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Development and Deployment of Virtual Test Systems

An enabler to faster and efficient vehicle development

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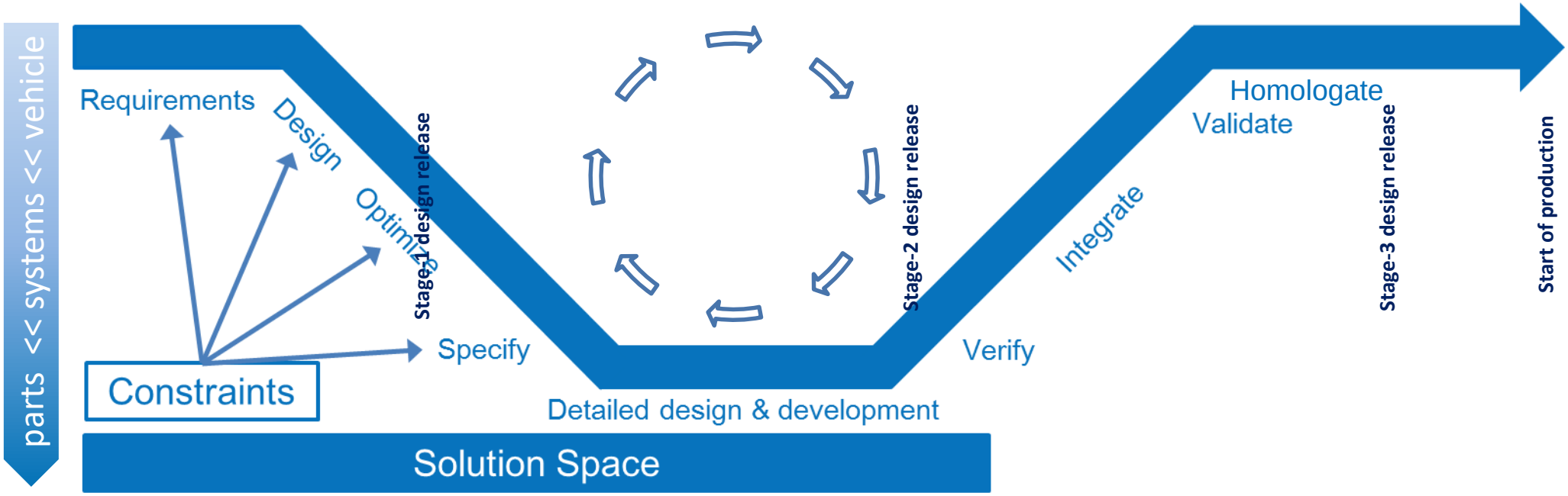
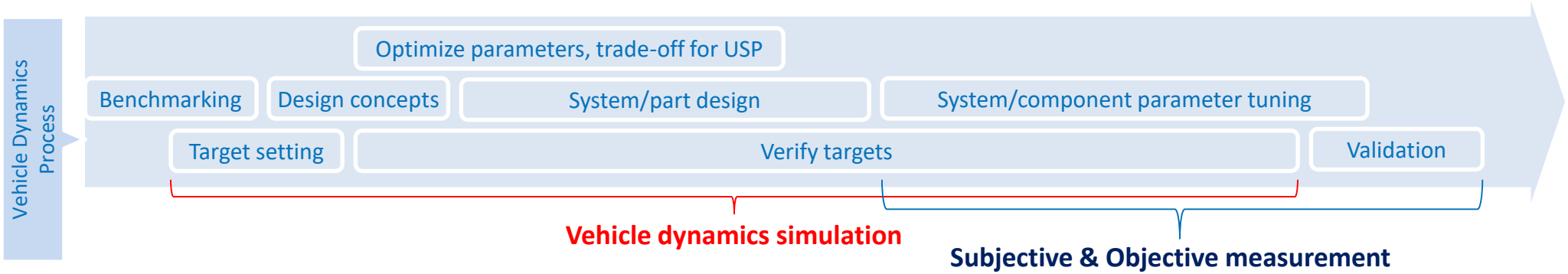
Contents

Objective

- Develop and deploy the methodology of virtual testing for vehicle dynamics.
- The new system to be parametric, capable to predict key parameters of interest to vehicle dynamics analyses.
- Adept in sustainable utilization through the life cycle of vehicle and enable optimization & automated testing.

