Inclusive Modeling with SysMD

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Inclusive Modeling with SysMD

SysMD

1. “Inclusive” systems engineering
2. SysMD Notebook & SysMD language
3. Development environment and software details
4. Roadmap for SysMD - *How can I contribute?*

Why “systems engineering”?
Why “inclusiveness”?

SysMD

First known complex project reported by literature [Genesis 11:1–9] is the tower of Bable:

> *“… let’s confuse their language, so that they may not understand one another's speech. … and they left off building the city.”*

Lesson learned: *successful system development* requires

1. **understanding** of people from different disciplines; they clearly use different languages.
2. **motivation** to use and invest in a “common language”.

Inclusive Modeling with SysMD

Modeling and analysis of requirements, specification, knowledge

- Inclusive modeling = we want to allow *everybody* in a development team to
  - document his knowledge and needs,
  - read a specification and requirements documents,
  - maintain documents & models.
- Motivate everybody by additional values beyond “documentation”
  - Consistency checking, from requirements, development to operation, runtime-verification,
  - AI based recommendations & queries,
  - Links with simulation, operation.

Related work

SysMD

- Markdown [Aaron Schwatz, John Gruber: http://www.aaronsw.com/weblog/001189]
  - Document software, i.e. GitHub
  - Jupyter Notebook, Matlab Notebook – Describe, Code, Execute approach
- DOORS [IBM]
  - Document, tracking requirements, manage of changes.
- OWL [https://www.w3.org/TR/owl-features/, https://www.w3.org/TR/turtle/]
  - Model knowledge; ~between natural and formal languages
- SysML [OMG]
  - Draw diagrams, comment/documentation model
- SysMLv2 [OMG, https://github.com/Systems-Modeling/SysML-v2-Release]
  - Textual language SysMLv2, interoperability via REST API, Metamodel

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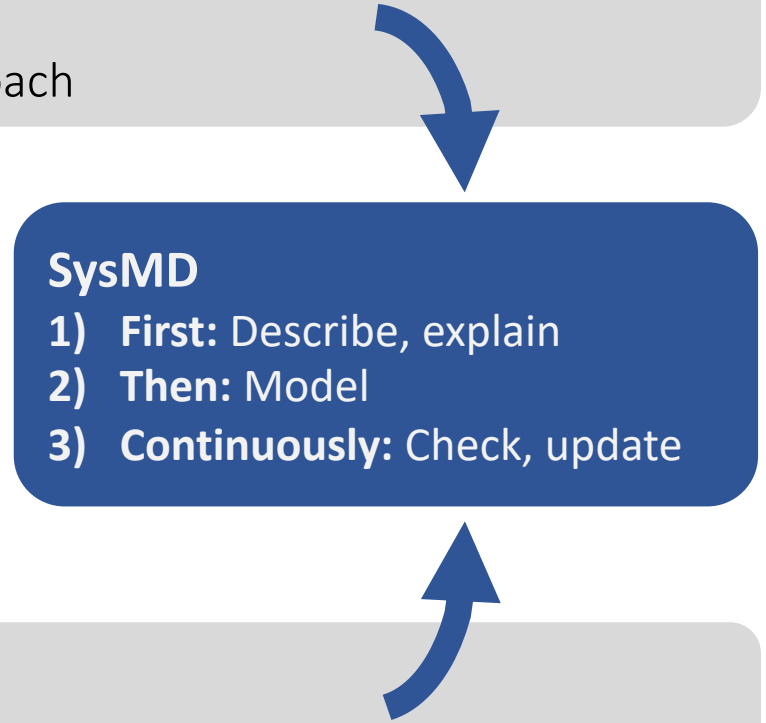

