2022
Annual INCOSE
international workshop
HYBRID EVENT
Torrance, CA, USA
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SysML v2 Submission Team (SST)
SysML v2 Update

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Presentation
Purpose & Agenda

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- Purpose
  - Provide an update from the 2021 IW on the status of SysML v2
- Agenda
  - SysML v2 Overview
  - Progress and Plans
  - Summary

Model-Based Systems Engineering

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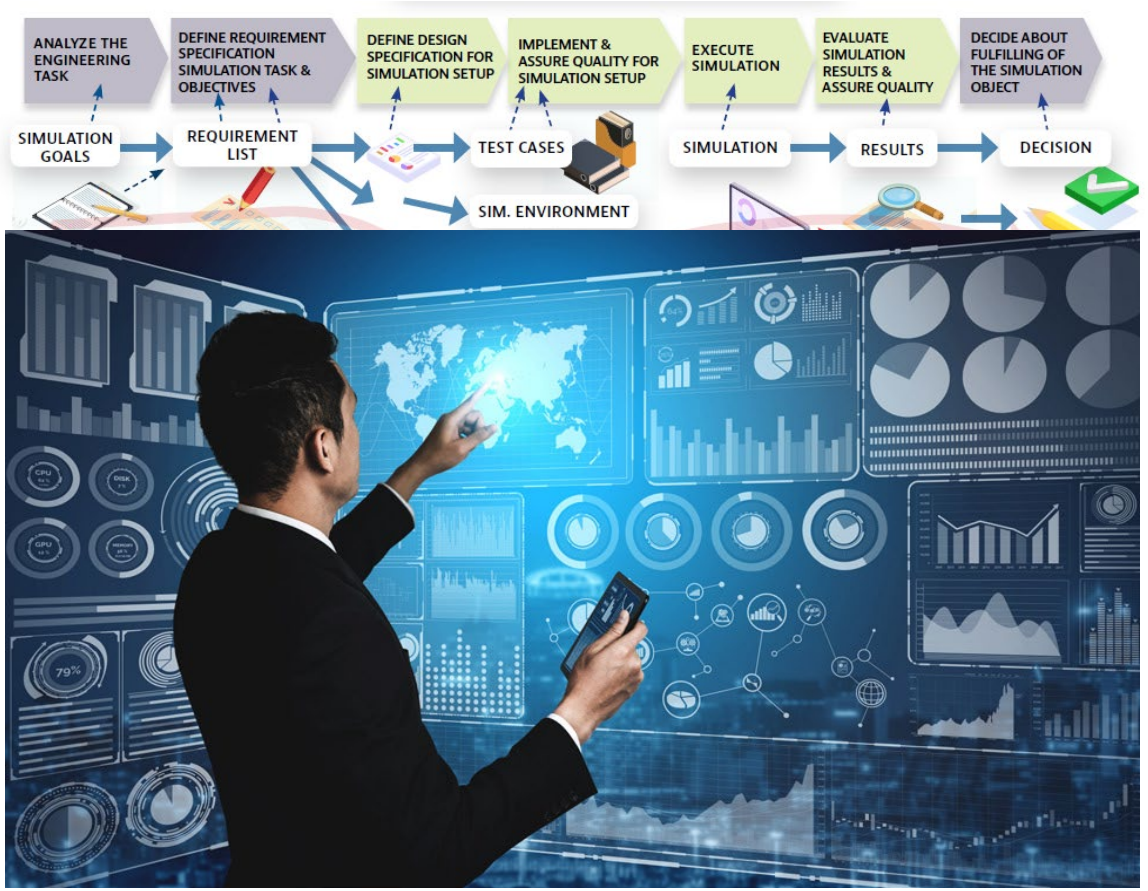
- Part of the digital transformation
- Spans the systems engineering lifecycle
- Facilitates
  - managing complexity and risk
  - more rapidly responding to change
  - reuse and design evolution
  - reasoning about and analyzing systems
  - shared stakeholder understanding
  - documentation and reporting



Source: INCOSE SE Vision 2035

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SysML v2 Overview

SysML v2 Track Leads

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- Project Management – Ed Seidewitz, Sandy Friedenthal
  - Infrastructure – John Watson, Chris Delp
- Requirements V&V – Sandy Friedenthal
- Transformation – Yves Bernard, Tim Weilkiens
- Metamodel Development – Karen Ryan
- API/Services Development – Manas Bajaj
- Pilot Implementation – Ed Seidewitz

