Introduction of Digital Twins and Tools for NextETRUCK

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ITS EUROPEAN CONGRESS
ISTANBUL
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IN COLLABORATION WITH:

HOSTED BY: ISTANBUL METROPOLITAN MUNICIPALITY, isbak

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Digital Twinning & Virtual Integration

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Different types of digital twins

Digital Model

Virtual representation of a physical system
No interaction between system and model

Digital Generator

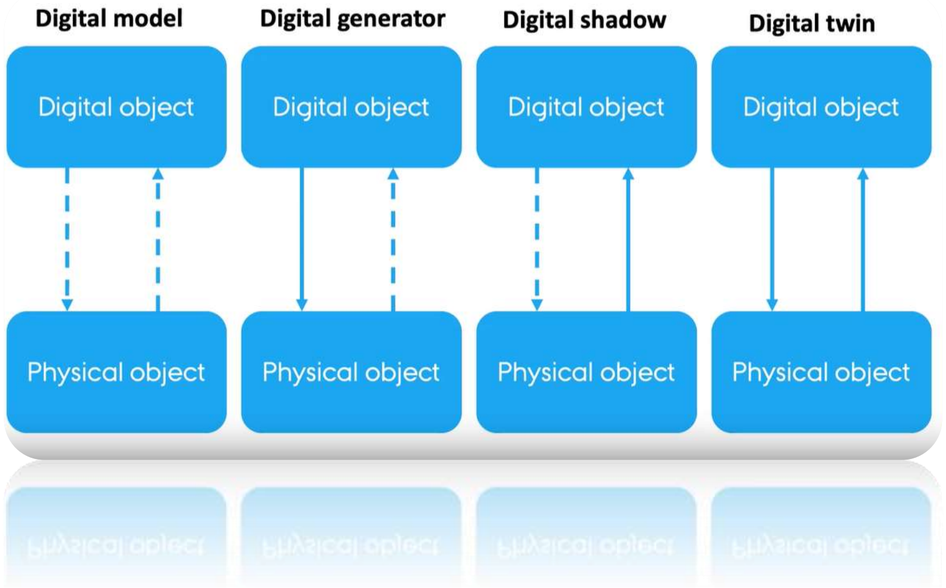
Physical system follows the model

Digital Shadow

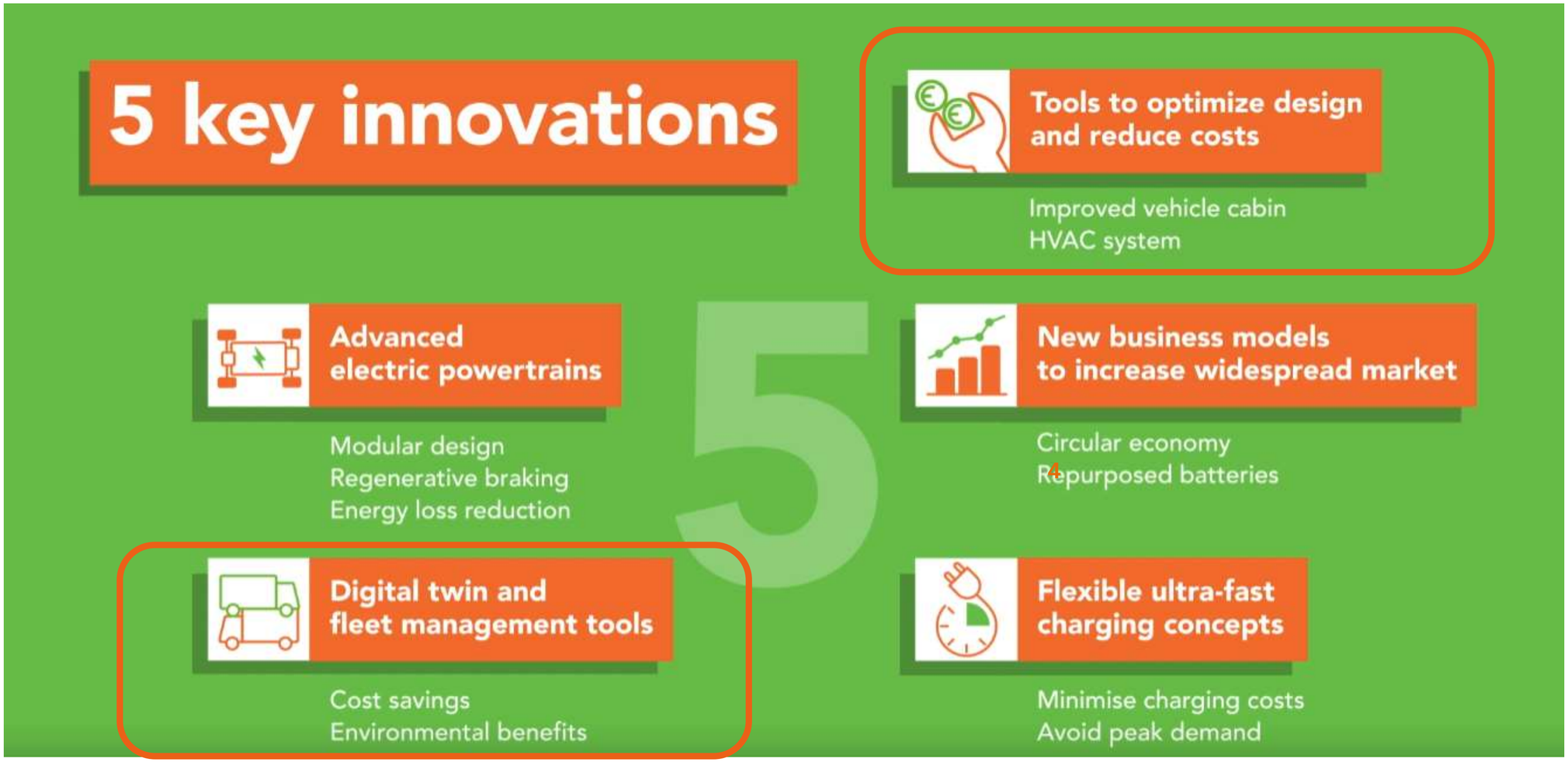
Model follows physical system

Digital Twin

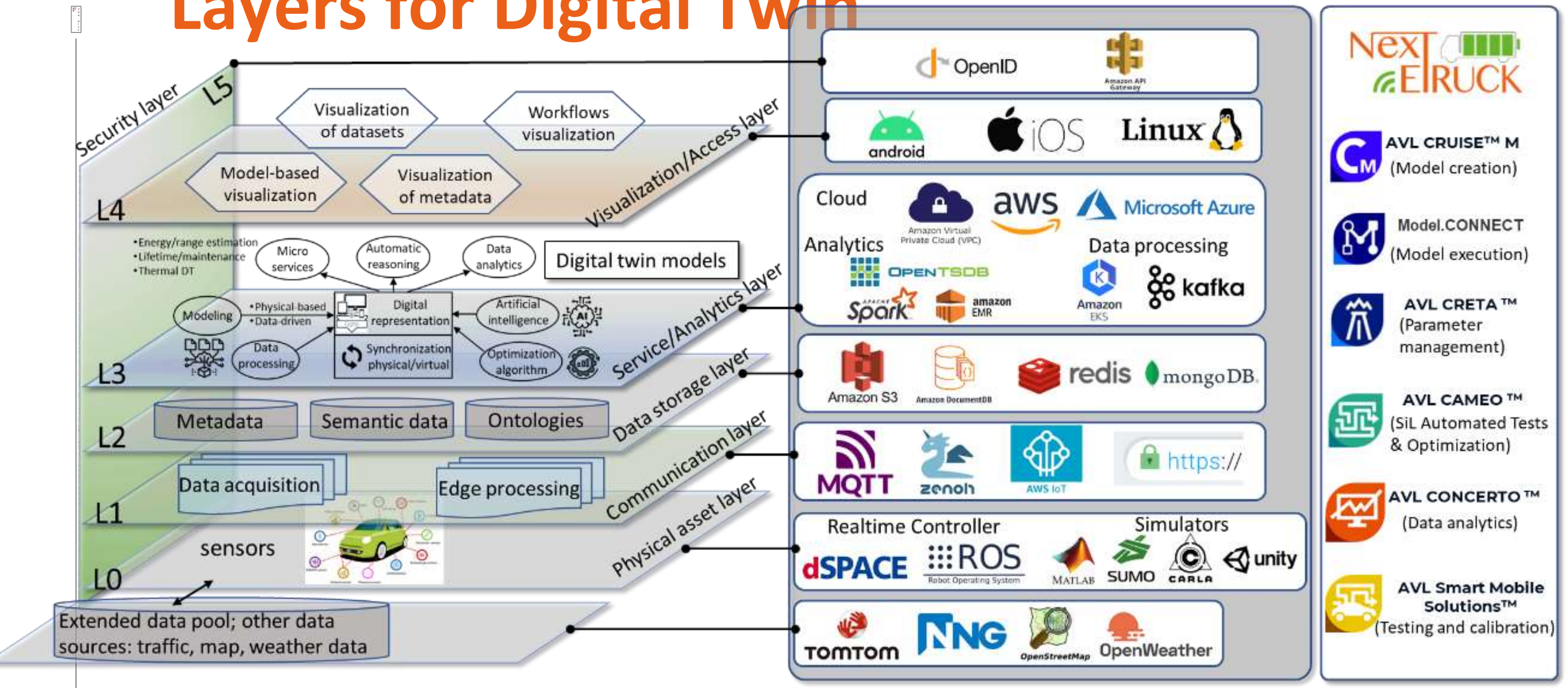
Virtual representation of a physical object or process
Bidirectional exchange of data between physical and virtual system
Used for process optimisation, observation, prediction,…



Why Digital Twin(s)?