Vehicle development and engineering the vehicle dynamics - process





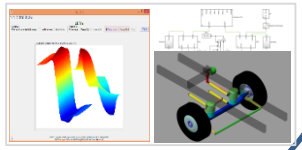
Vehicle dynamics simulation process

Vehicle data

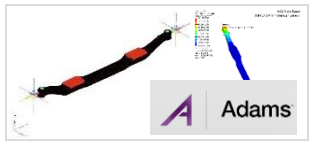
Vehicle model

trucksim MECHANICAL SIMULATION

Models/Methods



Part/system data



Tests and Maneuvers

- Ride Tests
- Handling Tests
- Transient Response Tests
- Stability Tests …

Safety

Vehicle characteristics -

Feel & Response

Overview of testing for vehicle dynamics simulation and its inputs

- Apart from development and tuning tests of vehicle, specific rig tests of vehicle and its systems are needed for useful vehicle dynamic simulations.
- Traditionally this tests are done with huge special purpose machines.
- A complete physical vehicle is loaded on the machine. Depending on the type of machine either all the tires or vehicle chassis are fixed to ground.
- Depending on the type of fixing(tires or chassis), 3-directional load and torque is applied in defined sequences.
- Forces, moments and deflections are measured at various points in the vehicle and vehicle systems to generate required parameters.

An effective TruckSIM model needs to have significant parameters for useful results

Axle dive: Dive table
No Caster Change

Axle X movement: Longitudinal Movement
No movement (R = 0)

Axle Y movement - jounce: Lateral Movement
No movement

Axle Y movement - roll: Lateral Movement
Roll Center: 53 mm Below Axle

Compliance Coefficients

	Left	Right	
Toe vs Fx:	0	0	deg/N
Steer vs Fy:	0	0	deg/N
Steer vs Mz:	0	0	deg/(N-m)
Camber vs Fx:	0	0	deg/N
Inclination vs Fy:	0	0	deg/N
Inclination vs Mz:	0	0	deg/(N-m)

Axle longitudinal vs Fx	0	mm/N
Axle lateral vs Fy	0	mm/N

Kinematic Properties

Nominal steering gear ratio: xx deg/deg

Speed Effect: Steer Gain vs. Speed
Always Steered

Define steer angles in vehicle coordinates

Left Wheel Kinematics: Steering kinematics
Left Wheel, 5 m Wheelbase

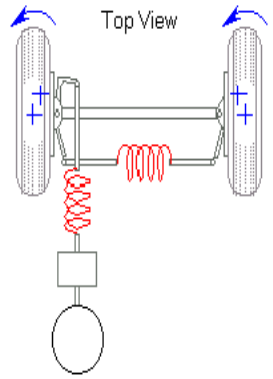
Right Wheel Kinematics: Steering kinematics
Right Wheel, 5 m Wheelbase

Ground-Friction Low-Speed Steer Torque

Left Side: Parking Torque
Zero

Right Side: Parking Torque
Zero

Steering Compliance

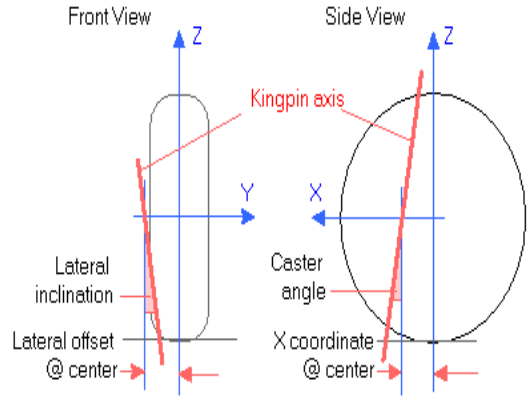


Steer left wheel

Tie rod compliance: right-wheel steer relative to left wheel due to right-wheel kingpin moment: xx deg/N-m

Steering column compliance: steer of both wheels due to kingpin moments on both wheels: xx deg/N-m

Kingpin Geometry



Axle Interactions

Axle wrap compliance:	xx	deg/N-m
Ratio: steer / wrap:	xx	deg/deg
Wheel steer vs. axle jounce:	xx	deg/mm