SST Participating Organizations

SST

- Aerospace Corp
- Airbus
- ANSYS medini
- Aras
- Army Aviation & Missile Center
- Army CBRND
- BAE
- BigLever Software
- Boeing
- U.S. Army DEVCOM Armaments Center
- CalTech CTME
- CEA
- Contact Software
- Defence Science and Technology Group
- DEKonsult
- Delligatti Associates
- Draper Lab
- ESTACA
- Ford
- Fraunhofer FOKUS
- Galois
- 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
- Lincoln Lab
- Lockheed Martin
- MathWorks
- Maplesoft
- Mercury Systems
- Mgnite Inc
- MID
- MITRE
- ModelAlchemy Consulting
- Model Driven Solutions
- Model Foundry
- NIST
- No Magic/Dassault Systemes
- OAR
- Obeo
- OOSE
- Ostfold University College
- Phoenix Integration/ANSYS
- PTC
- Qualtech Systems, Inc (QSI)
- Raytheon
- Rolls Royce
- Saab Aeronautics
- SAF Consulting *
- SAIC
- Siemens
- Sierra Nevada Corporation
- Simula
- Space Cooperative
- Sodius Willert
- System Strategy *
- Tata Consultancy Services
- Thales
- Thematix
- Tom Sawyer
- Twingineer
- UFRPE
- University of Western Switzerland (Rosas Center)
- 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 *

Systems Modeling Language™ (SysML®)

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Supports the specification, analysis, design, and verification and validation of complex systems that may include hardware, software, information, processes, personnel, and facilities

- SysML has evolved to address user and vendor needs
  - v1.0 adopted in 2006; v1.6 current version; v1.7 in process
- SysML has facilitated awareness and adoption of MBSE
- Much has been learned from using SysML for MBSE

SysML v2 Objectives

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- Increase adoption and effectiveness of MBSE by enhancing…
  - Precision and expressiveness of the language
  - Consistency and integration among language concepts
  - Interoperability with other engineering models and tools
  - Usability by model developers and consumers
  - Extensibility to support domain specific applications
  - Migration path for SysML v1 users and implementors

Key Elements of SysML v2

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- New Metamodel that is not constrained by UML
  - Preserves most of UML modeling capabilities with a focus on systems modeling
  - Grounded in formal semantics
- Robust visualizations based on flexible view & viewpoint specification and execution
  - Graphical, Tabular, Textual
- Standardized API to access the model

SysML v2

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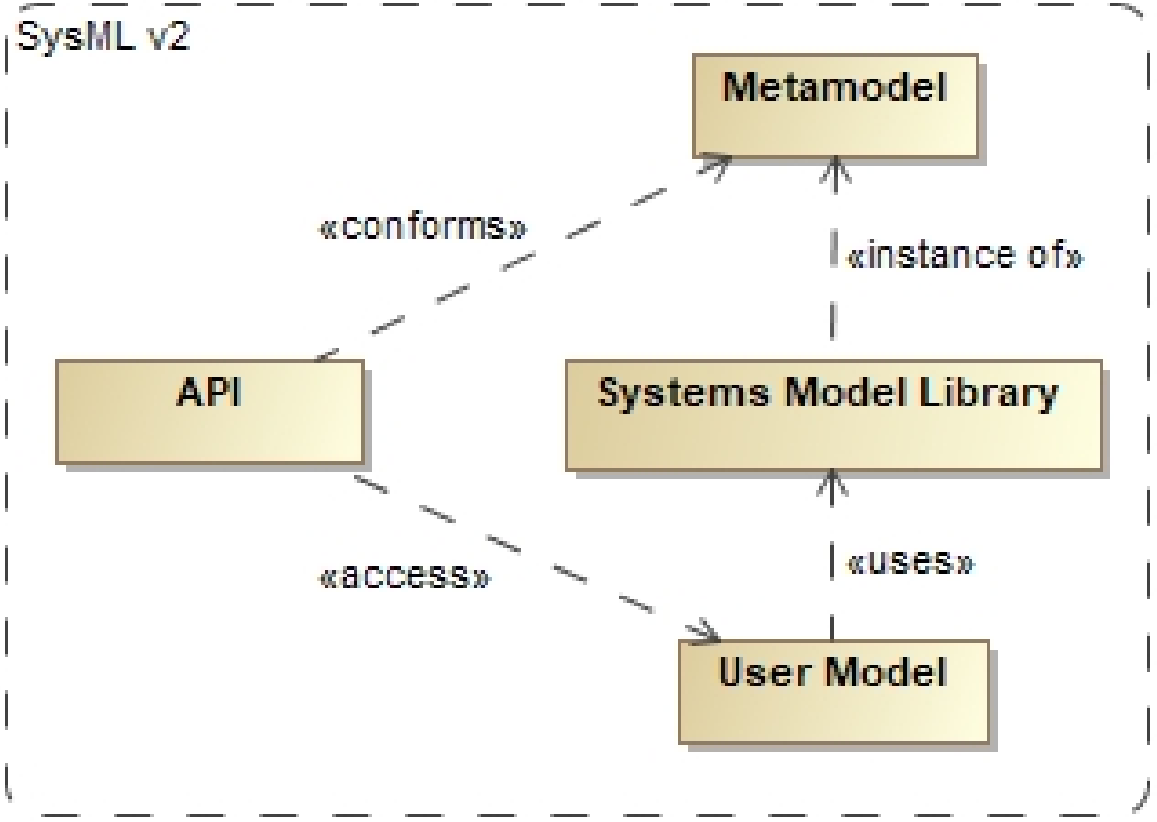
- Metamodel specifies the core concepts in the language and their semantics
- Systems model library instantiates the core concepts from the metamodel for use
- User creates the user model from the systems model library
- API accesses and operates on the user model from the repository



