



**DRIVE
SYSTEM
DESIGN**

Platform Energy Decisions and Modelling: A Data Driven Approach

Operational Energy Authority Industry
Engagement Day

16th October 2024

Richard Dunne
Head of Business Development

www.drivesystemdesign.com

SYSTEM DESIGN AND INTEGRATION

From requirements capture, target-setting and performance attributes management, to architecture concept optimisation using our 'ePOP' tool

eMOTOR ENGINEERING

From electromagnetic, thermal and structural analysis to hardware design and component manufacture and test

POWER ELECTRONICS ENGINEERING

Hardware and software development including our 'Open Platform Inverter' (OPI) system

CONTROL SYSTEM DEVELOPMENT

Application software for transmission, driveline and powertrain supervisory control, using our 'Infinite Control' open access library

TRANSMISSION AND DRIVELINE ENGINEERING

Clean-sheet design with customer-owned IP, covering system attributes from NVH to efficiency, cost and sustainability

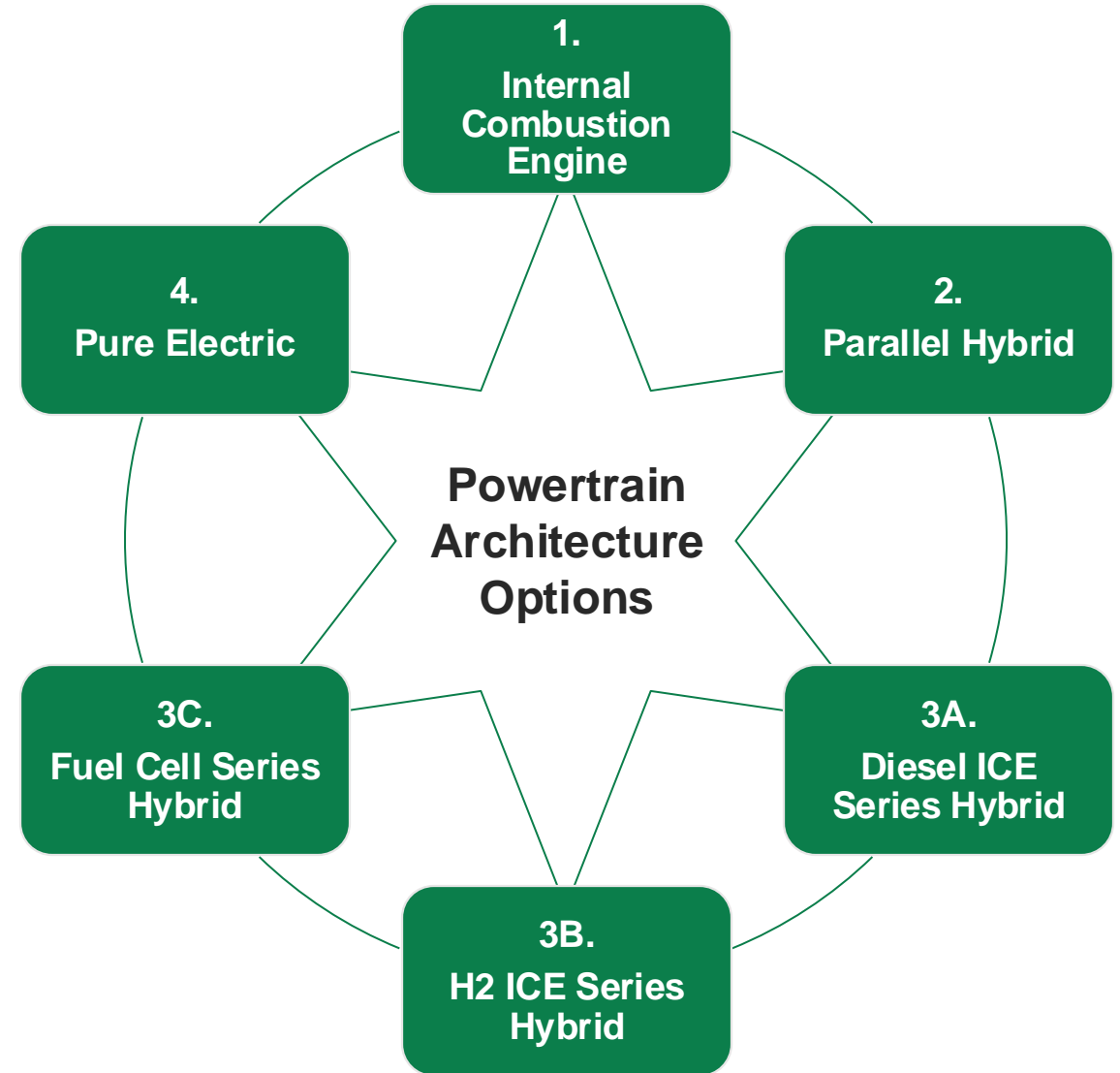
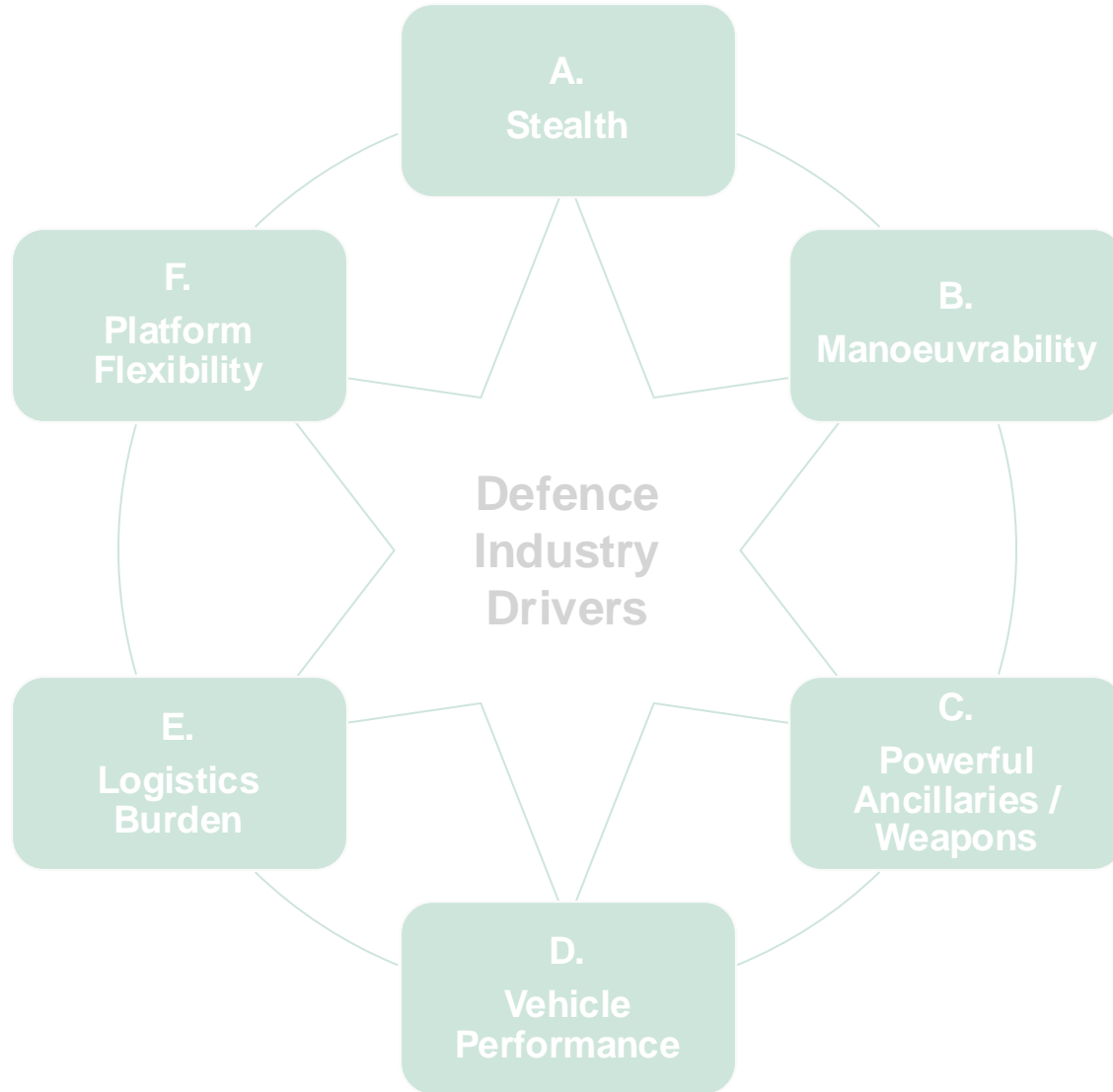
IN-HOUSE DEVELOPMENT ENGINEERING AND TESTING

In-house system and component development and verification testing for electrified drive units, transmissions and components
















































Traditional Approach to Platform Powertrain Architecture Definition

Experienced based selection of Drivers / Requirements and Architecture Options



Experienced Based Comparison of Powertrain Architectures Against Drivers

With ad-hoc simulation activities to explore the potential of each option

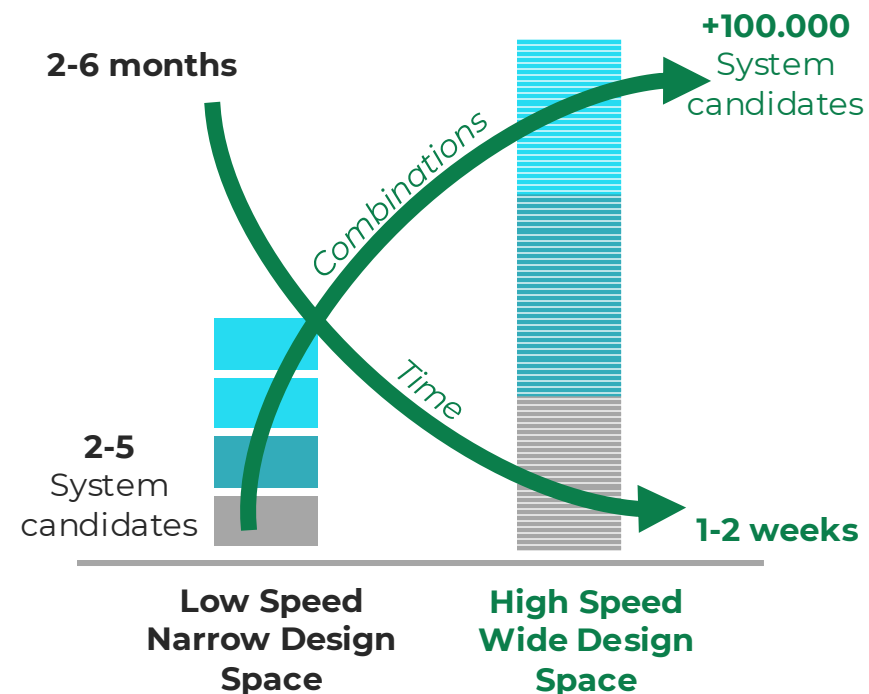
Powertrain Architecture	Sector Drivers					
	A. Stealth	B. Manoeuvrability ? Refuel / Charge Time ?	C. High Power Ancillary Systems	D. Vehicle Performance ? Initial Investment ?	E. Logistics Burden ? Re-training ?	F. Platform Flexibility
1. ICE			Baseline			
2. Parallel Hybrid						
3A. Diesel ICE Series Hybrid	 	 Robustness ?	 	 	 ? Cyber Security ?	
3B. H ₂ ICE Series Hybrid	 		 			
3C. Fuel Cell Series Hybrid	  	 ? Interoperability ? 	 	 		 ? Legacy Platforms ?
4. Pure Electric	  	 		 		 

