«DigitalEngineering»

DEKonsult

What to Expect from SysML v2?

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MBSE2020 Workshop, 28-29 September 2020, ESTEC

Re-introducing myself

- Many of you know me as a systems engineer from the ESA CDF
- I retired from ESA per 31 December 2019
- Started own consultancy company DEKonsult beginning 2020
  - Specializes in the advancement of digital engineering standards, methods and tools in support of multi-disciplinary engineering of complex systems
  - Continued in the SysML version 2 Submission Team for OMG
  - Working on a Model Based Engineering Primer and Training Course for NAFEMS

What is SysML?

- Systems Modeling Language – by Object Management Group (OMG)
  - As http://www.omgsysml.org says it:
    a general-purpose graphical modeling language
    for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities
  - Only a language – Not an MBSE methodology
  - SysML v1 is a profile & extension of UML2
    - Strength: Implementation on mature UML tool possible & good support for software intensive systems
    - Weakness: “Software engineering flavoured” lead to steep learning curve for many systems engineers
  - OMG standard (officially “adopted specification”)
    - Version 1.0 released 2007
    - In real industrial use since 2010 – v1.2
    - Many tool implementations – COTS and open source
    - Latest release is v1.6 (December 2019)
    - v1.7 under development – will be the final version 1

The four pillars of SysML (v1)

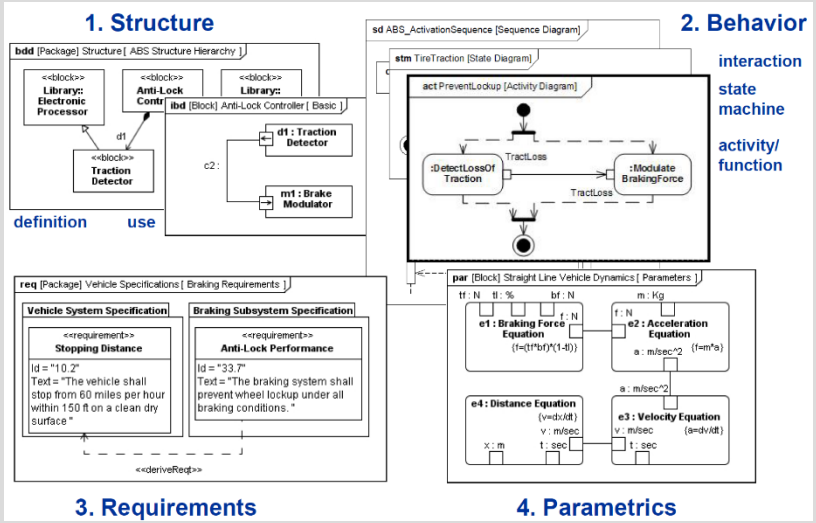
1. Structure
— Block Definition Diagrams
- Inheritance
- Part decomposition

— Internal Block Diagrams
- Decomposition
- Interfaces (Ports) and Connections

— Packages
- Model organisation

3. Problem Specification
— Requirements
- Satisfy / Trace
- Basics of verification

— Use Cases & Actors



2. Behavior
— Activity Diagrams
- Process modelling and control flow

— Sequence Diagrams
- Time-based/ordered interaction
- Messaging

— (Finite) State (Machine) Diagrams
- Asynchronous discrete behavior

4. Parametrics
— Parametric Diagrams
- Parameterized constraints
- (Specification of) Calculations / Analysis / Simulation

OMG SysML v2 Timeline

2015 — 2016 — 2017 — 2018 — 2019 — 2020 — 2021 — 2022

Request for Proposal

- Including SE Concept Model
- Started 2015
- Language RFP released Dec 2017
- API RFP released May 2018

