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Applying a System of Systems Perspective to Hyundai-Kia's Virtual Tire Development

Presenter Bio



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Outline

- Background
- SoS Rationale
- Virtual Tire Development Process
- Process Orchestration
- Conclusion & Observations



Motivation

Background

Key Motivations for Hyundai

**Siloed Performance
Development**

**Disconnected
Development**

Communication

Knowledge Capture

Traceability

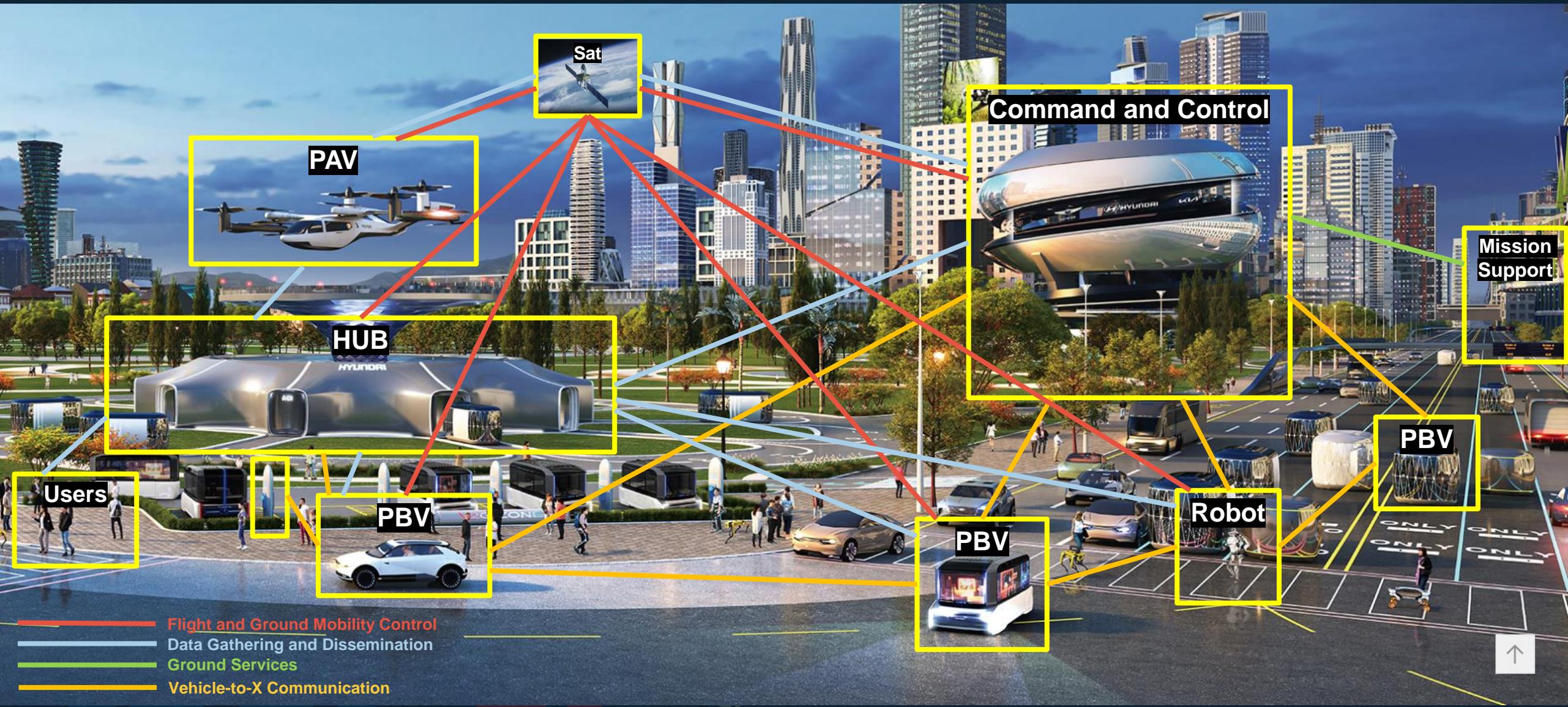
Challenges



EV Mobility

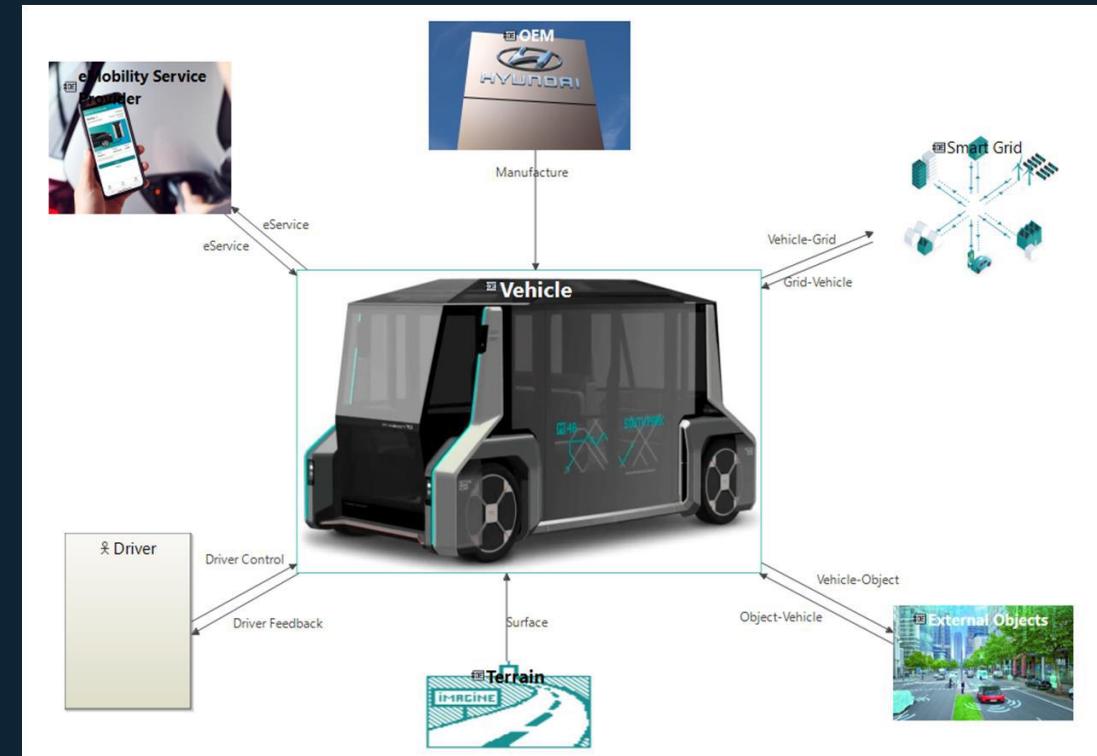
SoS Rationale

The Essence of Future Mobility Lifestyle – Hyundai Motor Group



Narrowing the Case for EV Mobility SoS

1. Operational Independence
2. Managerial Independence
3. Geographical Distribution
4. Evolutionary Development Processes
5. Emergent Behavior



Project Scope

To develop a ‘purpose built vehicle’ concept architecture that can:

1. Provide a descriptive reference of the SoS context, its constituent vehicle’s functions, structure, and interfaces,
2. Enable early vehicle/tire performance verification based on predefined metrics and,
3. Enable system-to-subsystem collaboration with downstream subsystem and component designers/architects through a cross-domain collaboration platform