Why ePOP? - DSD Approach for Developers and System Specifiers

DSD's Electrified Propulsion Optimisation Process (ePOP) allows users to investigate the complex challenges of powertrain architecture analysis across all areas: from engineering, to costing to strategic planning

An ability to efficiently and objectively address the challenges will be key for successful planning and suppliers:

- Identify the right / best-in-class technology fast
- Draw **conclusions from large number of combinations**, achieving a more in-depth analysis of the design space
- Ensure wider platform and strategic influences are considered as fundamental concept criteria
- **Adapt rapidly to continuously changing requirements**
- Discover underlying trends and identify the **optimum portfolio solutions**
- Communicate design strategy across disciplines and sectors via common industry language and process

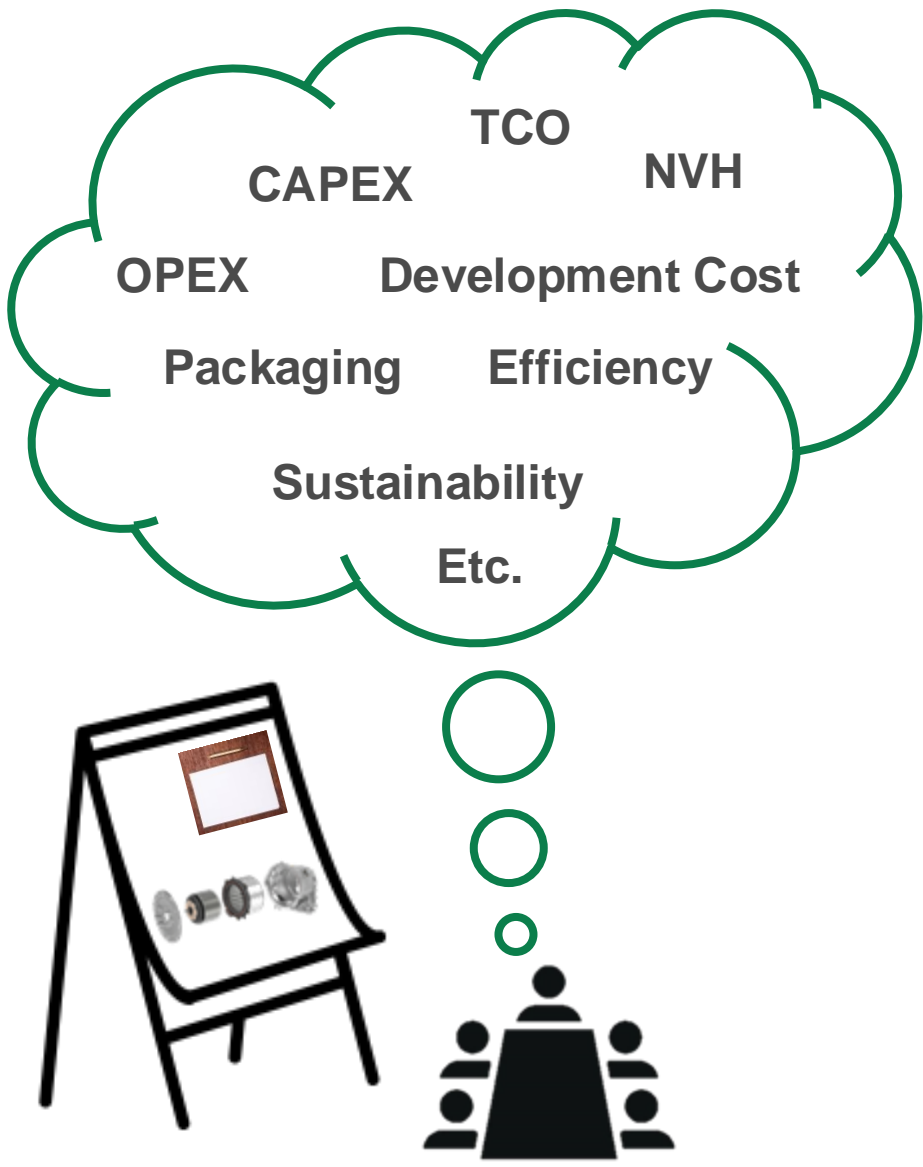
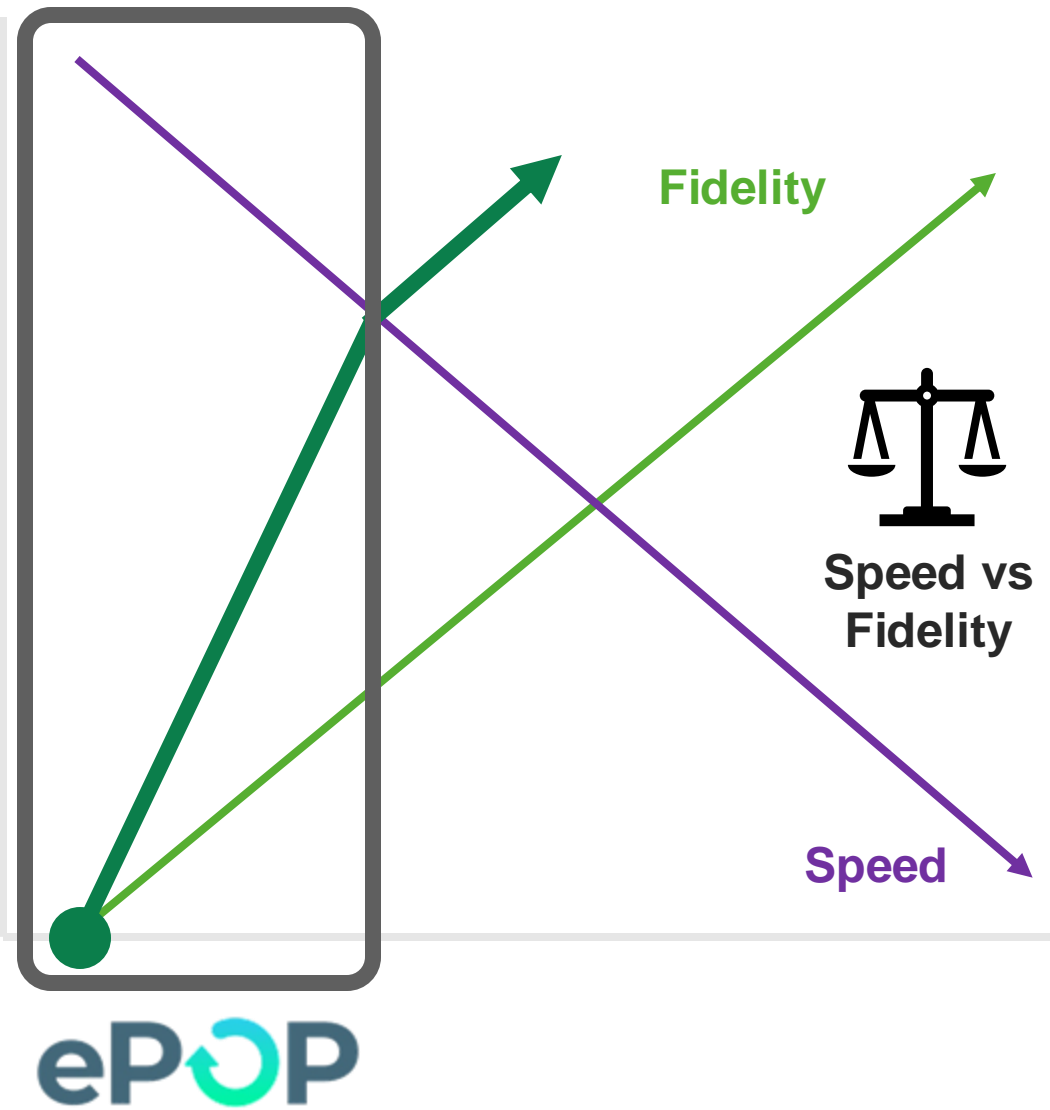


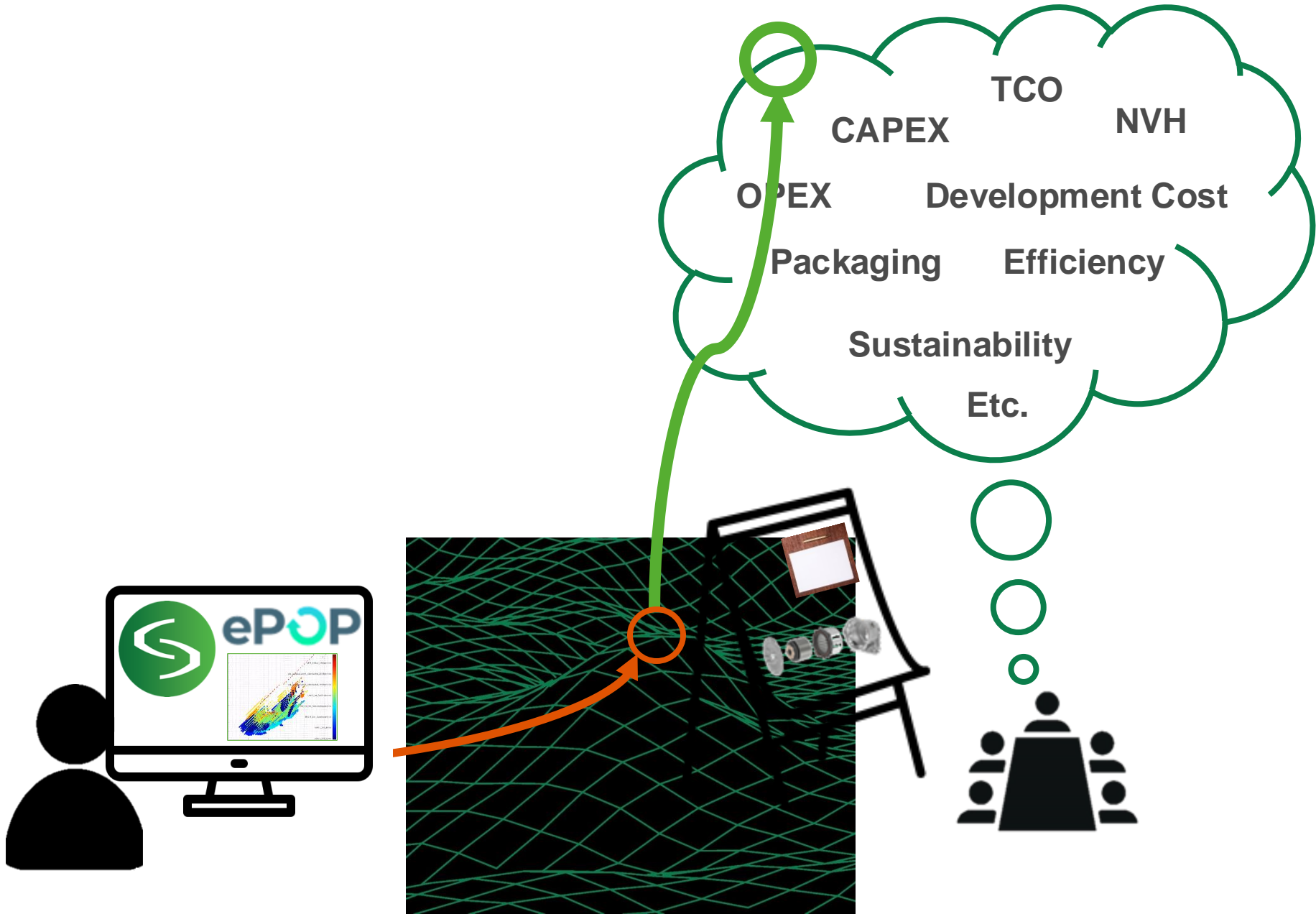
ePOP can typically consist of >100,000s specifications while traditional approaches only consider 2-5 specifications at early stages

ePOP provides and understanding of the design space like no other process does, customers do frequently find non-intuitive knowledge hidden in the data