Layers for Digital Twin



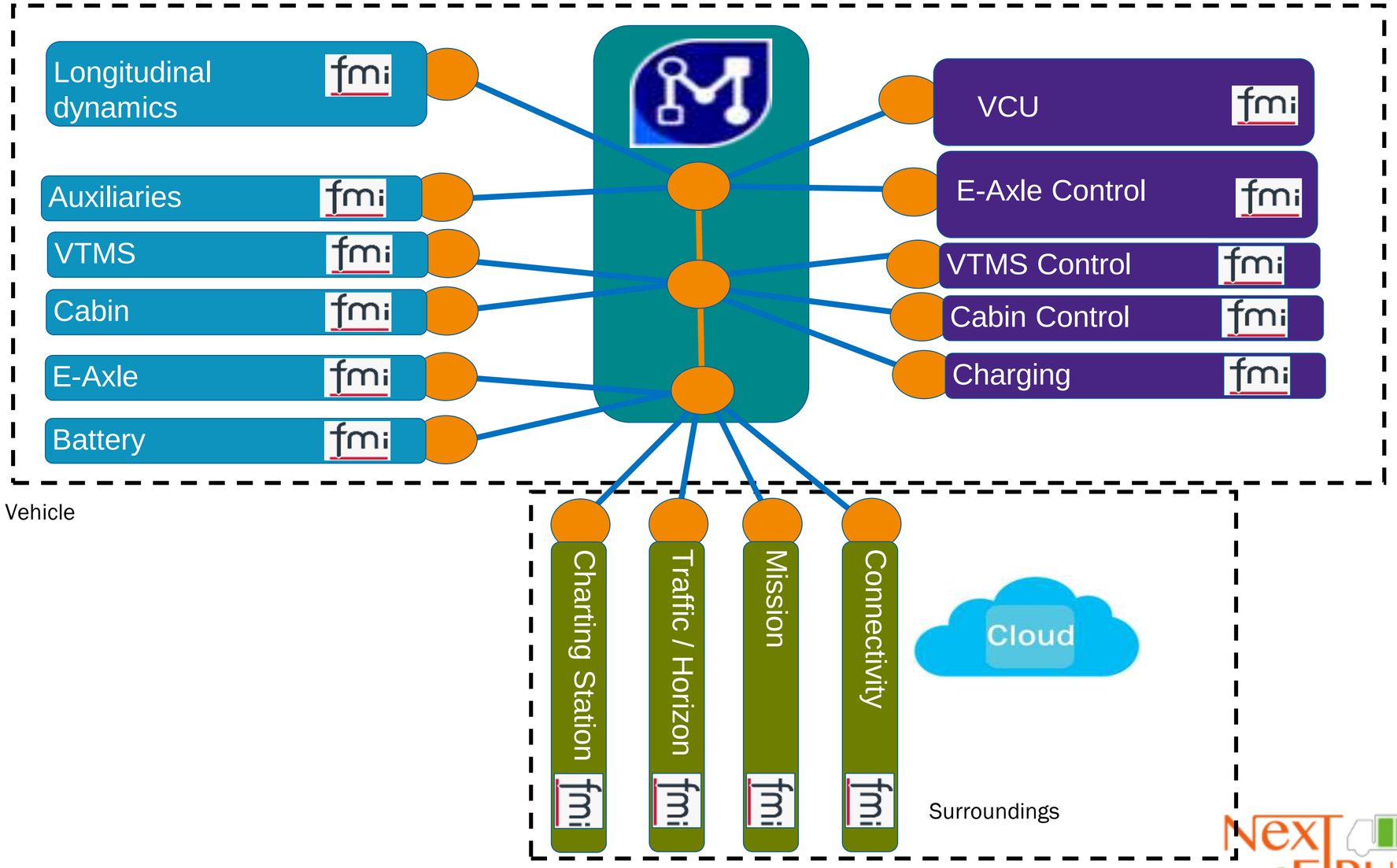
Multi-layer digital twin architecture

Existing Commercial Software Tools
(highly heterogeneous)

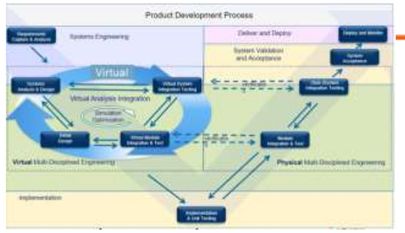
NextETRUCK
Digital Twin Platform

TNO innovation for life

DGT-concept



NextETruck
Digital Twin



System definition

- System modeling/ SysML
- Use cases
- Architecture/ interface

Model-Based SysML Systems Engineering

Model calibration

- Sub-system model identification and verification
- Autonomous calibration

Simulation

Simulation parameters

- Vehicle parameters
- Ambient parameters
- Depot locations
- Charging facility locations
- Grid, schedules

Matlab/Simulink Simulation Model (Powertrain, thermal, E/E, ECU)

MATLAB

ECU_1 (BMS) ECU_2 ... ECU_n

battery PE EM gear DF

Thermal management system

Update design variables

Optimization loop

- Objective functions
- Constraints
- Searching algorithm

No

Terminating condition?

