Virtual Development and Physical Testing Powering InfiMotion's 12-in-1 Electric Drive Unit

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Outline

PART ONE
Who are we?

PART TWO
Our Product Development Philosophy

PART THREE
12 in 1 EDU – Challenge, Solution & Enablers

PART FOUR
Summary

InfiMotion - already proven in Europe

Example of what we have achieved in Europe
– so far

- Supplier of sub-systems to **JLR**
- EDU system supplier for **Lotus Eletre**
- EDU system supplier for purpose-built **German OEM** with FCA Europe
- Software supplier to large **German OEM**
- EDU system supplier to **premium BEV OEM**
- Software supplier to **European premium brand**

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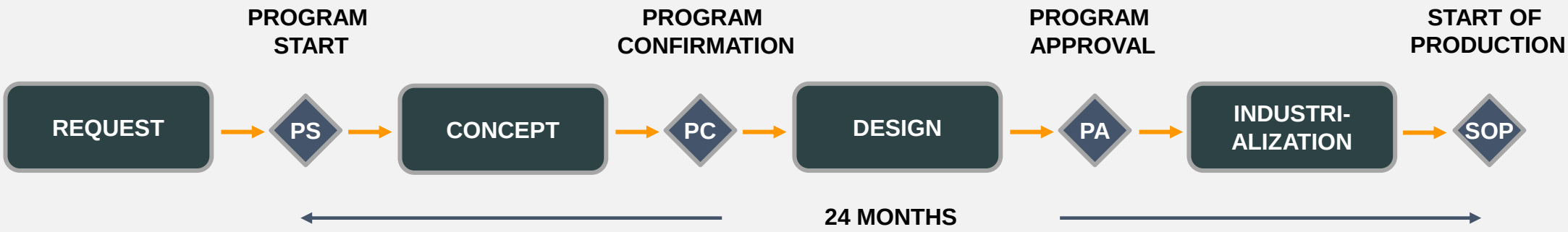
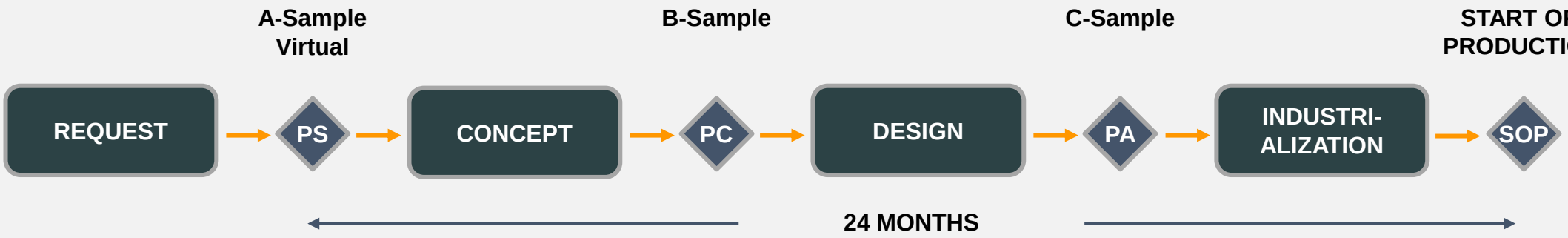
PS to SOP in 24 Months

- InfiMotion's target is PS to SOP in 24 months
- Simulation Centric Design is key → Frontloading
- Frontloading of: Requirements Evaluation, Verification and Validation