Dedicated team of engineers develop the tools behind the process, which expanding capabilities and roadmaps to support evolving customer needs

ePOP... 80% of the Answer, 10% of the Effort



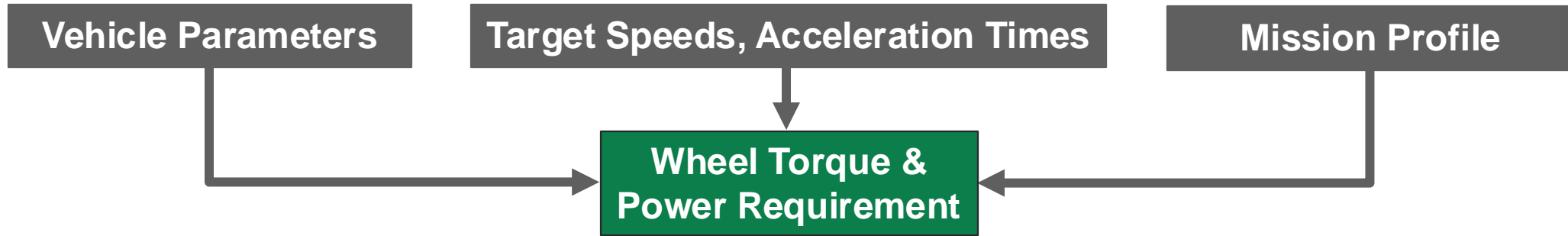


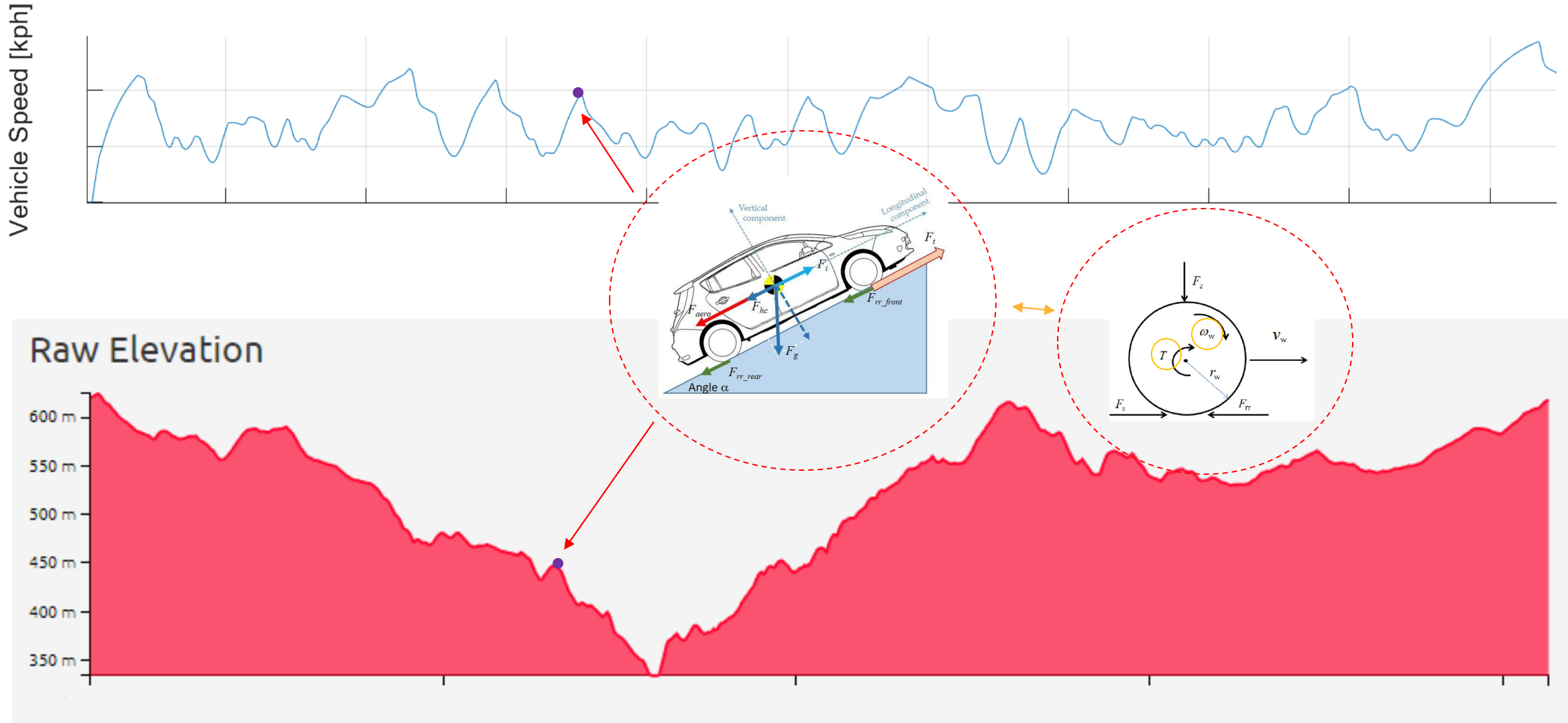
1. Design Space Definition

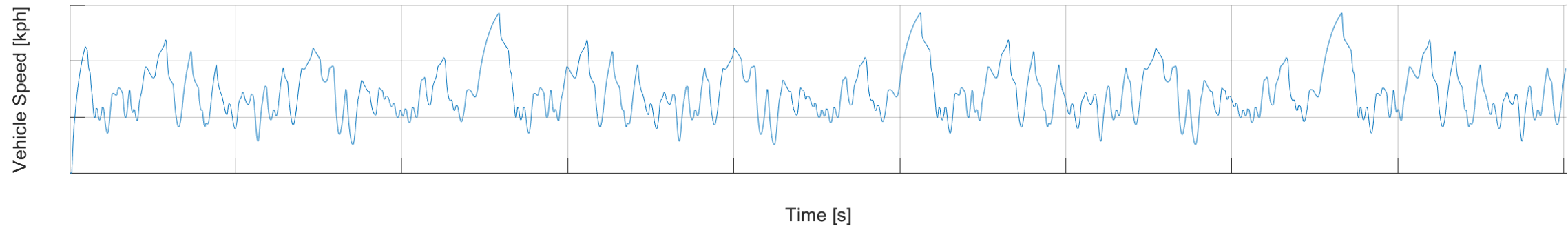
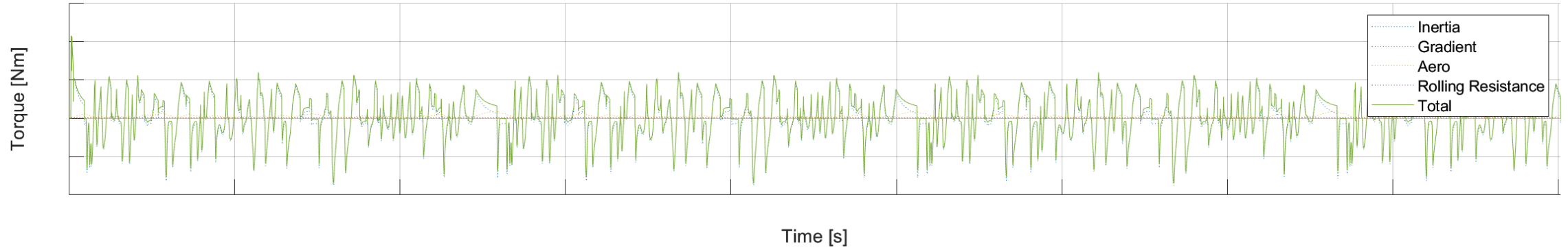
**2. Baseline Powertrain
Optimisation**