SysML v2 Language Capabilities

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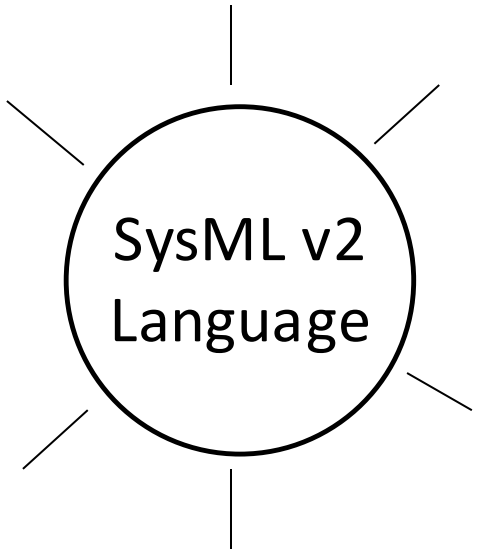
Requirements

Behavior
- function-based
- state-based
- sequence-based
- use cases

Structure
- decomposition
- interconnection
- classification



Analysis
- analysis cases
- expression language

Verification
- verification cases

View & Viewpoint

Vehicle Part Definition
Replaces SysML v1 Block

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- The vehicle part definition is characterized by different kinds of features including
  - Attributes
  - Ports
  - Actions
  - States
  - …

«part def» Vehicle
attributes mass :> ISQ::mass = dryMass + cargoMass + fuelMass dryMass :> ISQ::mass cargoMass :> ISQ::mass fuelMass :> ISQ::mass position :> ISQ::length velocity :> ISQ::speed acceleration :> ISQ::acceleration avgFuelEconomy :> distancePerVolume electricalPower :> ISQ::power
ports fuelCmdPort : FuelCmdPort ignitionCmdPort : IgnitionCmdPort vehicleToRoadPort : VehicleToRoadPort
perform actions providePower
exhibit states vehicleStates

Vehicle Part Definition
Textual Syntax

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- The textual syntax reflects the same model as the graphical syntax

```
part def Vehicle{
    attribute mass :> ISQ::mass = dryMass + cargoMass + fuelMass;
    attribute dryMass:>ISQ::mass;
    attribute cargoMass:>ISQ::mass;
    attribute fuelMass:>ISQ::mass;
    attribute position:>ISQ::length;
    attribute velocity:>ISQ::speed;
    attribute acceleration:>ISQ::acceleration;
    attribute avgFuelEconomy:>distancePerVolume;
    attribute electricalPower:> ISQ::power;
    port fuelCmdPort:FuelCmdPort;
    port ignitionCmdPort:IgnitionCmdPort;
    port vehicleToRoadPort:VehicleToRoadPort;
    perform action providePower;
    exhibit state vehicleStates parallel {↔}
}
```

