Advancing Automated Driving Development at Torc with Model-Based Systems Engineering

2023-10-18 Marcus Liebhardt

TORC

Abstract

Highly Automated Driving Systems are complex and safety critical. The latter is particularly important in the application to trucking. The industry addresses these challenges with a range of best practices, which, however, often require significant efforts. Model-Based Systems Engineering offers several advantages which reduce these efforts, thereby boosting the development and application of highly automated driving systems.

Agenda

- Introduction
- Automated Driving & MBSE
- MBSE Benefits

TORC

Introduction

About the Presenter, Torc and our Mission

Presenter

Marcus Liebhardt

- Heading one of Torc's Systems Engineering teams focusing on describing the complete **vehicle behavior** and its interaction with the environment, actors & external systems.
- Spearheaded introduction of MBSE
- Biography
  - Passionate autonomous systems enabler equipped with a Control, Software and Systems Engineering background, experience in start-ups, SMEs and large corporates in Europe and Asia, applications in R&D, elderly care, and last-mile logistics, and a strong focus on product; most recently advancing Torc’s development of automated driving for the trucking industry with the help of Model-Based Systems Engineering

ABOUT TORC

Torc Robotics (**Torc**) is a leader in autonomous vehicle development. In 2019, Torc became an independent subsidiary of Daimler Truck AG, the global leader and pioneer in trucking.

WHAT WE DO

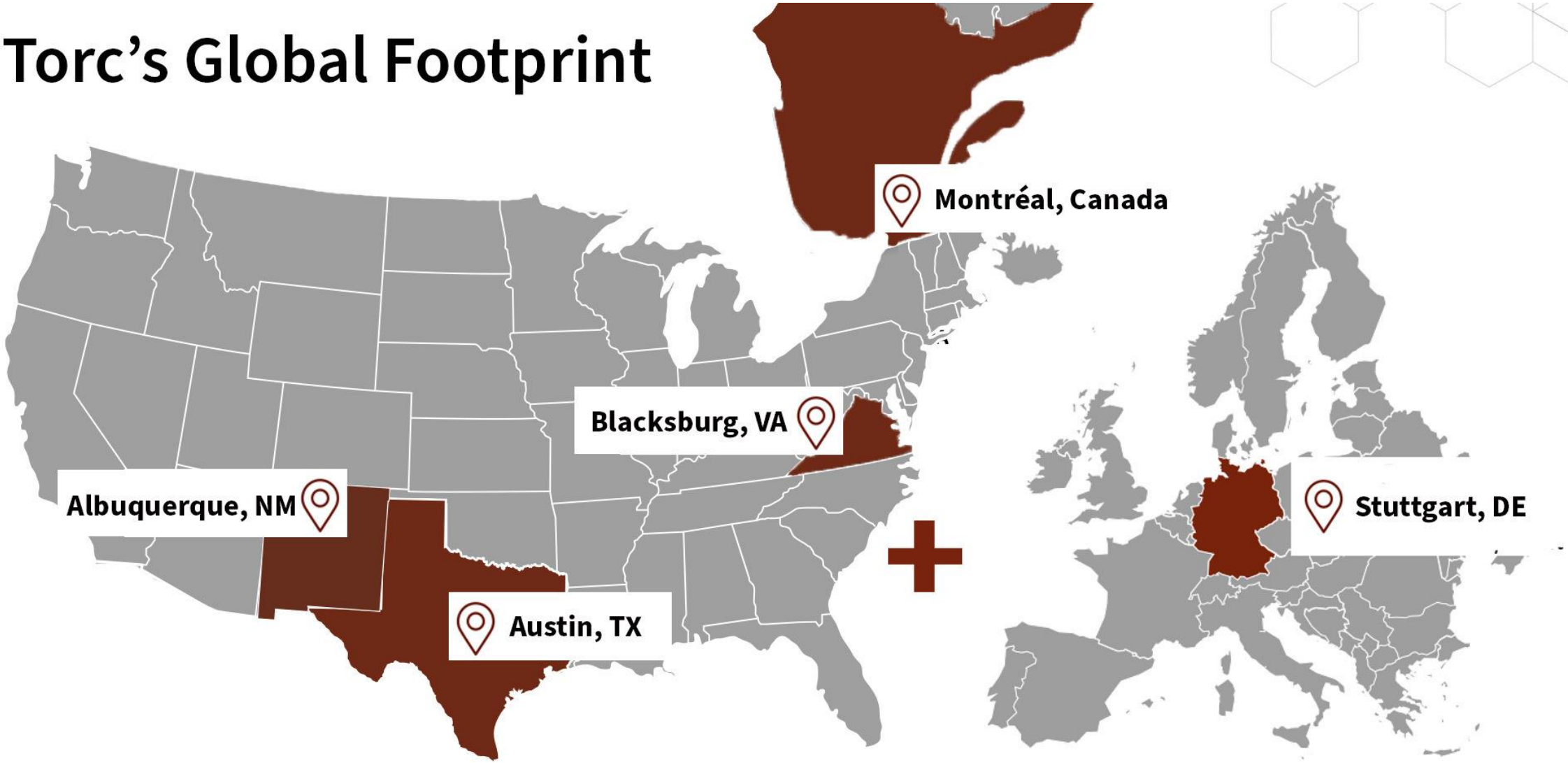
Torc is focused on commercializing Level 4 **autonomous** trucks for long-haul **trucking.**