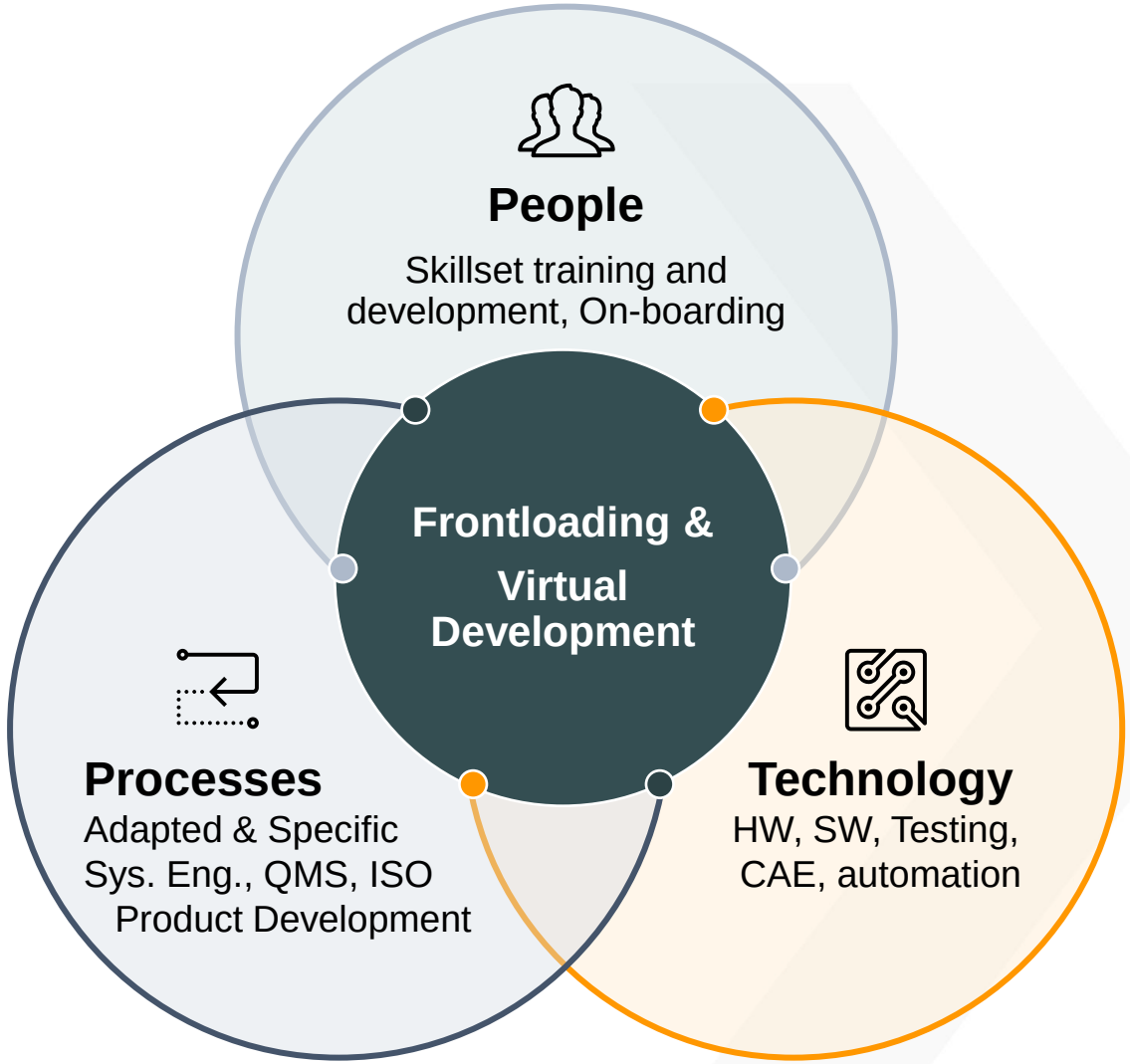


Challenges in 24 Months to SOP

- **High quality virtual A-sample**
  Strong CAE methodologies, design commonality and model correlation
- **Reduced, targeted, “sufficient” testing**
  Customer centric DVP, in-house testing, test to failure, in-house prototyping
- **Requirements handling process**
  System Engineering, integration of PLM, ALM and requirements handling