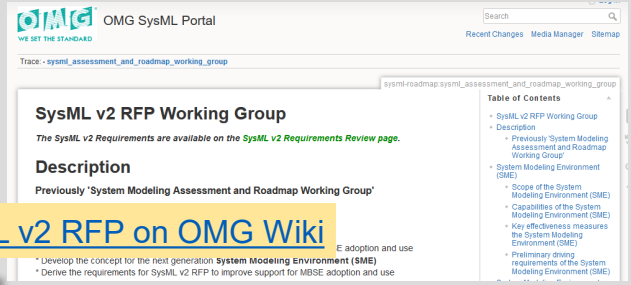
Submission Team

- Initially two submission teams – since end 2018 merged into one
- Started Jan 2018 on language
- Started June 2018 on API
- Initial submission of language & API Spec's delivered for OMG review on 17 Aug 2020
- Includes working language and API prototype implementations – open source release on Github scheduled for October 2020

Finalization Task Force

- v2.0 expected summer 2021
- Also first production tool implementations

Use …



SysML v2 RFP on OMG Wiki

Public overview SysML v2 approach by Ed Seidewitz

SysML v2 Requirements and Constraints

- Extensive RFP (Request for Proposal)
  - Based on thorough analysis addressing the shortcomings of SysML v1
  - Broad participation from many industry sectors
  - Part 1: Systems Modeling Language (SysML®) v2 RFP
    - 141 mandatory and 31 non-mandatory requirements
    - See https://www.omg.org/cgi-bin/doc.cgi?ad/2017-12-2
  - Part 2: Systems Modeling Language (SysML®) v2 API and Services RFP
    - 19 mandatory and 25 non-mandatory requirements
    - See https://www.omg.org/cgi-bin/doc.cgi?ad/2018-6-3
- SysML v2 shall be based on SMOF (Semantic Meta Object Facility)
  - Provides support for temporal aspects and multiple classifications
  - Information modelling founded on strong formal, semantic framework
  - Allows for mapping to other semantic frameworks like RDF/OWL2
- Must provide migration path from SysML v1 – that can be automated
  - For both tool and model/data transition

Snippet from Language RFP

6.5.2.5 Behavior Requirements

BHV 1: Behavior Requirements Group

BHV 1.01: Behavior

Proposals for SysML v2 shall include the capability to model a Behavior that represents the interaction between individual structural elements and their change of state over time.

SysML v1.X Constructs: Activity, State Machine, Interaction, Simple Time

BHV 1.02: Behavior Decomposition

Proposals for SysML v2 shall include the capability to decompose a behavior to any level of decomposition, and to define localized usages of behavior at nested levels of decomposition.

Supporting Information:

The decomposition of behavior should conform to a similar pattern as the decomposition of structure, and include capabilities for specialization, redefinition, and sub-setting.

The decomposition should also include the equivalent capability to decompose a SysML v1 activity on a BDD, and the ability to decompose actions using a structured activity node.

SysML v1.X Constructs: Composited Association of Behavior Classifiers with Adjunct Properties

BHV 1.03: Function-based Behavior Group

BHV 1.03.1: Function-based Behavior

OMG RFP 9 December 2017 49

SysML v2 Submission Team (SST)