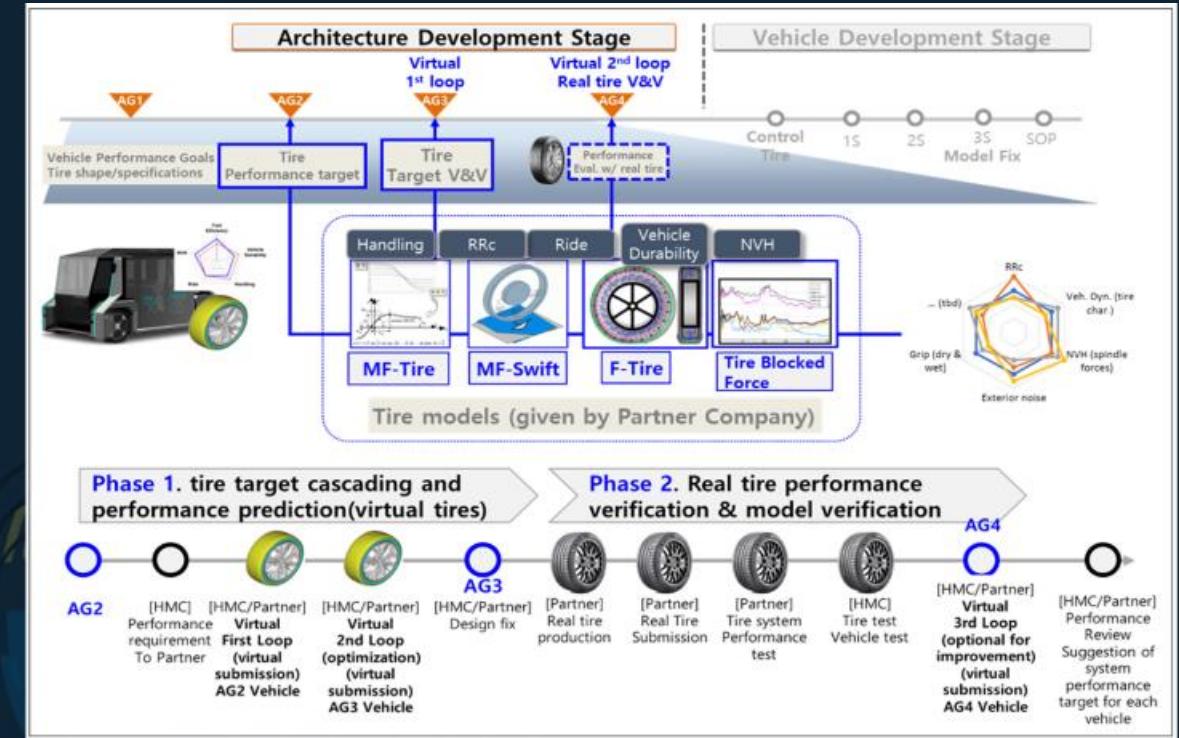


Hyundai-Kia

Virtual Tire Development Process

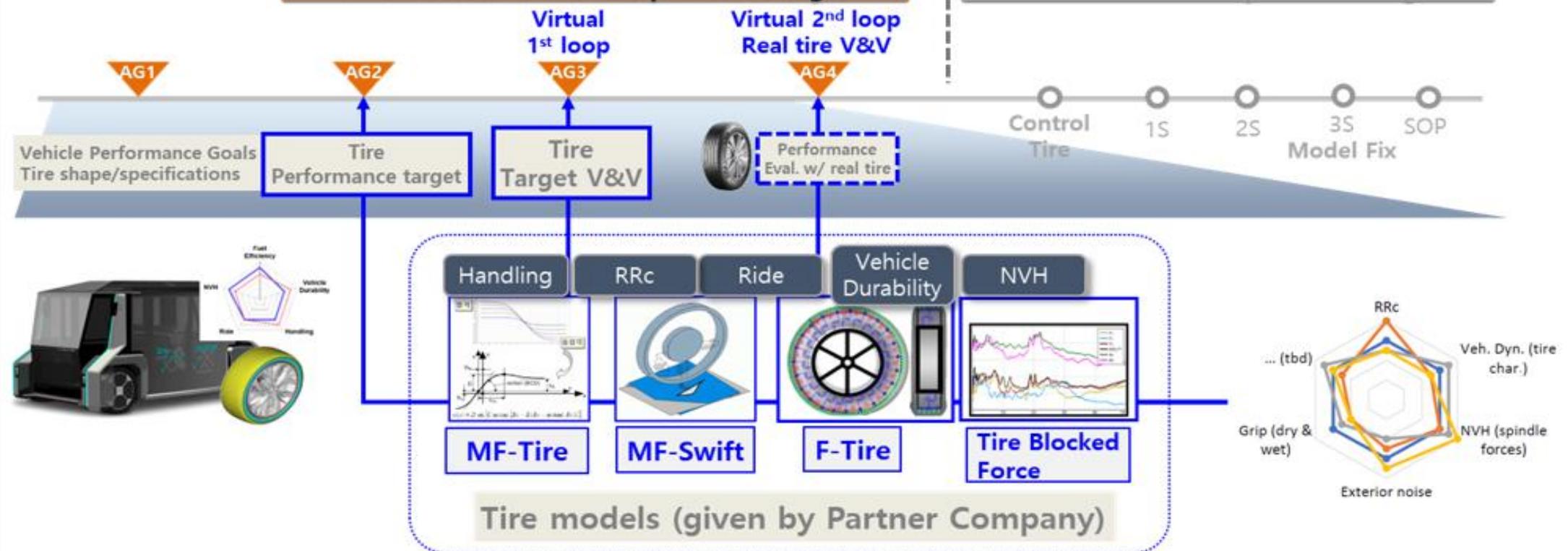
Process

1. Vehicle level performance tradeoffs
2. Vehicle-tire targets cascading
3. Tire level performance tradeoffs



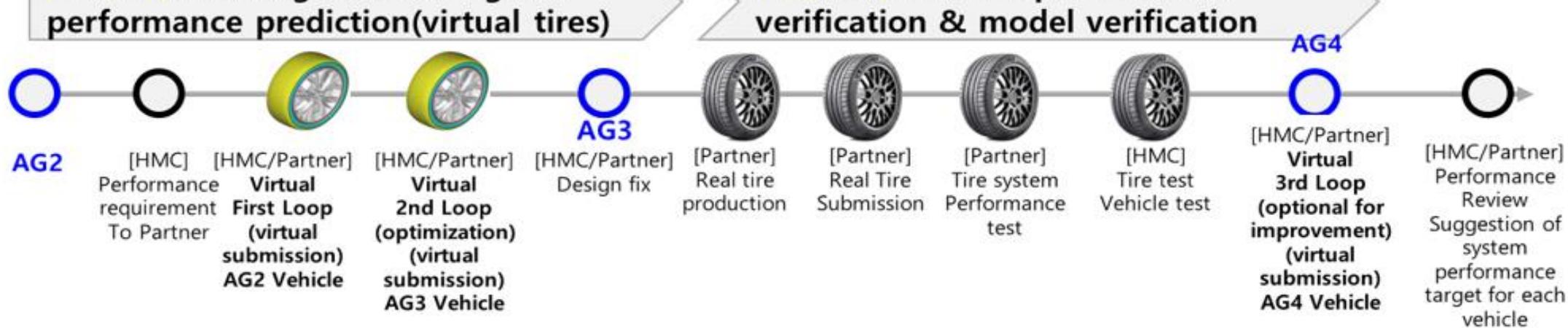
Architecture Development Stage

Vehicle Development Stage



Phase 1. tire target cascading and performance prediction(virtual tires)