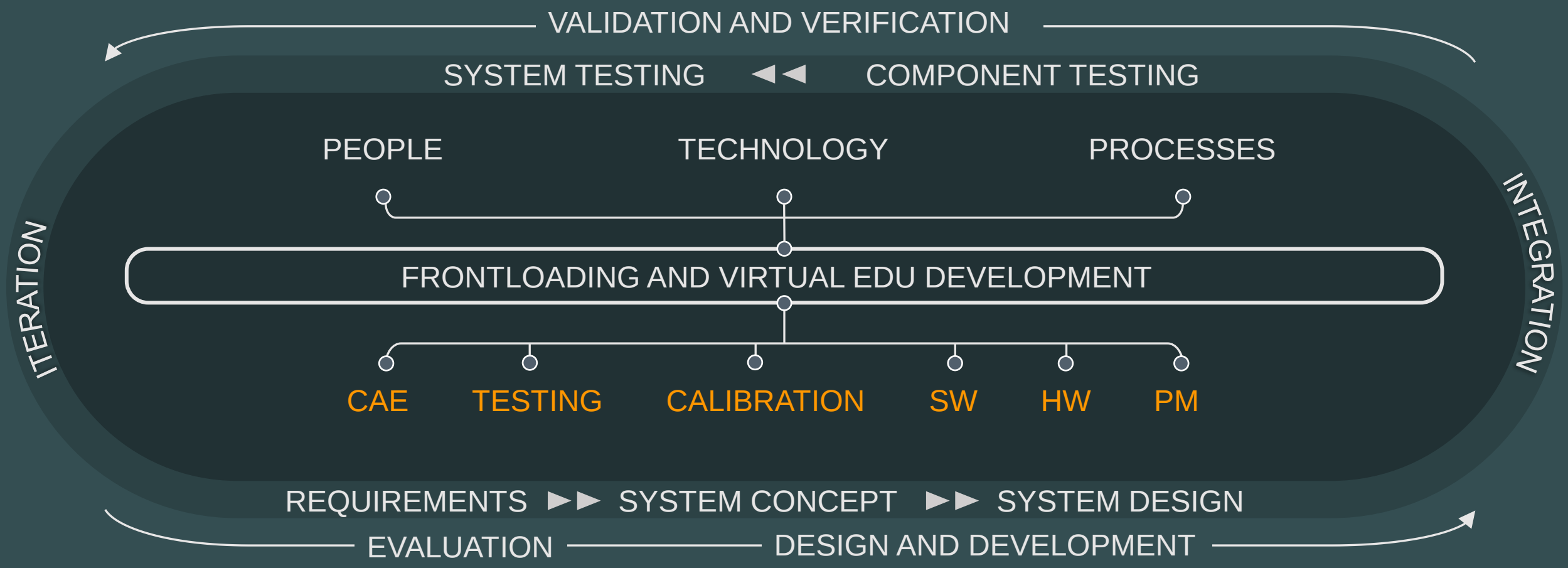


3 Enablers for Frontloading and Virtual EDU Development



Optimizing the relationship increases efficiency and accelerates product development

Virtual EDU Development – Validation & Testing



Eliminating silos between different areas increases productivity

InfiMotion Validation Approach By Virtual and Physical Testing

Test to **correlate**

Correlate to **extrapolate**

Extrapolate to **design**

» High Testing and Virtual capabilities needed

Testing and verification capabilities

- The first use case of a **30 000 RPM motor test bench in the world**
- Test bench parameters **covering testing requirements of electric drive systems** of passenger cars, light duty, and performance vehicles, covering up to 550kW motor testing
- Compatible with **several voltage platforms** (400V/800V/1000V)
- **Full environmental test capabilities** (altitude, humidity, thermal, vibrations, dust)
- Load **EMC test capabilities**, compatible with EDU, motors, battery packs, static and dynamic EMC test requirements

2 Powertrain tests

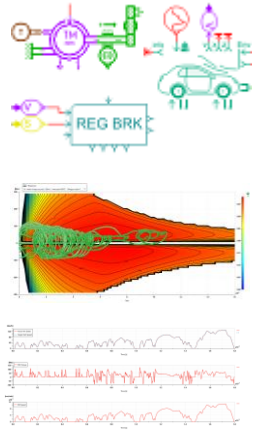
10 Environment tests

3 Motor tests

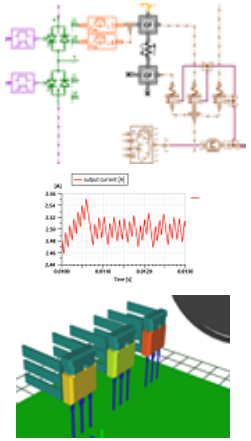
EMC test with load

Virtual methods

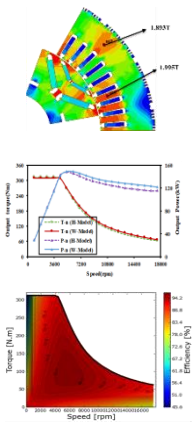
1 SYSTEM



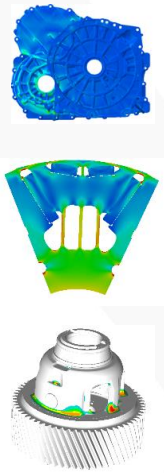
2 ELECTRICAL



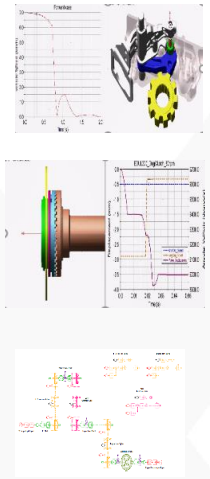
3 ELECTROMAGNETICS



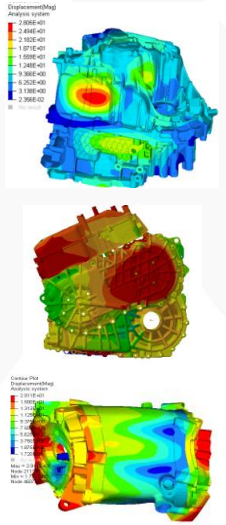
4 STRUCTURE



5 DYNAMICS

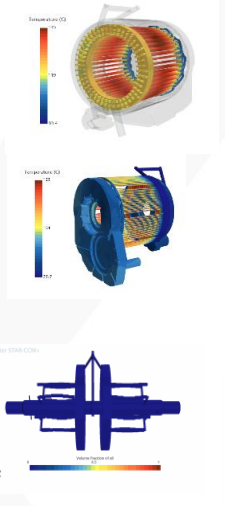


6 NVH

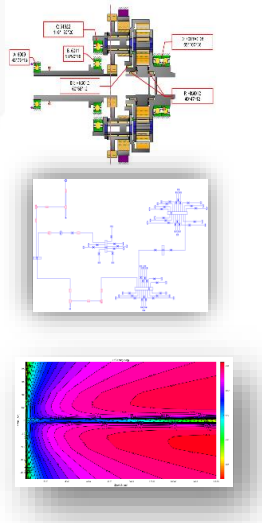


7 FLUIDS

8 THERMAL



9 EFFICIENCY



- 0D/1D/3D Full virtual development capabilities
- Model factory w. continuous improvement
- In-house computational resources
- MIL/SIL/HIL Virtual testing capabilities