Yes

Optimal sizing solutions

Simulation results

- Energy consumption
- Vehicle states (SoC, power, ...)
- Charging states (occupation, power)
- Depot states

TCO calculation

Cost parameters

- Unit cost data
- Component service life
- Discount rate
- Interest rate
- Cost escalation/ degression per component

TCO model

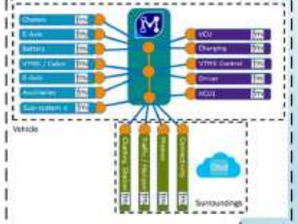
- CAPEX model (vehicles, batteries, infrastructure)
- OPEX model (driver, energy, maintenance)

python

Web-based

Co-simulation

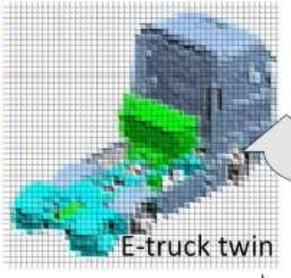
fmi Functional Mock-up Interface



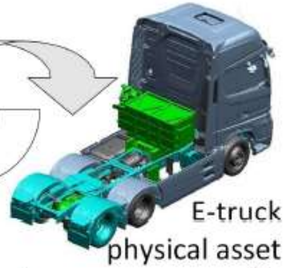
- Real-time capability models
- Scalable models
- Model.CONNECT™ platform

Cloud/ edge computing/ IoT setup

Data fusion



E-truck twin

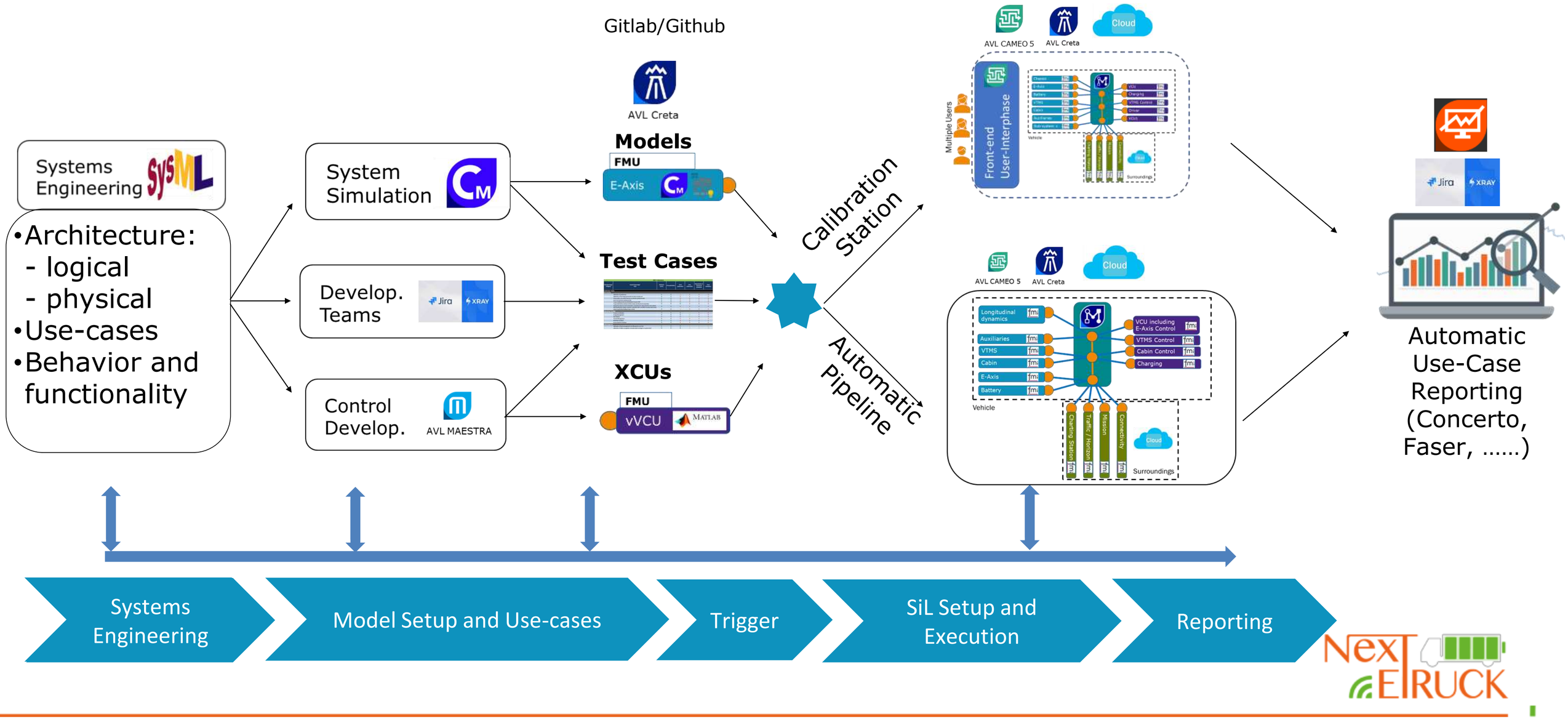


E-truck physical asset

Pre-sizing optimization → MiL/HiL/Model Calibration → Data/IoT → Sensors

NexT ETRUCK

Example of SiL setup (as development and test tool)

