

Systems Engineering for eMobility Commercial Vehicles

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- **Introduction & Motivation**
- **eDrives & Fuel Cell Integration**
- **Systems Engineering**
- **Conclusions**



- **Introduction & Motivation**
- eDrives & Fuel Cell Integration
- Systems Engineering
- Conclusions



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Development Engineer eMobility & Systems Engineering Commercial Vehicle Powertrain
- 11/2016 - 03/2017 AWTC Europe, Wolfsburg, German
Calibration Engineer for automatic transmission
- 10/2010 - 08/2016 *Studies in Mechanical- (B.Sc.) and Automotive-Engineering (M.Sc.) at Technical University Braunschweig*



More than 25 sites worldwide



More than 35 years of experience



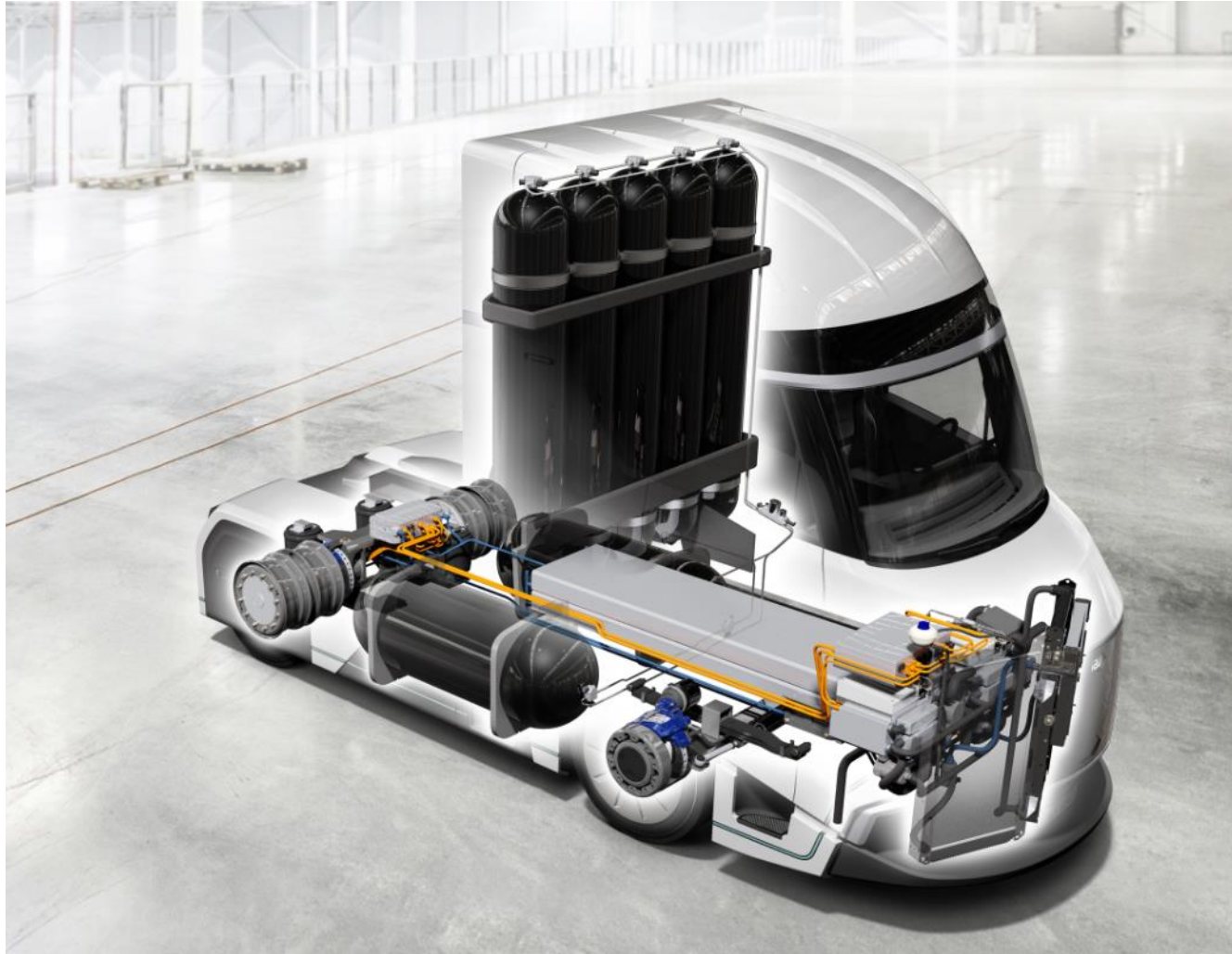
More than 8,200 members of staff



More than 65 % engineers



More than 1000 annual turnover (€ m)



„Future trucks will look different!“

- CO₂ limits & reduction of greenhouse gas emissions are a global topic
- ZEVs need to kick-in quickly
- Use cases, regional diversity and complete vehicle fleets have to be considered
- TCO will define market entrance
- New players will speed-up development pace and enable new business models
- Suppliers with all kind of components are storming the market

→ How does this effect business?