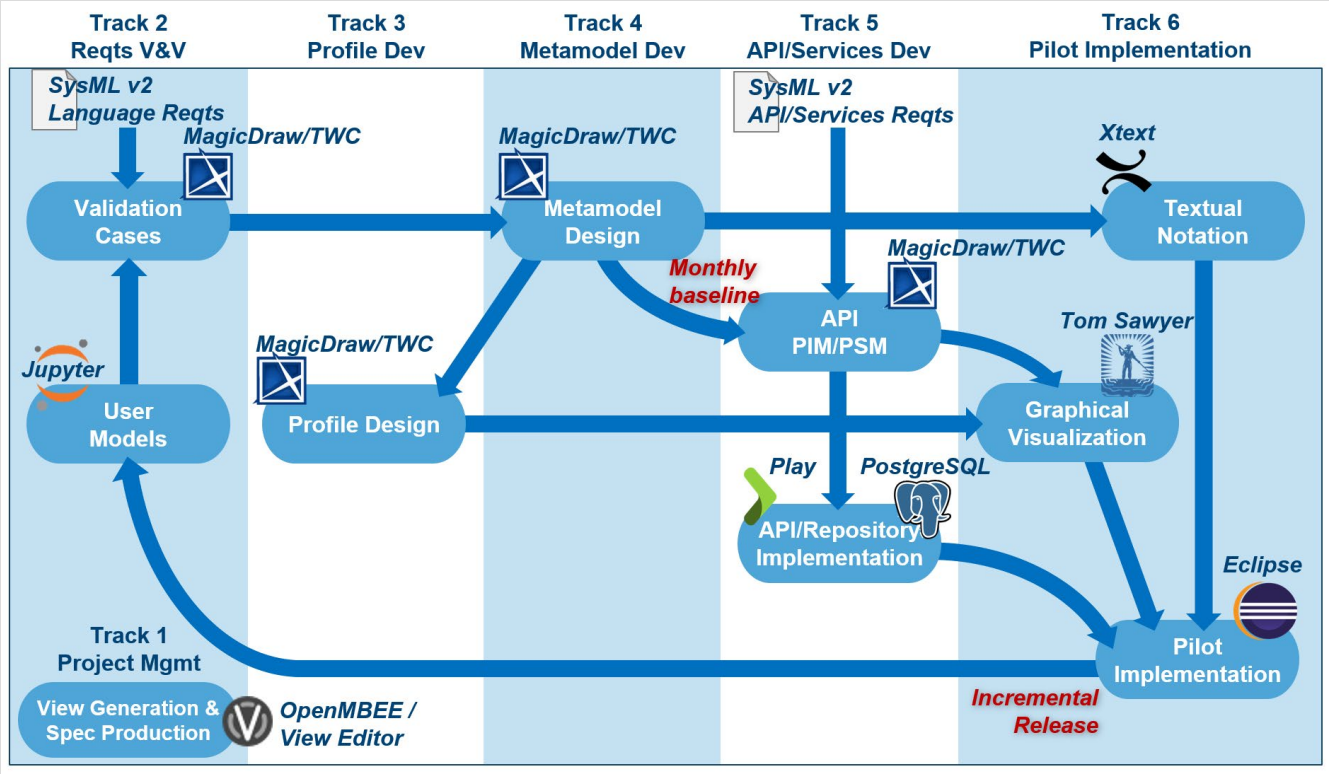
Participating Organizations

- Aerospace Corp
- Airbus
- ANSYS medini
- Aras
- Army Aviation & Missile Center
- Army CBRND
- BAE
- BigLever Software
- Boeing
- Army CCDC Armaments Center
- CEA
- Contact Software
- DEKonsult
- Draper Lab
- Elbit Systems of America
- ESTACA
- Ford
- Fraunhofer FOKUS
- General Motors
- George Mason University
- GfSE
- Georgia Tech/GTRI
- IBM
- Idaho National Laboratory
- IncQuery Labs
- Intercax
- Itemis
- Jet Propulsion Lab
- John Deere
- Kenntnis
- KTH Royal Institute of Technology
- LieberLieber
- Lightstreet Consulting
- Lockheed Martin
- MathWorks
- Maplesoft
- Mgnite Inc
- MITRE
- ModelAlchemy Consulting
- Model Driven Solutions
- Model Foundry
- NIST
- No Magic/Dassault Systemes
- OAR
- Obeo
- OOSE
- Ostfold University College
- Phoenix Integration
- PTC
- Qualtech Systems, Inc (QSI)
- Raytheon
- Rolls Royce
- Saab Aeronautics
- SAF Consulting *
- SAIC
- Siemens
- Sierra Nevada Corporation
- Simula
- Sodius Willert
- System Strategy *
- Tata Consultancy Services
- Thales
- Thematix
- Tom Sawyer
- UFRPE
- University of Cantabria
- University of Alabama in Huntsville
- University of Detroit Mercy
- University of Kaiserslautern / VPE
- Vera C. Rubin Observatory
- Vitech
- 88solutions

