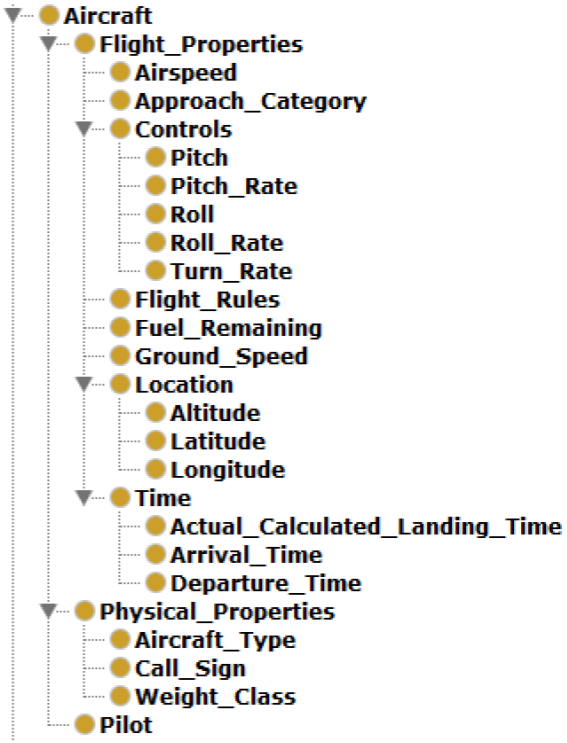
System Entity Structures (SES) Ontology to model the elements of a simulation scenario.

ASDL Ontology

The complete ASDL Ontology was developed in Web Ontology Language (OWL) using Protégé Ontology Development Environment.

An OWL ontology describes a domain in terms of classes, properties and individuals and may include rich descriptions of the characteristics of those objects.