→ What are measures to cope with these requirements?



Modular eMobility Platform

- IAV has launched an in-house project for an electrified bus application
- BEV modular platform, usable for customized eMobility solutions
- Commissioning of the pre-series vehicles has started already

Systems Engineering: Covering the whole V

- Overall vehicle development requires Systems Engineering methods due to high complexity and interdisciplinary (HW, SW, E/E, FuSa..)
- Use of Systems Engineering methods (according ISO/IEC 15288)
- Certified Systems Engineers Level B Trainings
- Process development and implementation based on eMobility experience and customer series development projects



- IAV in the role of a system integrator
- Introduction of a holistic development process necessary



- Introduction & Motivation
- **eDrives & Fuel Cell Integration**
- Systems Engineering
- Conclusions and Outlook

eDrives & Fuel Cell Integration Challenges

Function Integrated ICE



Provide torque

Drive power steering

Drive air compressor

Drive AC compressor

Heat cabin

Charge battery

Drive cooling fan



Modular Fuel Cell Electric Powertrain



Electric Drive Motor



Provide torque



Fuel Cell and HV-Battery



Generate and store electric energy



HV power steering pump



Drive power steering



HV air compressor



Drive air compressor



HV AC compressor



Drive AC compressor



HV Heater



Heat cabin



DC/DC



Charge battery



E-Fan



Drive cooling fan

Legend:

System / Sub-System

Functionality



Control Unit

From system integrator point of view:

→ Functionalities ≈ const, interfaces ↑↑, communication complexity ↑↑↑

→ NRMM: OEM is often ≠ powertrain developer, powertrain normally purchased

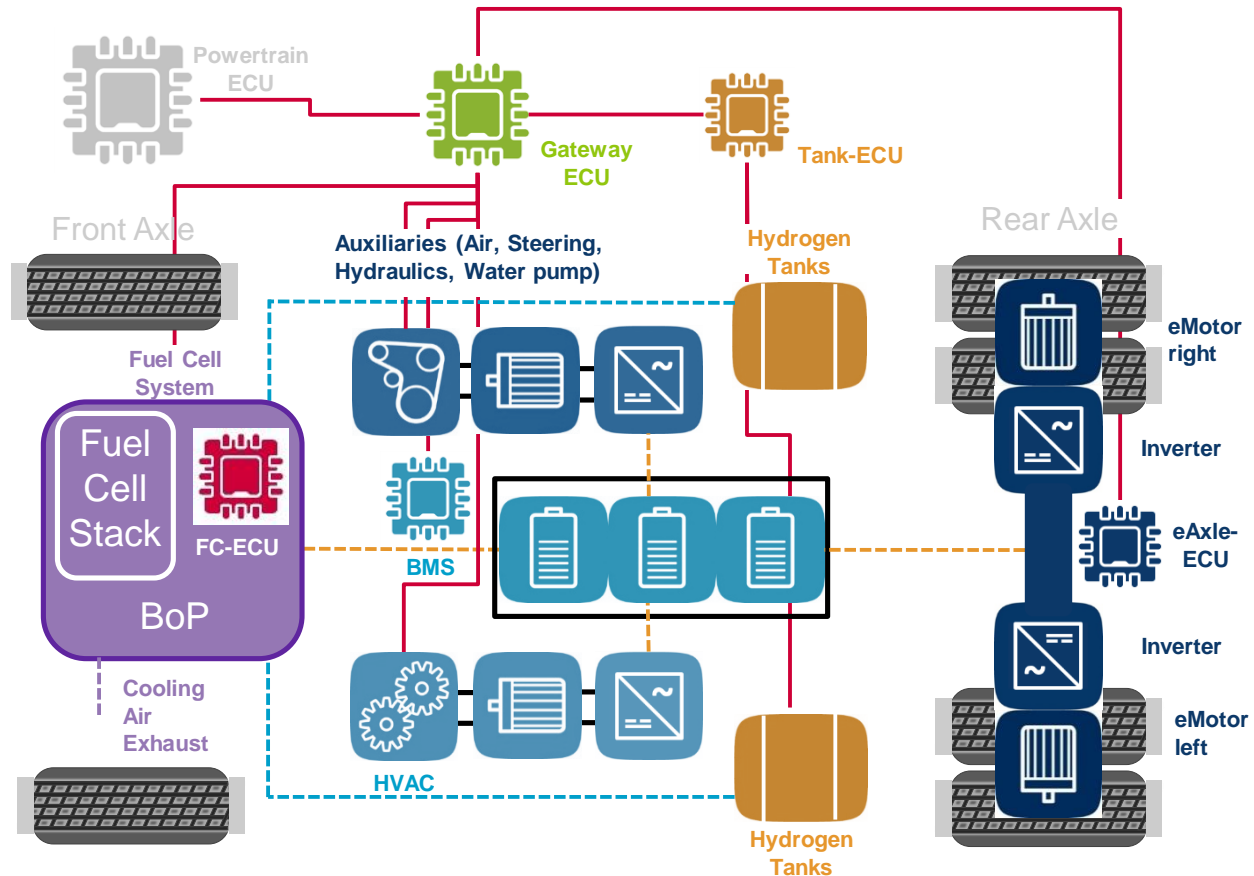
eDrives & Fuel Cell Integration Example



Connections

- Mechanic/hydraulic
- Comm. /AD-Signal
- - - - - HV
- · - · - Hydrogen

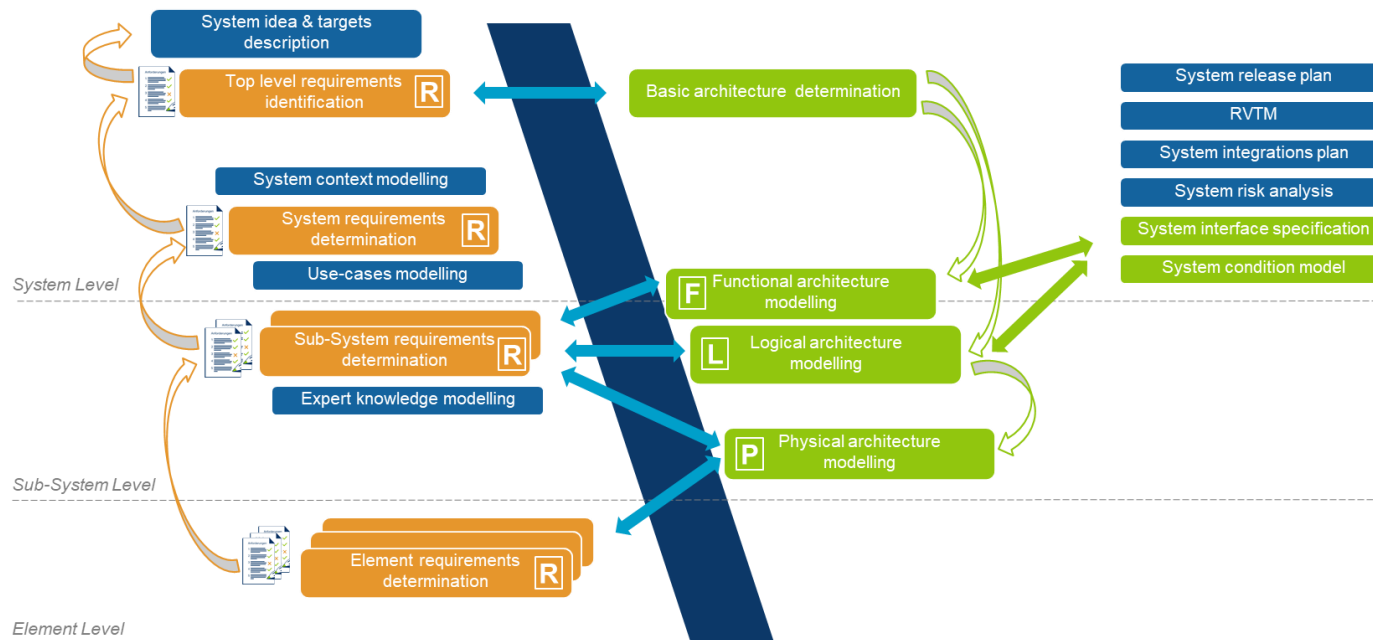
- OEM
- Supplier 1
- Supplier 2
- Supplier 3
- Supplier 4
- Supplier 5
- Supplier 6
- Supplier 7



- Many different component suppliers meet different standards and maturity levels
- Legal requirements e.g. in functional safety and cyber security ↑↑↑
- Appropriate processes, methods and tools are essential for a successful system integration!



- Introduction & Motivation
- eDrives & Fuel Cell Integration
- **Systems Engineering**
- Conclusions