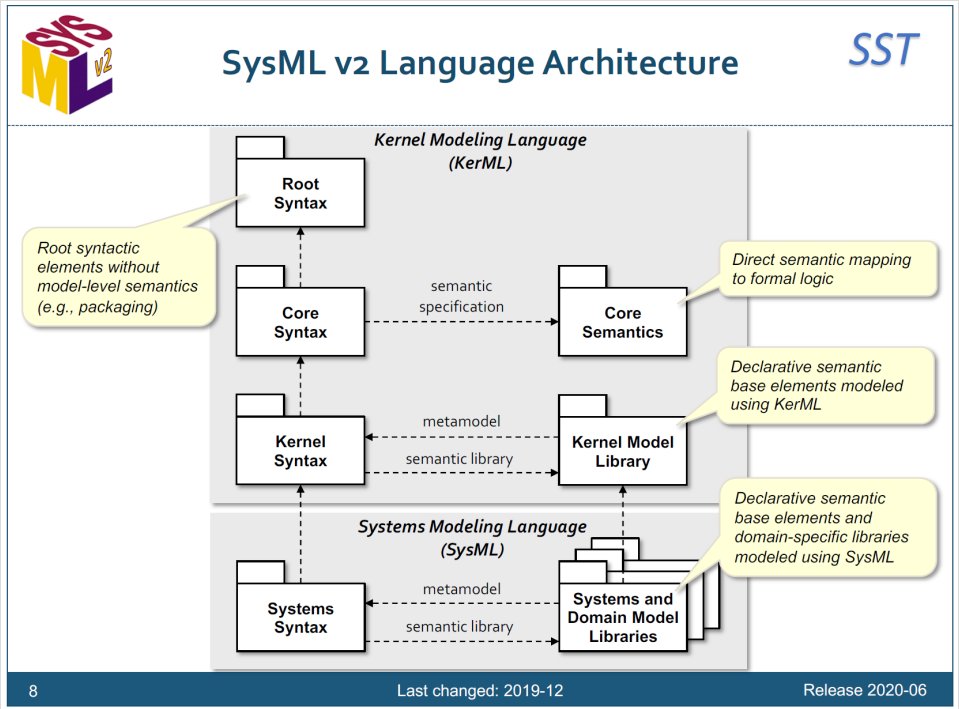
Academia/Research
End User
Tool Vendors
Government Rep
INCOSE rep *

- SST formed December 2017
  - Leads: Sandy Friedenthal, Ed Seidewitz
- Broad team of end-users, vendors, academia, and government liaisons
  - Currently around 174 members from 72 organizations
  - Large aerospace representation, but many other industry sectors as well
  - Majority of SysML tool vendors on board
- Develops integrated submission for both Language and API/Services

SST Agile / Incremental Development Approach



New Layered Architecture



- KerML: generic strong domain-independent formal semantic foundation
  - Not constrained by UML2
- SysML: adaptation and extension for systems engineering
- Similarly UML v3 could be the future adaptation for software engineering

Key SysML v2 Concepts and Innovations (1 of 3)

- Normative and informative model libraries over than profiles with stereotypes
- "Usage-Focused Modeling Approach"
  - Enables modeling deeply nested decomposition directly while creating Definitions (Types) in the background, without bothering the user
  - Maintains support and compatibility with SysML v1's "Type-First Approach"
- Feature (cf. SysML v1 property) as a first-class citizen
  - Can declare a feature (part, port, attribute, ...) as self-standing (e.g. in a library) and then use later
  - Features can be deeply nested, and deeply nested features can be redefined (without all the complications of SysML v1 in which this was very cumbersome)