Phase 2. Real tire performance verification & model verification





Virtual Tire Development with MBSE

Process Orchestration

Process Elements

1. System Architecture

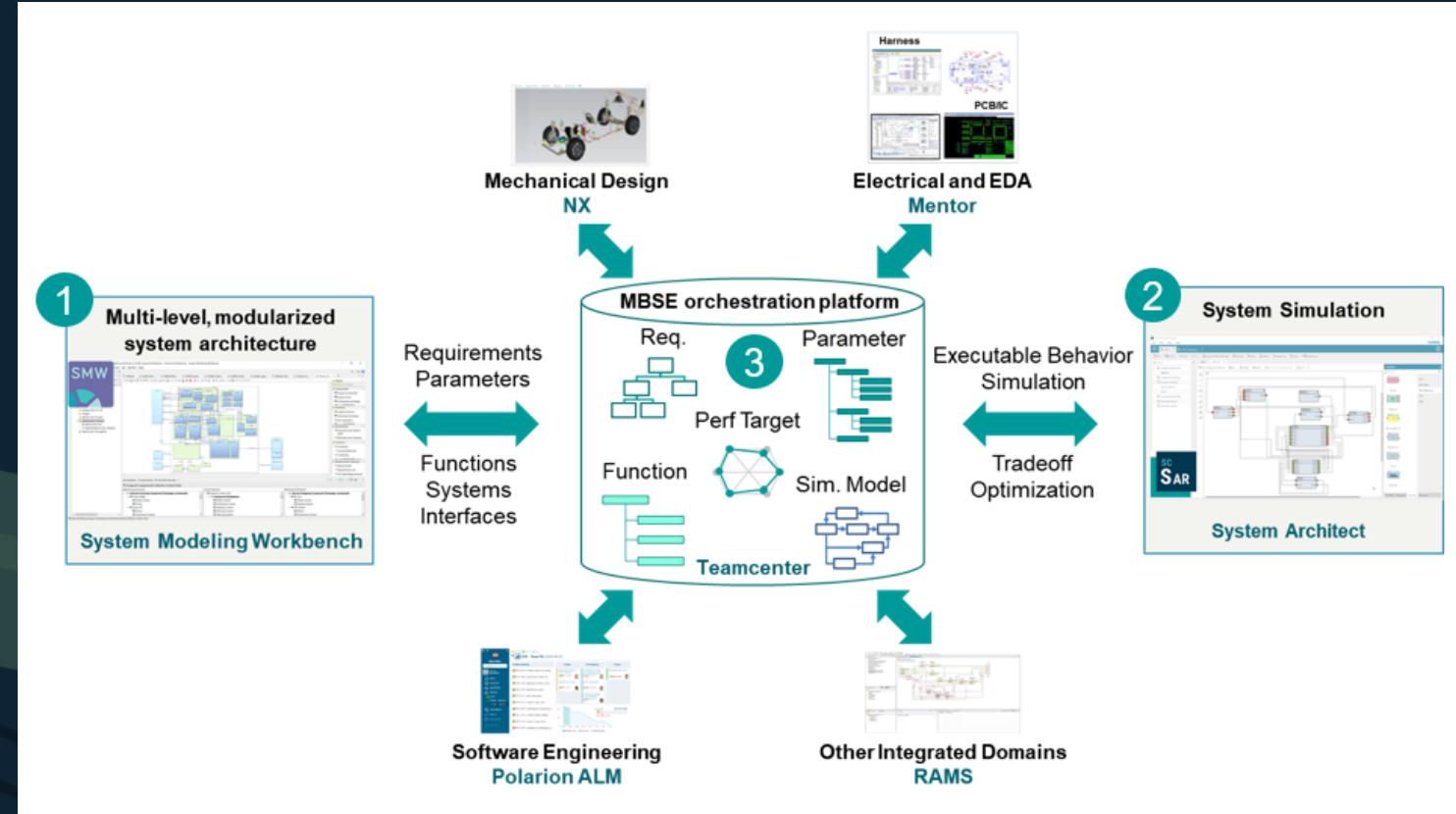
Modeling: System Modeling Workbench

2. System Simulation:

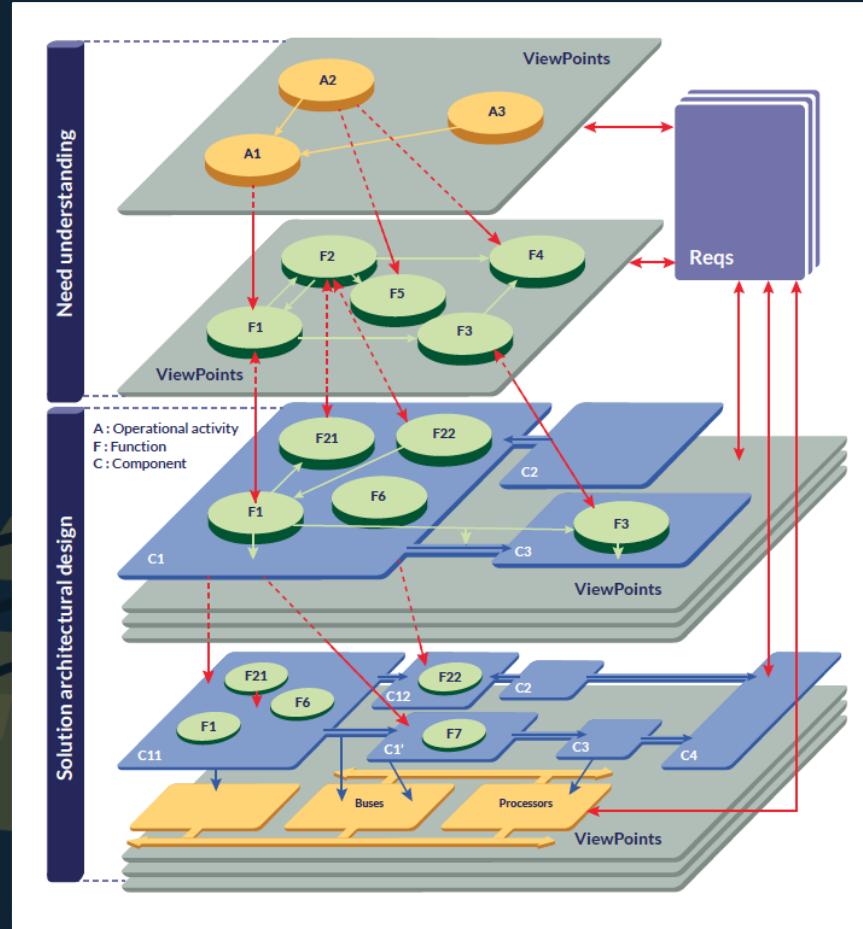
Simcenter System Architect,
Amesim

3. MBSE Orchestration:

Teamcenter



The Arcadia Method



Operational Analysis

What the users of the system need to accomplish

System Analysis

What the system need to accomplish for the users

Logical Architecture

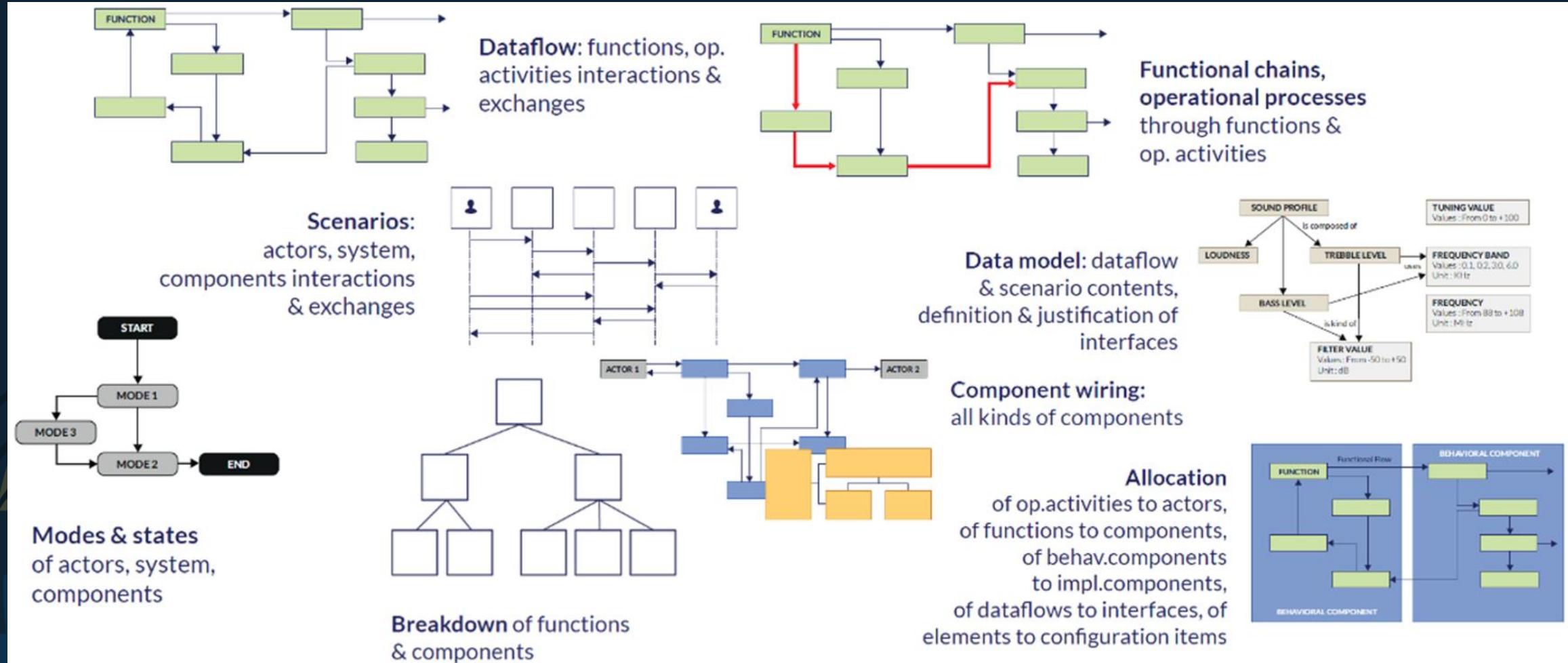
How the system will work to fulfill expectations

Physical Architecture

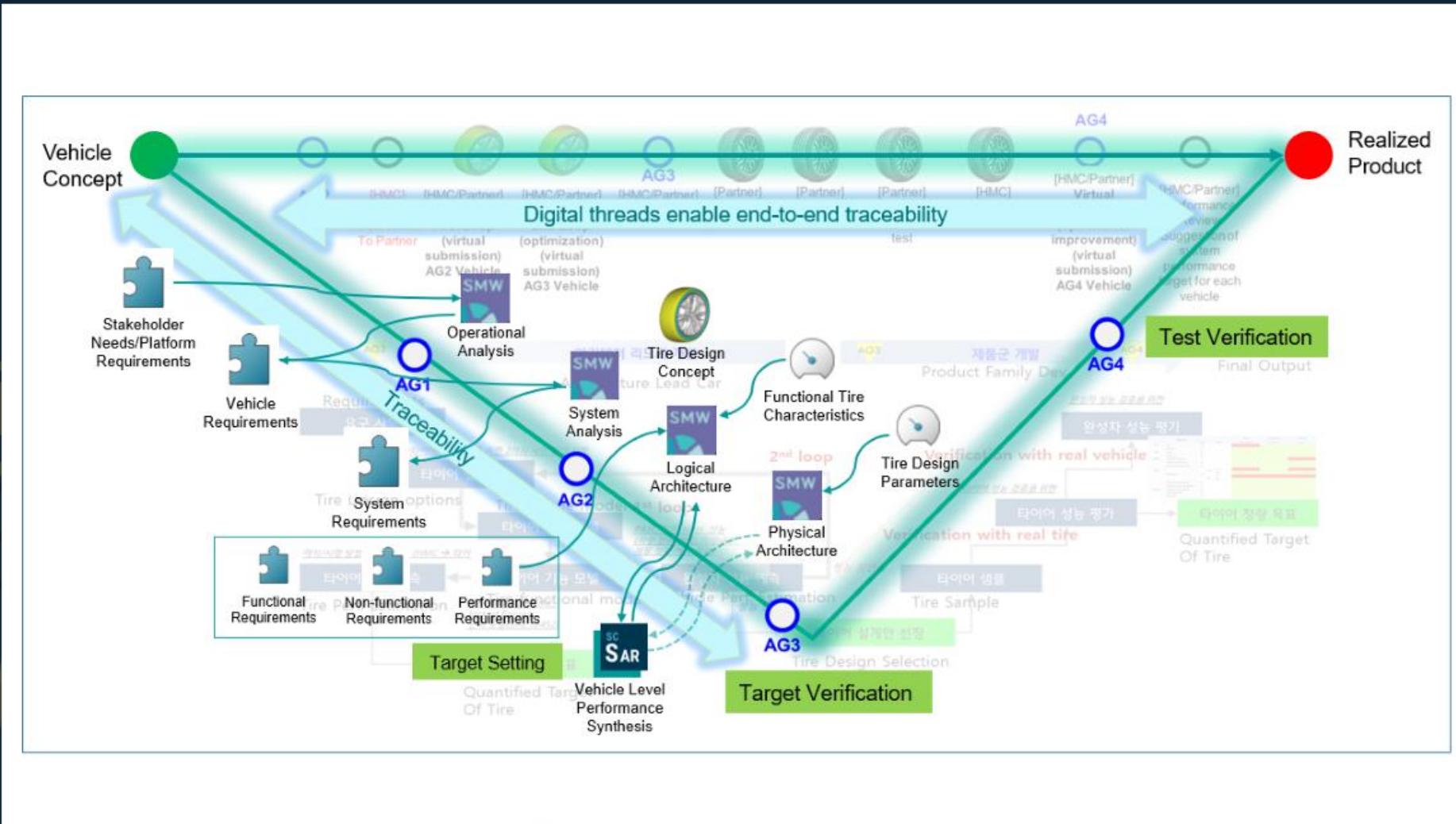
How the system will be developed and built

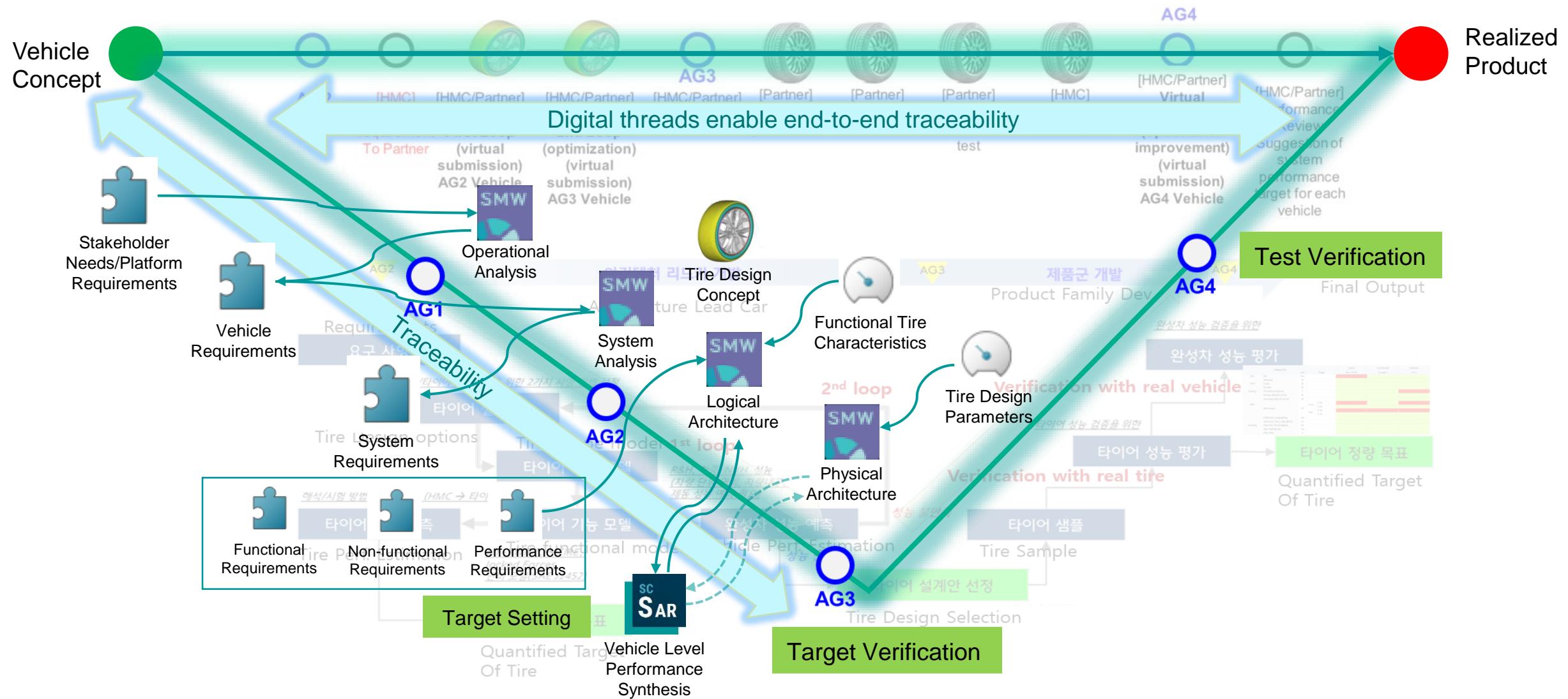
System Modeling Workbench

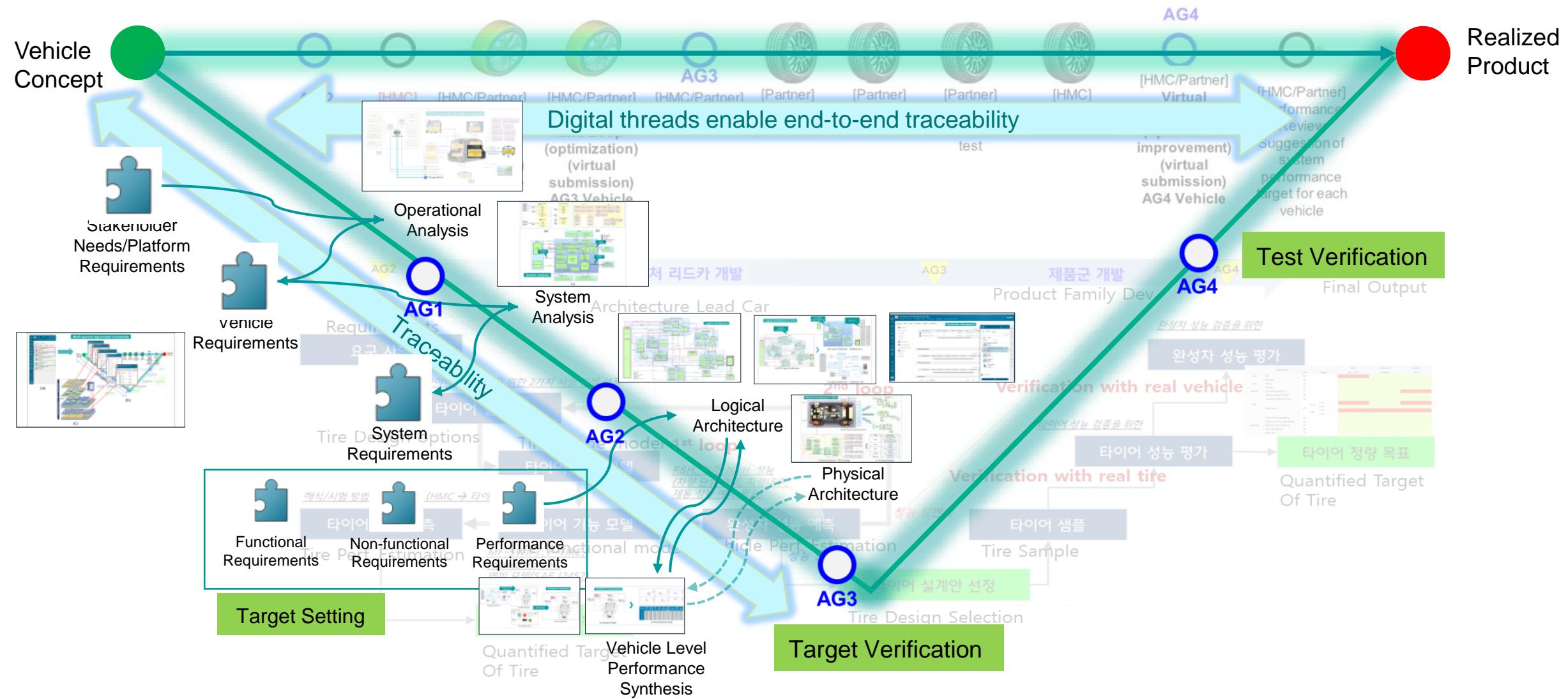
Arcadia Method – Key System Engineering Artifacts