Inclusive modeling with SysMD

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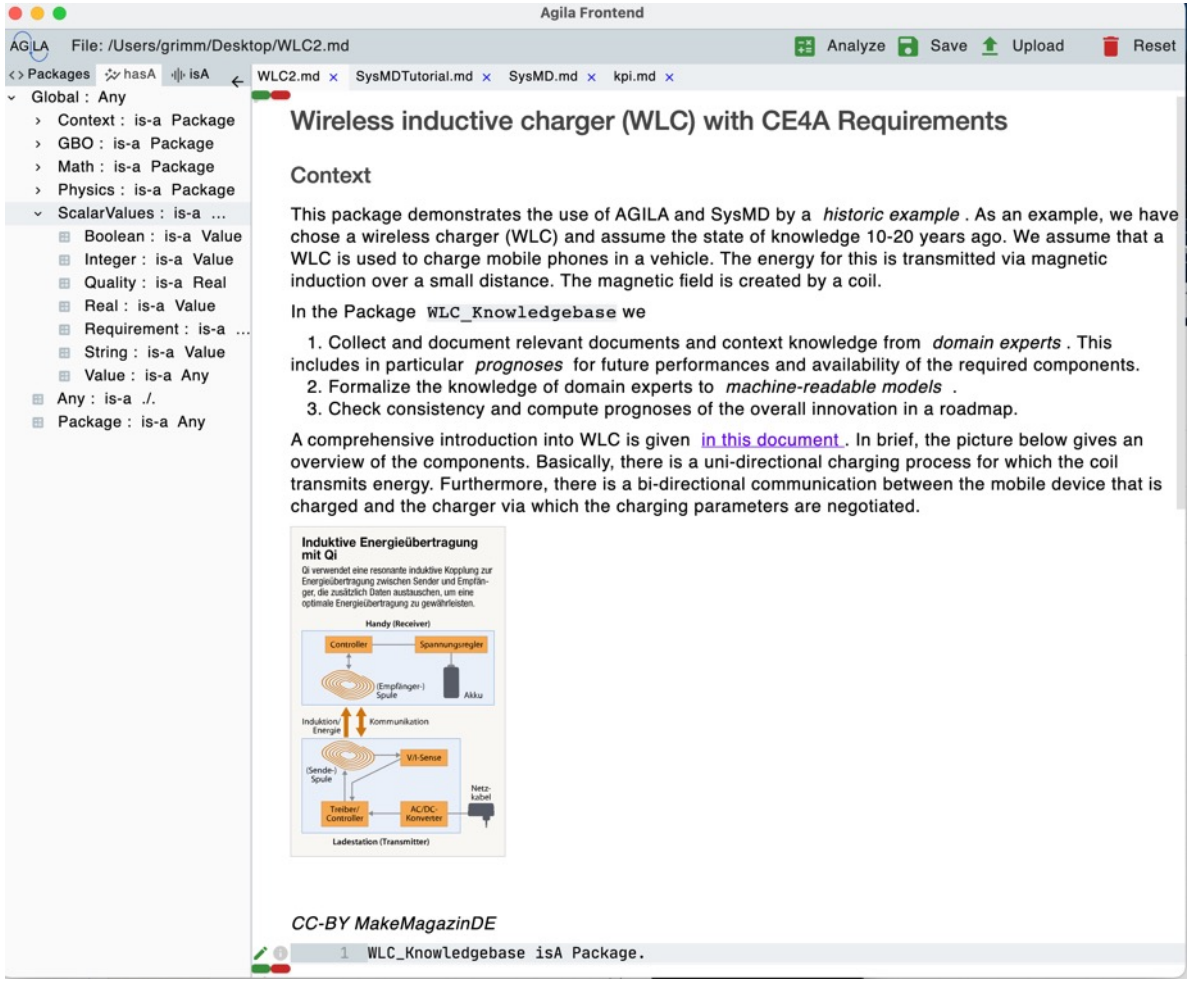
SysMD Notebook & Language Overview

SysMD Notebook

Notebook-like tool
Markdown editor
Markdown renderer
Code editor for SysMD/SysMLv2
Compiler
…

Proof-of-Concept implementation, work in progress



(further windows for results of analysis, errors, …)