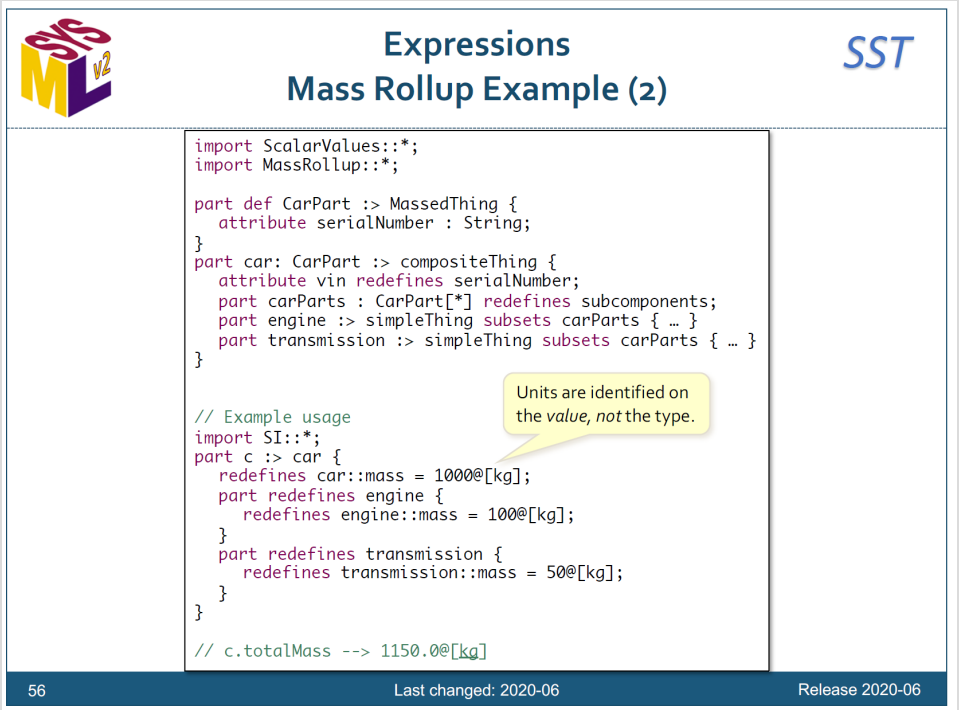
Key SysML v2 Concepts and Innovations (2 of 3)

- Object lifetimes (Occurrences) and 4D temporal / spatial extent
- Full textual language alongside graphical language
  - With bi-directional conversion either way
  - Integrated support for expressions and constraints
- Robust presentations / visualizations / renderings based on flexible views
  - Viewpoint & View
  - Supports graphical, tabular, textual forms
  - Allows to combine different structure and behavior elements in single view (diagram)
- Standardized API to access models / model repositories
  - Built-in life cycle model – versioning orthogonal to user model
  - Specification as Platform Independent Model (PIM)
  - 3 Platform Specific Model (PSM) API realizations: REST-API, OSLC and Java
    - REST-API and OSLC share JSON-LD representation of objects

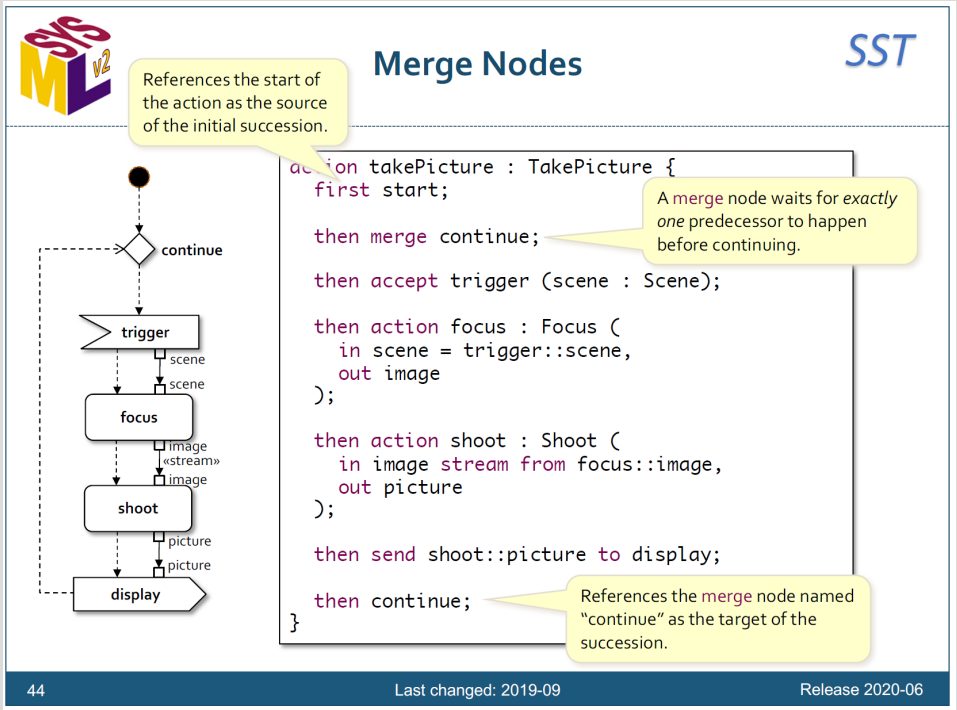
Key SysML v2 Concepts and Innovations (3 of 3)