Vehicle States

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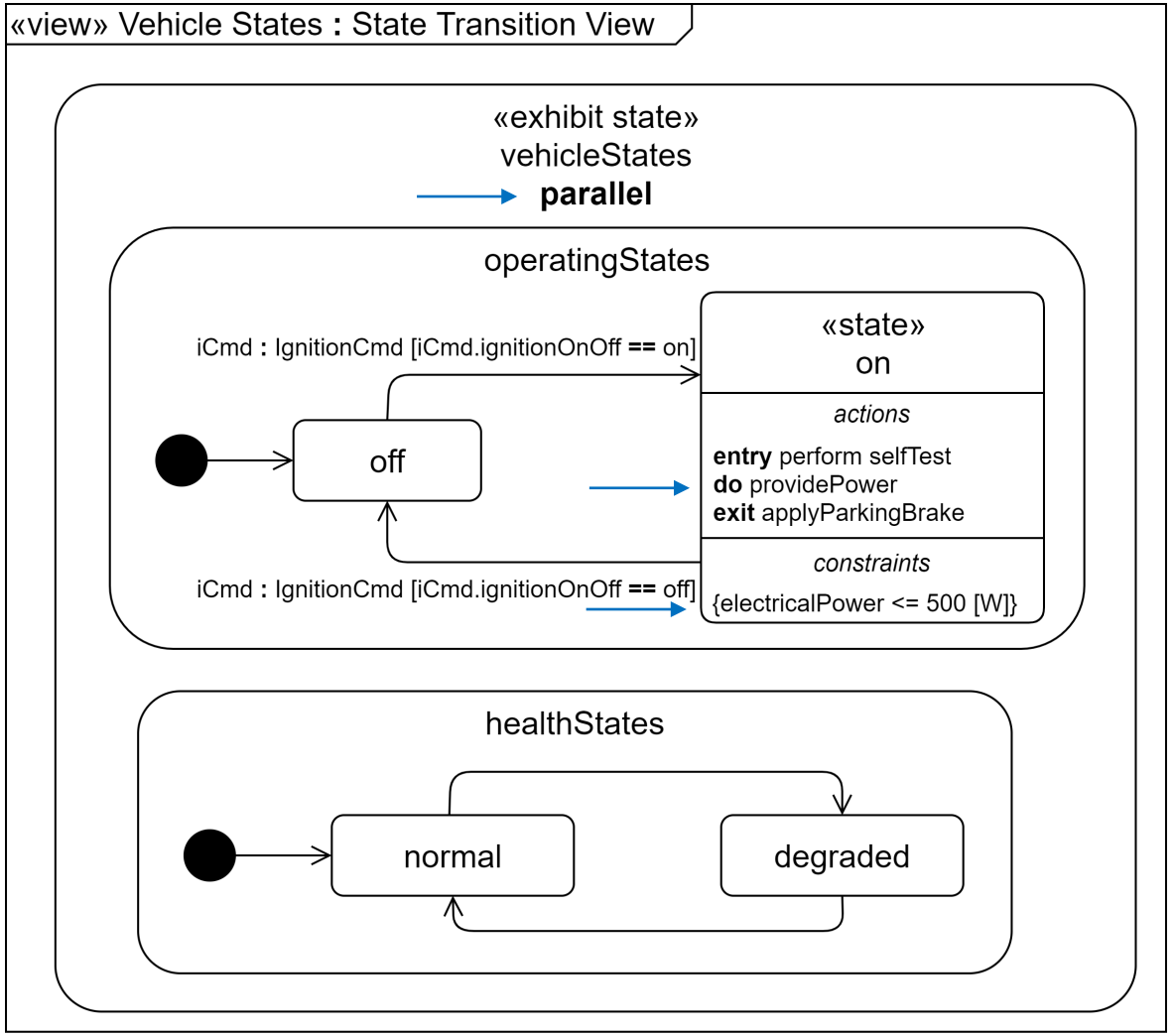
- States are hierarchical and can include:
  - parallel states (e.g., concurrent states) and mutually exclusive states
  - entry, exit, and do actions
  - constraints