SysMD Language

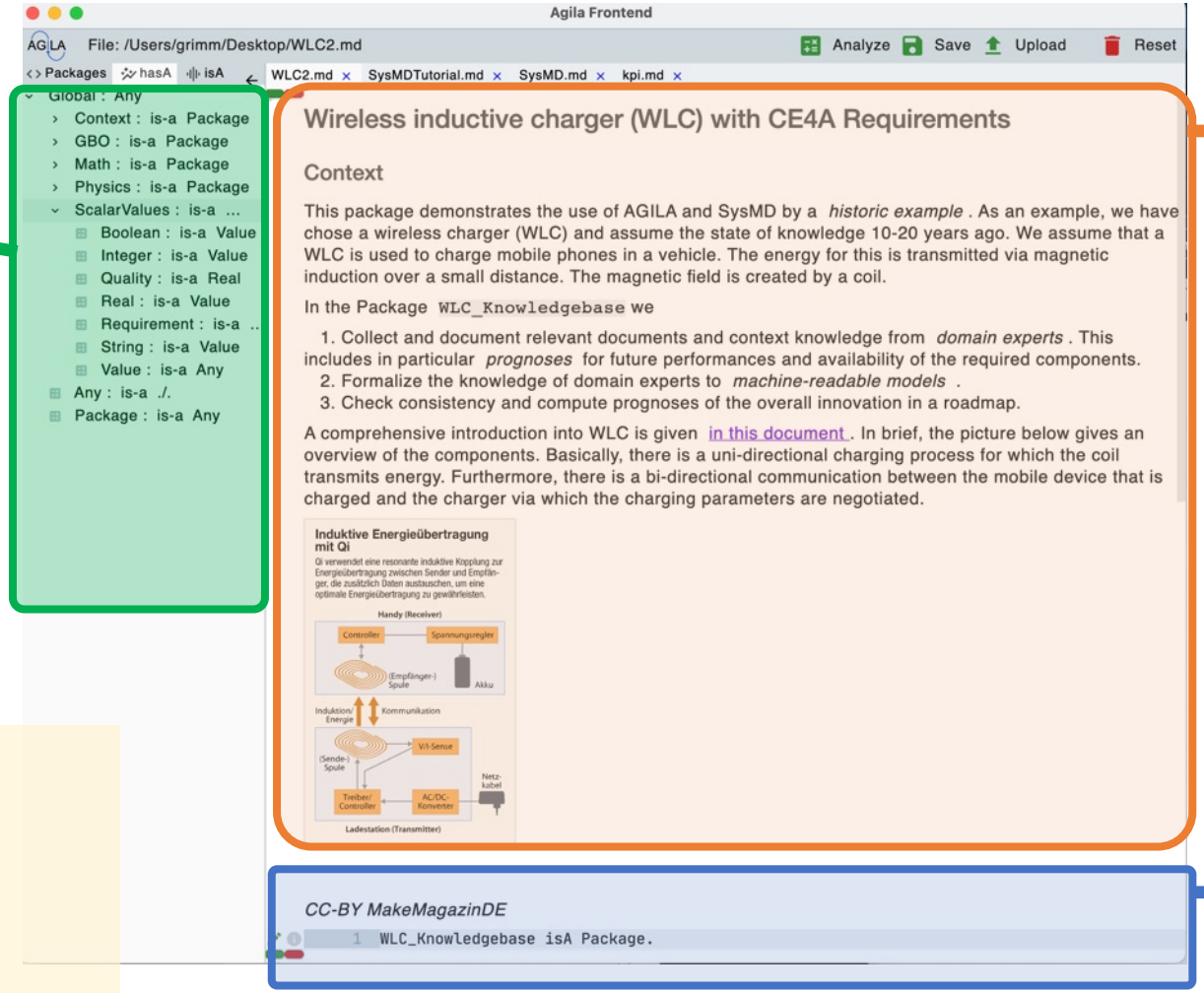
modeling & documentation language

- *Markdown (MD)*
- *Feature models*
- *Requirements*
- *Constraints*
- *…*

SysMD Notebook: UI Overview

Navigation

- Projects
  - Branches, Commits
- Taxonomy
- Decomposition/ownership
- Relationships



Documentation

- Markdown-format
- Tables, figures, links, …

Models

- In SysMD, SysMLv2 textual
- Taxonomy
- Decomposition
- Values, constraints
- Relationships

Not shown are windows for

- *Results of analysis*
- *Agenda*
- *Warnings, errors*

SysMD Notebook: Constraint Propagation (Bi-Dir.)