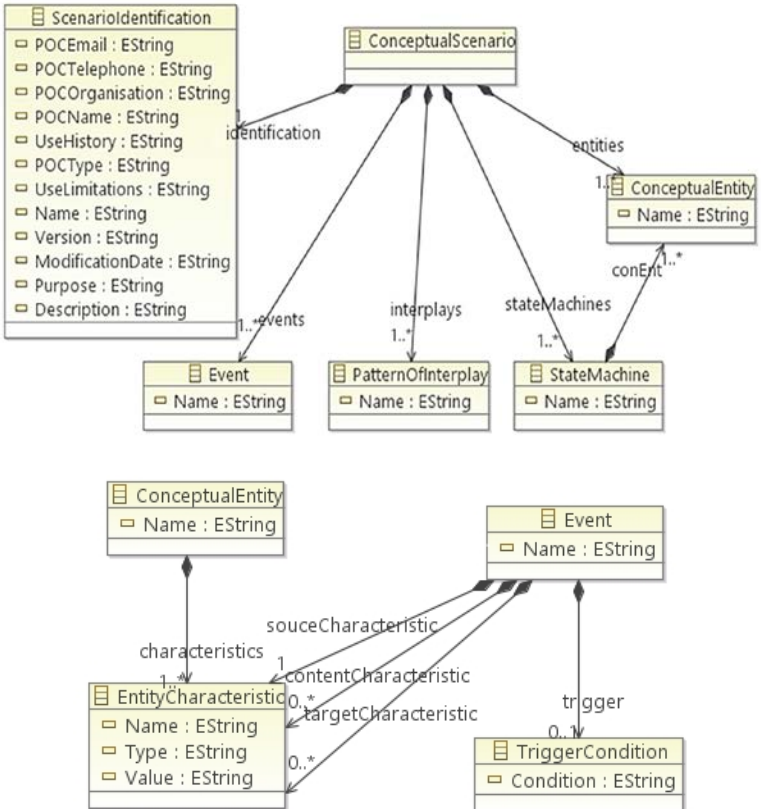
(a) Top View

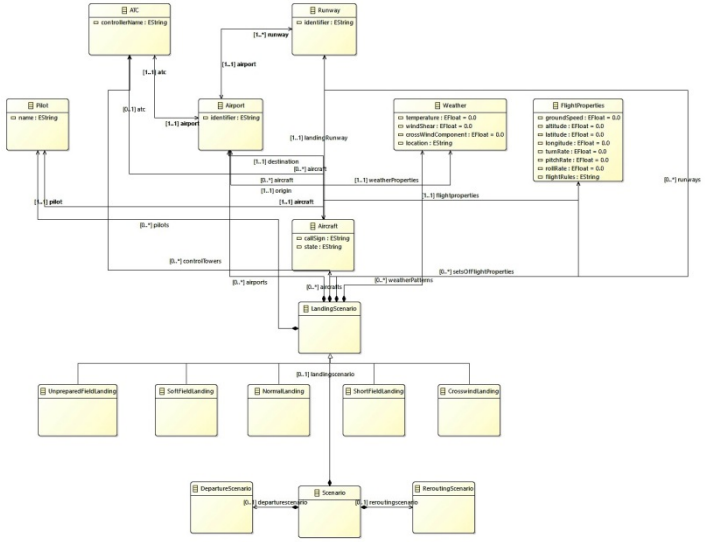


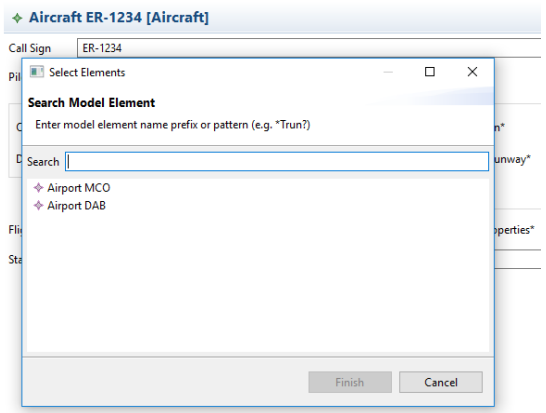
(b) Aircraft

https://github.com/ASDL-prj/Ontology

ASDL Metamodel and Scenario Development



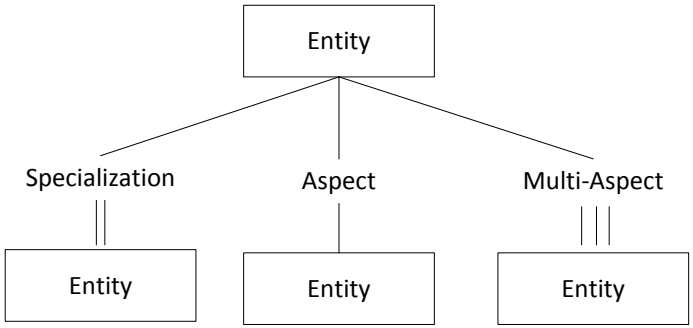