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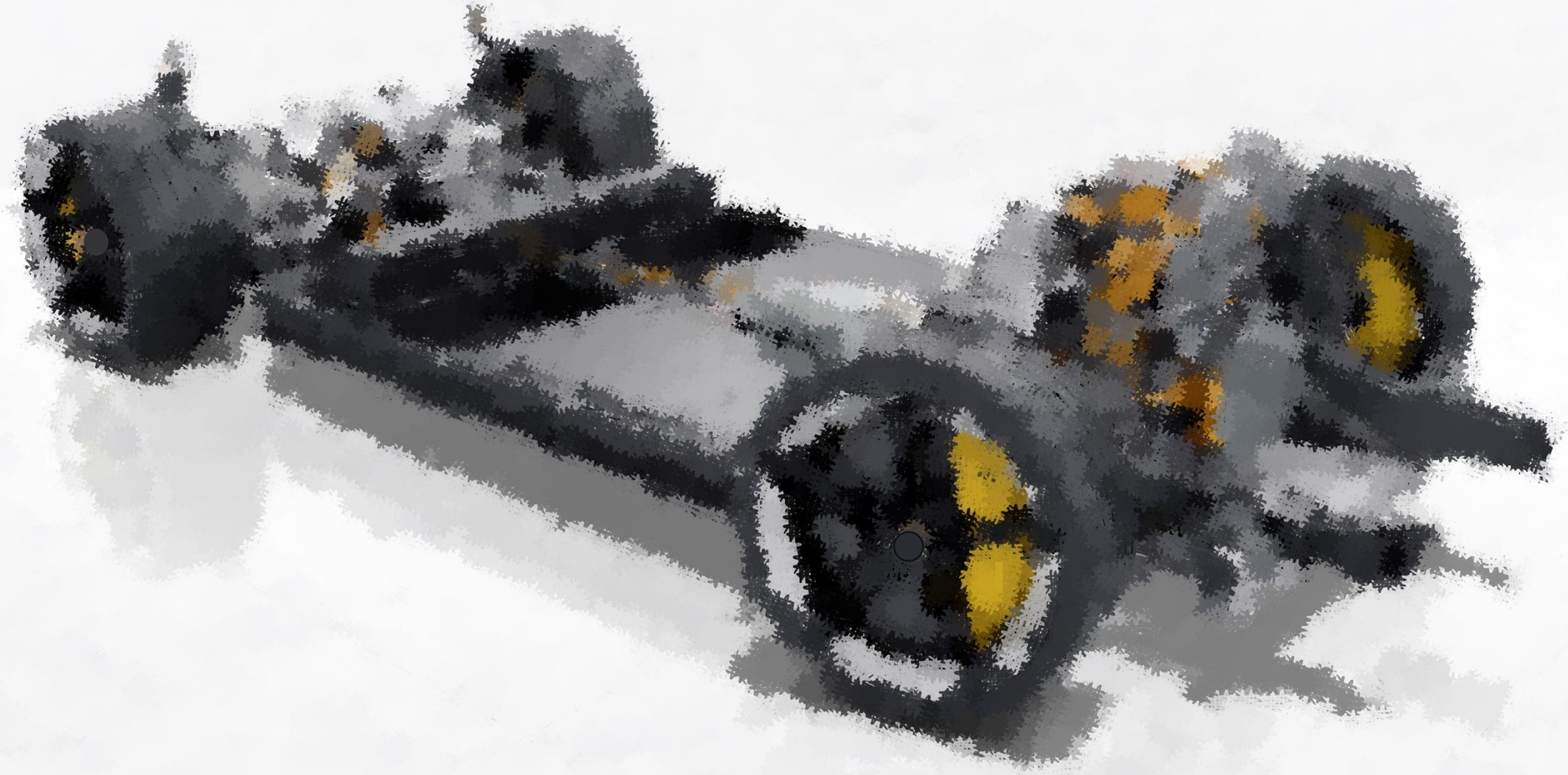
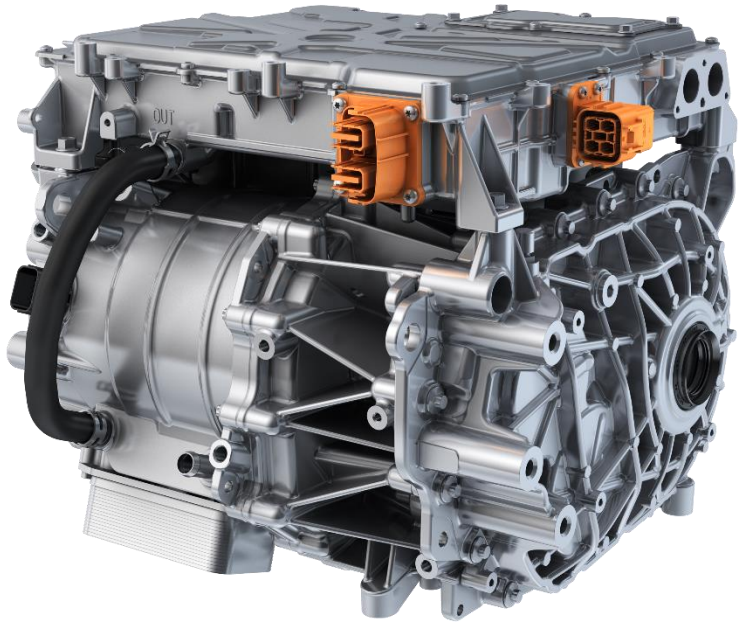
Challenge – Vehicle Integration