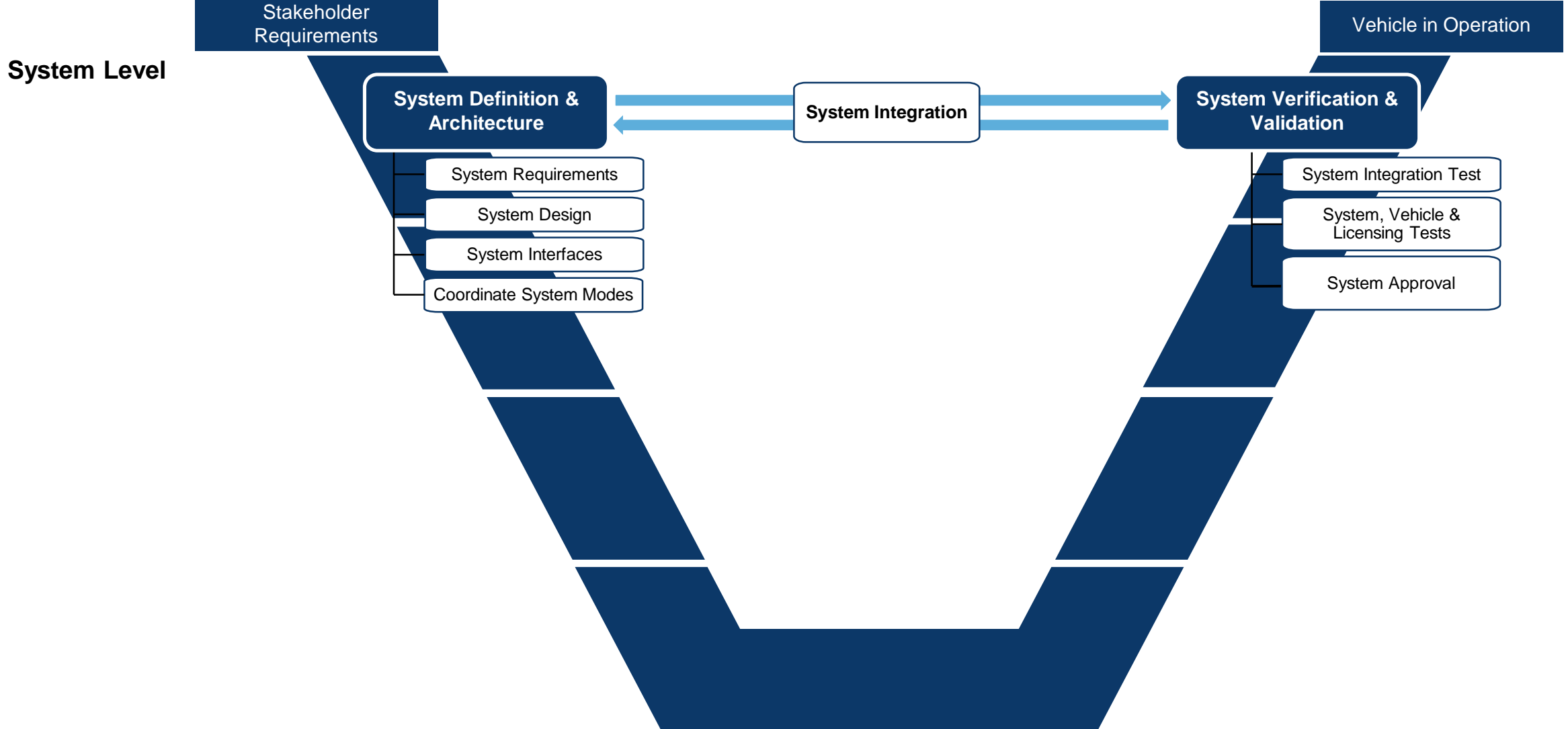


How engineering gets “Seamless”