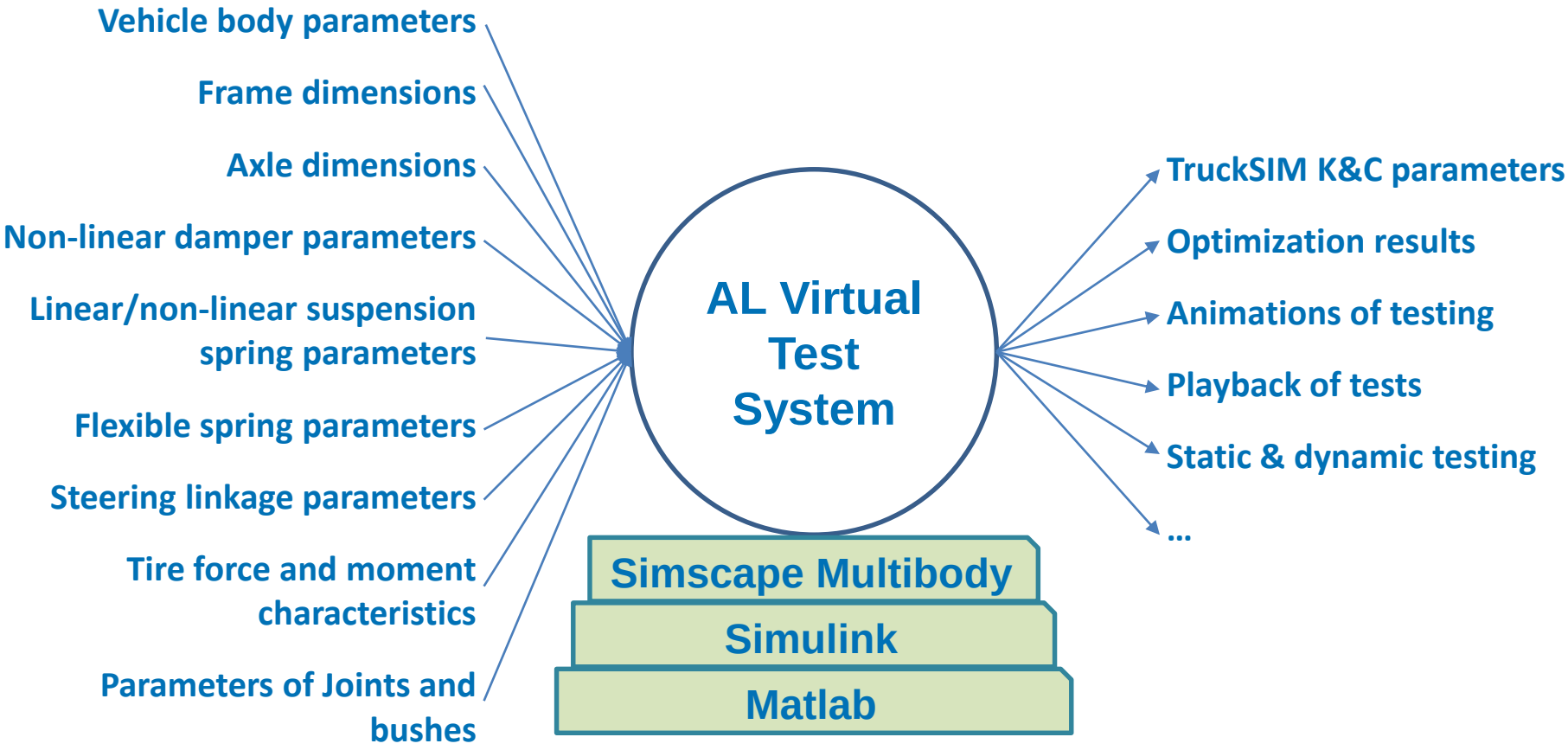
	Left	Right	
Lateral offset @ center:	xx	xx	mm
Lateral inclination:	xx	xx	deg
X coordinate @ center:	xx	xx	mm
Caster angle:	xx	xx	deg