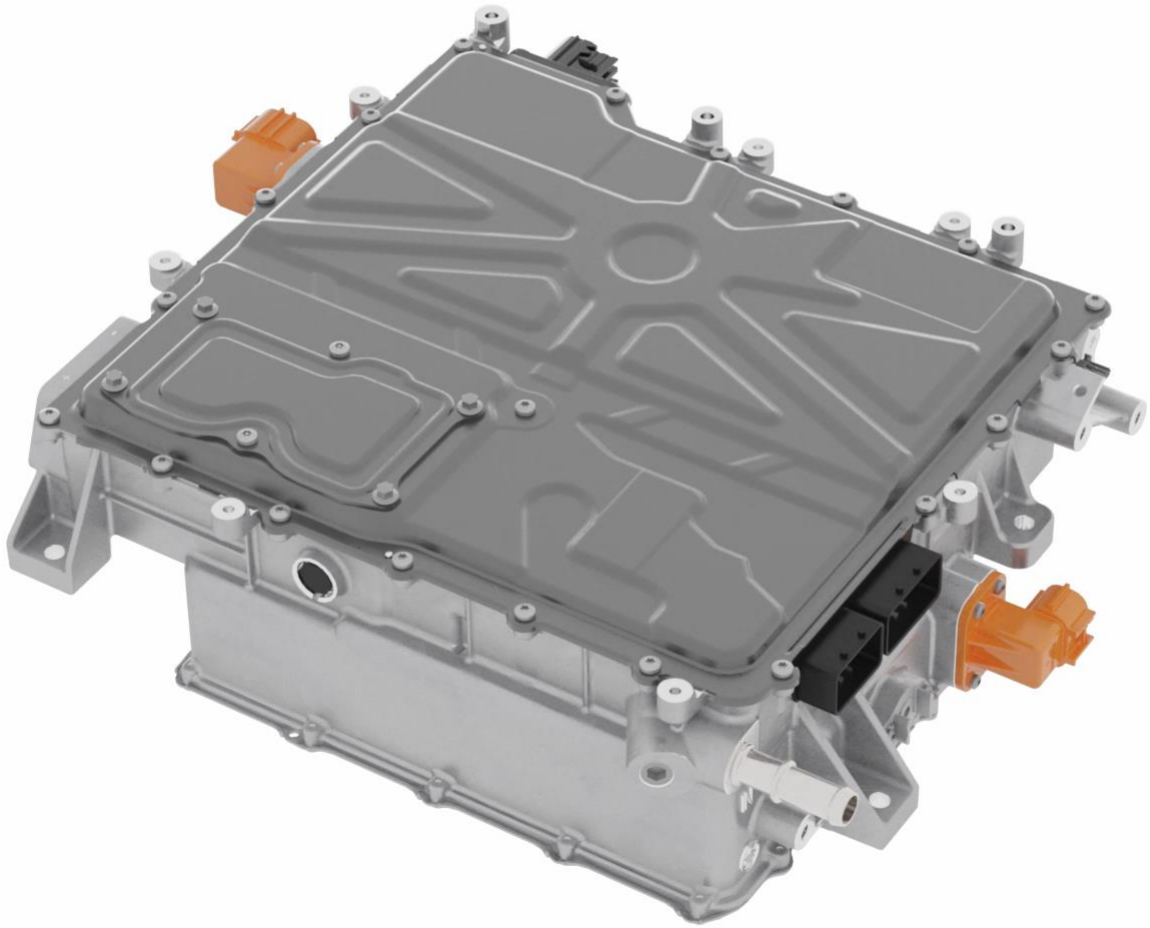


Solution – Integration into EDU

- Integration of **hardware** functions into the EDU, like PDU, OBC and DCDC leads to reduction of housings, cables, and connectors, as well as simplifying the thermal management system
- Integration of **software** functions into the MCU leads to more efficient use of the controllers
- Compared to previous setup there are **significant benefits**:
  - total space savings of about 5 liters, saving 8%
  - total weight reduction about 3kg, saving 13%,
  - total cost reduction about 20%