We believe this approach will make us the first company to deliver a profitable solution at scale.

OUR TIMELINE

We are driving the future of freight, and safety dictates our timeline. For autonomous trucks to be widely adopted, they must be safe, economically viable for major fleets, and produced and maintained at scale. Torc is working on all three. Our safety protocols, data, testing, and product roadmap indicate product launch in 2026, with scalable market entry in 2027.

Torc's Global Footprint



Automated Driving & MBSE

Applying Model-Based Systems Engineering to Automated Driving

Providing a seamless autonomous ecosystem

DAIMLER TRUCK

Redundant Chassis "Autonomy Ready Cascadia"

AD Kit Integration

+

TORC®

Virtual Driver

AD Kit Specification

AD Software

Mission Control

Channel to interact with Virtual Drivers

Lifecycle Management

System to manage Software Maintenance

+

Customer / Partner

Operation

Operations of Mission Control

DAIMLER TRUCK

Maintenance & Services

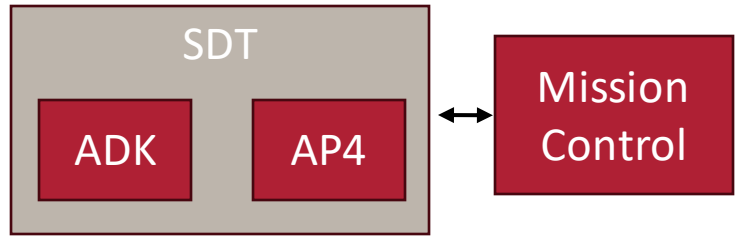
Roadside Assistance

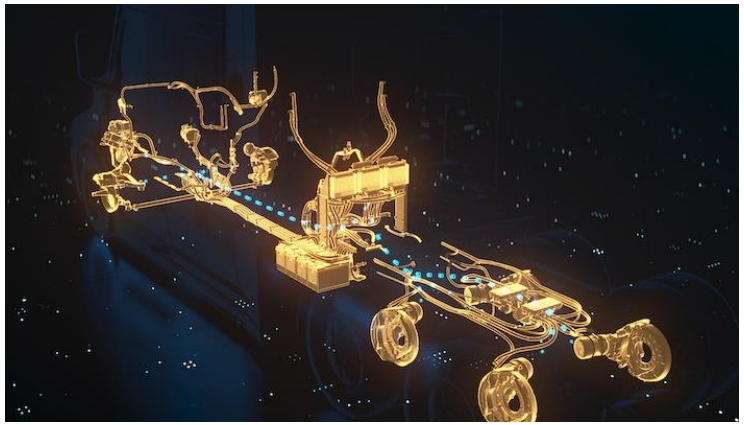
Transfer Terminal

MBSE @ Torc

Systems Engineering at Torc

- Responsible for describing the self-driving truck (SDT) & supporting external systems, e.g. Mission Control
- Driven by inputs from Product Management defining the product and capturing the needs of customers, users and supporting partners
- Designs system architecture & decomposes requirements to component level
  - Focuses on the automated driving system (AD Kit, ADK)
    - Contains all hardware and software to perform all of the dynamic driving task
  - Produces Requirements for
    - In-house development of the application software
    - Redundant chassis (AP4) developed by Daimler Truck North America
    - Hardware (ECUs, sensors etc.) and middleware developed by partners
- Works hand-in-hand with testing (verification & system integration)