Status quo and challenges

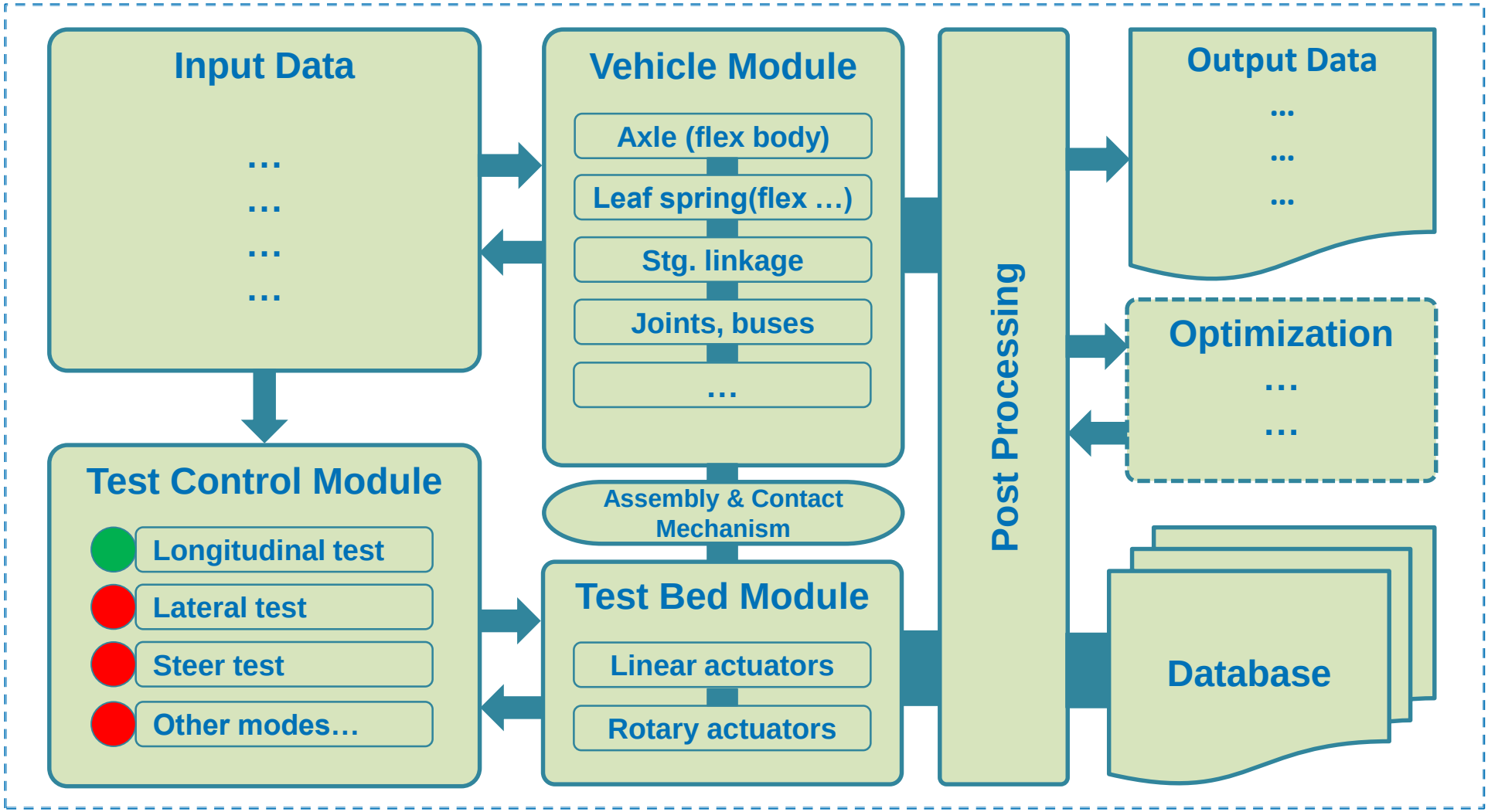
- Specialized vehicle dynamics test rigs for heavy trucks and buses are rare, globally.
- Building specialized rig (for vehicle dynamics parameter measurement) for heavy commercial vehicle is economically unviable due to huge capital, time and less than optimum facility utilization for single OEM.
- Commercial virtual test systems specifically for truck & bus configurations are not yet mature.
- Multibody simulations with existing commercial tools need expertise, detailed vehicle model and relatively more time apart from computationally expensive.
- There is need for seamless integration of virtual test system simulation and truckSIM simulations for faster throughput.
- Current scenario of vehicle development demands hundreds of vehicle configurations to be designed to deliver preset vehicle dynamics performance target.
- In upfront simulations and design tuning, the importance of correct parameters input can’t be overstated.