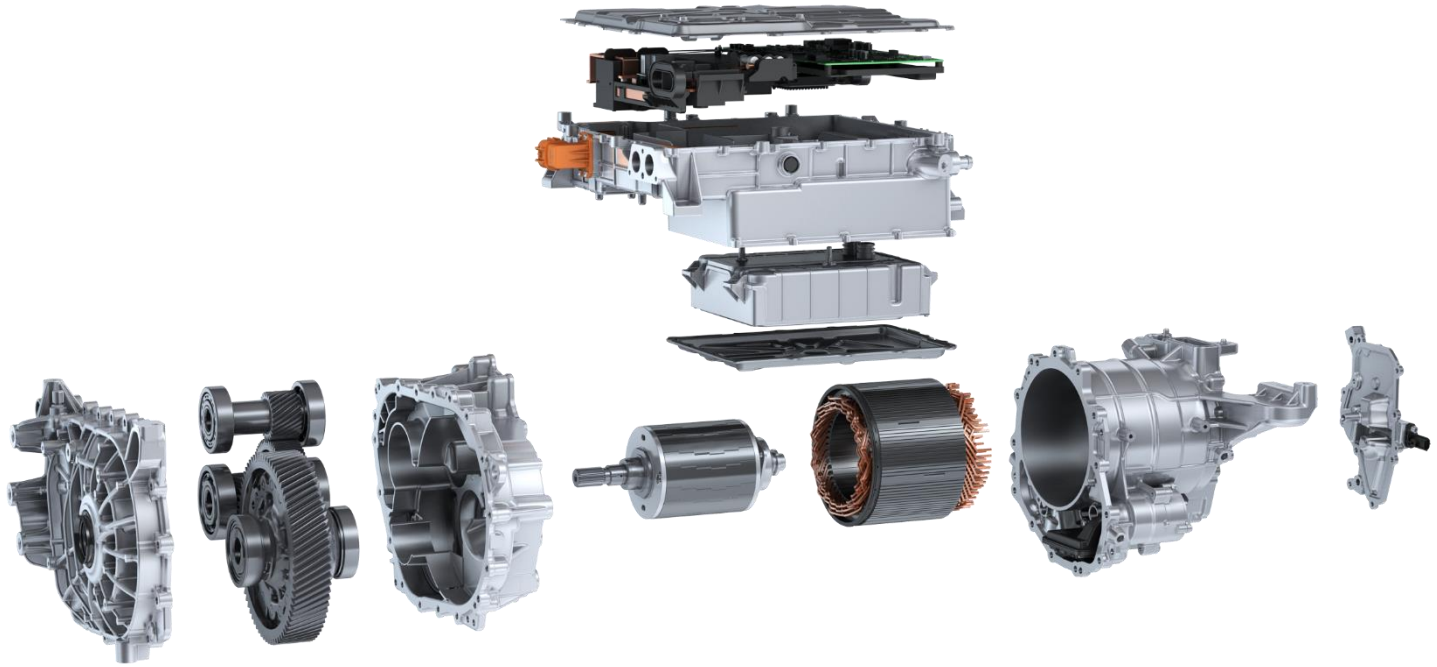
Solution – Integration into EDU



Example L402 - Integration into EDU

L402 (12-in-1) function list

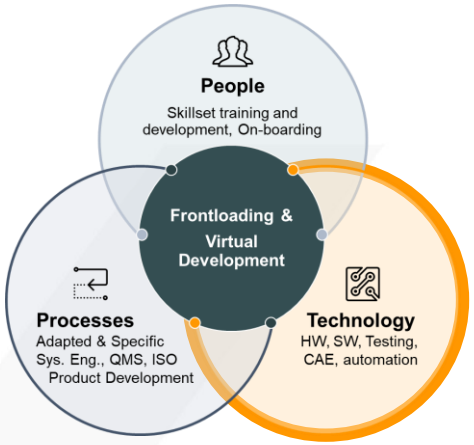
- E-machine — PMSM, 160 kW
- Reducer — Layshaft, Single gear, 2-step
- MCU — Motor Control Unit, IGBT 400V
- OBC — On board 3-phase AC-charger, 11kW
Bi-directional V2G/V2L-ready
- DC/DC — 12V output, 2.5 kW
- PDU — Power Distribution Unit
- BMS LV — Battery Management System - low voltage
- BMS HV — Battery Management System - high voltage
- VCU — Vehicle Control Unit
- TMS — Thermal Management System
- GWRC — Vehicle Stability Control System
- EVCC — EV Communication Controller (HVDC Charging)