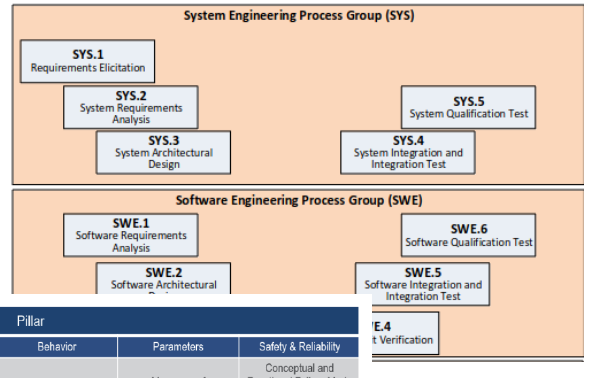




MBSE @ Torc

Relevant Processes, Methods & Tools

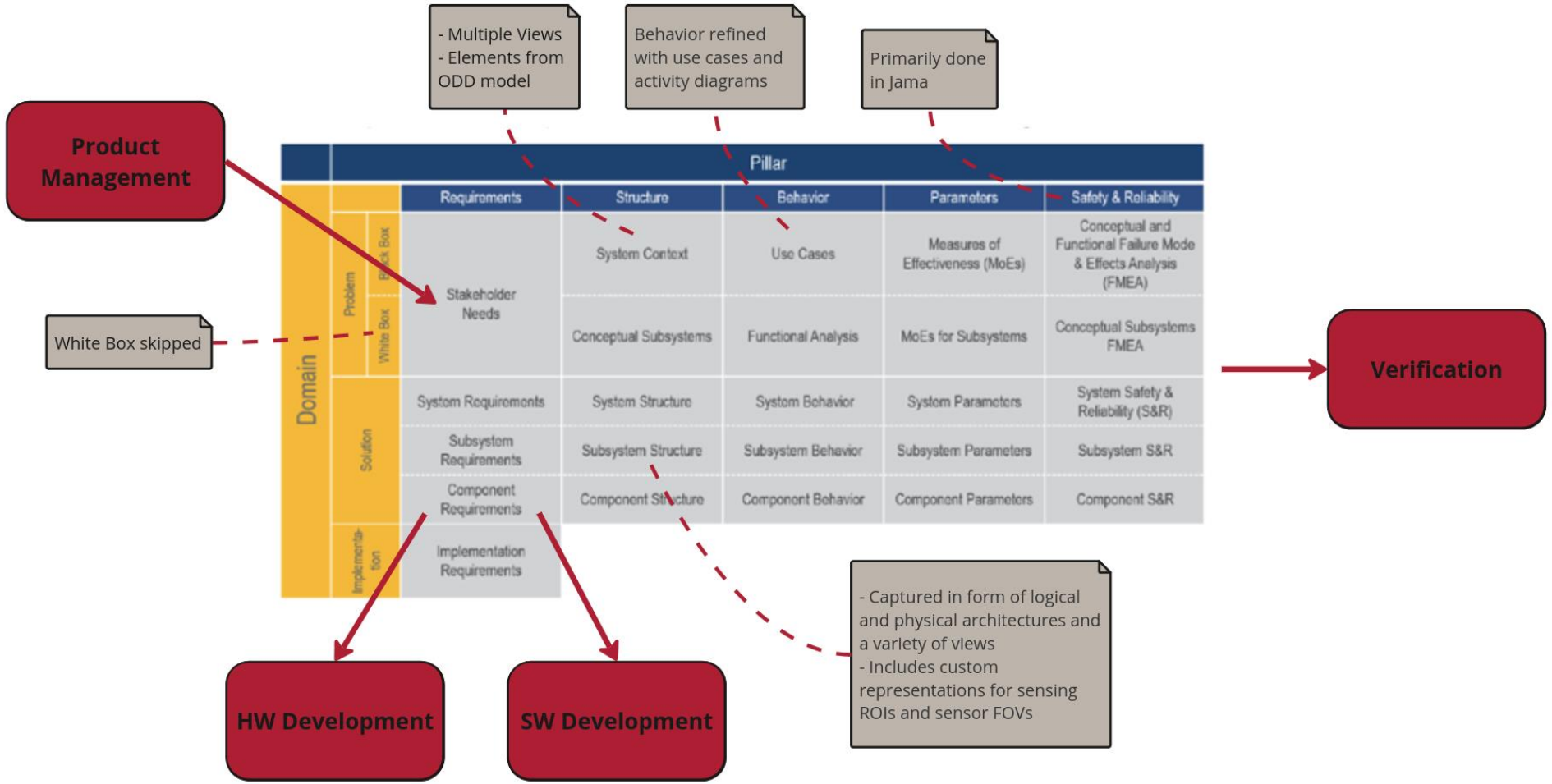
- Processes
  - ASPICE
  - ISO 15288 Systems and Software Engineering
  - ISO 26262 Functional Safety
  - ISO 21448 Safety Of The Intended Functionality
  - ISO 21434 Cyber Security
- Methods
  - Customized Magic Grid
- Tools
  - JAMA (Requirements Management)
  - Cameo (Modeling of system behavior, structure & parameters)
  - And more to support development
    - E.g. ideation (Miro, Confluence), task tracking (JIRA) etc.