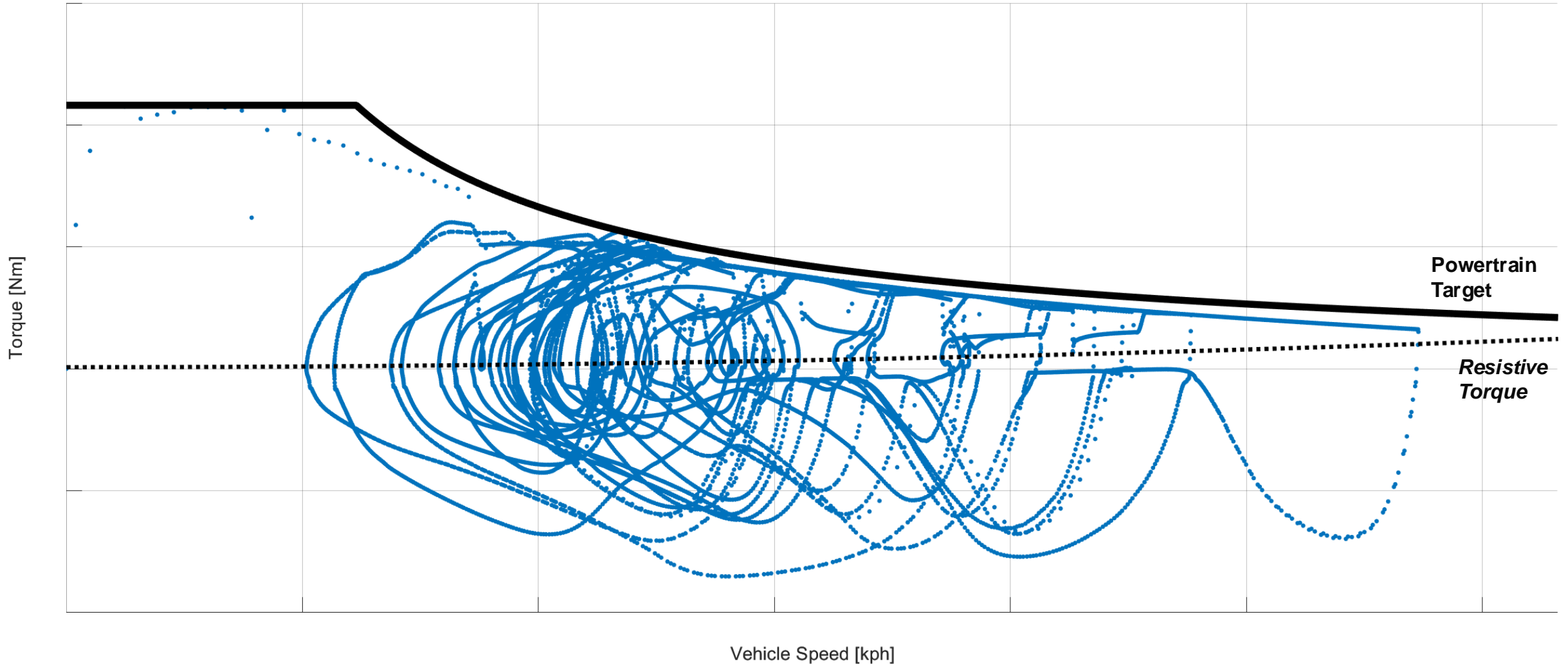
**3. Modularity and Sensitivity
Study**

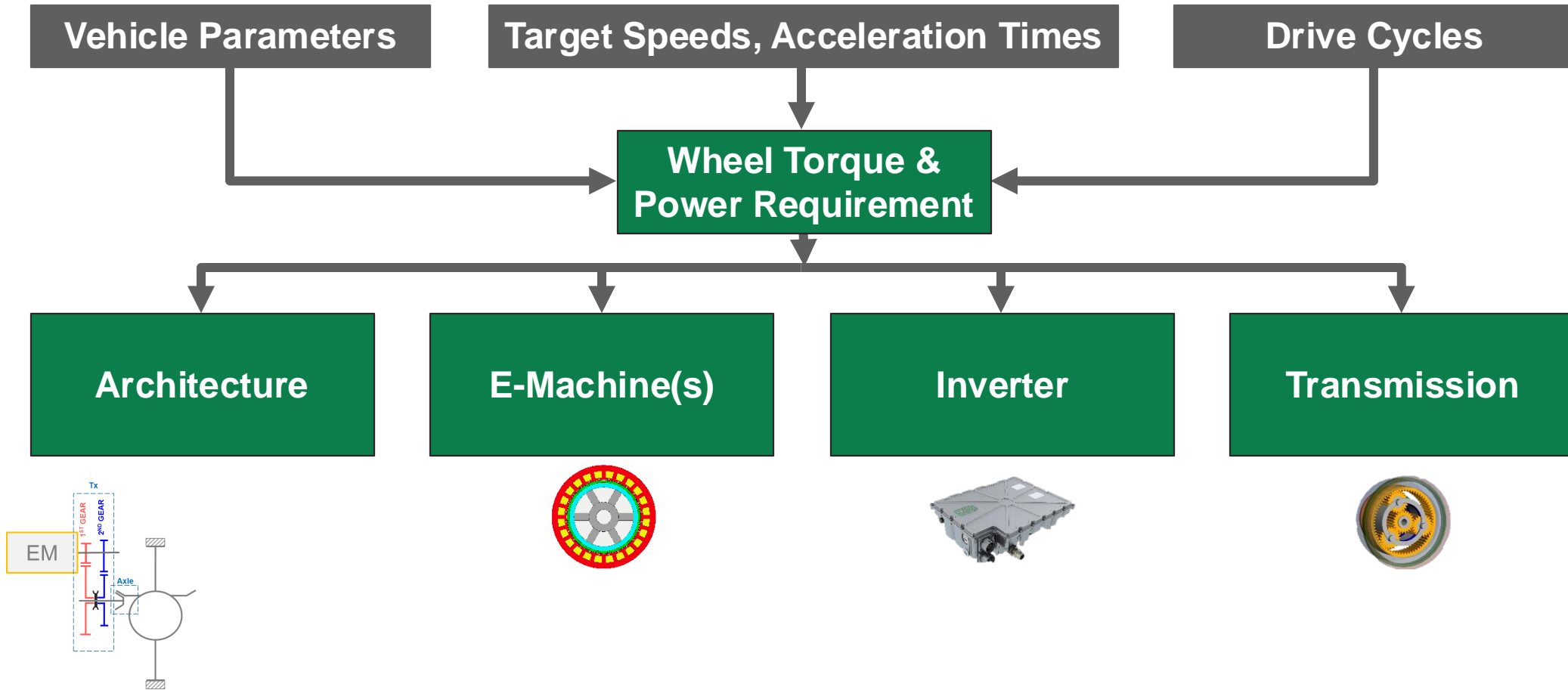




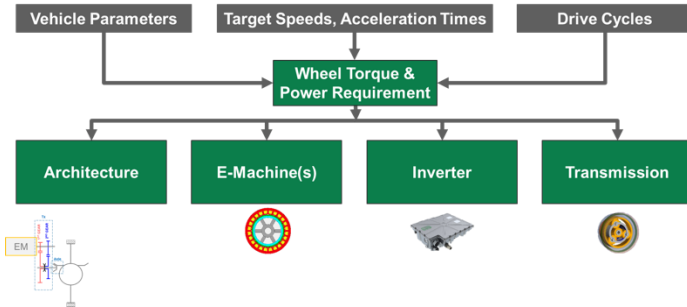




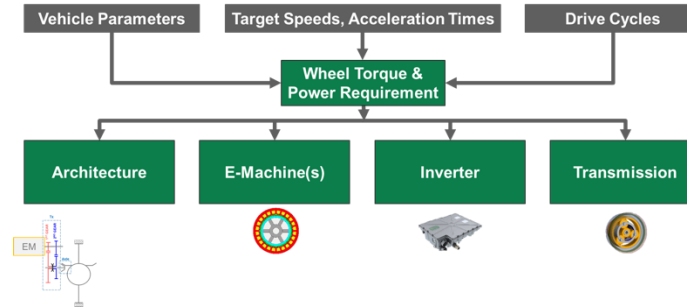




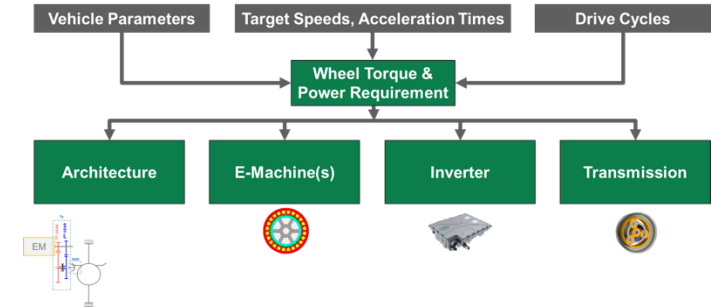
Platform A



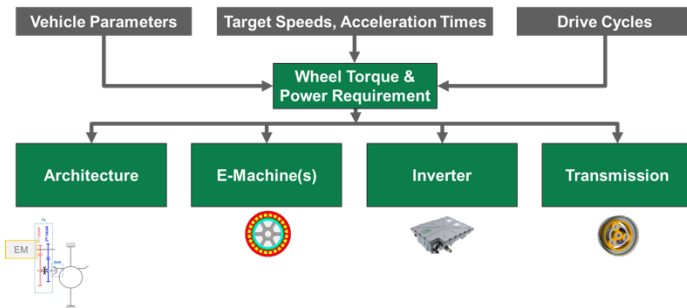
Platform B



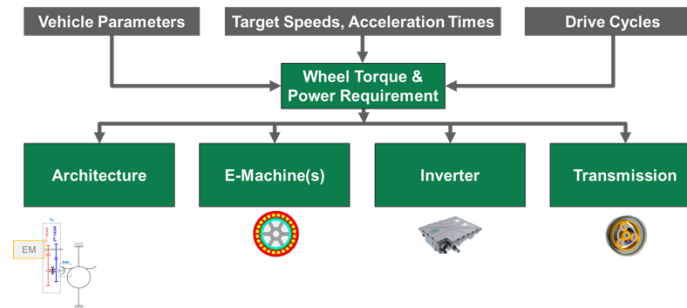
Platform C