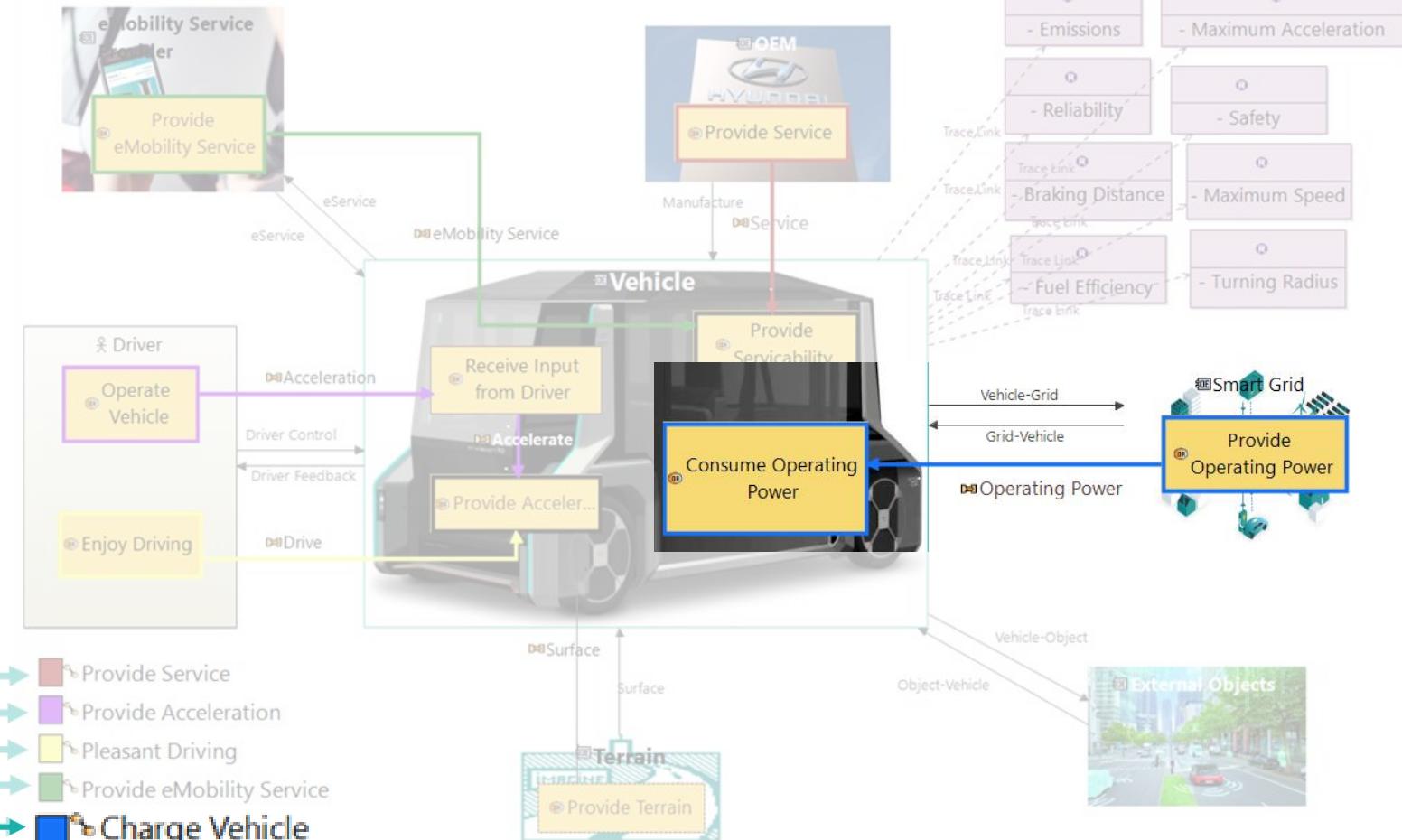
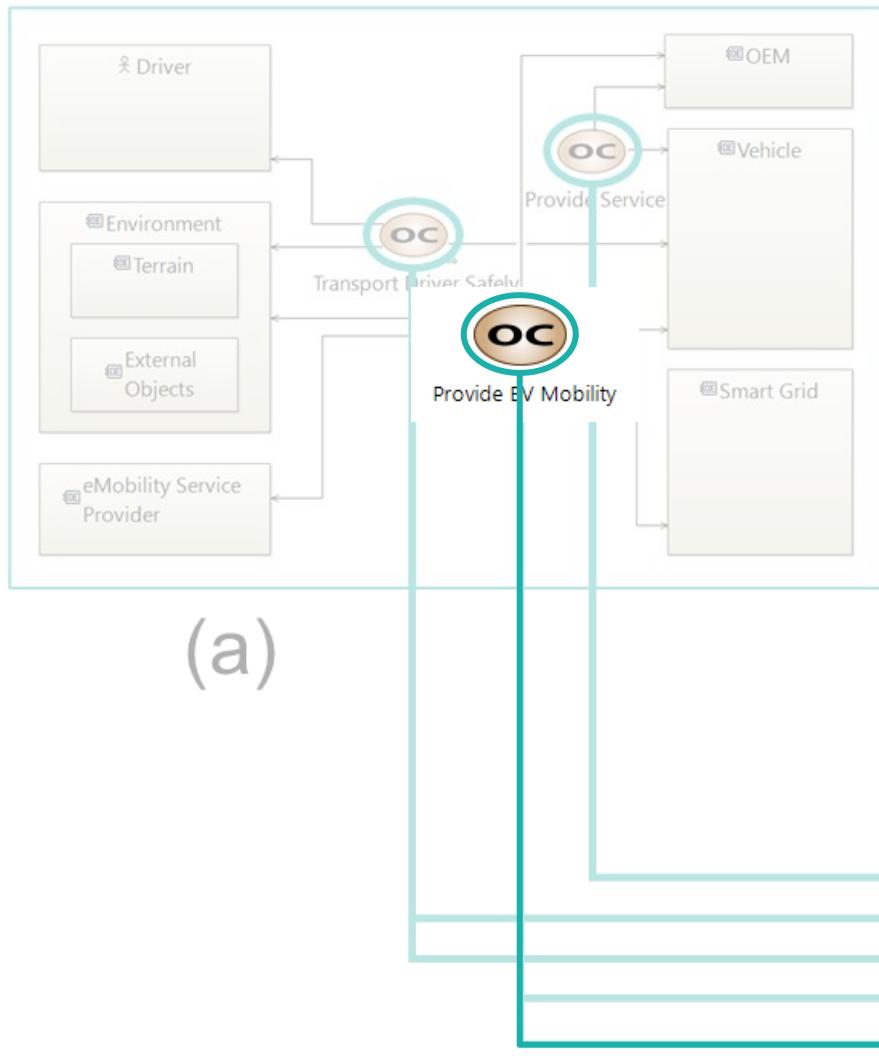
Process