		Pillar				
Domain		Requirements	Structure	Behavior	Parameters	Safety & Reliability
Problem	Black Box	Stakeholder Needs	System Context	Use Cases	Measures of Effectiveness (MoEs)	Conceptual and Functional Failure Mode & Effects Analysis (FMEA)
Problem	White Box	Stakeholder Needs	Conceptual Subsystems	Functional Analysis	MoEs for Subsystems	Conceptual Subsystems FMEA
Solution		System Requirements	System Structure	System Behavior	System Parameters	System Safety & Reliability (S&R)
Solution		Subsystem Requirements	Subsystem Structure	Subsystem Behavior	Subsystem Parameters	Subsystem S&R
Solution		Component Requirements	Component Structure	Component Behavior	Component Parameters	Component S&R
Implementation		Implementation Requirements				

MBSE @ Torc

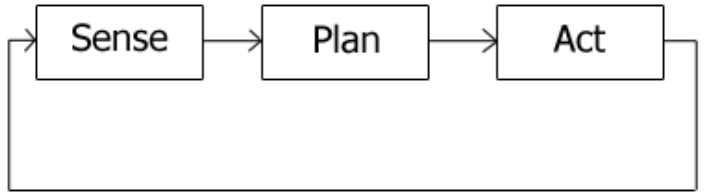
Customized MagicGrid Approach



Automated Driving

Challenges

- Not only complicated, but **complex**
  - Evolution of existing technology + revolution to address yet unsolved problems
  - Single large control loop
    - Most functions & system elements influence each other



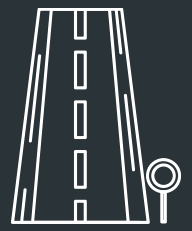
- Safety critical
  - Consistency & traceability are key

MBSE Benefits

Leveraging Model-Based Systems Engineering

Benefits

Fosters Understanding



Reduces cost & time-to-market

Improves Traceability & Consistency

Fosters understanding

Important for complex systems

Improves traceability & consistency

Essential for safety-critical systems

Reduces cost & time-to-market

Valuable for all projects

Benefits created by **Modeling, SysML, Cameo & MagicGrid**

MBSE Benefits

Modeling & SysML

- Fosters understanding
  - Visual and parametric representations more intuitive and less prone to interpretation errors
  - Additional information captured through relationships
  - Detailed definition of behavior and structure and their decomposition
  - (Semi-)Formalized approach recommended for safety-critical systems (ASIL-D)
- Traceability and consistency
  - Multiple views on the same elements
  - Relationships between all elements
  - Single-source of truth
- Reduces cost & time-to-market
  - Allows re-use of elements (e.g. functions, requirements)
  - Fosters efficient function allocation

MagicGrid & Cameo Systems Modeler

- MagicGrid
  - Systematic approach
  - Well described framework with a significant user base
    - Eases adoption and further development
  - Straightforward approach addressing many needs
  - Customizable to address special cases and gaps
  - Eases usage of SysML and correct application
- Cameo
  - Enables traceability across all elements
  - Fosters collaboration
    - Collaborative design (Cameo + TWC)
    - Reviews (Collaborator)
  - Supports large user base

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	Implementation		Implementation Requirements				

Outlook

More Opportunities

- Simulation (Cameo Simulation Toolkit)
  - Foster system behavior understanding
  - Identify model deficiencies early
- Code generation
  - E.g. interface generation
- Improve integration with external tools
  - E.g. requirements synchronization and traceability with Jama
- Metrics
  - E.g. generate and monitor key Safety Performance Indicators

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