Vehicle States
Textual Syntax

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```
exhibit state vehicleStates parallel {
    state operatingStates {
        entry action initial;
        state off;
        state on {
            entry action performSelfTest;
            do providePower;
            exit action applyParkingBrake;
            constraint {electricalPower<=500[W]}
        }
        transition initial then off;
        transition off_To_on
            first off
            accept ignitionCmd:IgnitionCmd via ignitionCmdPort
                if ignitionCmd.ignitionOnOff==IgnitionOnOff::on
            then on;
        transition on_To_off
            first on
            accept ignitionCmd:IgnitionCmd via ignitionCmdPort
                if ignitionCmd.ignitionOnOff==IgnitionOnOff::off
            then off;
    }
    state healthStates {
        entry action initial;
        state normal;
        state degraded;
```

SysML v2 Reuse Patterns

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- Definition and usage
  - A definition element defines an element such as a part, action, or requirement
  - A usage element is a usage of a definition element in a particular context
  - Pattern is applied consistently throughout the language
- Variability
  - Variation points represent elements that can vary
    - Variation applies to all definition and usage elements
  - A variant represents a particular choice at a variation point
  - A choice at one variation point can constrain choices at other variation points
  - A system can be configured by making choices at each variation point consistent with the specified constraints

Vehicle Part Defined by Vehicle Part Definition

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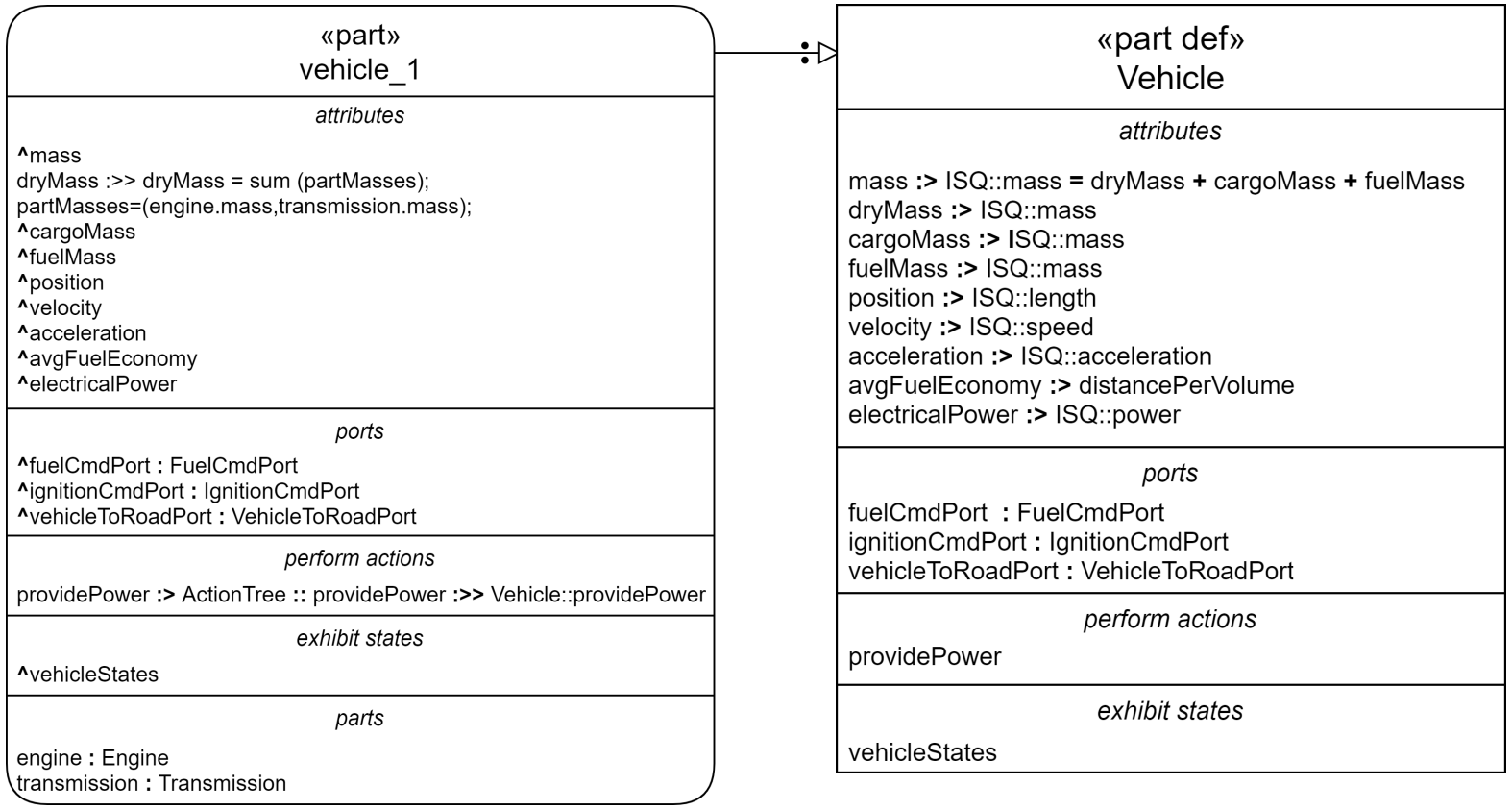
- Parts are specializations of their definitions (defined by)
  - Enables adaptation of each usage to its context by inheriting and redefining its features



Vehicle Part
Textual Syntax

SST

nested part →

```
part vehicle_1:Vehicle{
    attribute mass redefines mass;
    attribute dryMass redefines dryMass = sum (partMasses);
    attribute partMasses=(engine.mass,transmission.mass);
    perform ActionTree::providePower redefines providePower;
    part engine:Engine{
        attribute mass redefines mass default 200 [kg];
        port fuelCmdPort:>>fuelCmdPort=vehicle_1.fuelCmdPort;
        port ignitionCmdPort:>>ignitionCmdPort=vehicle_1.ignitionCmdPort;
        perform ActionTree::providePower.generateTorque;
        part cylinders[6]:Cylinder;
    }
    part transmission:Transmission{
        attribute mass redefines mass default 60 [kg];
        perform action amplifyTorque:>> amplifyTorque = ActionTree::providePower.amplifyTorque;