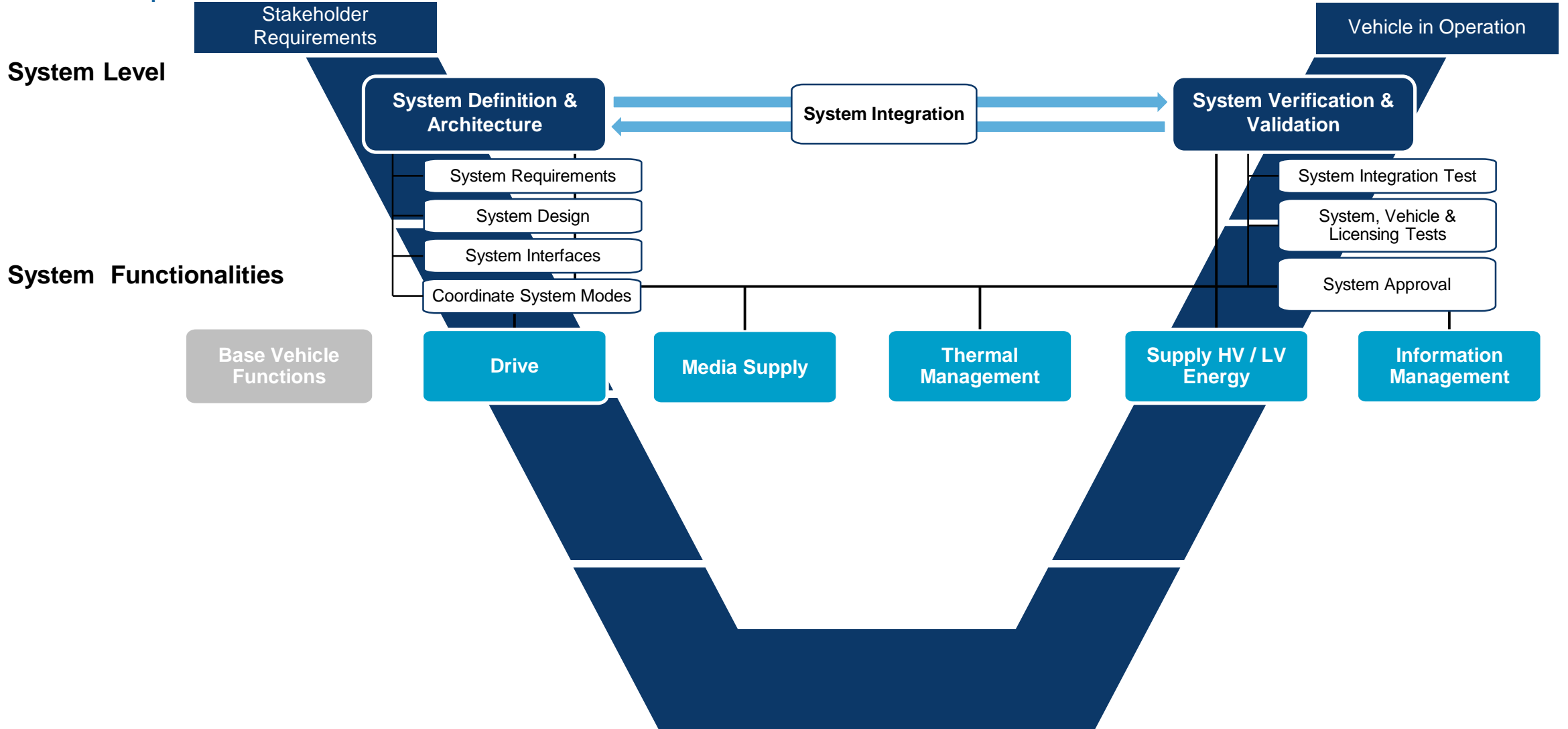
- Iterative and recursive approach
- From **R** to **F** to **L&P**
 - Requirements
 - Functional architecture
 - Logical architecture
 - Physical architecture
- Continuous traceability of requirements, artefacts and decisions
- High frontloading focus for minimizing project risks
- Using architecture views to communicate with all disciplines and domains
- Common collaboration platform (Atlassian tools)

→ Systems Engineering for ensuring hand-in-hand (“Seamless”) collaboration in complex eMobility projects