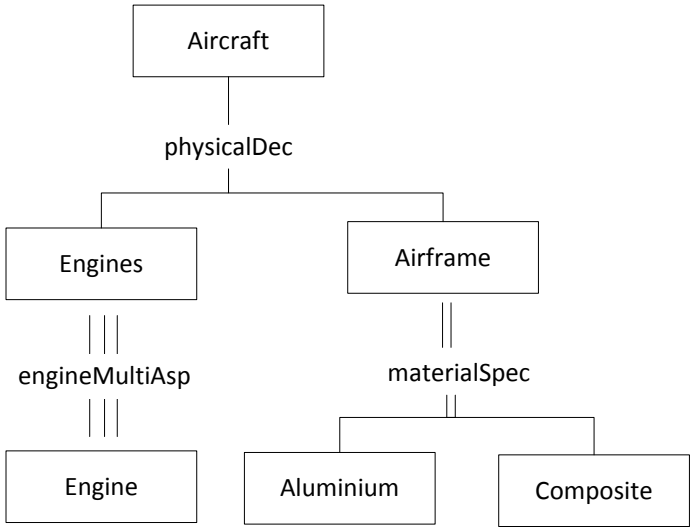


BOM based approach using Eclipse Modeling Framework

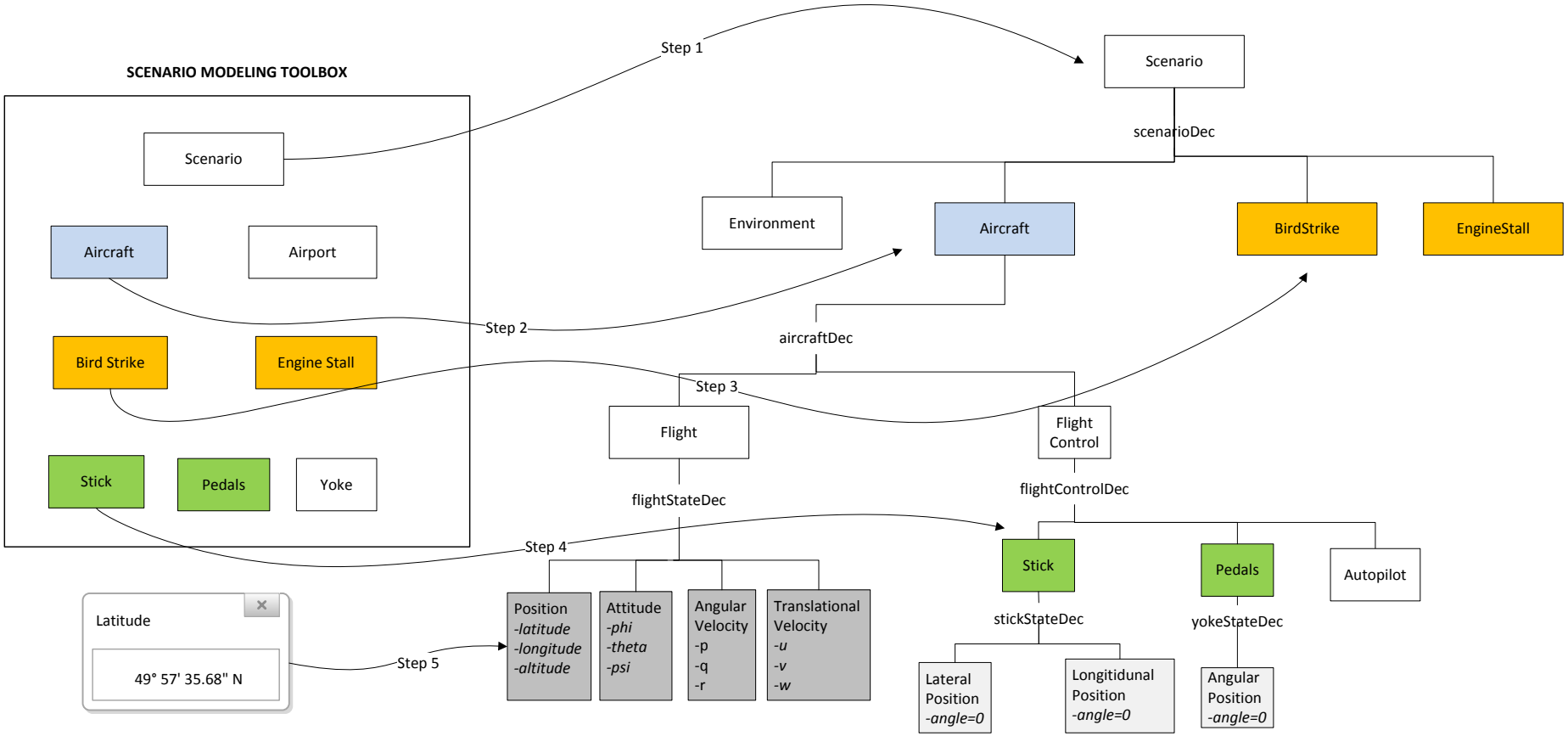
System Entity Structures – SES

The **SES** is a high-level ontology for the specification of a set of system structures and parameter settings for modeling and simulation.