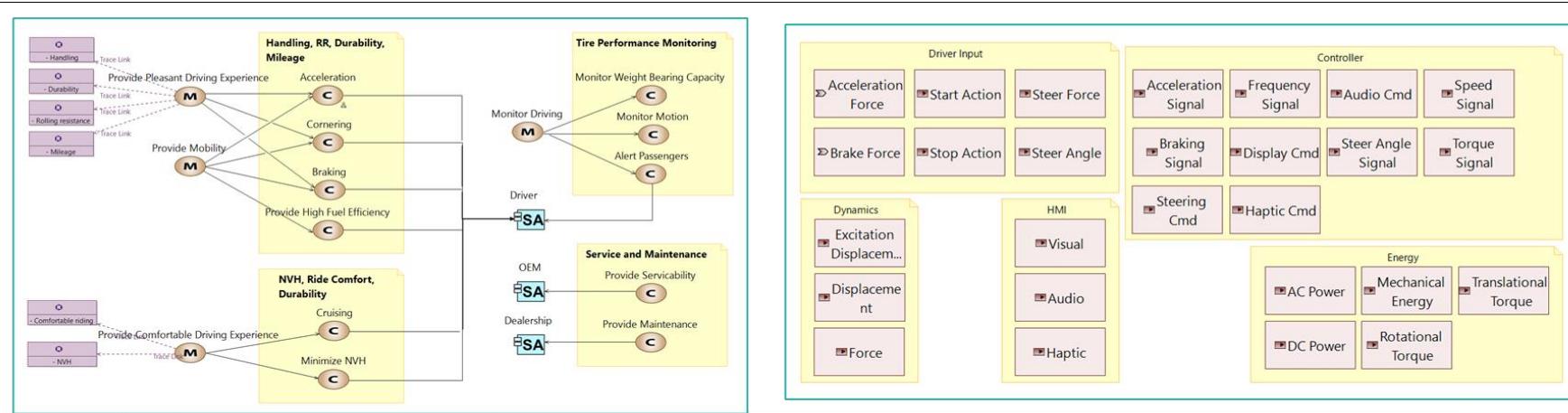




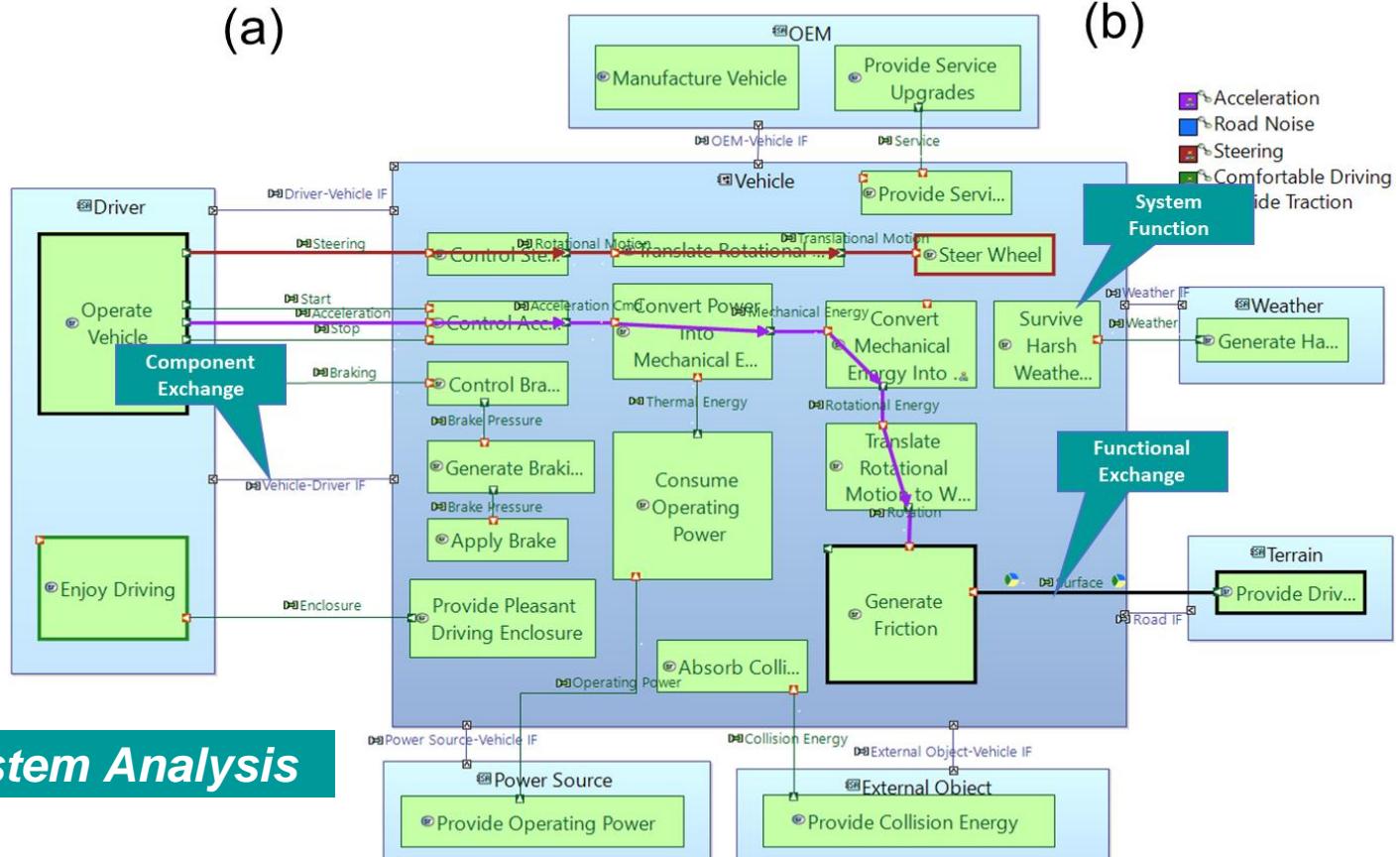
SoS Context and Operational Analysis



(b)



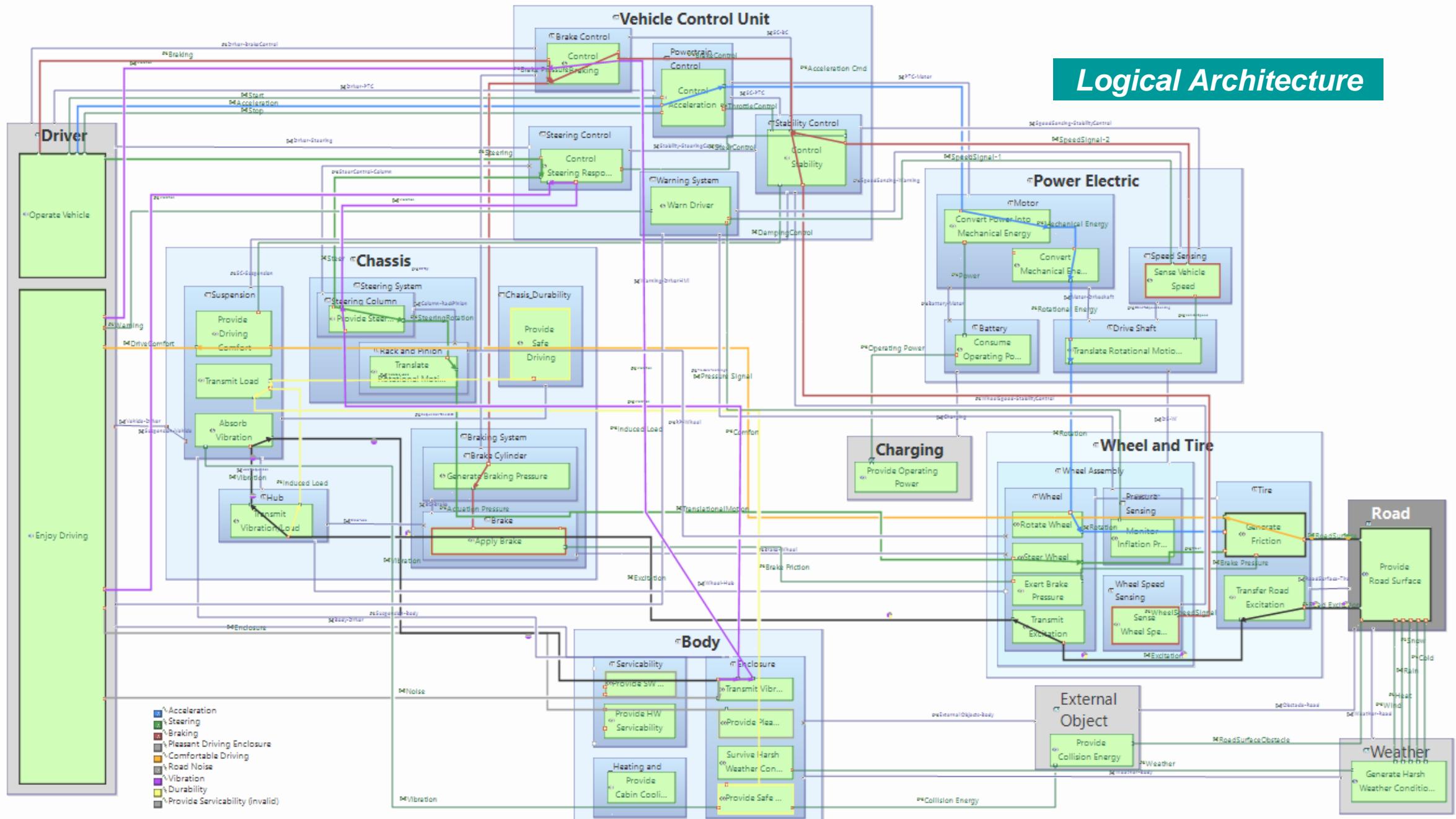
(a)



System Analysis

(c)

Logical Architecture

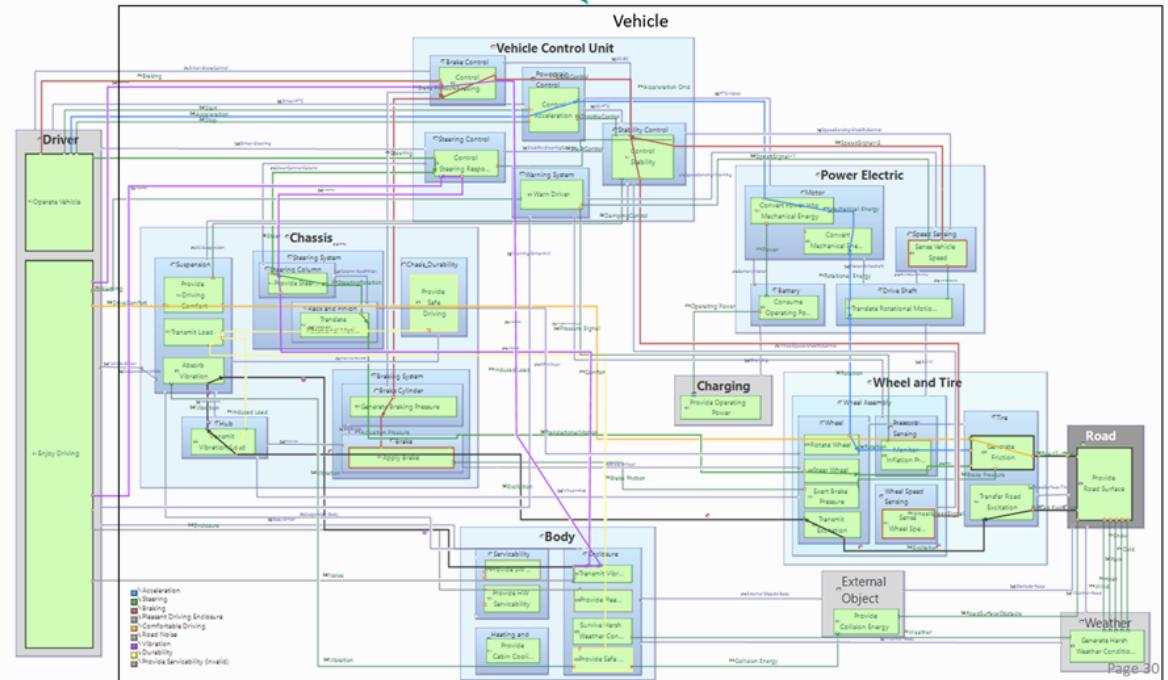


Logical Architecture & FTCs

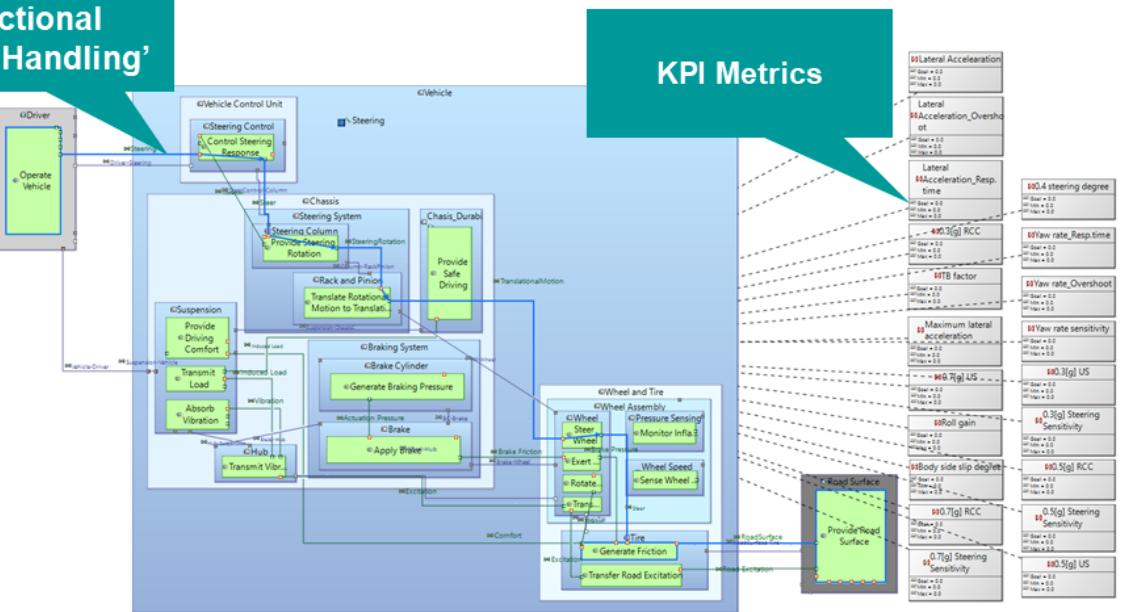
Functional Chain ‘Handling’