Approach to virtual test system

- Physical modelling using simscape ‘Multibody’ methodology is made use for the development of virtual test system.

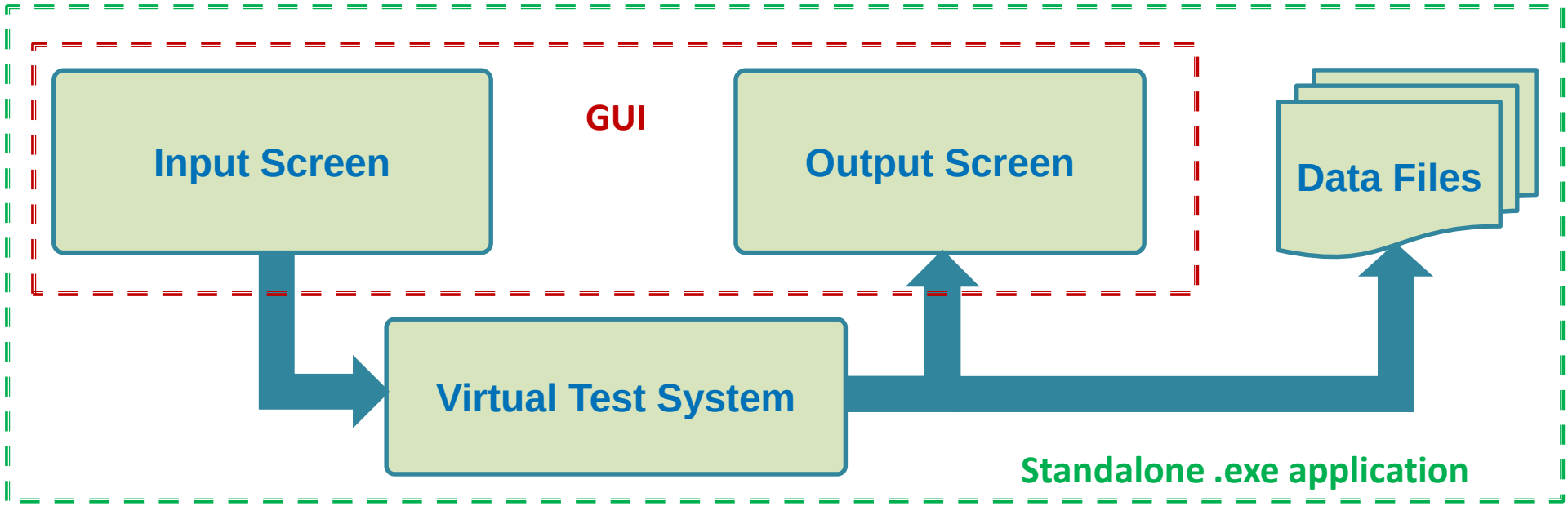


Virtual test system workflow

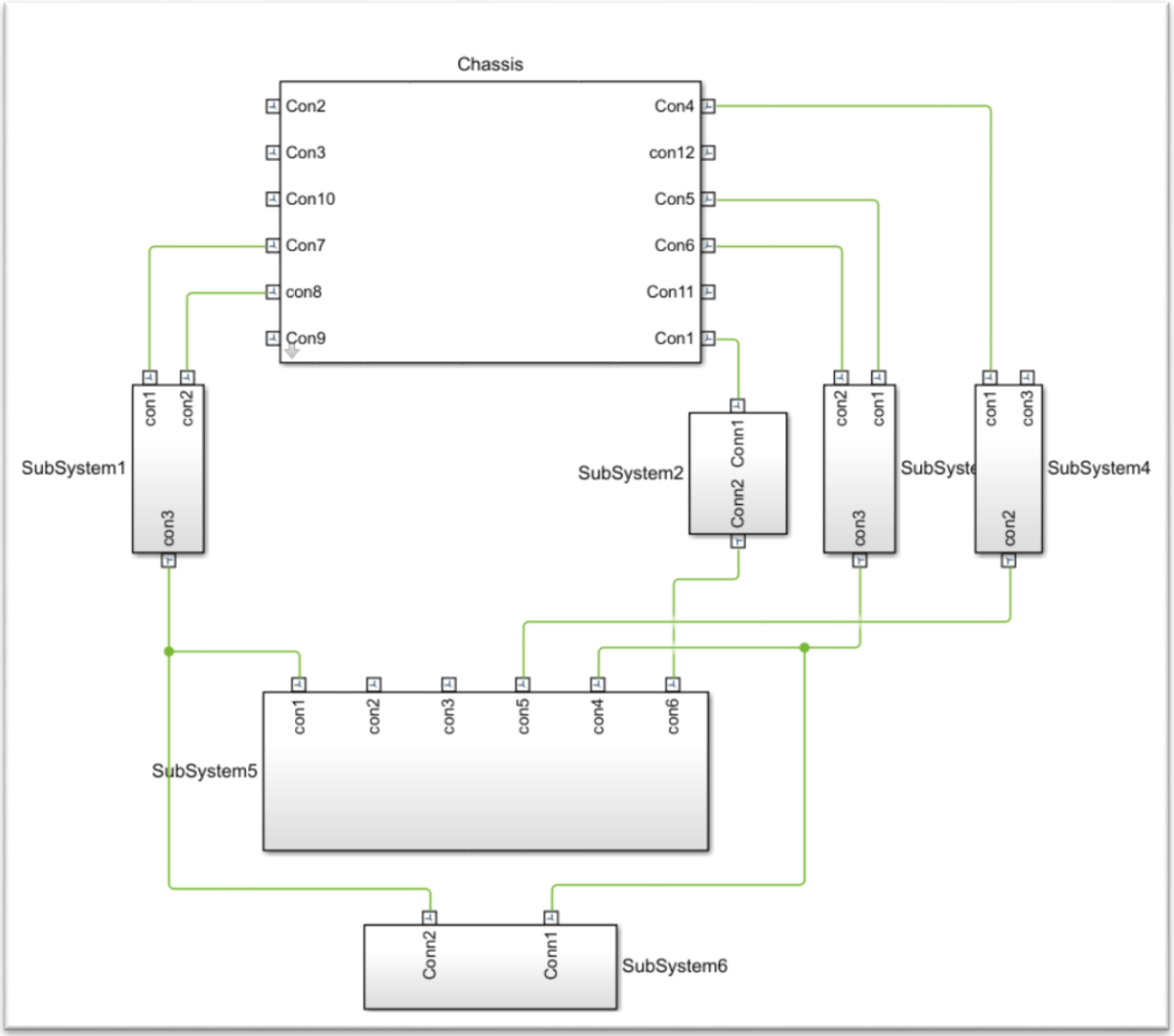


Deployment to user group

- Virtual test system developed in simscape toolboxes are being converted to standalone executables with suitable GUI using MATLAB and Simulink coder tool boxes.
- Such standalone .exe files installed in different user PCs enable various pre-defined tests be performed by vehicle dynamics engineers.
- Thus, wide use of virtual test system by domain engineers for various vehicle projects result in effective upfront engineering.