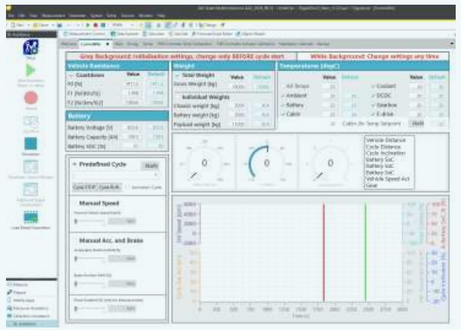


NextETRUCK Baseline Vehicle environment

Multiple Users

DB Managers

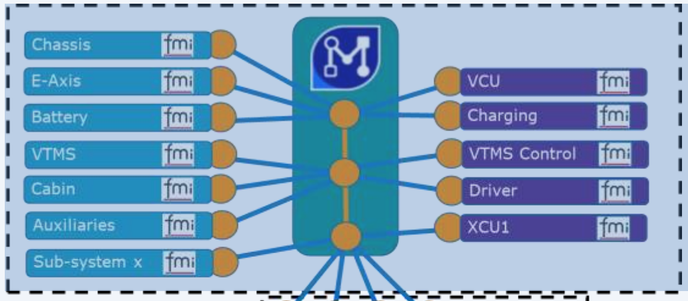
Front-end User-Interface



CAMEO & SMS

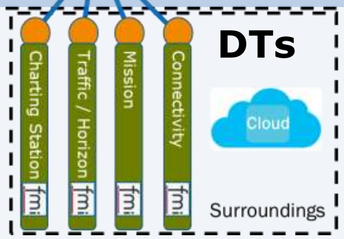
Simulation Environment

Local or Cloud deployment



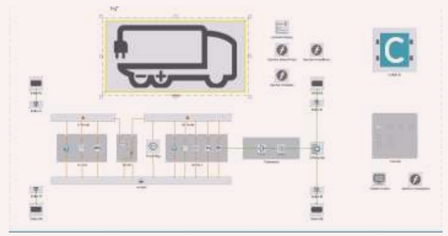
Vehicle

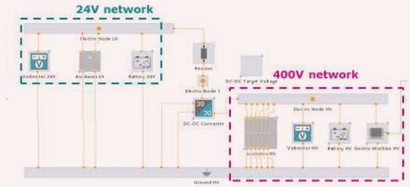
OR



Model.CONNECT

Model Creation





Overview of electrical network in CruiseM