KPI Metrics

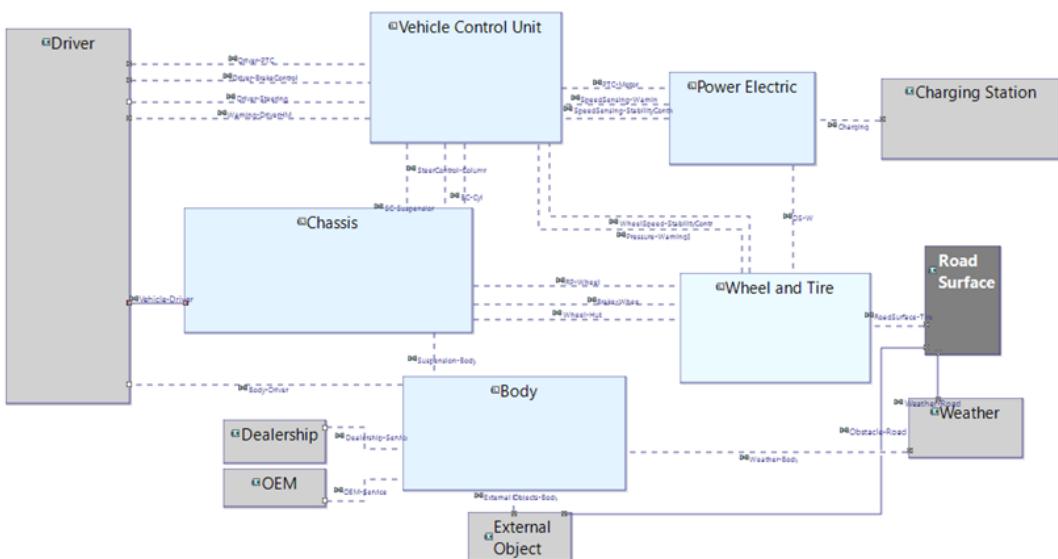
Logical Architecture



(a) PBV Logical Architecture



(b) Logical Architecture – Handling View



(c) Logical Architecture – Component View

[Overview](#) [Trends](#) [History](#) [Participants](#) [Relations](#) [Attachments](#)

Verification Management

 Requirements Test Procedures Functions Systems Parts Simulation Models Simulation Analyses Product and Test EBOMs Parameters Others Reports

Element Name	Revisi...	Target	Result	Owner	Type	Structure
Step Steer Verification	A	True		kmk (kmk)	Requirement Revisi...	False
Virtual Turning Verification	A	True		kmk (kmk)	Requirement Revisi...	False

SIMULATION MODELS

Element Name	Revisi...	Target	Result	Owner	Type	Structure

SIMULATION ANALYSES

Element Name	Revisi...	Target	Result	Owner	Type	Structure

PARAMETERS

 Selection Select Hide Excel Start Manage Copy Parameters**Add** Pin Panel Close**Add**[New](#) [Palette](#) [Search](#) [Results](#) [Filters](#)

Keywords: * (5 Results)