We just started production of L402 in China for a Chinese OEM

Enablers – Xin1 integration

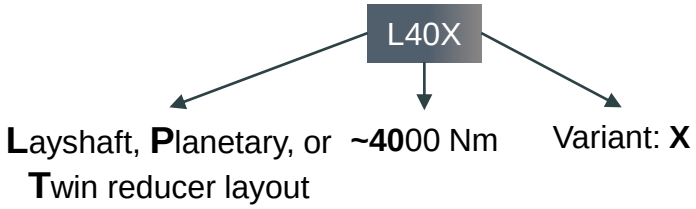
Technology enablers for X in 1 Integration:

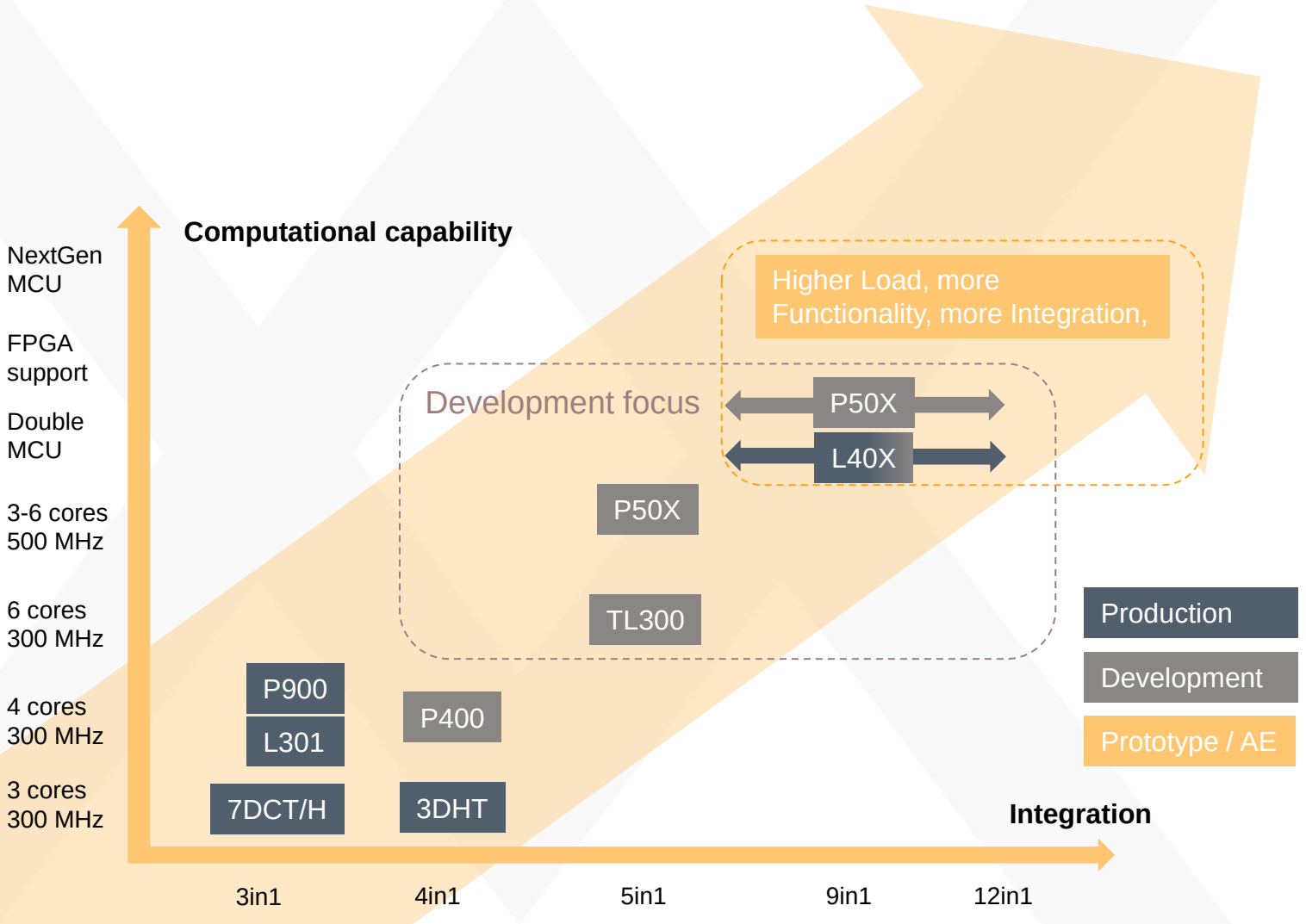


- Instead of multi-ECU vehicle system, **integrate applications into the MCU** and delete redundant ECUs
- **Inhouse** development of **hardware** and **software**
  - Enabler to **integrate black box** hardware and software
- The size of **core application** to control the EDU normally range **< 25% of the MCU capacity**
  - **Application load and timing** are important variables to consider when integrating Xin1
- Continuous Integration **Software Factory** enabling fast integration of software components, white or black box