MATLAB & SIMULINK

CRUISE M

FMU

Model & Parameter Management

Parameter Management

Model Management

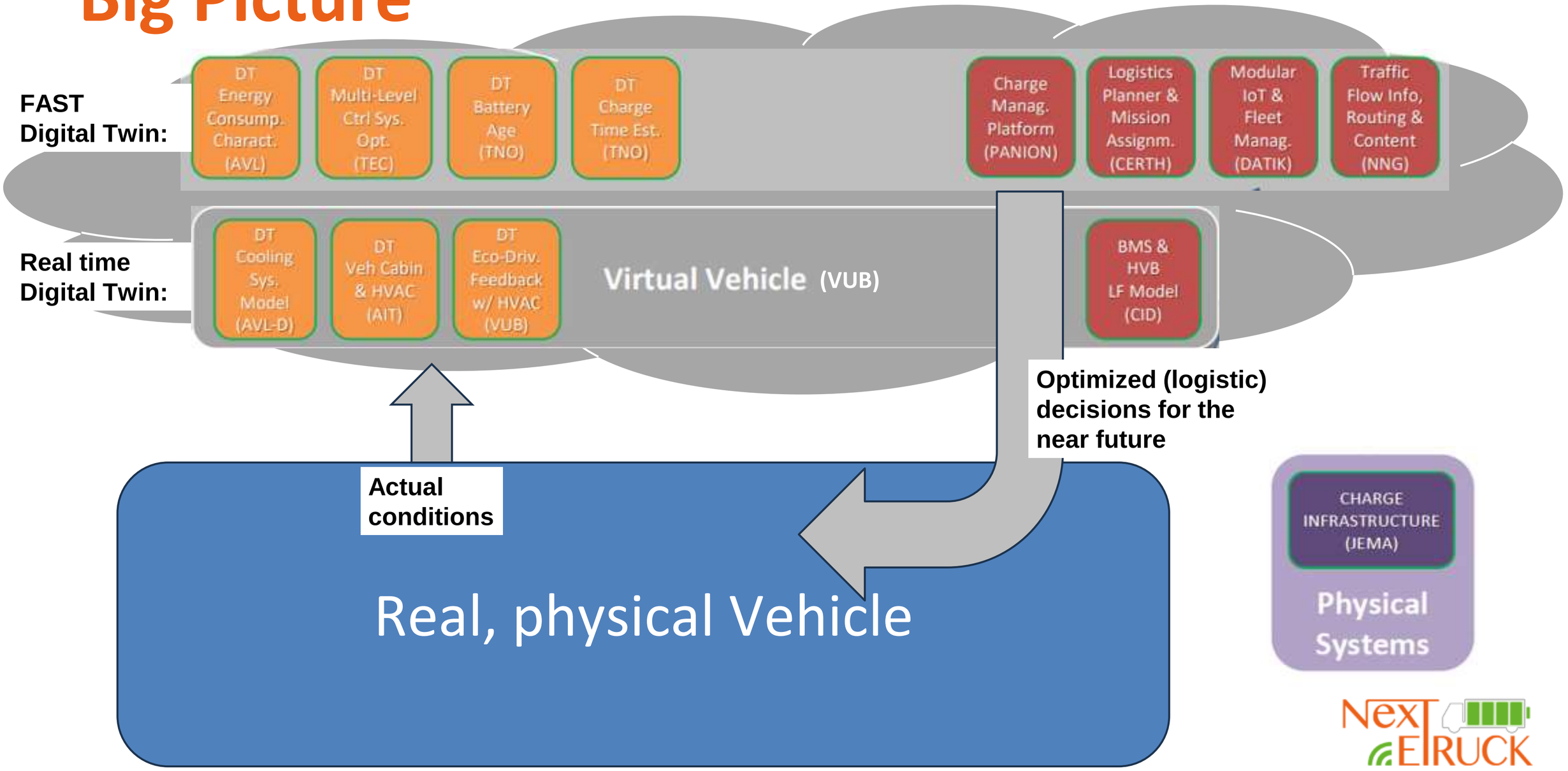
CRETA

Initialization and Calibration variables

GitHub

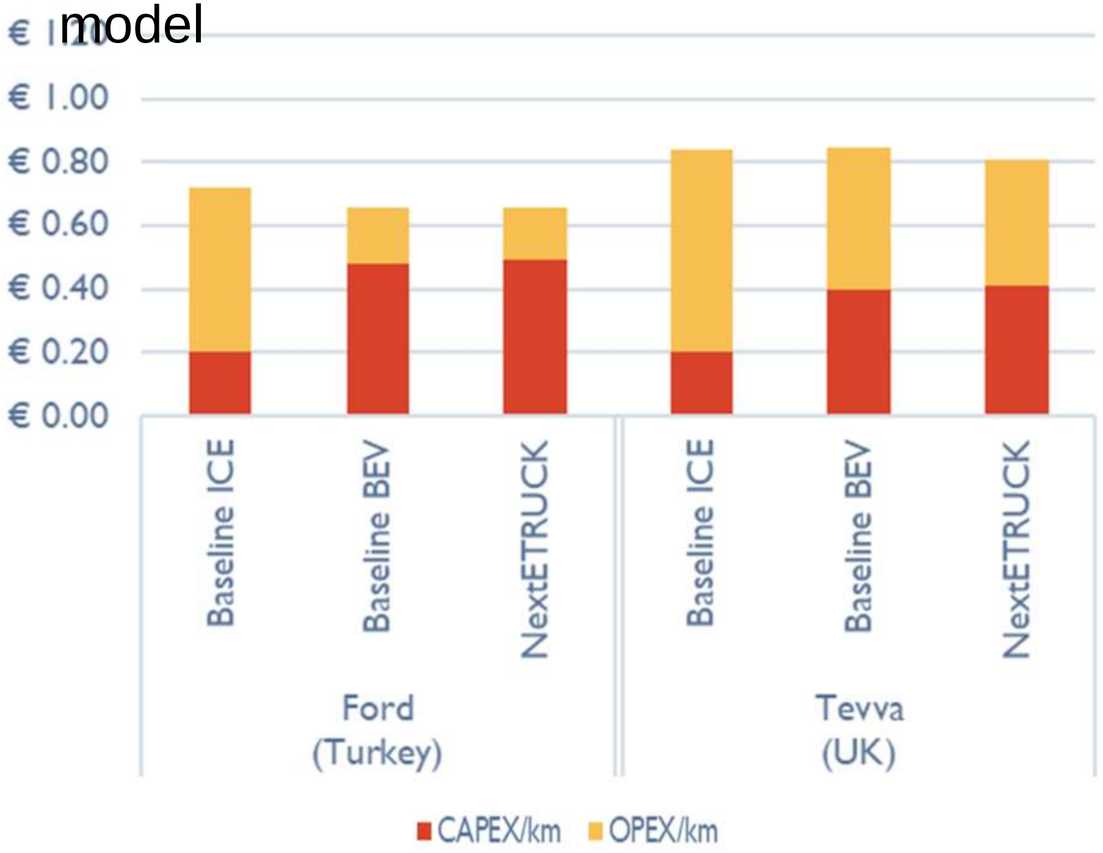
FMUs and Whole Vehicle projects

Big Picture

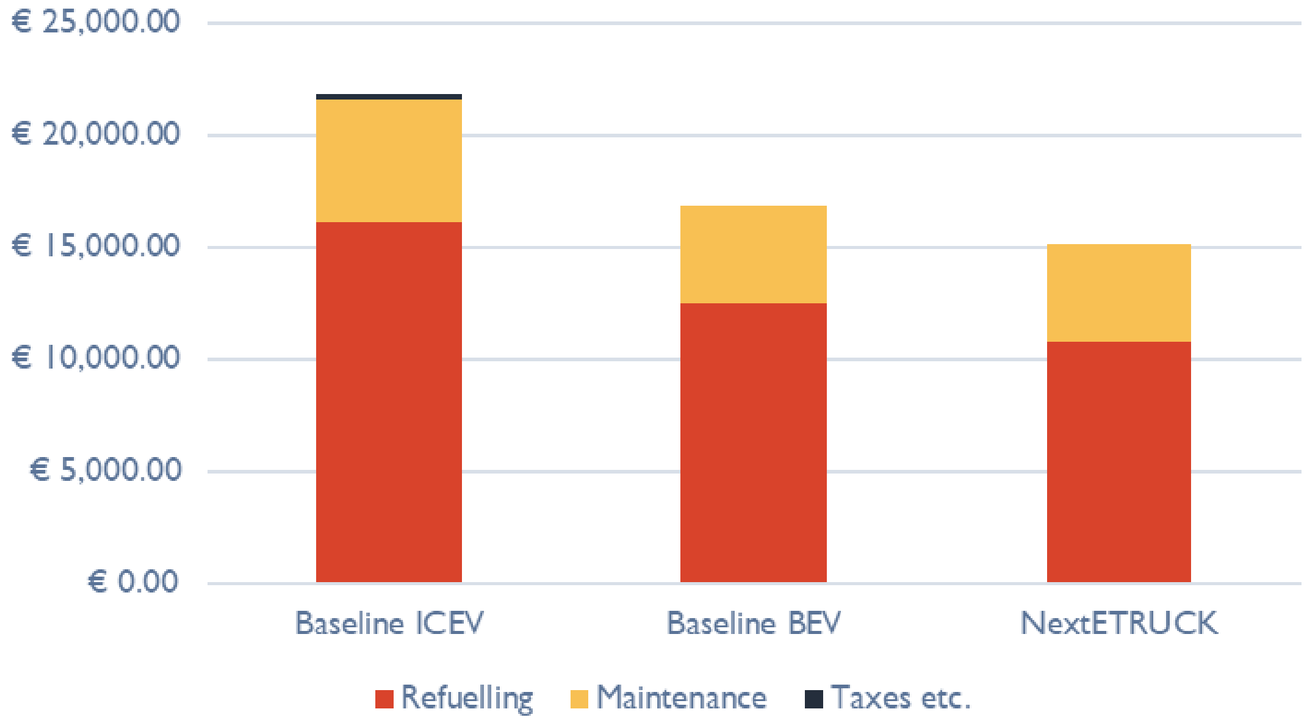

FAST
Digital Twin:
DT Energy Consump. Charact. (AVL)
DT Multi-Level Ctrl Sys. Opt. (TEC)
DT Battery Age (TNO)
DT Charge Time Est. (TNO)
Charge Manag. Platform (PANION)
Logistics Planner & Mission Assignm. (CERTH)
Modular IoT & Fleet Manag. (DATIK)
Traffic Flow Info, Routing & Content (NNG)
Real time
Digital Twin:
DT Cooling Sys. Model (AVL-D)
DT Veh Cabin & HVAC (AIT)
DT Eco-Driv. Feedback w/ HVAC (VUB)
Virtual Vehicle (VUB)
BMS & HVB LF Model (CID)
Optimized (logistic) decisions for the near future
Actual conditions
Real, physical Vehicle
CHARGE INFRASTRUCTURE (JEMA)
Physical Systems