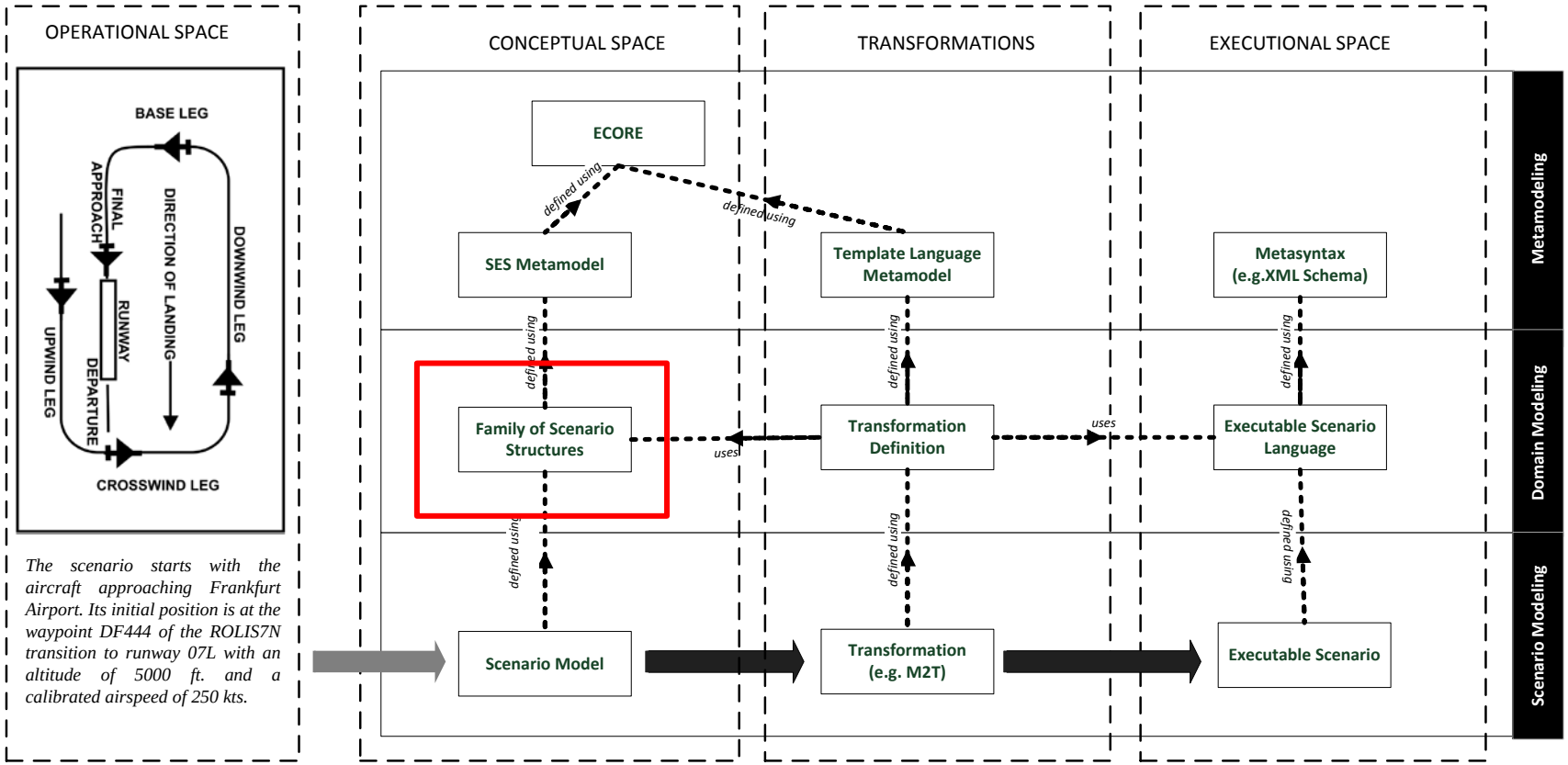




Scenario Modeling



SES Ontology and Scenario Development



Comparison

ASDL Ontology

+ OWL provides a more expressive formal basis for ontology construction.

+ Protégé is a mature tool with a wide community support.

- Both Protégé and OWL are not natural to scenario developers.

- Formal semantics of OWL is based on description logic which is out of their body of knowledge.

SES Ontology

+ SES with its simple formal semantics which is based on systems theory can be easily grasped and used by scenario developers.

- There is a lack of mature tool sets and common techniques for SES development.

- Its application out of modeling and simulation academia is very limited. Therefore it is hard to talk about a community support.

Durak, U., Jafer, S., “Tackling the Complexity of Simulation Scenario Development in Aviation”, SCS SpringSim 2017, 23.-26. April 2017, VA, USA

Conclusion

Structuring scenario development in **Operational**, **Conceptual** and **Executable Space** is crucial.

Using a structured approach with **ontologies** creates a shared vocabulary.

Since ASDL ontology using OWL is not natural to scenario developers, we **focus on SES ontology.**

Continuing to work on using an **industrial standard** for domain specific modeling.

- Extended Markup Language – XML based

AIAA MSTC is the platform to share ideas and work together on the standard language.

Striving for Effectiveness

Goal

Create a standardized simulation scenario definition language, which allows sharing scenarios across different simulator environments.

Draft first step (Benchmarking Experiment)

Have two groups use the same conceptual scenario, which is defined using the standard language for setting up a simulator campaign.

Compare two simulator campaigns to validate scenario shareability!

Thank you for your attention!

Questions?

Torsten Gerlach, torsten.gerlach@dlr.de
Umut Durak, umut.durak@dlr.de

DLR (German Aerospace Center)
Institute of Flight Systems
Lilienthalplatz 7
38108 Braunschweig
Germany