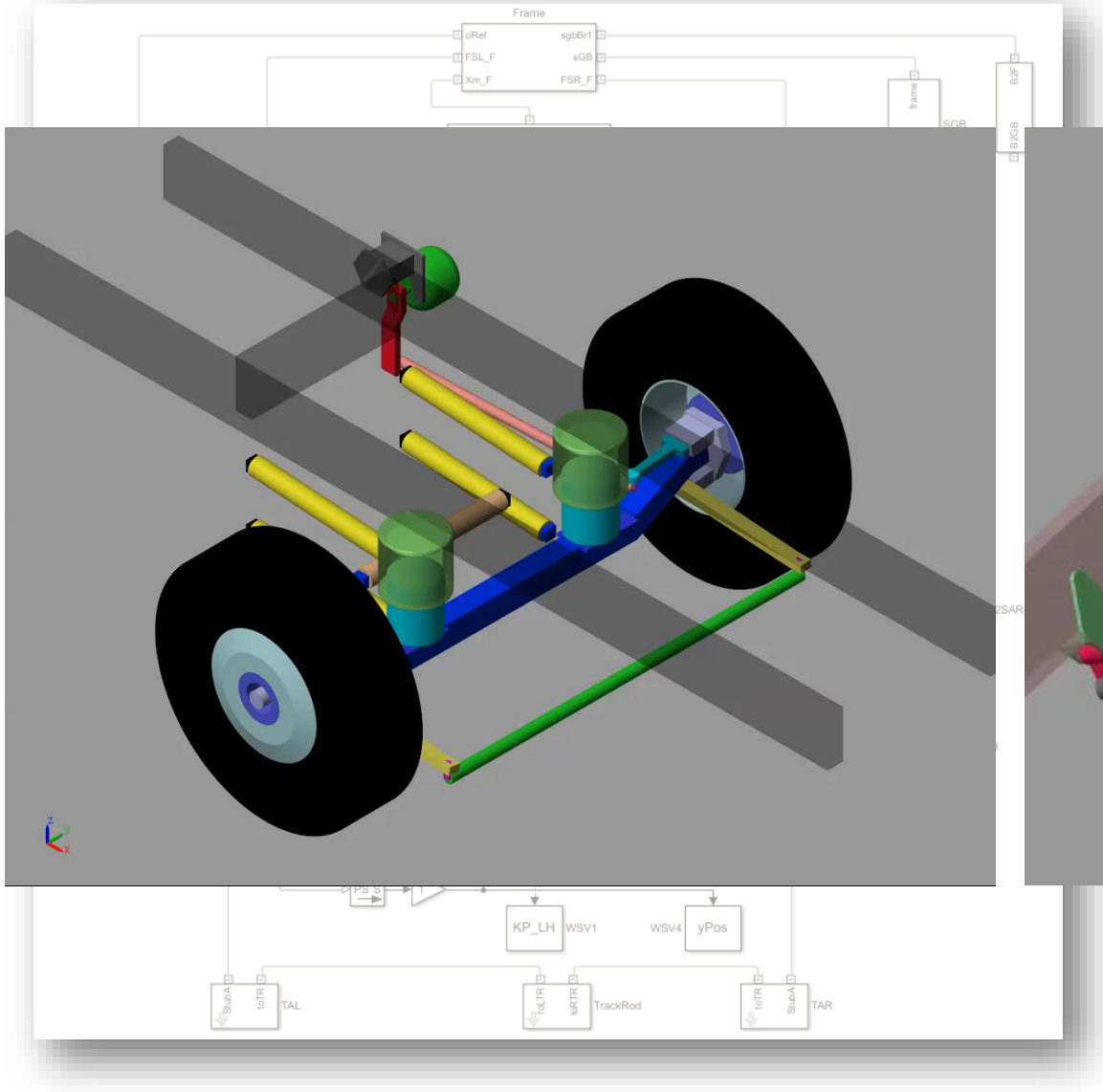
The solution: Virtual test system by simscape multibody