- Direct dependencies given by expressions
  - Bi-directional constraint propagation for Reals, Integers;
    - Check and conversion of Units, Domains (SI, national units, dB, Date/Time)
  - Satisfiability problem for Booleans
- Inheritance
  - Models variants or potential solutions of similar things
  - Consistency check: Liskov principle satisfied?
- Decomposition
  - SUM(…) computes aggregations (transitive)
  - Constraint propagation includes cardinality

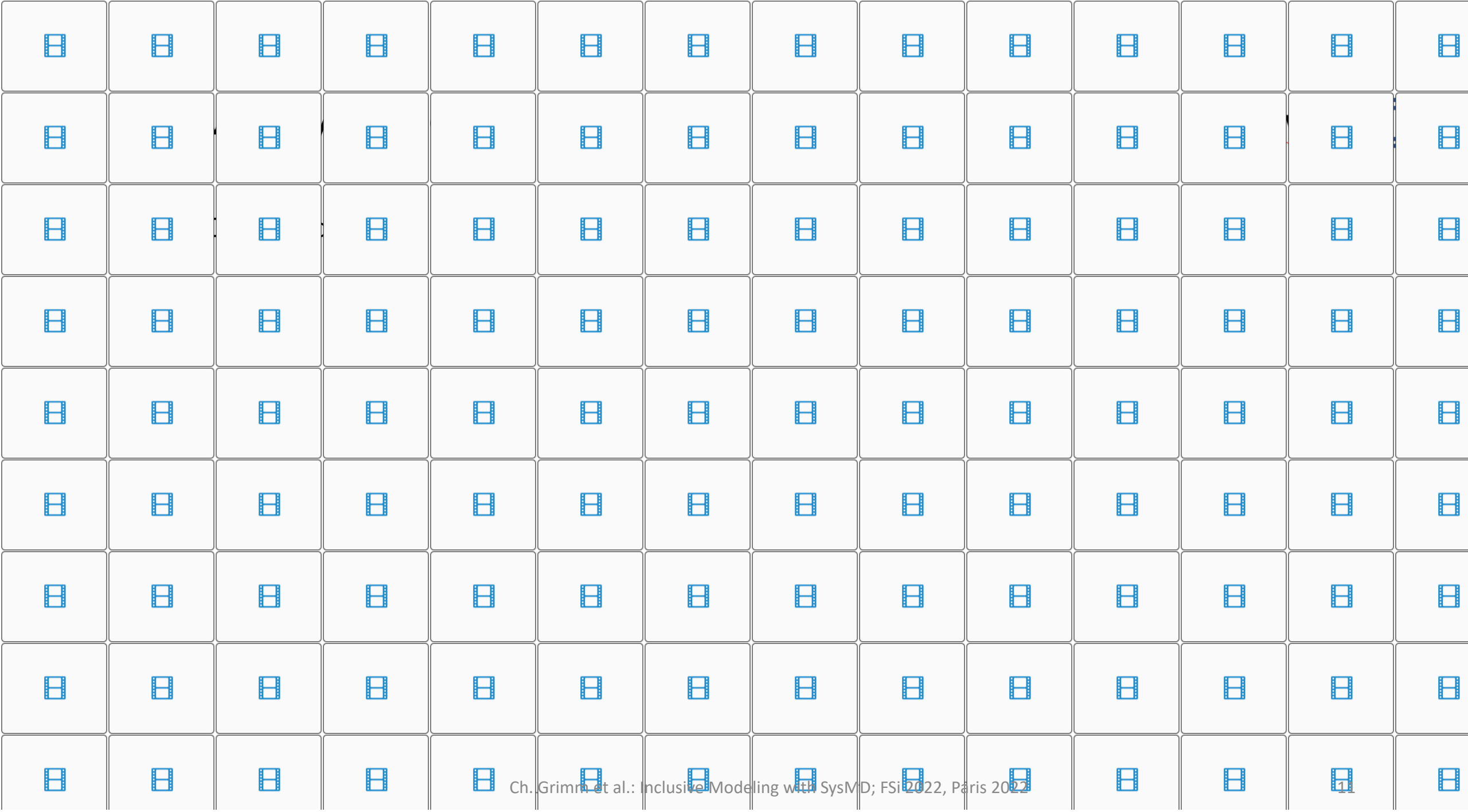
```
1  Example isA Component.
2  Example hasA
3      height:  Real(10 .. 100)[cm],
4      width:   Real(1 .. 1.1) [m],
5      length:  Real(1 .. 1.1) [m],
6      volume:  Real(1 .. 2) [m^3] = height * width * length.
```

```
1  Vehicles::Car hasA power: Real(10 .. 1000) [kW].
2  Vehicles::VW  hasA power: Real(20 .. 1010) [kW].
3  Vehicles::BMW hasA power: Real(150 .. 400) [kW].
```

```
Vehicles::Car::power = 10..1000 kW
Vehicles::VW::power = 20..1010 kW
Vehicles::BMW::power = 150..400 kW
INFO in Vehicles::Vehicle: different units in different subclasses
ERROR in Vehicles::VW::power: INCONSISTENCY: subclass value
20..1010 of power must be refinement of superclass value 10..1000
```

```
1  Vehicles::Car hasA
2      body: CarParts::Body,
3      wheels: [4 .. 4] CarParts::Wheel,
4      engine: [1 .. 2] CarParts::Engine,
5      mass: Real [kg] = SUM(mass).
```

```
Vehicles::Car::mass = 500..700 kg
```