    }
    connect engine.drivePwrPort to transmission.drivePwrPort;
}
```

Vehicle Part Decomposition

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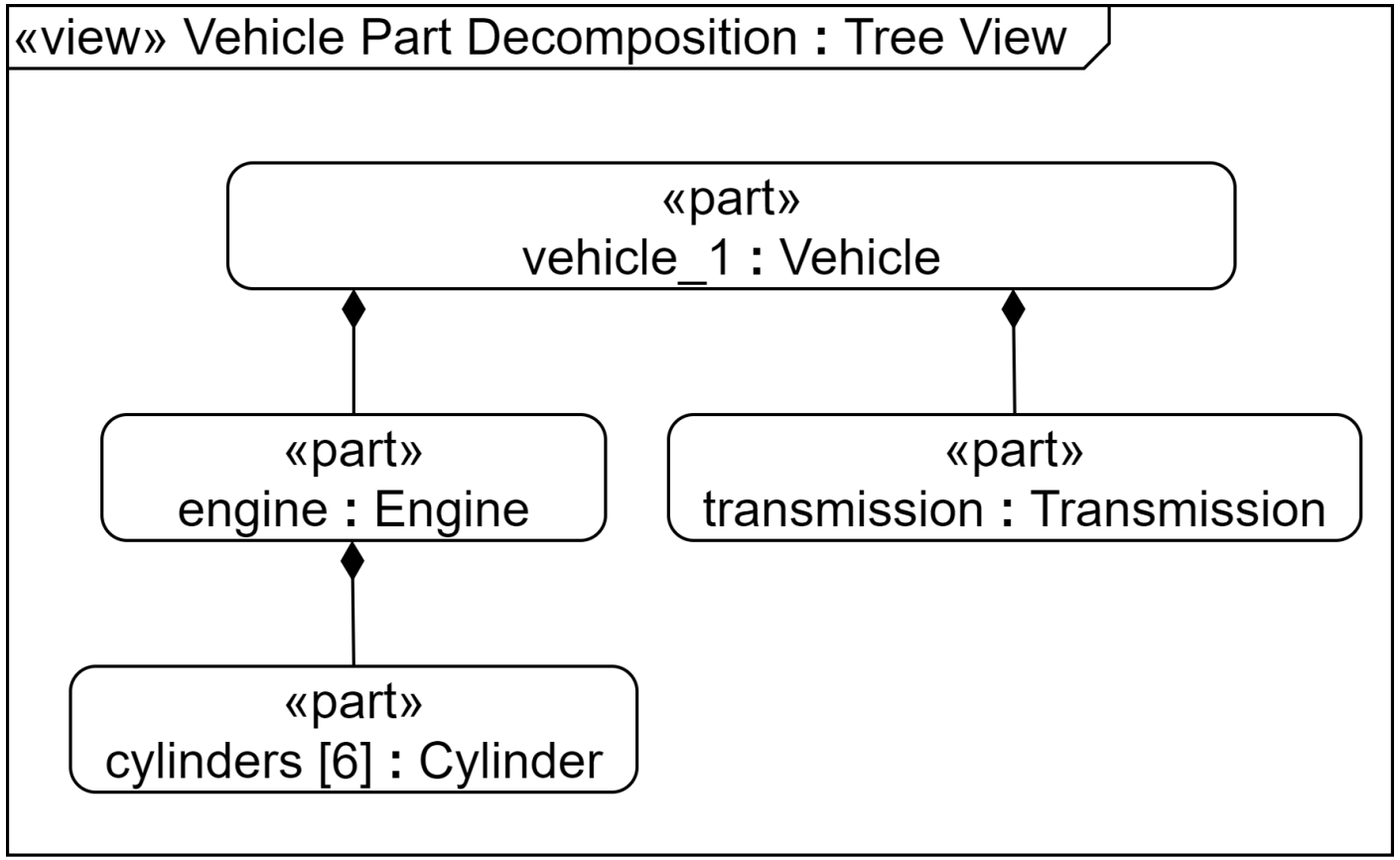

Vehicle Part Interconnection

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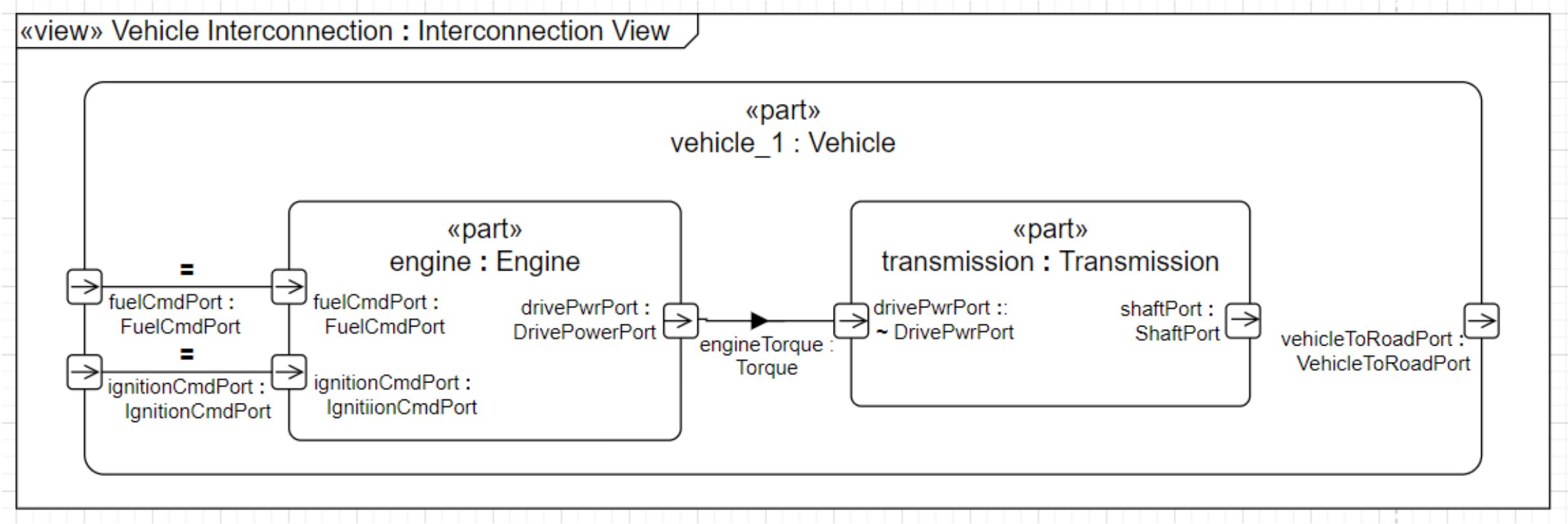
- Part interconnection contains parts, ports, connections, and flows



Vehicle Part Interconnection with Variation

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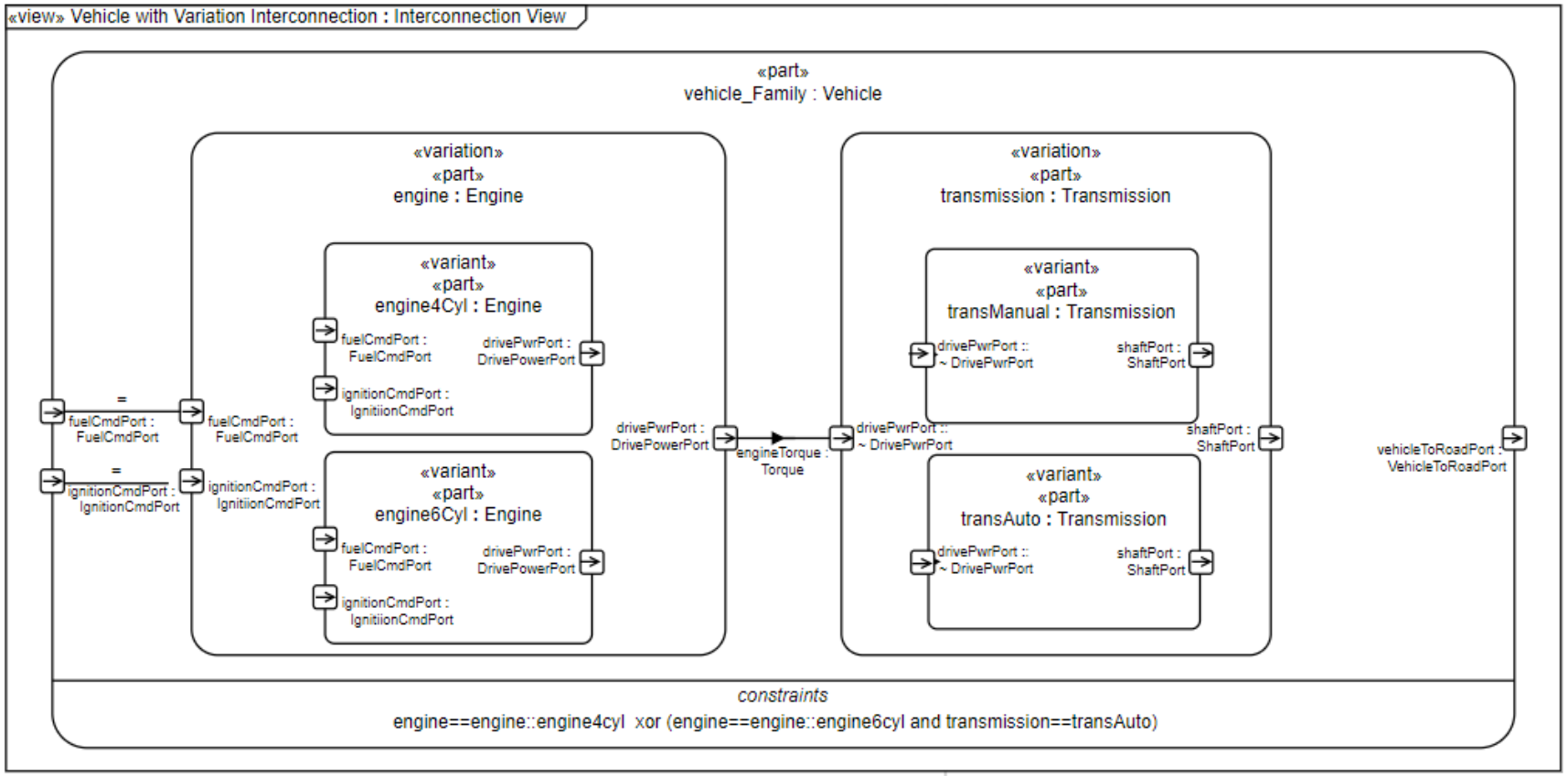
- Define vehicle configuration by specializing vehicle family with variation, identifying variants, and redefining features as required



SysML v2 to v1 Terminology Mapping (partial)

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SysML v2	SysML v1
part / part def	part property / block
attribute / attribute def	value property / value type
port / port def	proxy port / interface block
action / action def	action / activity
state / state def	state / state machine
constraint / constraint def	constraint property / constraint block
requirement / requirement def	requirement
connection / connection def	connector / association block
view / view def	view

Contrasting SysML v2 with SysML v1

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- Simpler to learn and use
  - Systems engineering concepts designed into metamodel versus added-on
  - Consistent application of definition and usage pattern
  - More consistent terminology
  - Ability to decompose parts, actions, …
- More precise
  - Textual syntax and expression language
  - Formal semantic grounding
  - Requirements as constraints
- **More expressive**
  - Variant modeling
  - Analysis case
  - Trade-off analysis