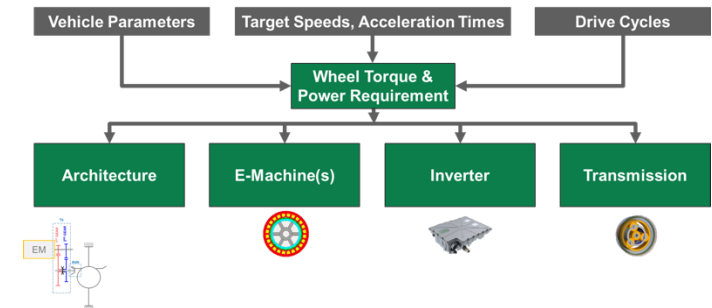
Platform D

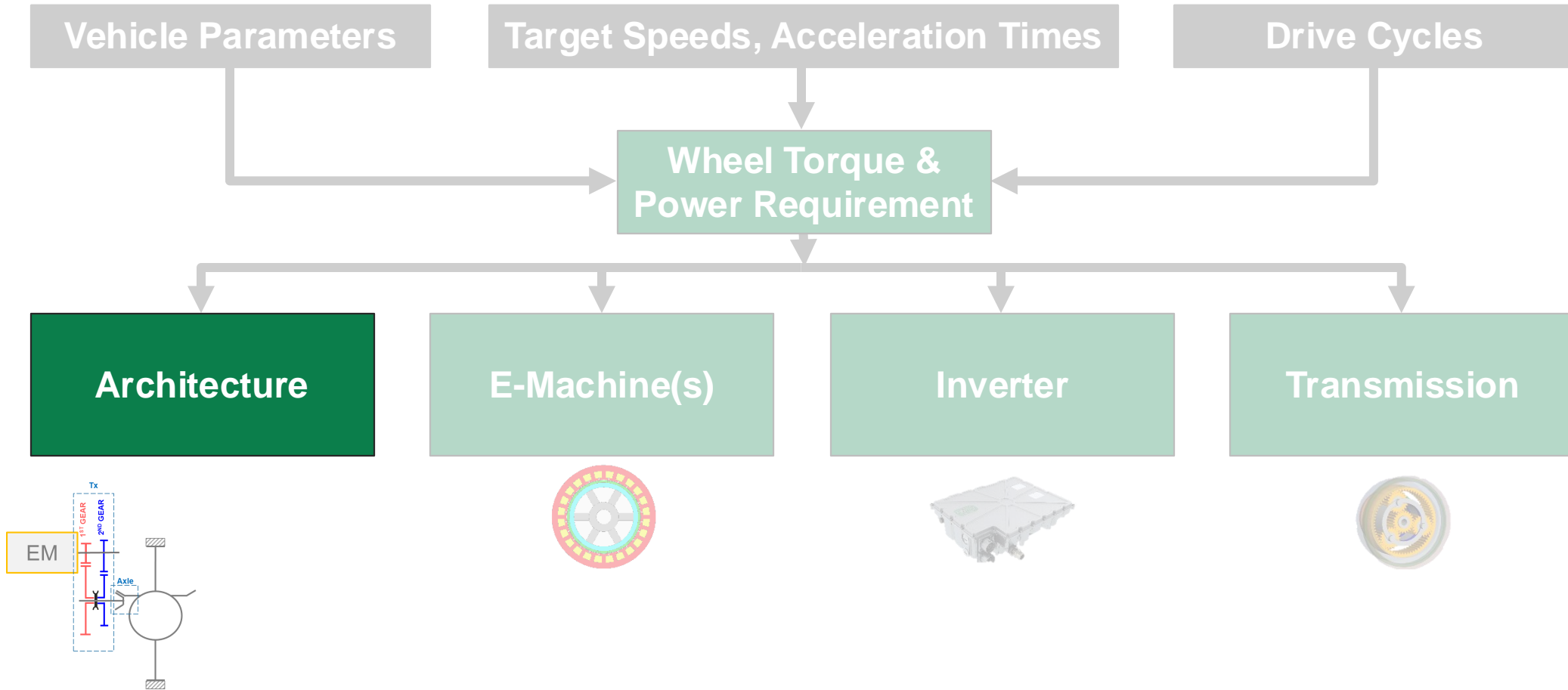


Platform E



Platform X



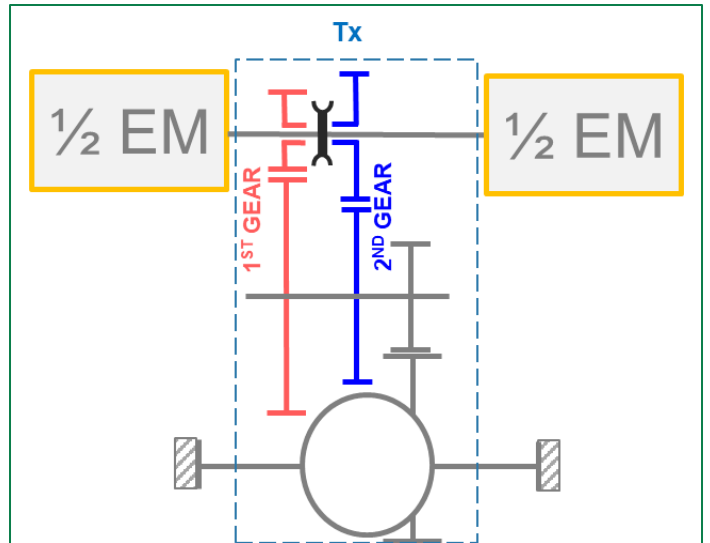
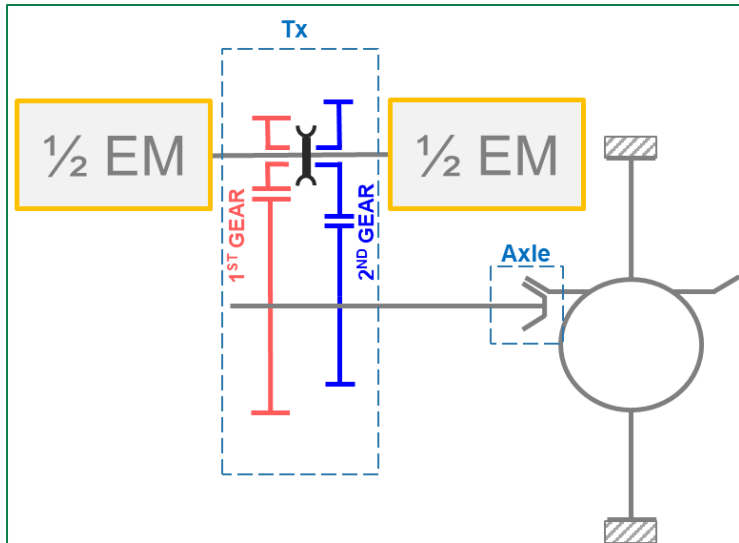
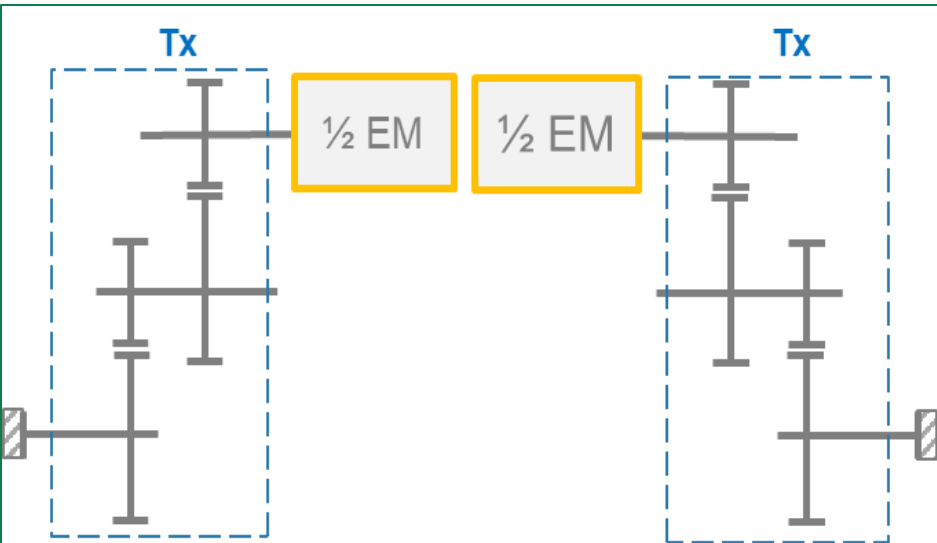
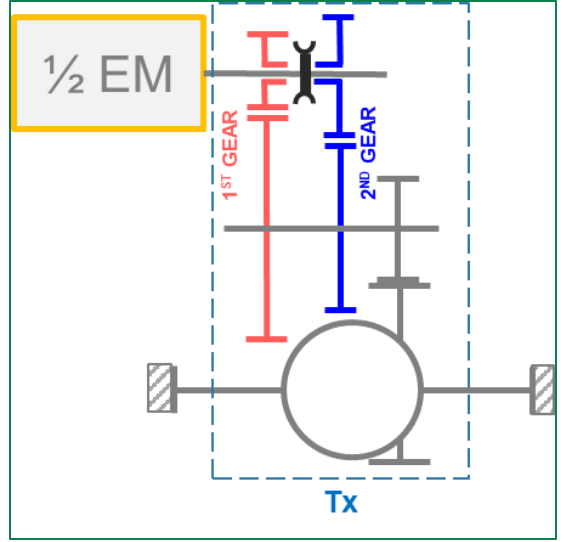
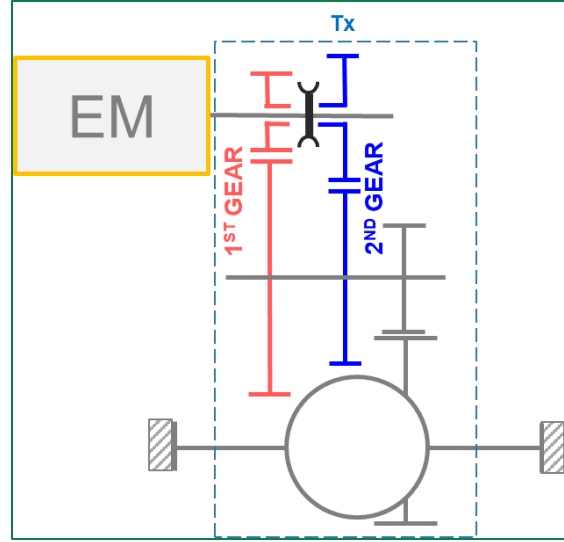
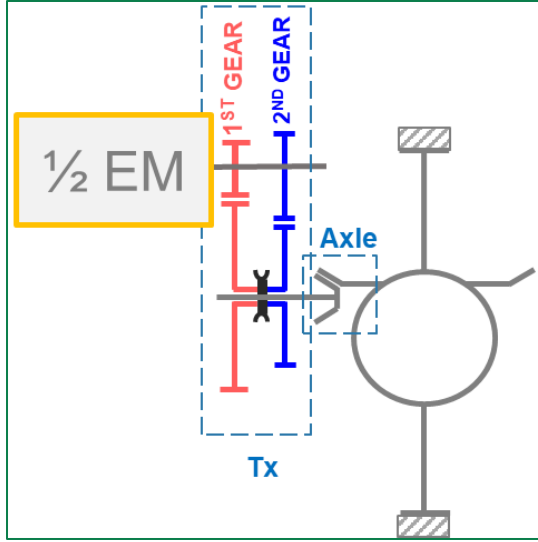
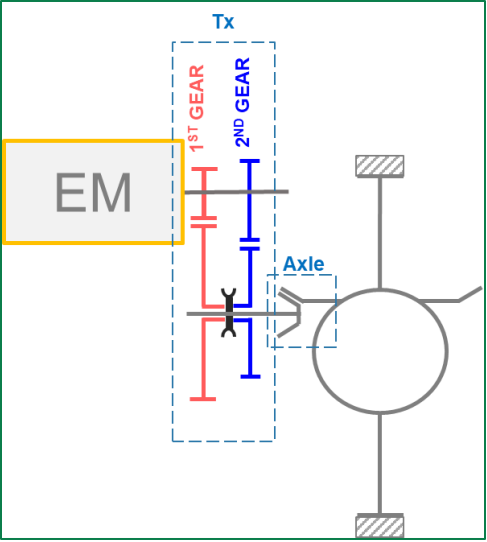