Step Steer Analysis

000560

Revision: A



Tire Architecture - Gold Copy

000558

Revision: A

 Open

Vehicle

000550

Revision: A



Step Steer

000547

Revision: A

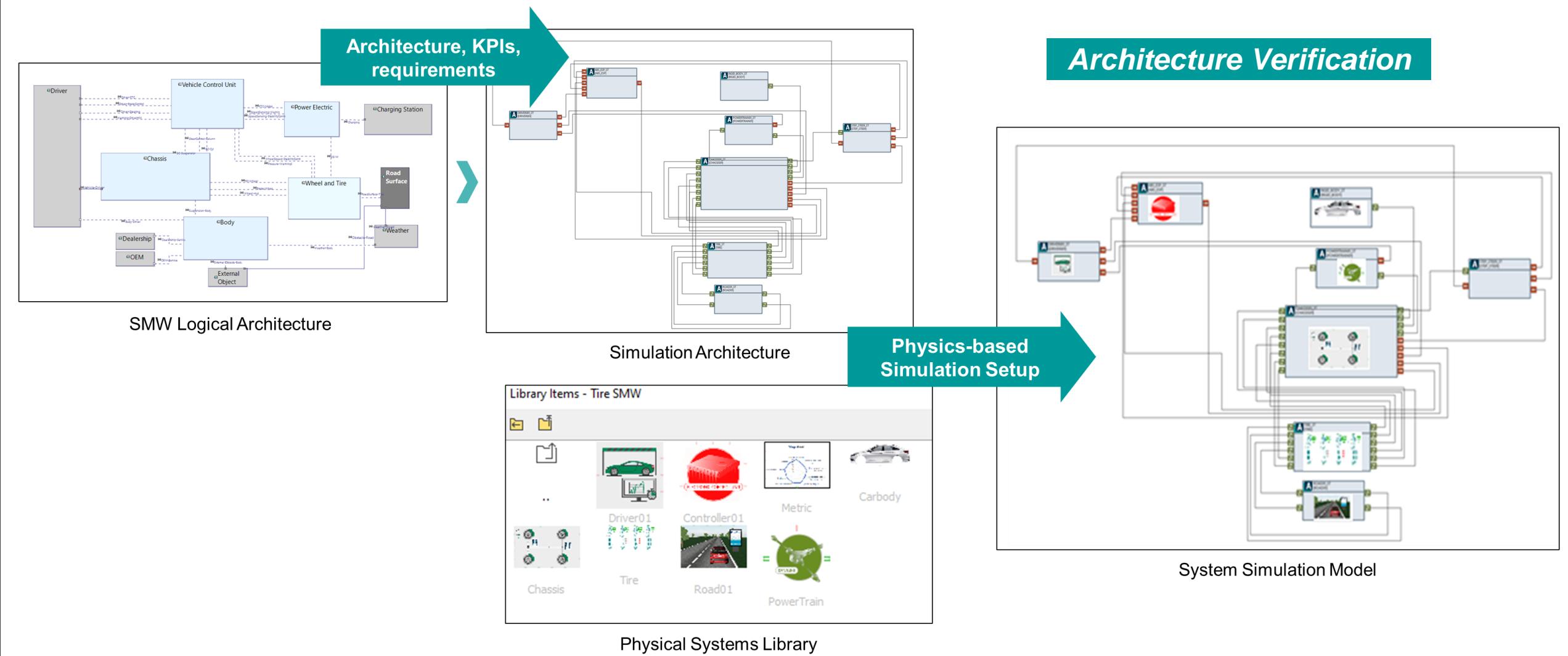


NX_Template

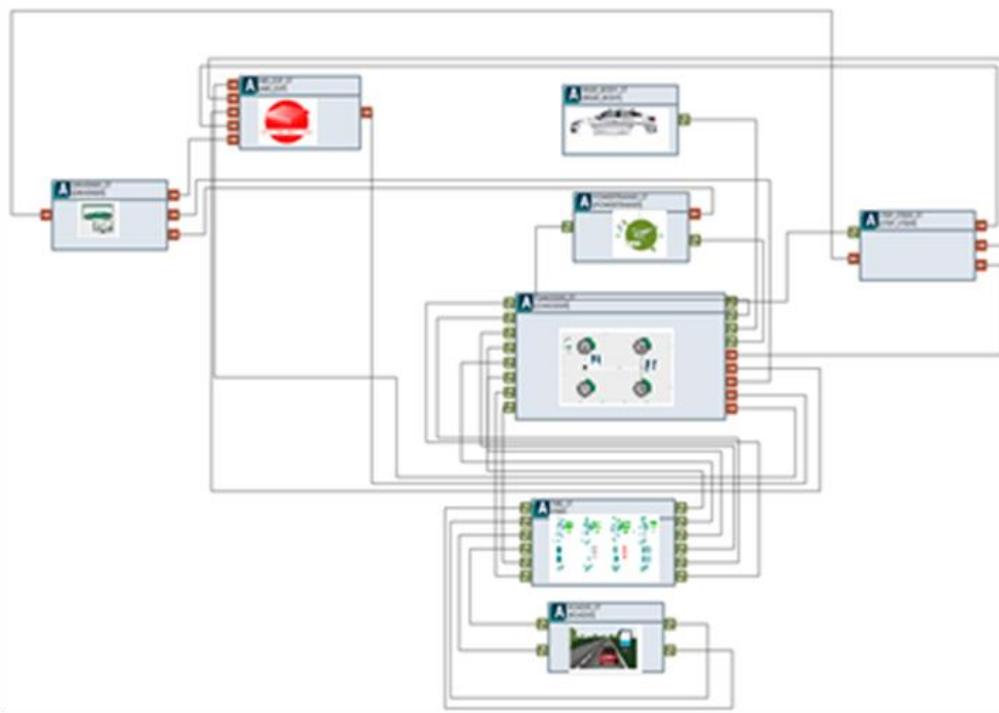
BatchMesh

Revision: A

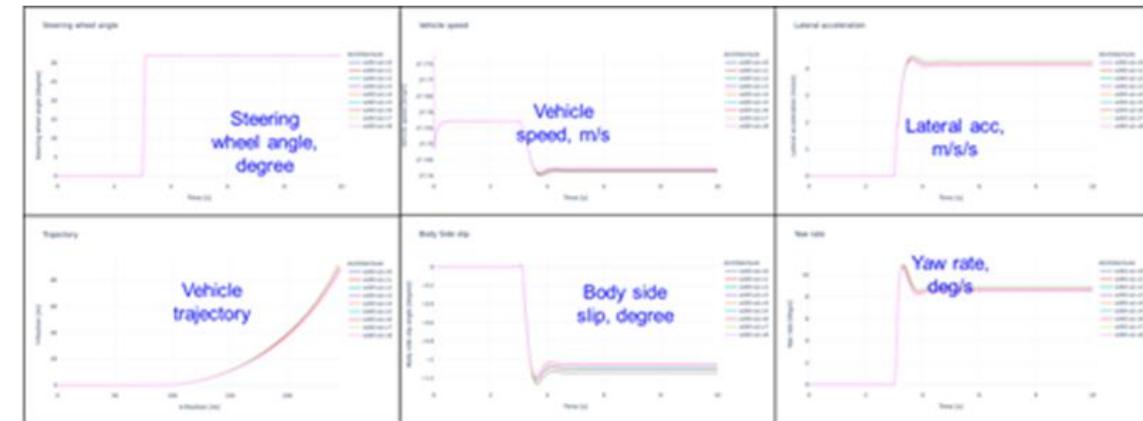
 New Edit Manage Share View



Verification Postprocessing



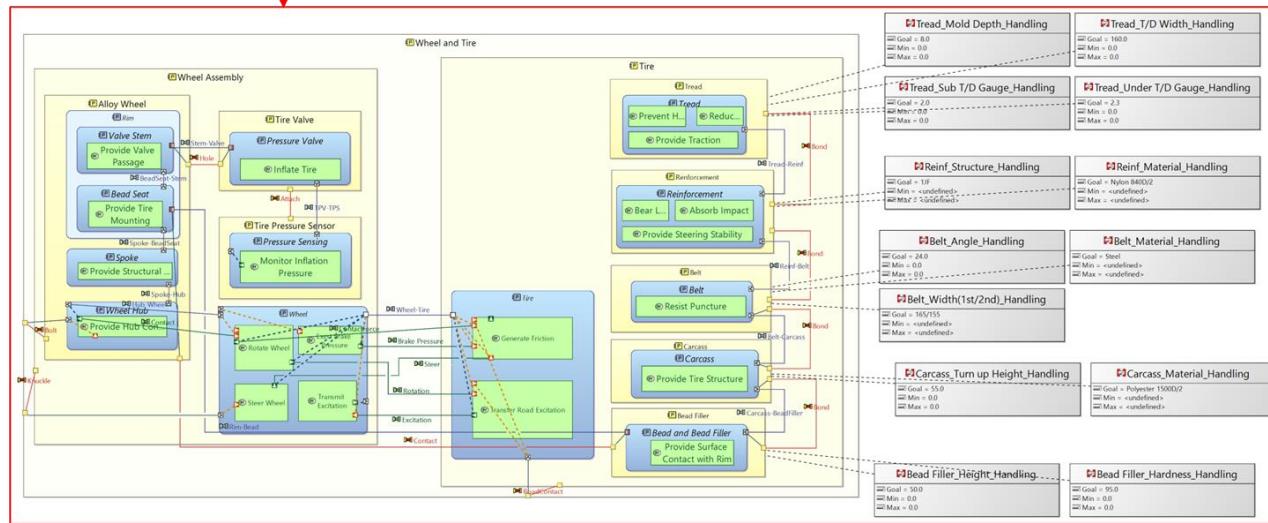
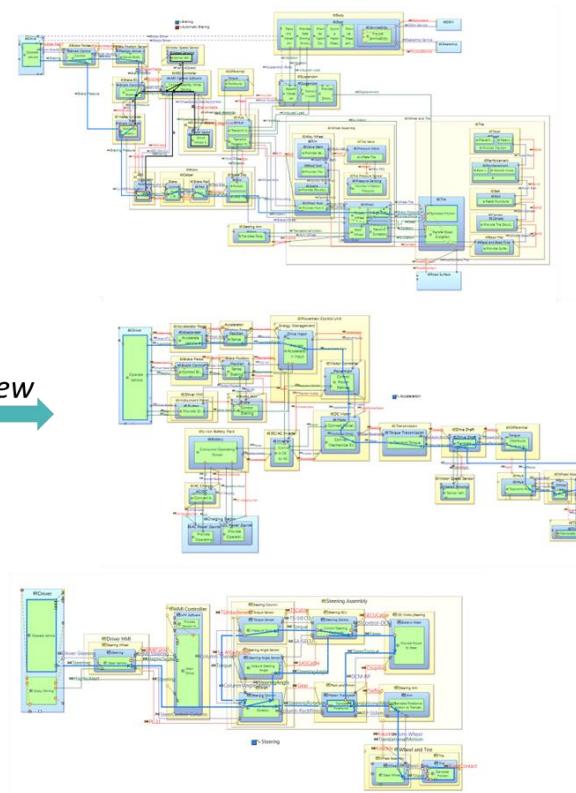
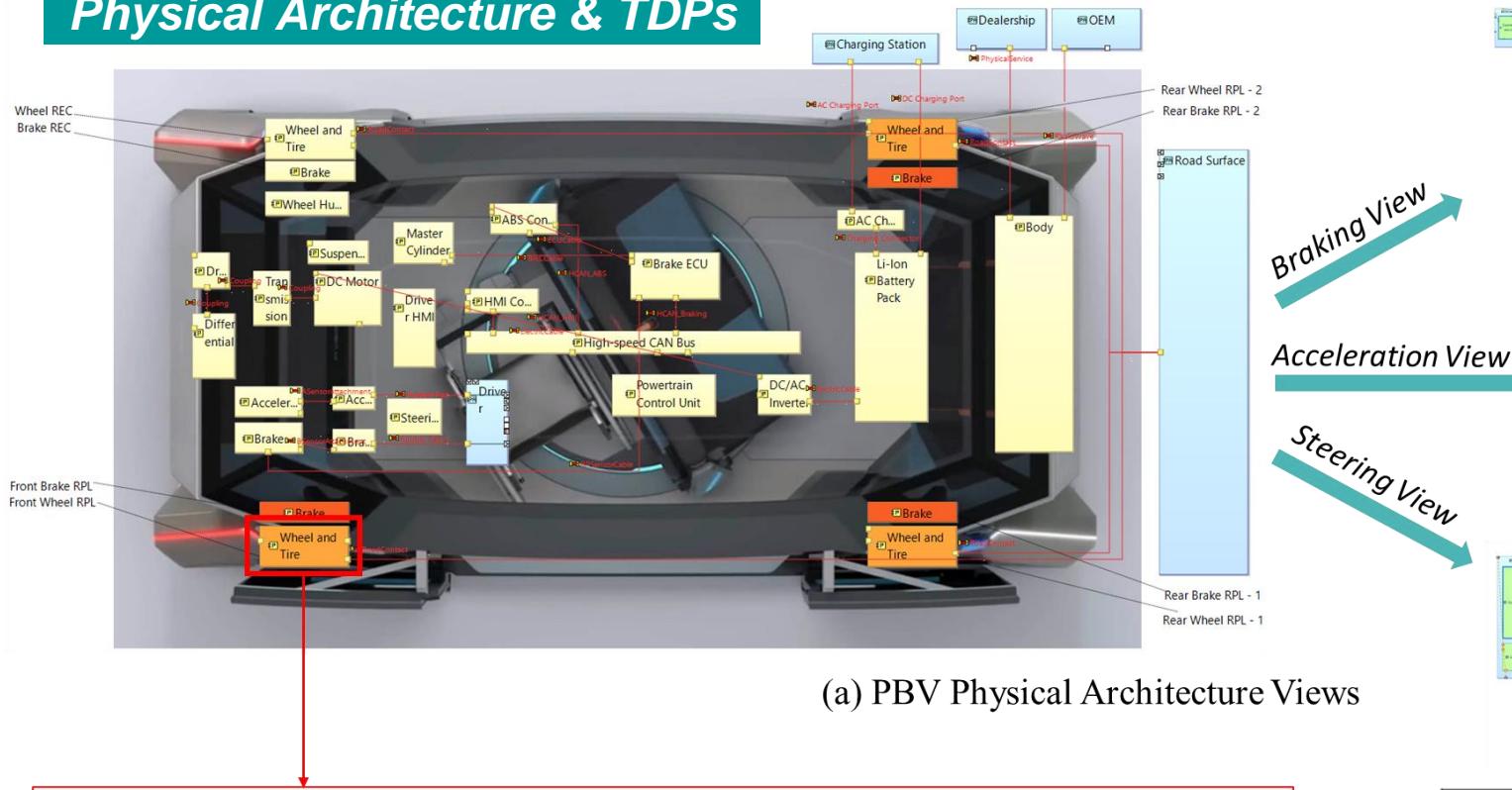
(a) Simulation Model



(a) Post-processing results

Architectur e	Yaw rate overshoot, %	Yaw rate response time, s	Lat acc overshoot, %	Lat acc response time, s	0.4g steering angle, deg	Yaw rate sensitivity, deg/sec/100deg	Roll gain, deg/g	Body Sideslip, deg	TB factor, deg*sec
1	25.44	0.08	4.62	0.19	32	27	0.08	1.05	0.28
2	24.05	0.08	4.51	0.19	32	27	0.07	1.09	0.32
3	23.26	0.08	4.41	0.19	32	28	0.07	1.14	0.34
4	23.23	0.08	4.41	0.19	32	28	0.07	1.14	0.34
5	25.44	0.08	4.62	0.19	32	27	0.08	1.05	0.28
6	24.17	0.08	4.51	0.19	32	27	0.07	1.09	0.32
7	24.19	0.08	4.52	0.19	32	27	0.07	1.1	0.31
8	23.15	0.08	4.41	0.2	32	28	0.07	1.15	0.34
9	25.59	0.08	4.62	0.19	32	26	0.08	1.05	0.28

Physical Architecture & TDPs



Part	Item (TDP)
Tread	T/D Width (mm)
	Mold Depth (mm)
	Under T/D Gauge (mm)
	Sub T/D Gauge (mm)
Reinf.	Material
	Structure
	Material
Belt	Width (1st/2nd) (mm)
	Angle (deg)
	Material
Carcass	Turn up Height (mm)
	Material
Bead Filler	Hardness (Hs)
	Height (mm)

(c) Tire Design Parameters

Home > HKMC Tire > 0. REQ (5 Objects)

Owner: kmk (kmk) Date Modified: 19-Aug-2022

Navigate Overview

Vehicle Requirements (SPEC-000010, Revision: A)

System Requirements (SPEC-000011, Revision: A)

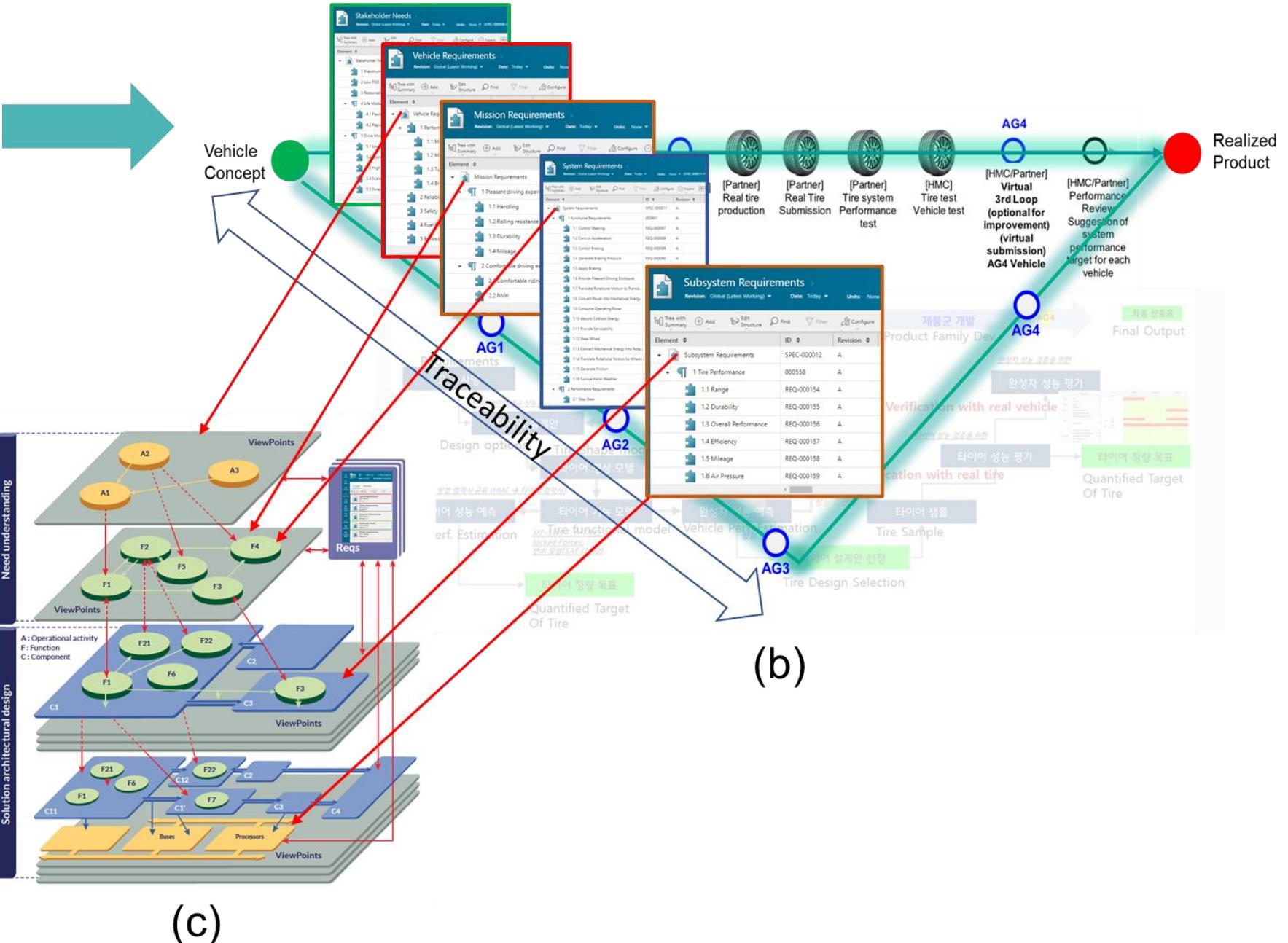
Subsystem Requirements (SPEC-000012, Revision: A)