  - Individuals, snapshots, time slices
  - More robust quantitative properties (e.g., vectors, ..)
  - Query/filter expressions
  - Metadata
- **More extensible**
  - Simpler language extension capability
    - Based on model libraries
- **More interoperable**
  - Standardized API

Progress and Plans

SysML v2 Spec (Clause 7)
SysML v2 Language Description

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7.2 Elements and Relationships
7.3 Annotations
7.4 Namespaces and Packages
7.5 Dependencies
7.6 Definition and Usage
7.7 Attributes
7.8 Enumerations
7.9 Occurrences
7.10 Items
7.11 Parts
7.12 Ports
7.13 Connections
7.14 Interfaces
7.15 Allocations
7.16 Actions
7.17 States
7.18 Calculations
7.19 Constraints
7.20 Requirements
7.21 Cases
7.22 Analysis Cases
7.23 Verification Cases
7.24 Use Cases
7.25 Views and Viewpoints
7.26 Language Extension (planned Q1 2022)

Most of the core language functionality is baselined

High Priority Remaining Work

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Language

- Finalize specification of graphical syntax
- Time semantics and change/time events
- Simple geometry (spatial semantics and shape library)
- Language extension
- Behavior execution guidance
- Model interchange
- Conformance cases
- Complete SysML v1 to v2 transformation

API & Services

- Cross project element referencing
- Conformance tests
- OSLC PSM
- Query specification updates
- API Recipes

Additional work to be done during finalization

SysML v2 Milestones

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- December, 2017 SysML v2 RFP issued
- June, 2018 SysML v2 API & Services RFP issued
- August, 2020 Initial Submission
- February, 2021 Stakeholder Review