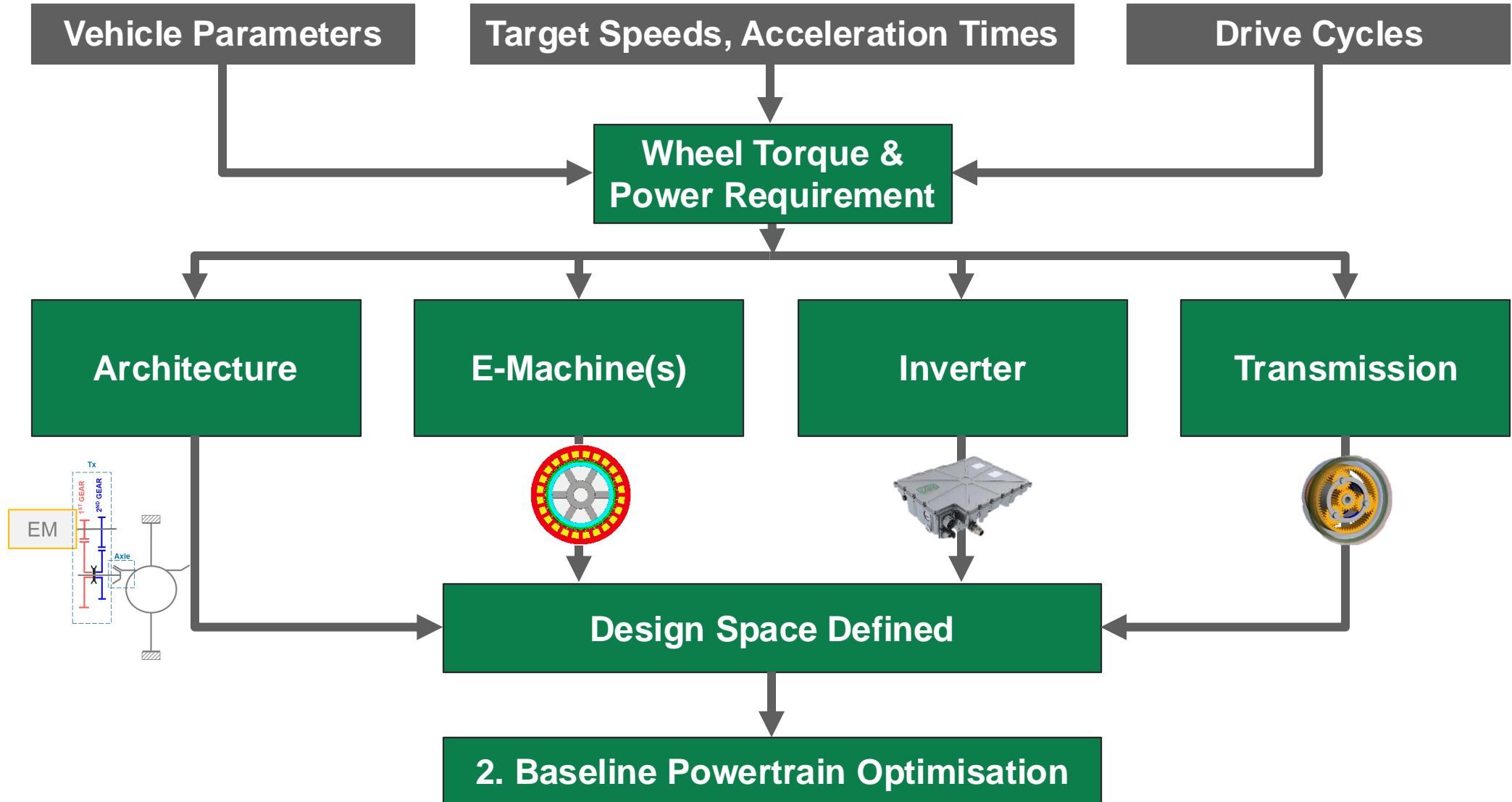
Architecture

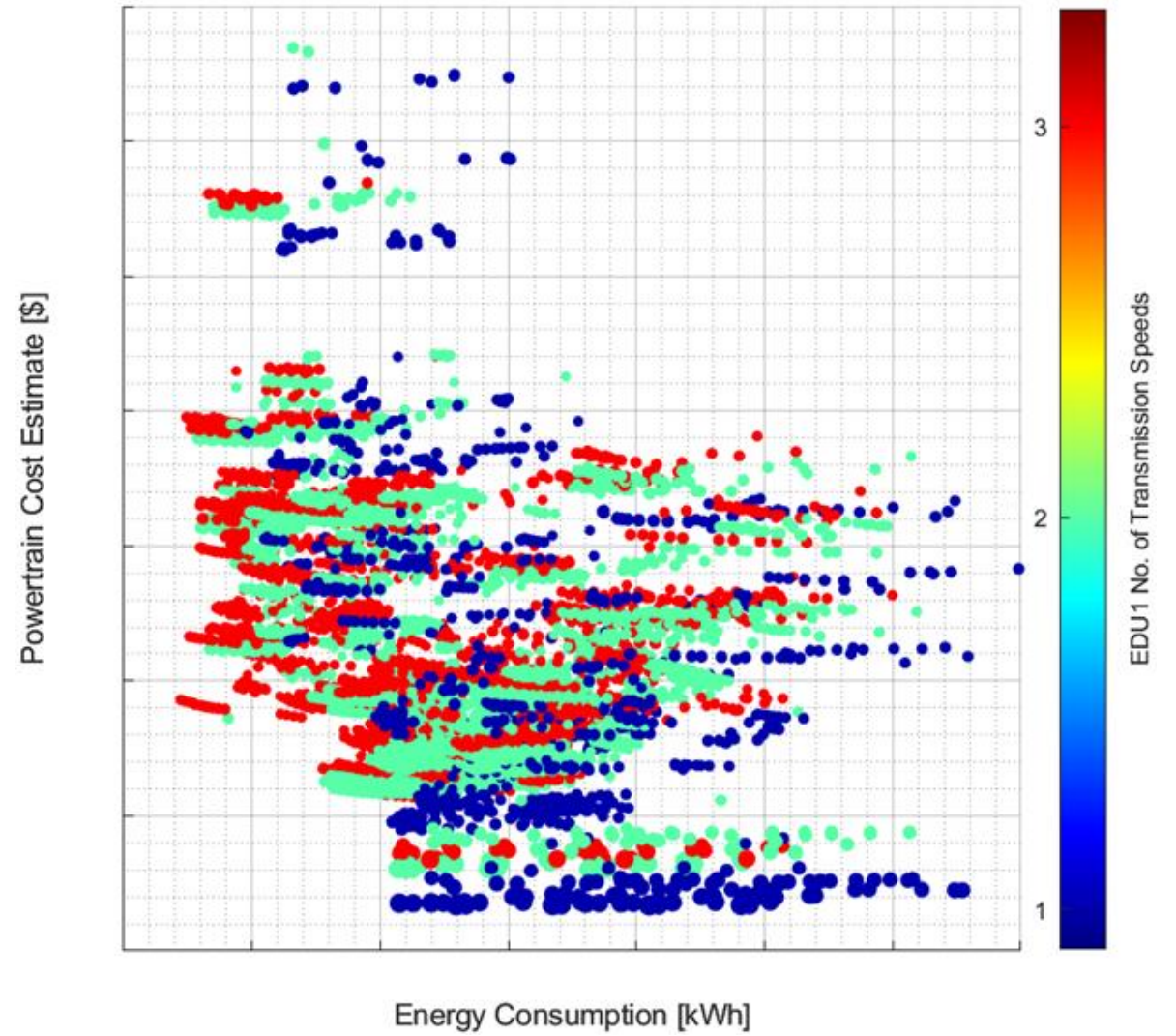
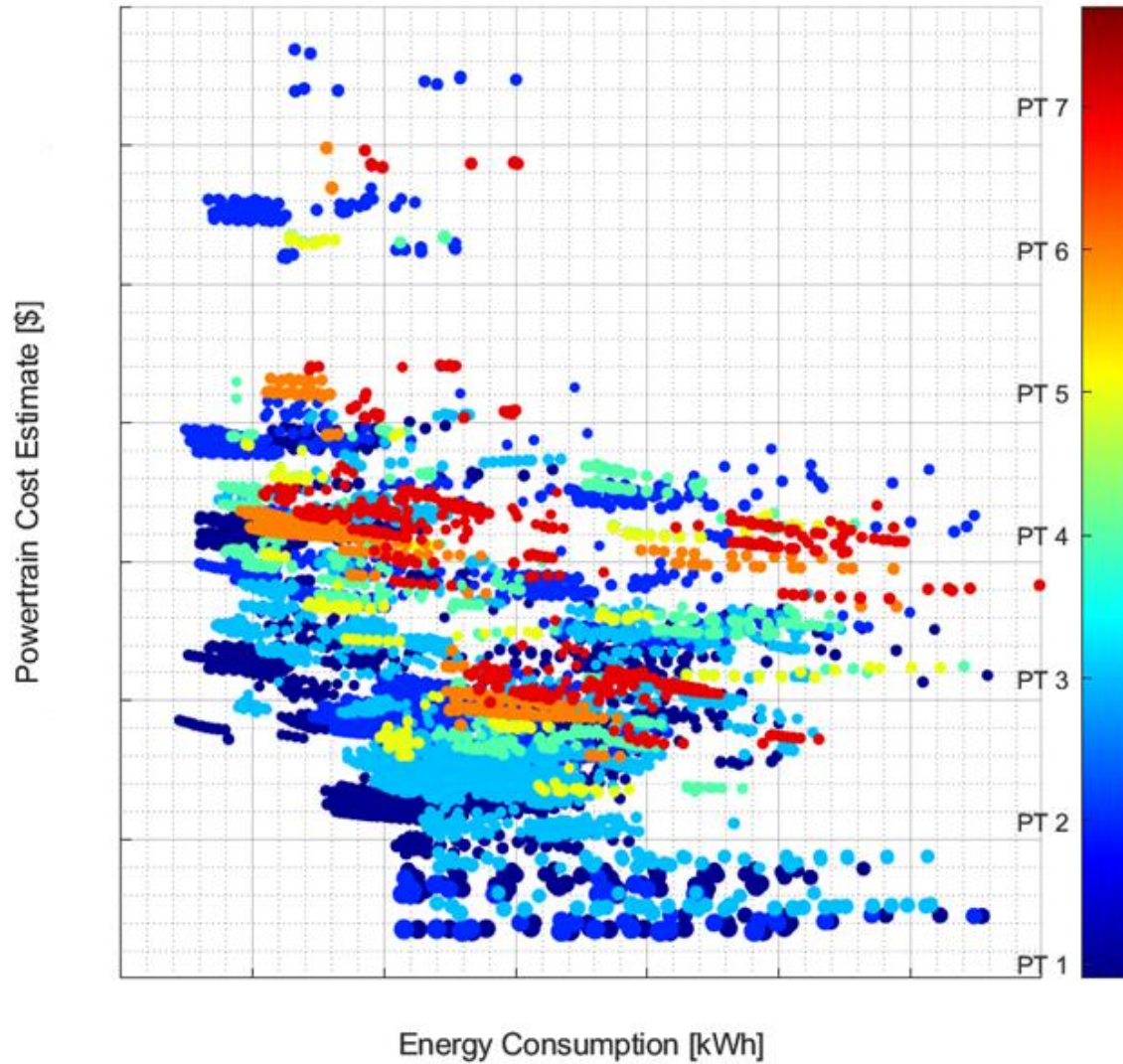
E-Machine(s)