- Richer model packaging (modularity)
  - Clean, robust model of imports, name-spacing, so-called “smart packages”
- New functionality:
  - Clean modeling of Individuals (single objects in M1) and Instances (in M0)
  - Variability / variation points
    - Support for design alternative, options, trade-offs
  - Support for Analysis (specification)
    - Analysis case, execution and results – Link with specification model
  - Support for Service Oriented Architecture (signal, required and provided interface ends, ...)
  - Predefined Model Libraries
    - Quantities, Units, Scales and Quantity Dimension library (SI and US Customary)
      - With automated unit/scale conversion and support for coordinate systems
    - Basic 3D geometry (library)
      - To support e.g. enveloping shapes, interface definitions

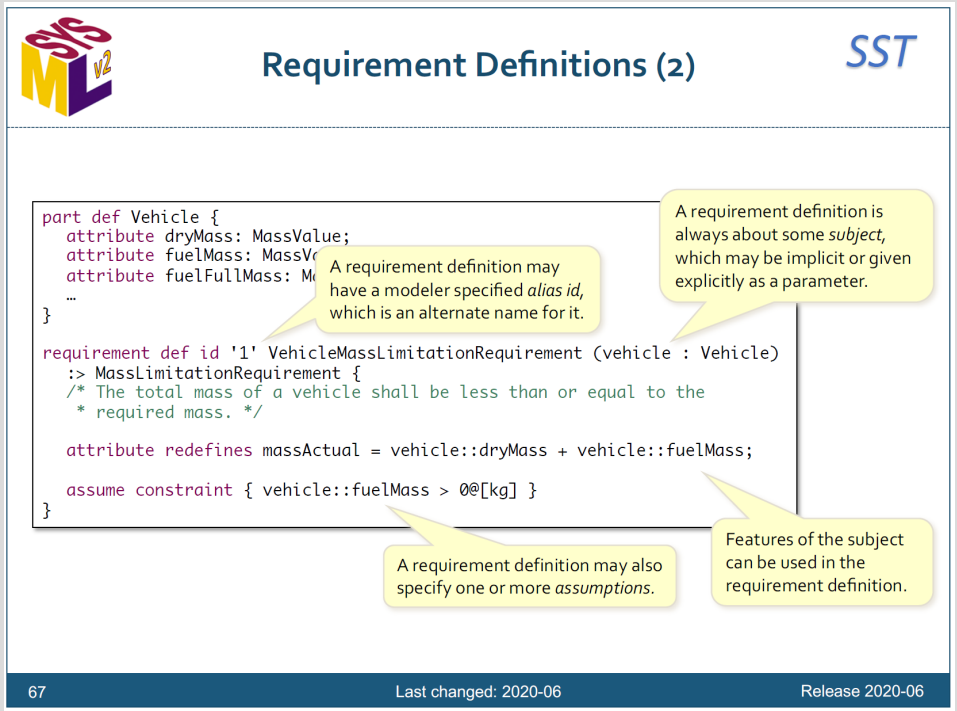
Example Textual Notation: Parts, Attributes, Quantities & Units, Redefinition, …