Results for Design Optimization of BEV Trucks

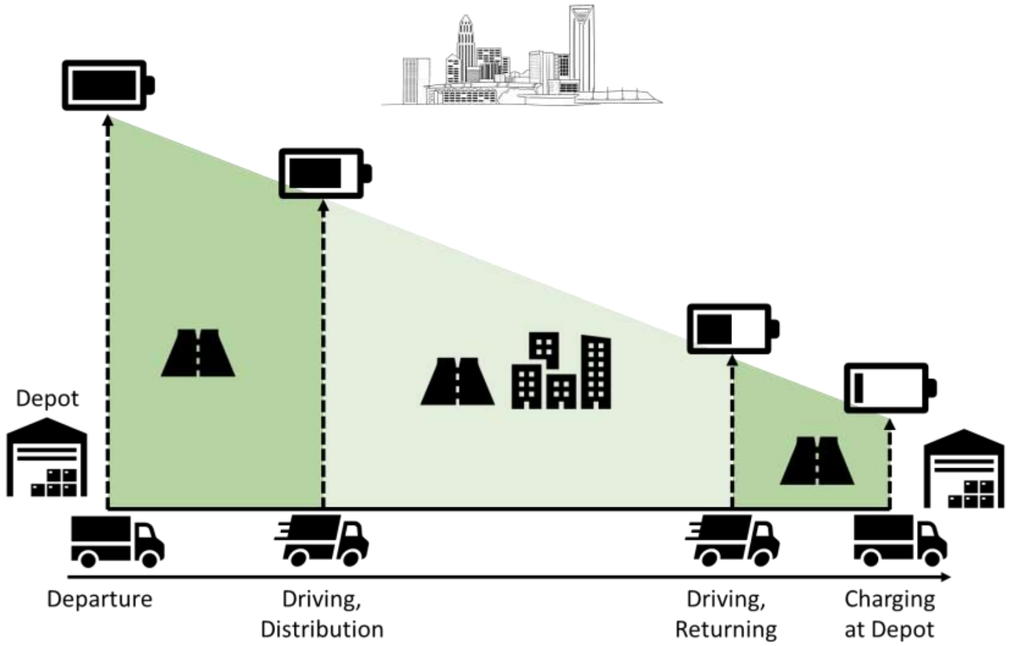
TCO per km for the generic 16-ton truck model



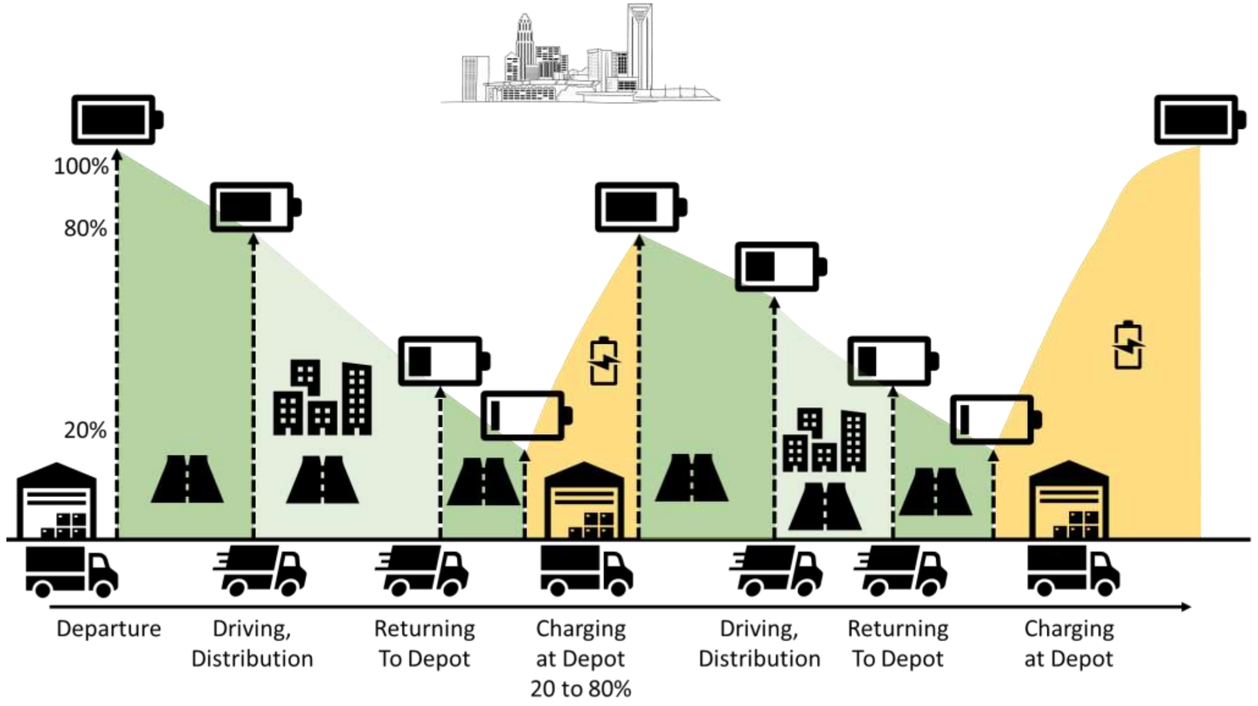
OPEX breakdown



Charging strategy and Planning



a) Charging strategy when the truck drives from and to a depot with deliveries in between, without requiring a charging stop in the day.



b) Charging strategy when the truck requires to have charging stops in the day to ensure the operations can take place during the day.

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