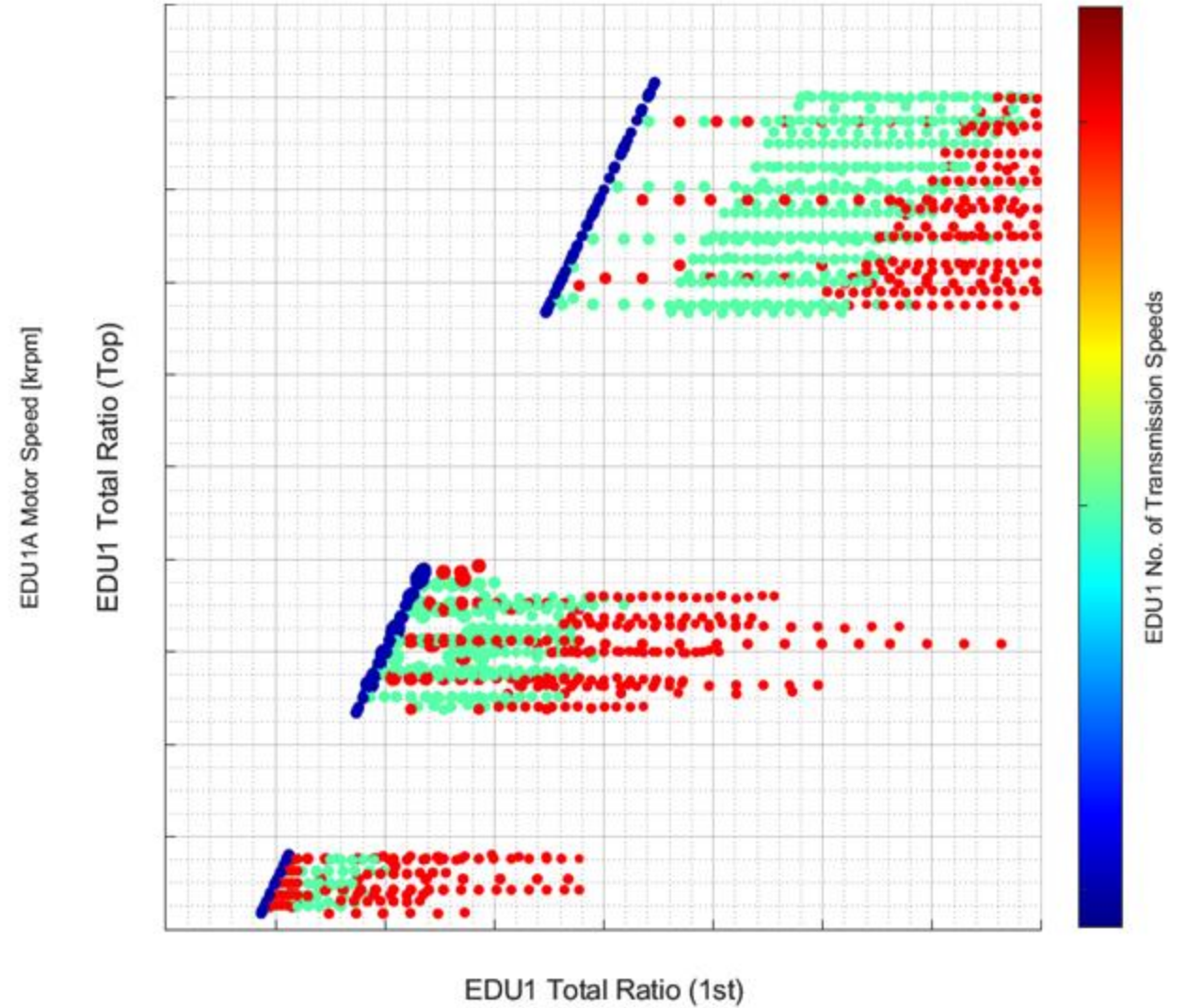
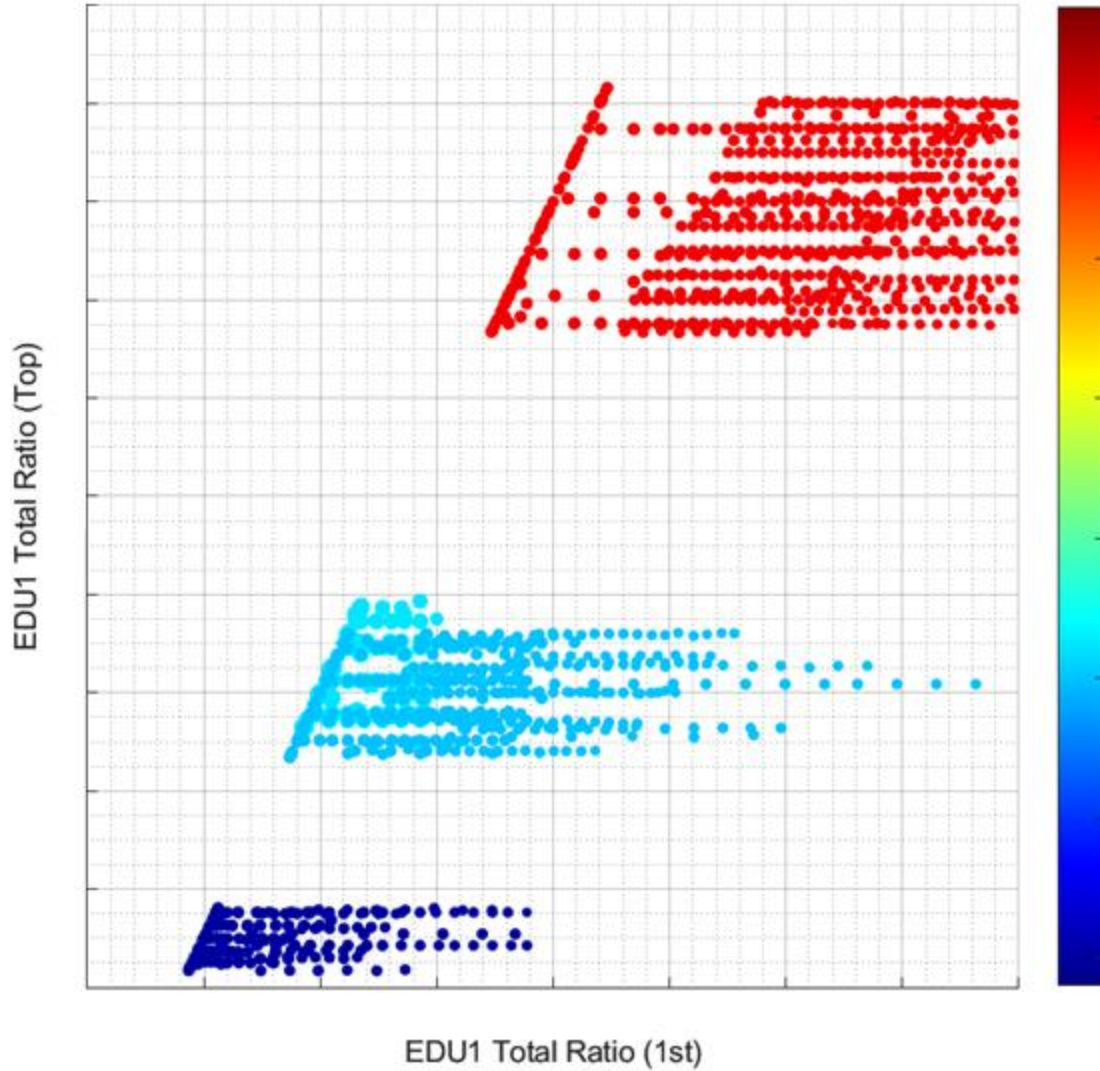
Inverter