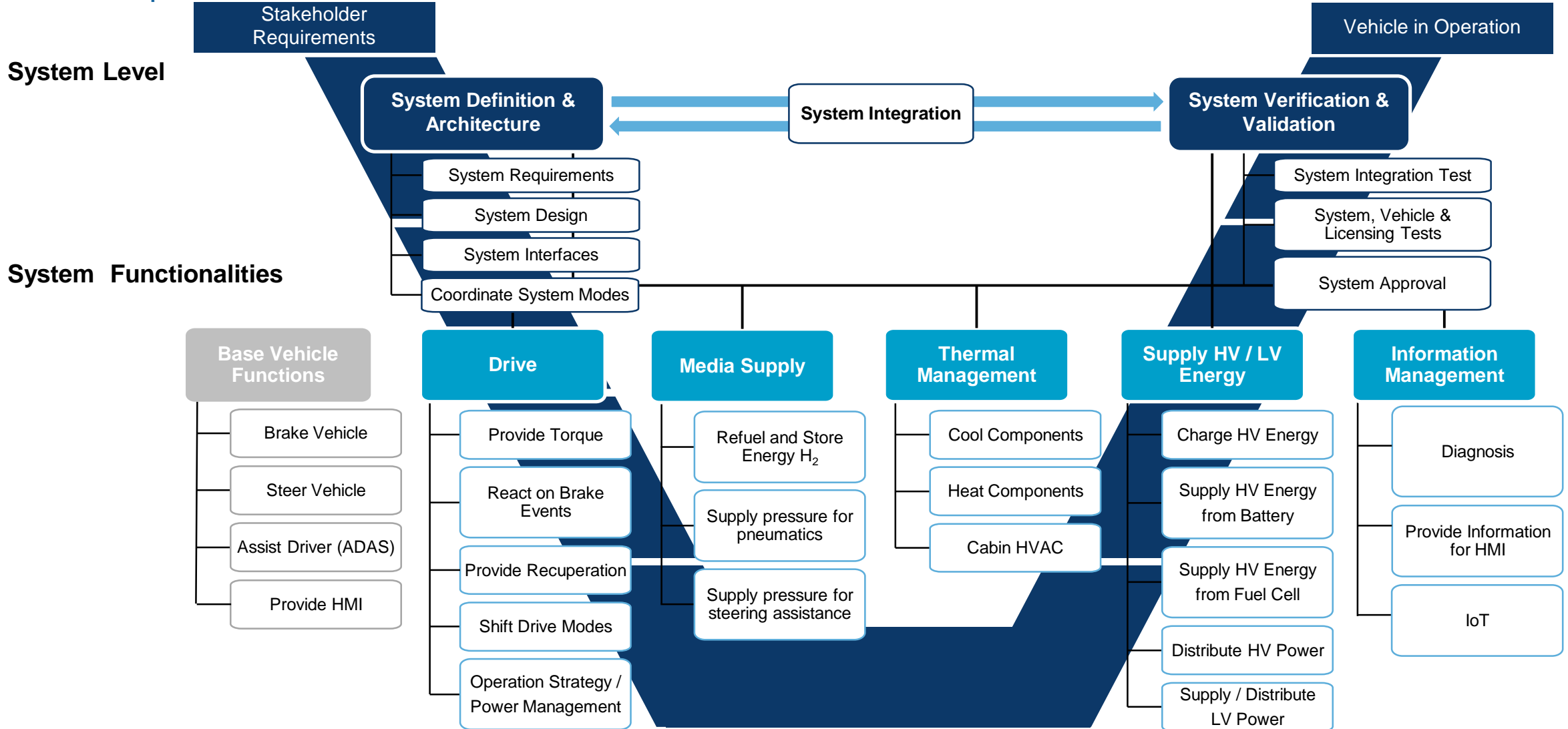
Systems Engineering Example



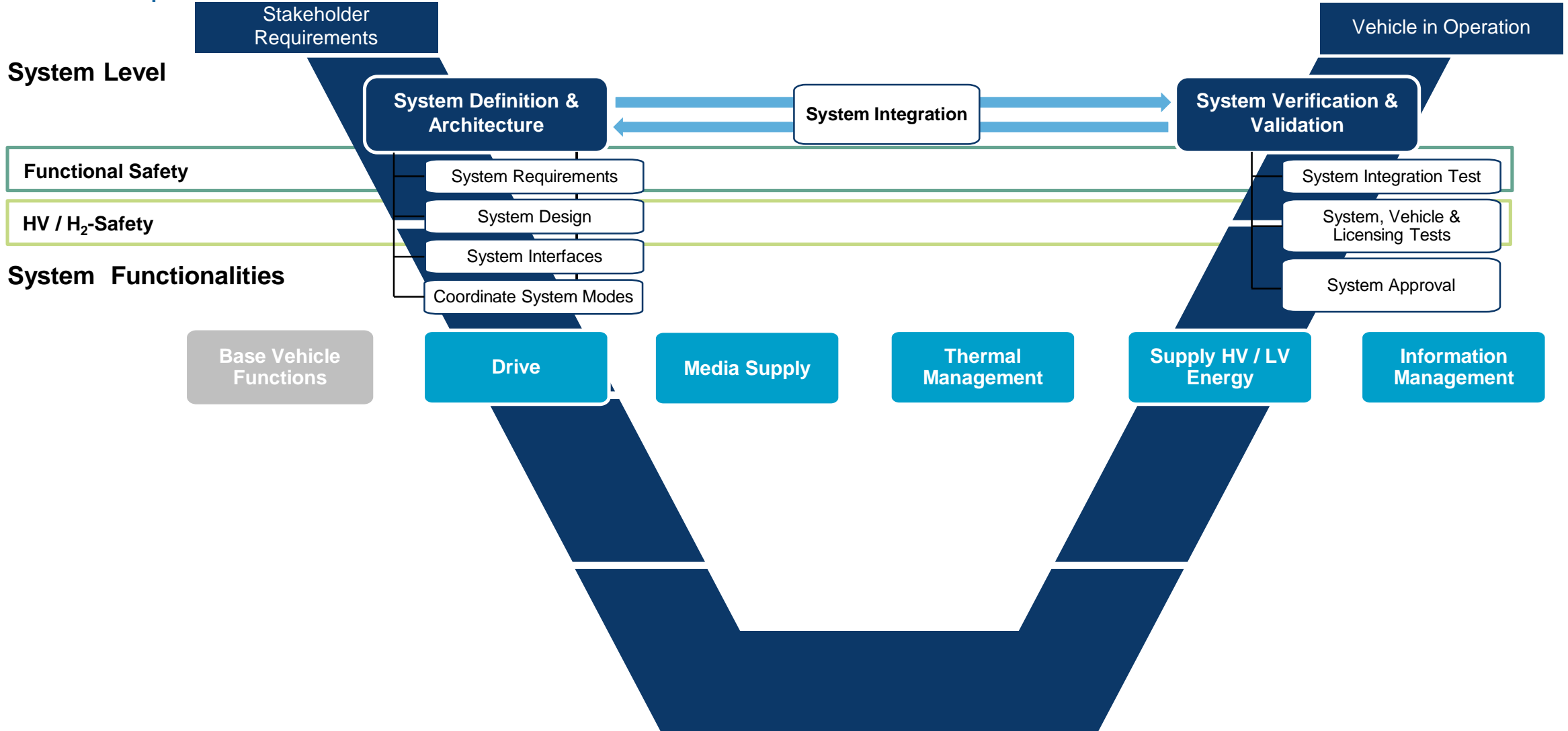
Systems Engineering Example



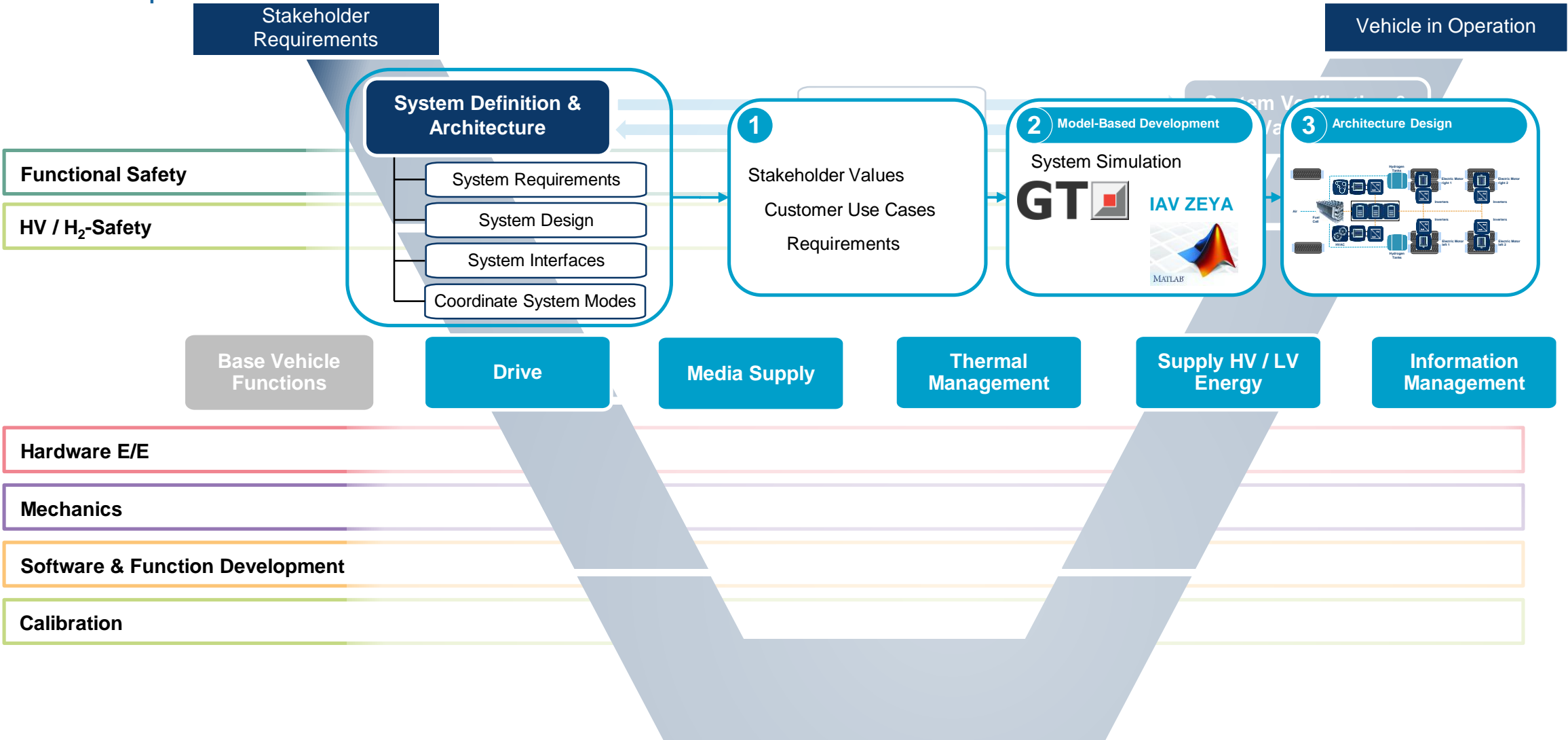
Systems Engineering Example



Systems Engineering Example



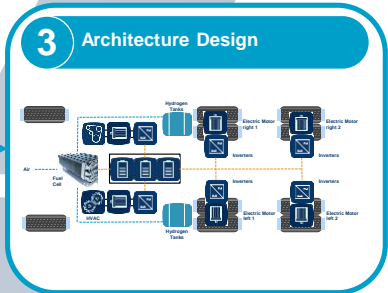
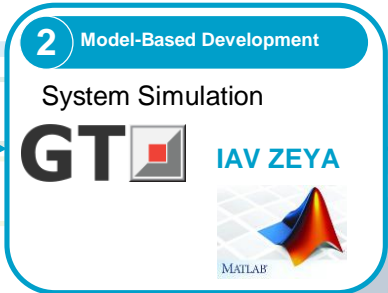
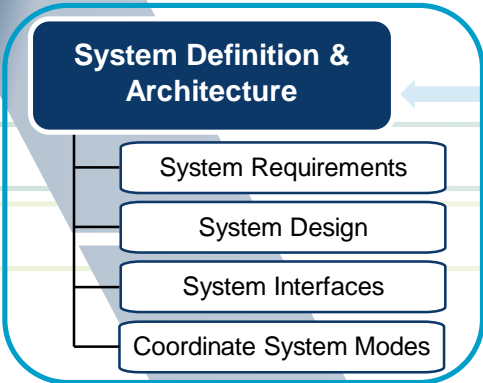
Systems Engineering Example



Systems Engineering Example

Stakeholder Requirements

Vehicle in Operation



Functional Safety

HV / H₂-Safety

Hardware E/E

Mechanics

Software & Function Development

Calibration

Drive

- Provide Torque
- React on Brake Events
- Provide Recuperation
- Shift Drive Modes