- August, 2021 Revised Submission
- November, 2021 2nd Revised Submission (OMG evaluation initiated)
- 2nd Qtr 2022 Final Submission (date to be confirmed)
- 2nd Qtr 2023 Finalized Specification (pending OMG approvals)

Summary

SST Public Repositories
Current Release: 2021-12

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- Monthly release repository
  - https://github.com/Systems-Modeling/SysML-v2-Release
- Release content
  - Specification documents (for KerML, SysML and API)
  - Training material for SysML textual notation
  - Training material for SysML graphical notation
  - Example models (in textual notation)
  - Pilot implementation
    - Installer for Jupyter tooling
    - Installation site for Eclipse plug-in
  - Web access to prototype repository via SysML v2 API
  - Web access to Tom Sawyer visualization tooling
- Open-source repositories
  - https://github.com/Systems-Modeling
- Google group for comments and questions
  - https://groups.google.com/g/SysML-v2-Release
    (to request membership, provide name, affiliation and interest)

Summary

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- SysML v2 is addressing SysML v1 limitations to improve MBSE adoption and effectiveness
  - Precision, expressiveness, usability
  - Interoperability with other engineering models and tools
- Approach
  - Simplified SysML v2 metamodel with formal semantics overcomes fundamental UML limitations
  - Flexible graphical notations and textual notation
  - Standardized API for interoperability
- Roadmap to final submission planned for Q2/Q3 2022

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Attend the SysML v2 Demo

Sunday, January 30

10:00 – 3:00 PT

Salon F

Thank you!!