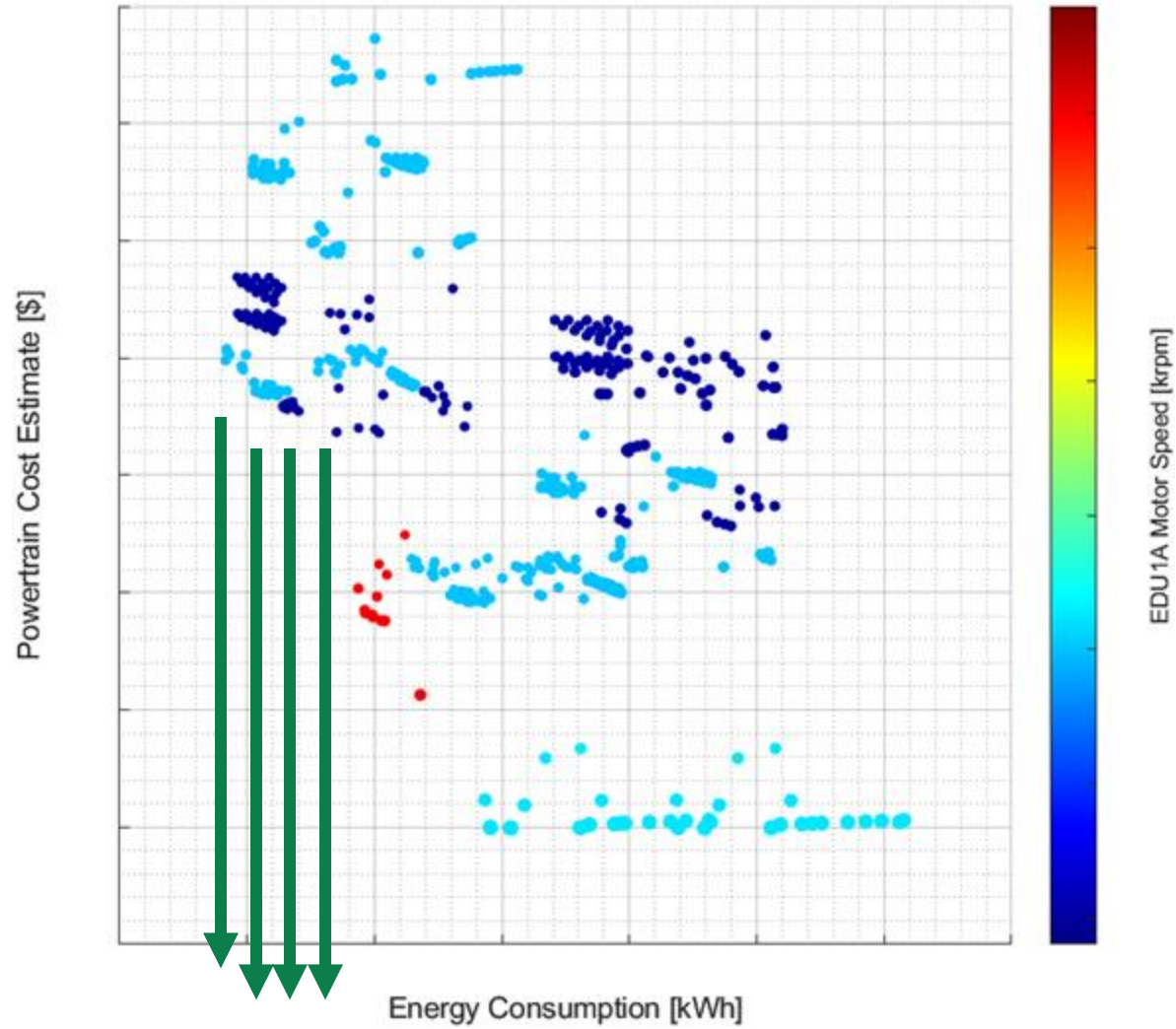
Transmission









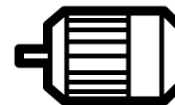
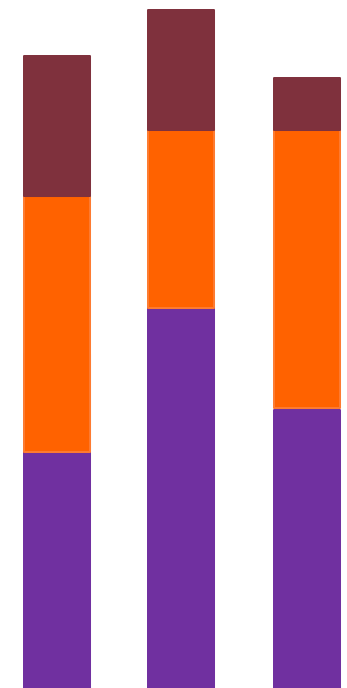
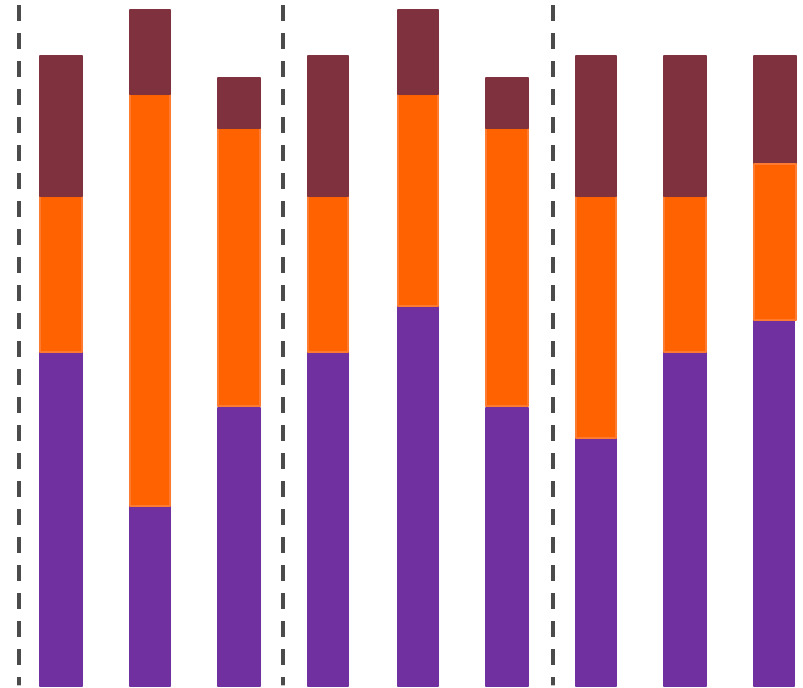


Find Lowest TCO Powertrain

Understand Contributions

Quantify TCO Sensitivities

Consolidate TCO Sensitive Variables



CASE STUDIES – Multi-speed ‘3 in 1’ EDU – ‘Family’ Architecture Strategy

Optimisation using ePOP toolset

Tier 1 electronics supplier needed support in developing their technology strategy for full ‘3 in 1’ EDU supply



Project Objective

- Define the lowest cost and most efficient ‘3 in 1’ EDU architectures for a modular EDU family

DSD Responsibilities

- High-level mapping of the global vehicle requirements
- Simulation and evaluation of >200,000 EDU configurations for 2WD and 4WD vehicles
- Definition of EDU 3 in 1 specifications across full kW range, utilising the DSD ‘ePOP’ toolset

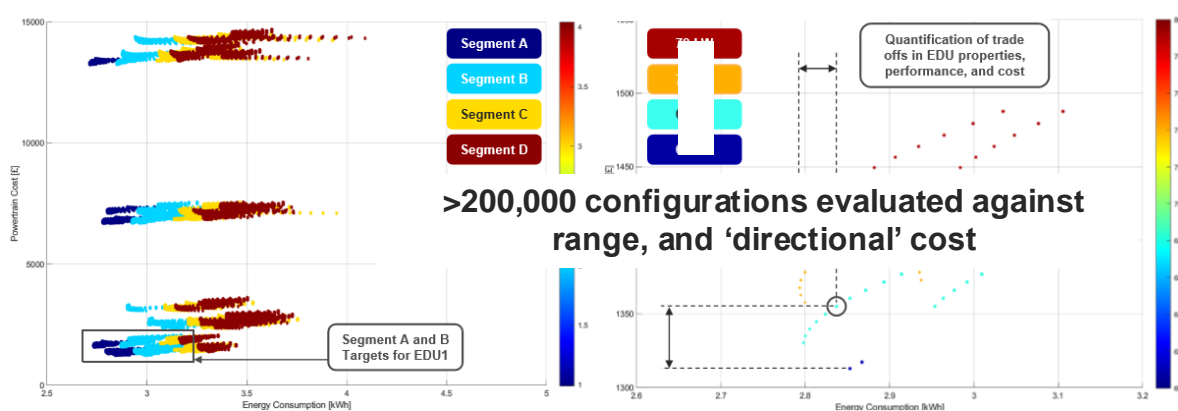
Outcome and Customer Benefits

- Full vehicle coverage at high efficiency and vehicle range with a low number of transmission and ratio variants, ‘simplified’ motor strategy, and 2 inverters
- Definition of single and multi-speed variants to take to phase 2

Timeline

- Mapping of global vehicle requirements – 6 weeks
- Setting up all 3 in 1 sub-systems and simulation – 6 weeks
- Analysing, optimisation, short-listing and finalising of all EDU specifications – 6 weeks

Phase 3 simulation and selection process performed using DSD’s ePOP tool.
 113,358 unique combinations for 2WD applications in Segments A-D (shown left), 149,324 for Segments A-F
 80,828 unique combinations for AWD applications in Segments D-F



		EDU1	EDU2	EDU3	EDU4	
Inverter	Power Module		←		Fuji IGBT x2	
	Type		←		←	
Motor	Peak Power at Base Speed (kW)		445		200	
	Maximum Peak Power (kW)					
	Active Length (mm)		118.3		238.2	
	Rotor Diameter (mm)		←		←	
	Stator Diameter (mm)		←		←	
Cooling	Method		←		←	
	Housing		←		←	
Transmission	1 st Stage Ratio		←		←	
	2 nd Stage Ratio		←		←	
	Total Ratio					
	Wheel Torque (Nm)		1888	1615		3102
	Disconnect for AWD?		←			←

minimised EDUs covering 60 – >250kW

ePOP Accuracy & Correlation <1%

Link to article (English): [ATZ: Optimizing and De-risking the Selection of Electric Drives](#)

No.	Correlation step	Complete WLTP energy demand error
1	Baseline ePOP – no modifications	3.22 %
2	Transmission calibrated	0.90 %
3	Transmission, motor, inverter fine-tuned	0.25 %

FIGURE 3 Correlated points on system level via various operating scenarios

No.	Correlation step	Complete WLTP energy demand error
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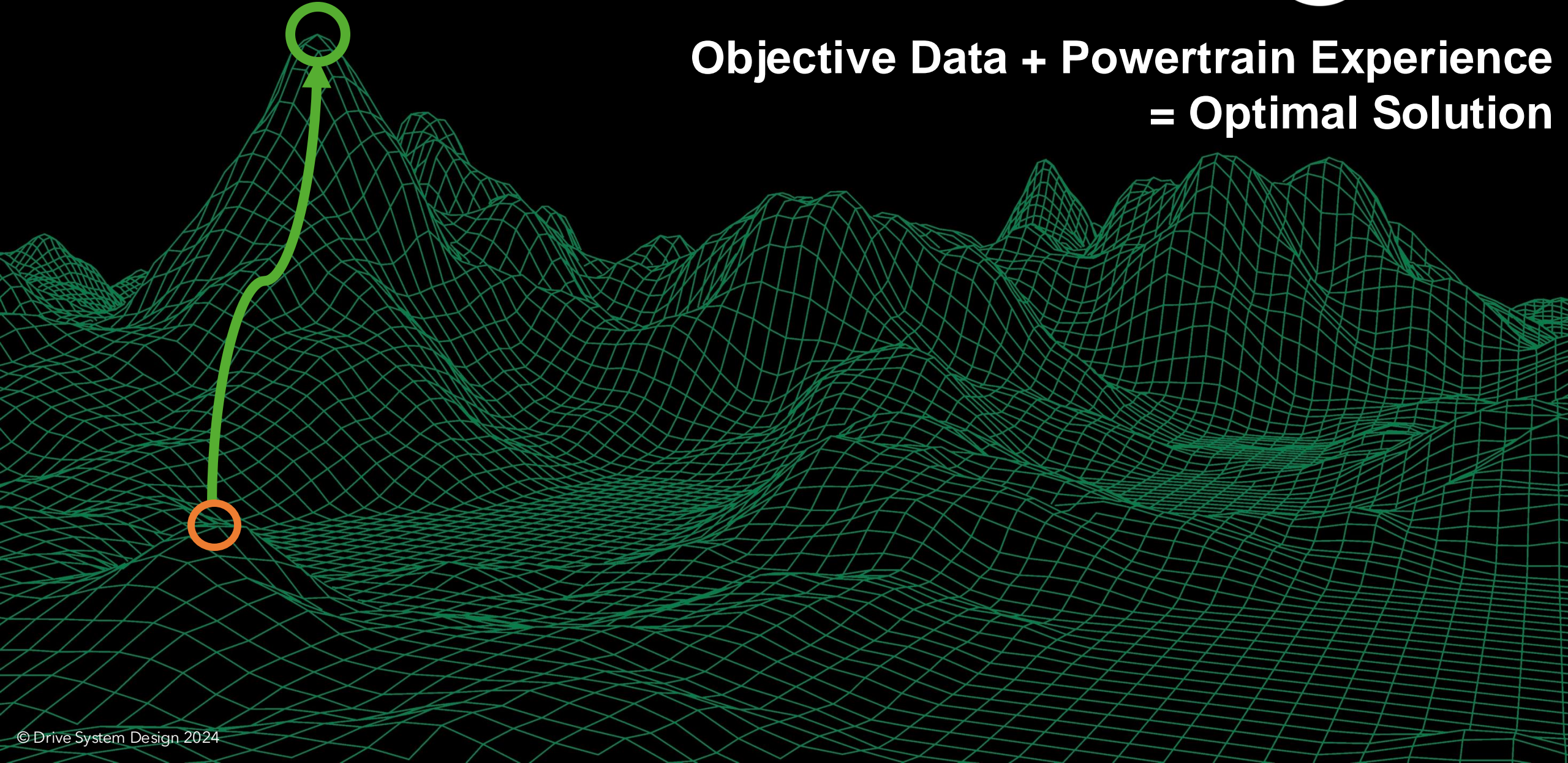
TABLE 1 Achieved correlation of simulation and real test: at the outset (No. 1), with transmission-only optimization (No. 2), and after final fine-tuning (No. 3) including motor and inverter optimization (© Drive System Design)

- <1%:**
- ✓ EDM
 - ✓ eMotor
 - ✓ PIM
 - ✓ GB

As demonstrated in this ATZ article with a Jaguar I-Pace demo, ePOP can deliver valuable assessments of critical factors such as efficiency and cost in **high accuracy** when considering the trade-offs between powertrain designs, even in its initial configurations. With modest revisions, that accuracy improved from 3.22% to 0.25%
 A level that can **instill confidence in the chosen architecture** that can also lead to **reduced development effort and cost**, and a compressed more **rapid time-to-market**.

FIGURE 3 Correlated points on system level via various operating scenarios

**Objective Data + Powertrain Experience
= Optimal Solution**





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