- Operation Strategy / Power Management

← 1 Functional manager

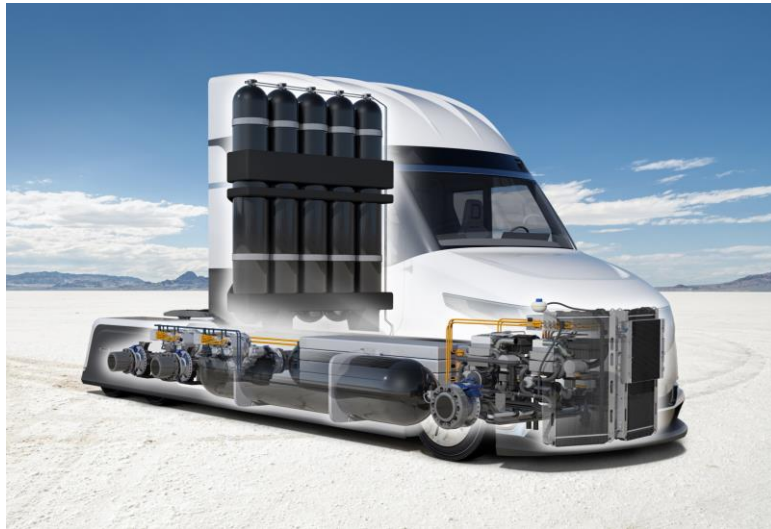
Interdisciplinary working group

Main Topics:

- Function oriented development
- Iterative and recursive approach in requirements definition & architecture design
- Functional safety (e.g. ISO 26262)
- Cyber security (if applicable)
- Software & function development
- HW, SW & mechanical integration
- Verification & Validation
- Certification and homologation



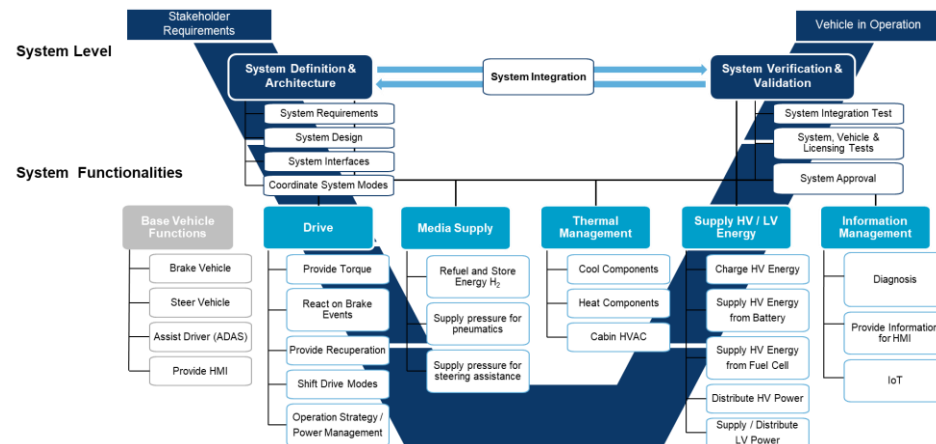
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- **Future truck concepts are characterized by:**
 - OEM base vehicle
 - Integration of supplier e-components and sub systems
 - Software & Function-Development

- **High level of complexity due to:**
 - High amount of individual components from different sources
 - Increasing legal requirements e.g. functional safety ISO 26262

- **In this context, IAV introduced:**
 - Modular eMobility platform
 - Development methodology for Commercial Vehicle



→ Systems Engineering methods for comprehensive electrified vehicle development projects

→ Managing high complexity for efficient system integration

→ “OEM Thinking” throughout the product life cycle

*Thank you very much for your attention!
Do you have any questions?*

Contact

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