Technology enabler – Computational Capability

- Application load and timing need to be considered when integrating Xin1 to choose the right controller setup
- CPU architecture and advancements enabler for integration
- Project-specific adaptations multi-role vs. dedicated designs (see L40X and P50X)





Technology Enabler - Software Integration

Software

Software modularity and re-useability

- E-machine control with various modulation types and control principles
- Adapting single and dual e-machine(s), Park-lock, Disconnect, Oil pump and Wet or Dog-clutch based transmissions

Toolchain

Complete toolchain

- In-house ASW & BSW development and integration
- Software factory with integrated SIL and HIL SW Build and verification (Cloud based)
- Validation and Calibration

Development compliance

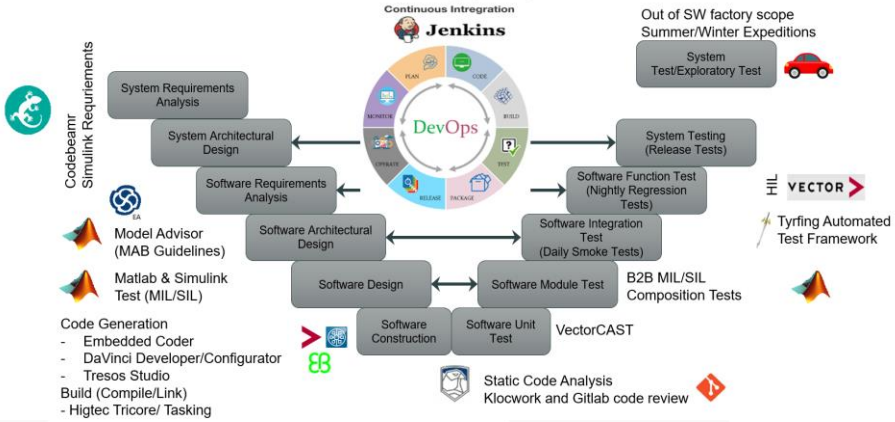
Fully compliant

- AUTOSAR,
- OBD OEM diagnostic,
- ISO26262 safety process,
- ASPICE L3 and
- Cyber security

Capabilities

- ASW & BSW development
- Application integration
- MIL , SIL, HIL and bench test
- Calibration verification
- CI of cloud-based software factories

The V-model as seen from a tooling perspective



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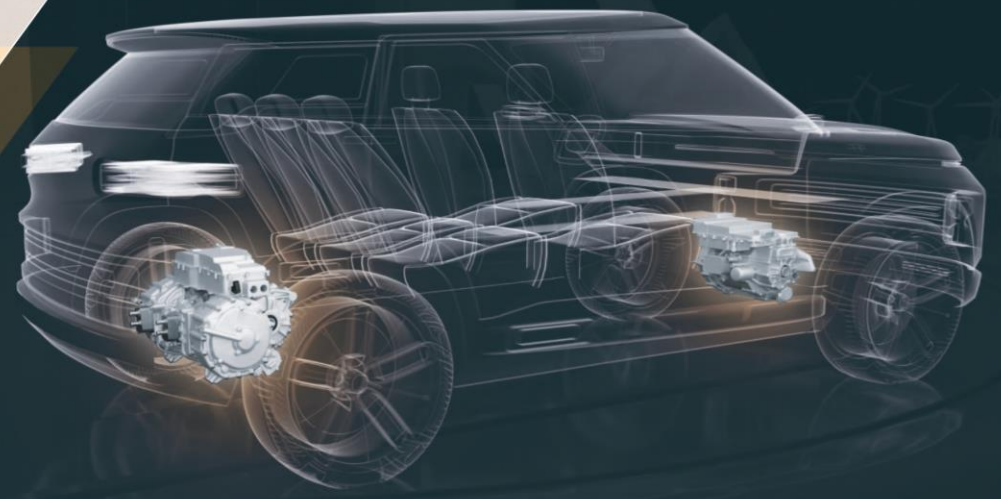
- **InfiMotion’s Product Development Philosophy**
  - PS to SOP in 24 months
  - Leveraging Virtual Development is key to front-loading and shortening lead times
  - Test to Correlate is a vital step

- **3 Enablers for Frontloading and Virtual EDU Development**
  - People
  - Technology
  - Processes

- **InfiMotion’s 12 in 1 EDU** → Solution to Challenging Electric Vehicle Systems Integration Issue
  - Total space savings of about 5 liters, saving 8%
  - Total weight reduction about 3kg, saving 13%,
  - Total cost reduction about 20%



Vielen Dank!

Thank you for your Attention

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