Example Textual Notation: Behavior, Action, control flow / merge node



Example Textual Notation: Requirement with properties and constraints



API and Services
3 Working prototype implementations

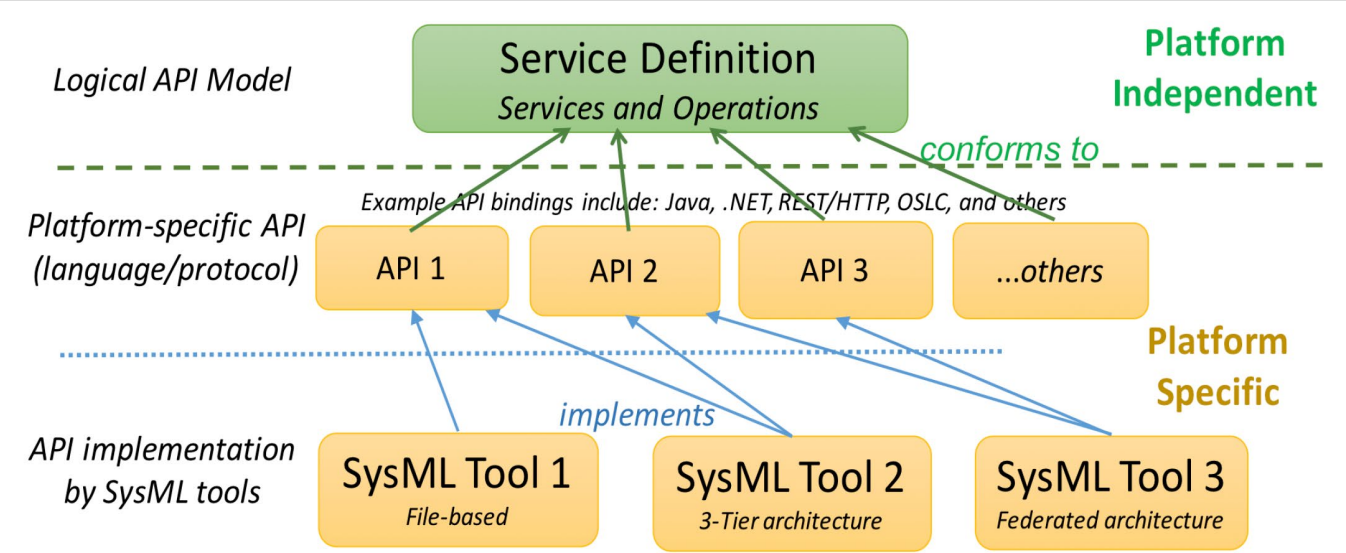


Figure 1. API and Services Architecture

Currently 3 prototype API implementations

- REST API
  - Conforms to OpenAPI spec, (https://www.openapis.org/)
  - Uses JSON-LD to encode objects
  - Publicly accessible server
  - Interfaced with auto-layout visualization by Tom Sawyer
- OSLC
  - Uses JSON-LD to encode objects (same as REST API)
- Java native

Why do I think SysML v2 is Important?

- It is the only global standardization effort that has the scale and vendor support to tackle the problem of fully digitalized open systems engineering
- It is thoroughly based on formal semantics / first order logic
  - Initial mapping to RDF/OWL2 DL done, but needs completion
  - Enables future use of OWL2 DL automated reasoners on SysML models
- Has powerful API with JSON-LD (REST and OSLC implementations)
  - Much better than XMI file based exchange for many industrial use cases
- It maps quite well to the (conceptual) data models in European Space
  - ECSS E-TM-10-23, E-TM-10-25, EGS-CC
  - Capella

Summary

- SysML v2 on its way to completion
  - Delivered submission on time in August 2020 for OMG review
    - Despite obvious COVID-19 obstacles
  - Expecting full v2.0 release per June 2021
- Fourth SysML v2 Public Incremental Release 2020-09 on its way
  - Check http://openmbee.org/sysml-v2-release/2020-06
  - Running textual prototype on Jupyter Notebook with REST API and Tom Sawyer auto-layout graphical language visualisation in web-browser
- Many serious improvements over SysML v1
  - Addressing many lessons learned and getting rid of UML/Software Engineering bias
  - Textual in addition to graphical notation

References

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