SysMLv2 vs. SysMD language

SysMD

SysML v2 (textual)

- Users: modeling and SE experts.
- Syntax close to programming languages.
- Documentation added to model.
- Expressions for modeling of constraints, spec.
- Based on KerML metamodel, SysML API

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SysMD

- Users: **domain experts**.
- Closer to **natural language**, “top-down”, interactive
- Model added to **documentation** (text, videos, …).
- Syntax separates **specification** and **modeling**.
- Based on KerML metamodel, SysML API (subsets).

```
Wheel {
  value mass: Real = 70 [kg];
  // model mass with 50 to 100 kg
}

Car :> Vehicle {
  part Wheel [4 .. 8];
  in value mass = … // model constraint, unit, …
```

```
Car isA Vehicle.

Car hasA
  wheel: [4 .. 8] Wheel,
  mass: Mass(100..1000) kg = sumHasA(mass).

Wheel hasA
  mass: all Mass(50 .. 100) kg = ….
```

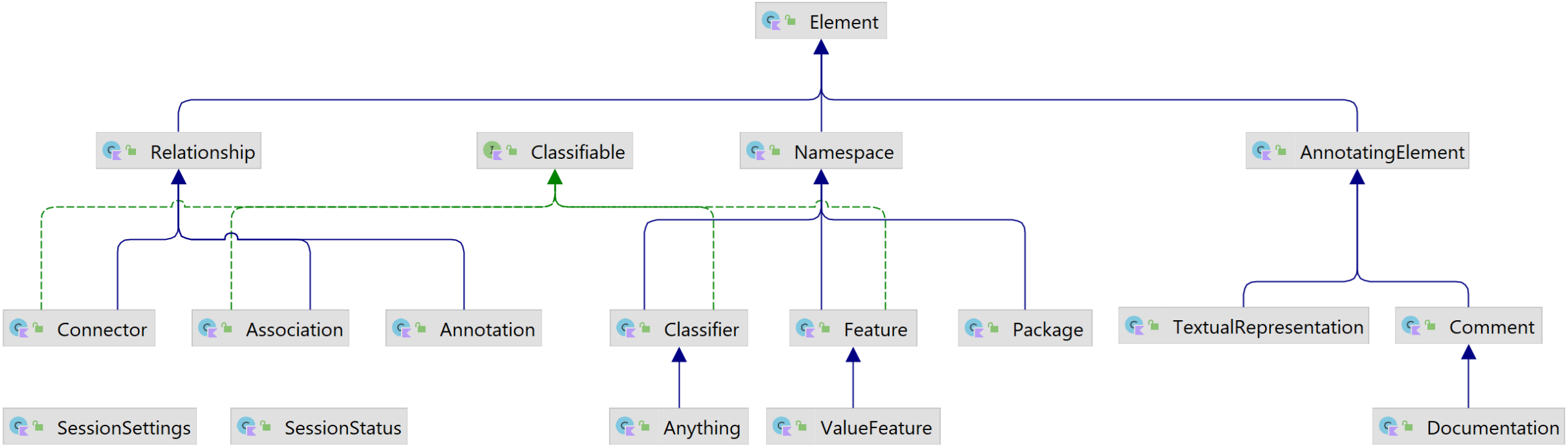
SysMD Syntax Cheatsheat

Subject	Predicate	Object	More	End
Name <*Element*>	**defines**	*Classification*	(; Classification)*	.
	Classification **isA**	*Name* <*Classifiable, ClassOfMetamodel*>		
	FeatureSpec. **hasA**	*Name*: [**all|one**] [Multiplicity] *Name*<*Type*> [Constraints] [= Expr.] → Instantiation	(, FeatureSpec)*	
	Import **imports**	*Name*<*Project, Namespace*>	(, Name)*	
	Relationship *Name* <*Association*>	*Name* <*Element*>	(, Name)*	

Pre-defined classes and projects

- Any(thing) = root of all taxonomies (isA); Global = root of ownership/features (hasA)
- ScalarValues (Classifies Real, Boolean, Integer, … as in SysMLv2)
- ISO26262 Ontology: Element, Function, Component, Part, SoftwareUnit, (…), also relationships:
  - Component *implements* Function, Component *satisfies* Requirement, Processor *executes* Software
- GBO, MissionProfiles, Math, Physics.

KerML metamodel implementation



Note:

1) We are not yet fully compatible … working on it, but quite ok.