Stakeholder Needs (SPEC-000009, Revision: A)

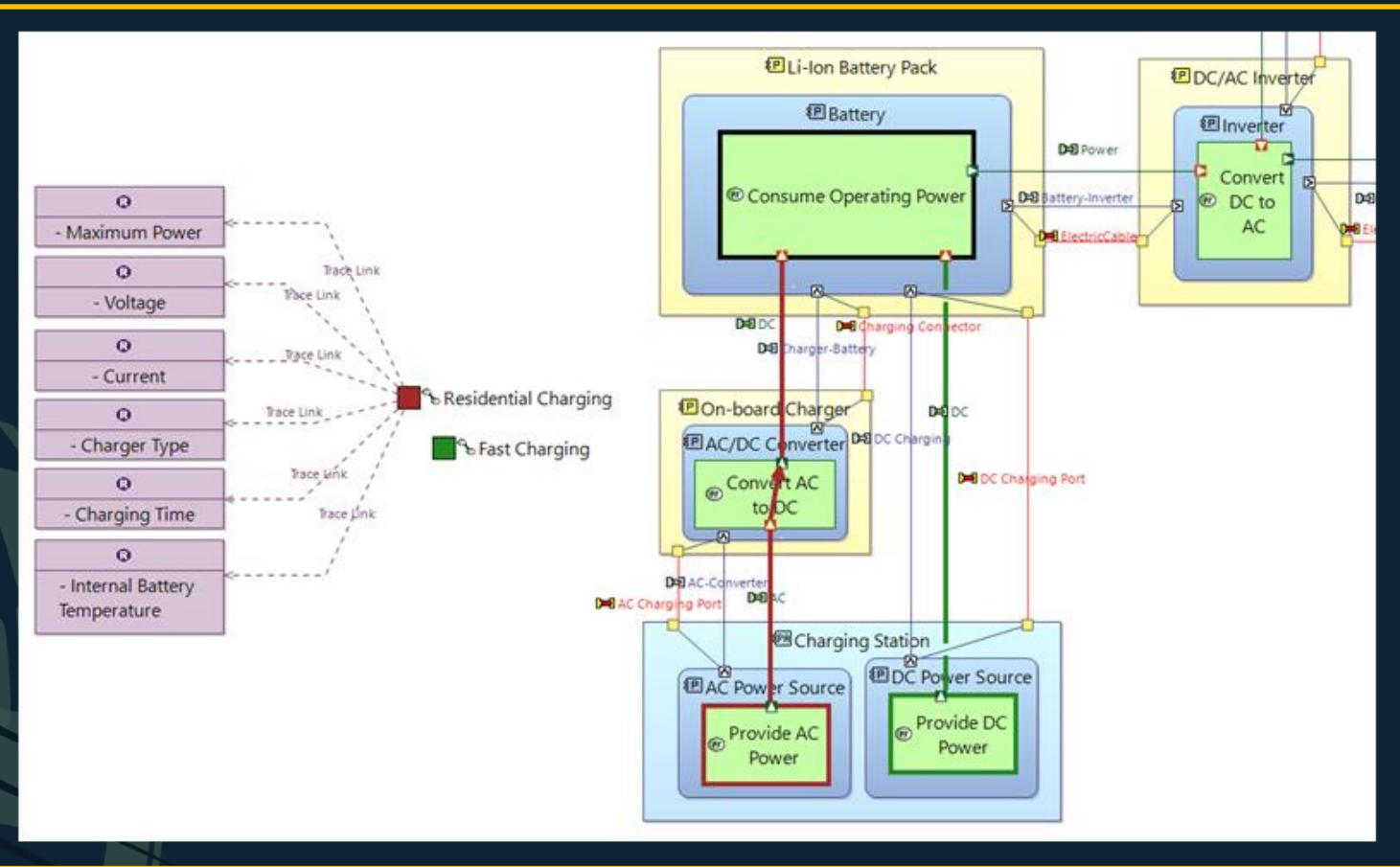
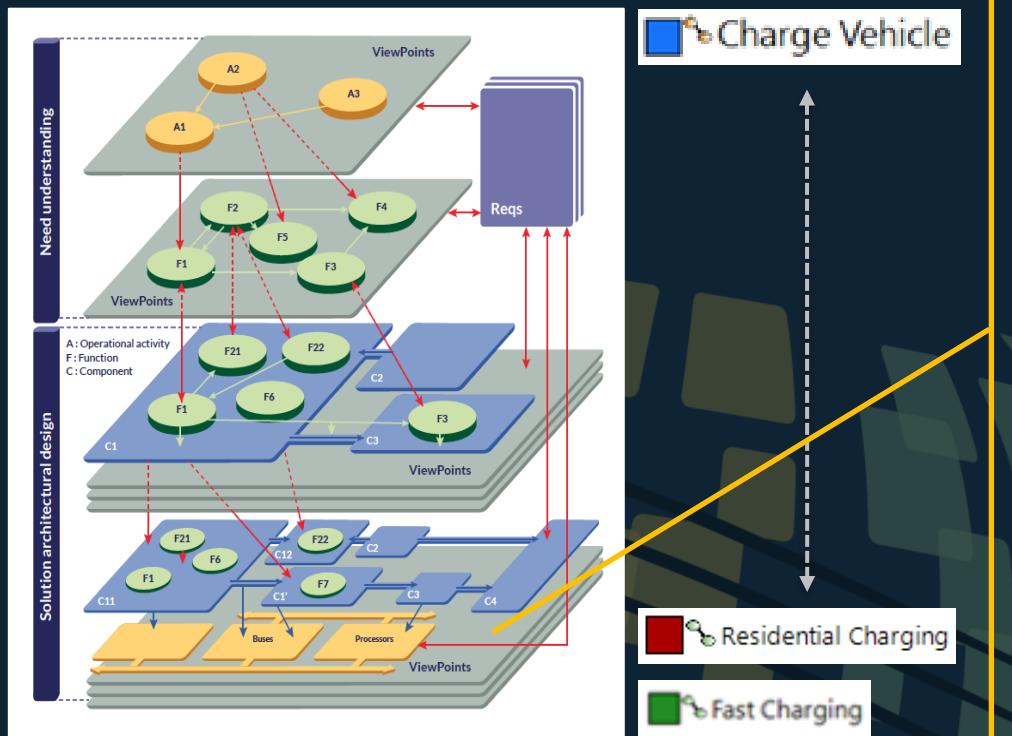
Mission Requirements (SPEC-000008, Revision: A)

Multi-layered requirement traceability

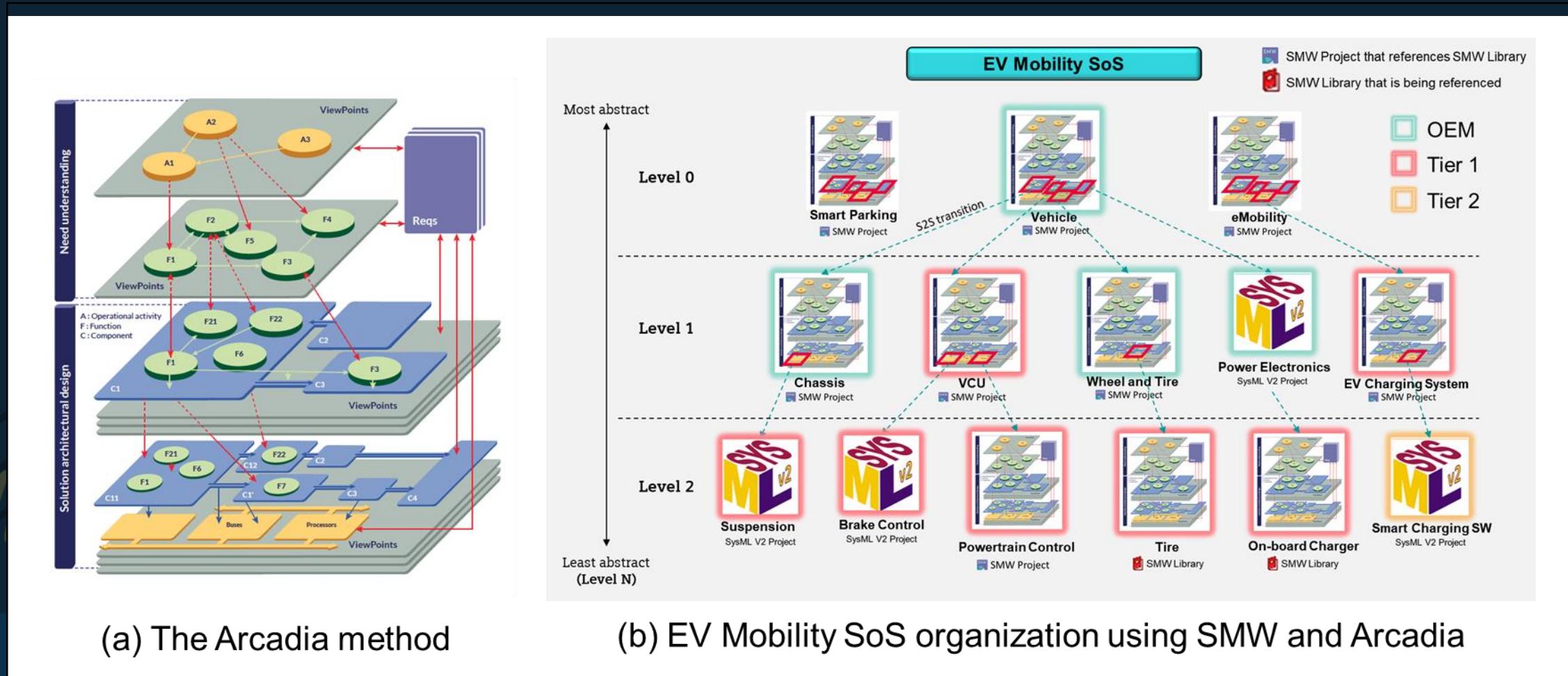
(a)



SoS Needs – Physical Architecture Traceability



SoS Modularization Concept





Lessons Learned

Conclusion & Observations

Conclusion

Reduced Time to Model

Parameter Traceability

SoS Knowledge Capture

Cross-enterprise Collaboration

Early Verification

Reusability

Benefits

Observations

- Huge potential for model-based approaches beyond Systems
- Increasing need for authoritative sources of truth, especially at early concept stages
- Architecture descriptions crucial for key decision makers across enterprise
- Heterogenous understanding of system architectures – a major challenge
- Need for a PLM backbone to MBSE more evident as more teams adopt MBSE across system development lifecycle

Acknowledgement

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Michael Baloh
Lokesh Gorantla
In Ho Shin
Hwi Seob Park

Additional Support/Review:

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Hugues Bertrand
Jason Wickers
Benedetta Iezzi
Fabien Retho

Want to know more?



2021.12.28 Hyundai Motor Group 5 min

The Essence of Future Mobility Lifestyle

<https://www.hyundaimotorgroup.com/story/CONT00000000000005028>

Google

hyundai smart mobility

what is hyundai's smart mobility solution?

ChatGPT

Thank you!



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