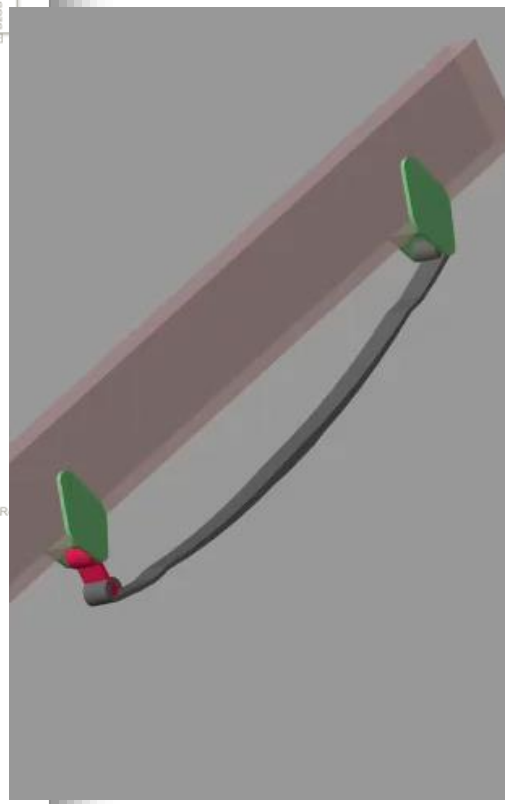


The solution: Virtual testing by simscape multibody…

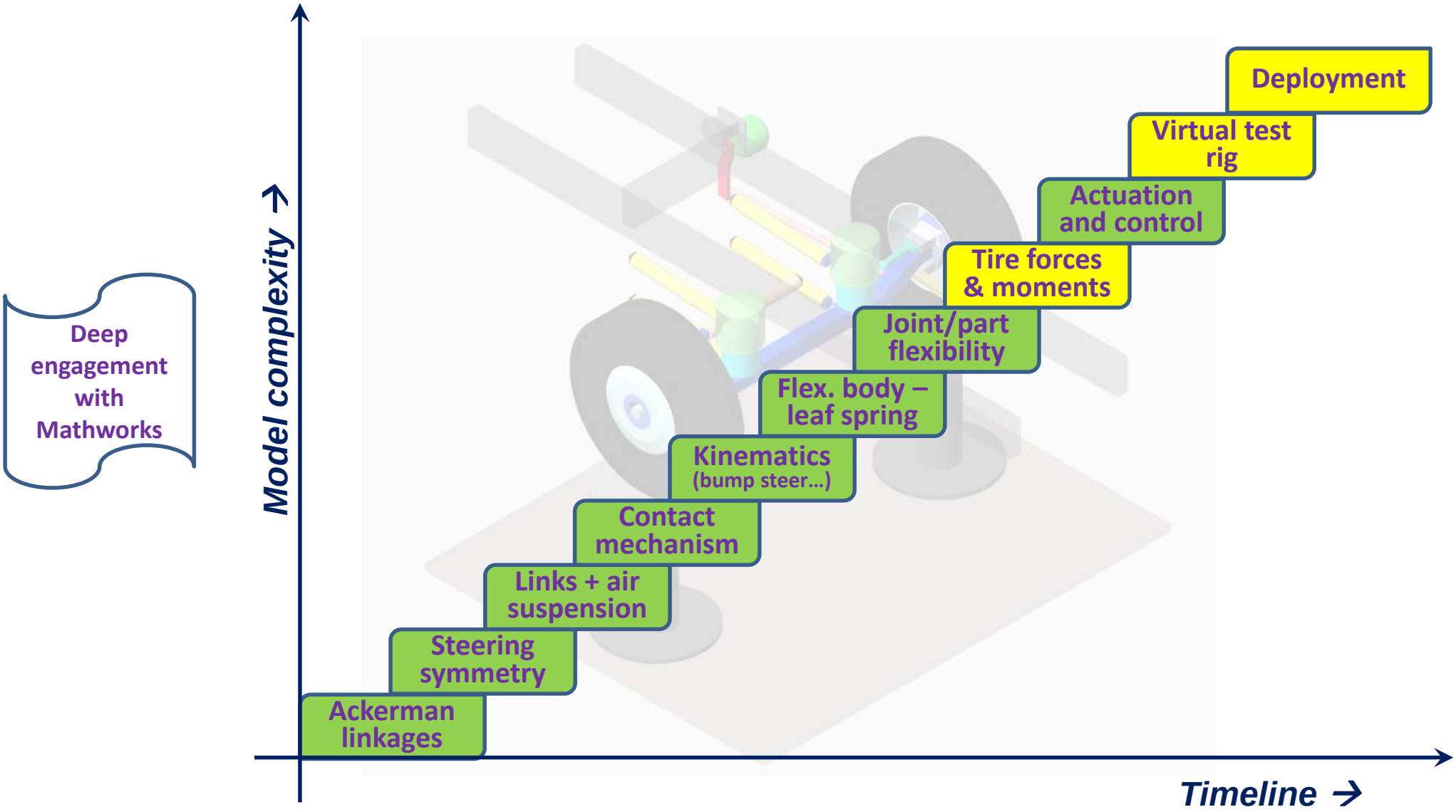
Features

- ✓ **Parametric model & less no. inputs**
- ✓ **Design optimization**
- ✓ **Scalable (2Axle, 3Axle, 4Axle, 5Axle trucks & buses…)**
- ✓ **Variants in minutes**
- ✓ **Models inertia, joint friction, stiffness…**
- ✓ **Highly customizable**
- ✓ **100% In-house (No-license fee)**





The solution:….Modular virtual testing system delivering needs of system design



The benefits

- No capital investment, faster throughput
- Analyze hundreds of vehicle configurations otherwise not feasible
- Effective target cascading and efficient target verification
- Aids what-if: throughout the development life - concept to production.
- Effective optimization and co-simulation
- Enables virtual testing of futuristic products/technologies.
- Results in effective trouble shooting of issues and possible solutions matrix.

Thank you!