2) We strive to consolidate number of classes a bit. (e.g., ValueFeature includes Expression, Multiplicity, FeatureValue, …)
3) We strive to increase performance, reduce complexity – not all relationships represented by instances of Relationship (e.g. ownership, inheritance)

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Development environment

SysMD

- Gradle v7 and/or IntelliJ IDEA, dependencies
  - Commonmark Markdown parser
  - Apache math (LP solver) and jAADD for CSP/nonlinear/discrete problems
- Kotlin JVM
  - Jetpack Compose Desktop for UI
- Optional for REST API, Backend
  - Spring boot, ArrangoDB as repository
- Junit Jupiter (500-1000+ tests depending on branch)

Development environment

SysMD

- Nothing is better than a live look at the code
  - Build: “gradle run”
- … and, of course, running code & demo ☺

(live … not as video)

SysMD home page

- `https://cpsgit.cs.uni-kl.de/open/sysmd`

Contents

SysMD wants you!

- Students, interested individuals (projects/theses/ …)
  - Improvements in Markdown rendering
  - Improvements in code editor
  - SysMLv2 textual, KerML interoperatbility
  - SAT/SMT interfaces
  - Tests
  - Knowledge bases, models
  - … any own ideas? …
- Industry
  - EC or nationally funded projects
  - Case studies

Outlook

SysMD

- Currently, still a few issues and bugs
  - Some industrial users do evaluation
  - WiP: Runtime-Verification, simulation-data needs integration
  - WiP: More beautiful Web-Frontend (React JS, Hierarchical documents, etc.)

- 1st Release to public (open source) Summer 2022
  - Basically, as shown, but with less bugs & some libraries
  - Open source for most parts

    (Small parts in probabilistic CSP are patent pending; NOT the modeling; is not necessarily needed)

- 2nd Release end 2023/2024: “modular digitalization toolkit”
  - Integrated DevOps interface
  - Generation of interfaces to virtual prototypes