Functional Development Process of the

electric Anti-Roll-Stabilizer eARS

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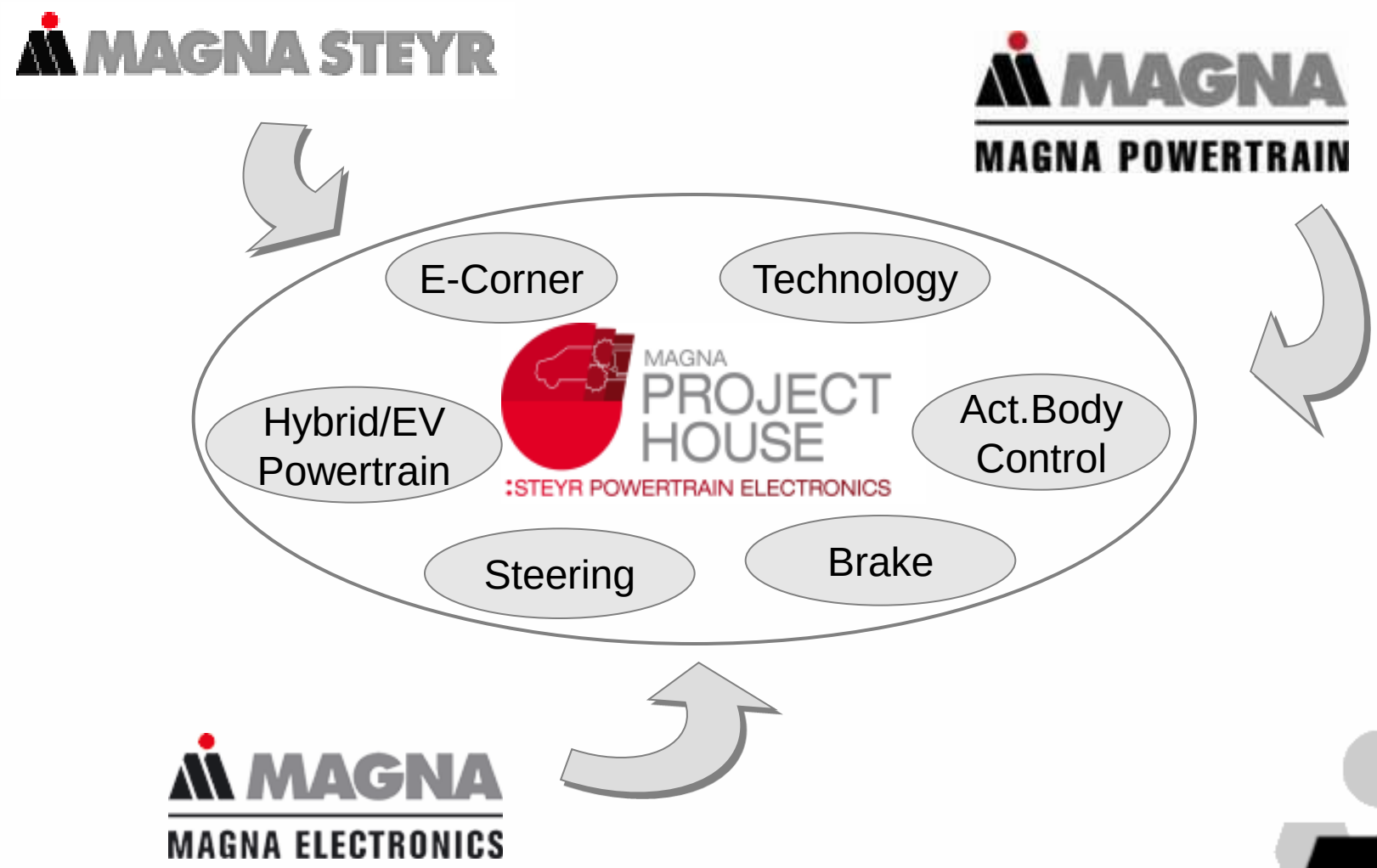
MAGNA PROJECT HOUSE
:STEYR POWERTRAIN ELECTRONICS

AGENDA

- Introduction Magna Project House
- Functional Development Process
- General System Overview
- Vehicle Dynamics Control & Simulation
- Component Design and System Simulation
- Component Test Bench
- Conclusion & Outlook

PROJECT HOUSE – Functional Areas



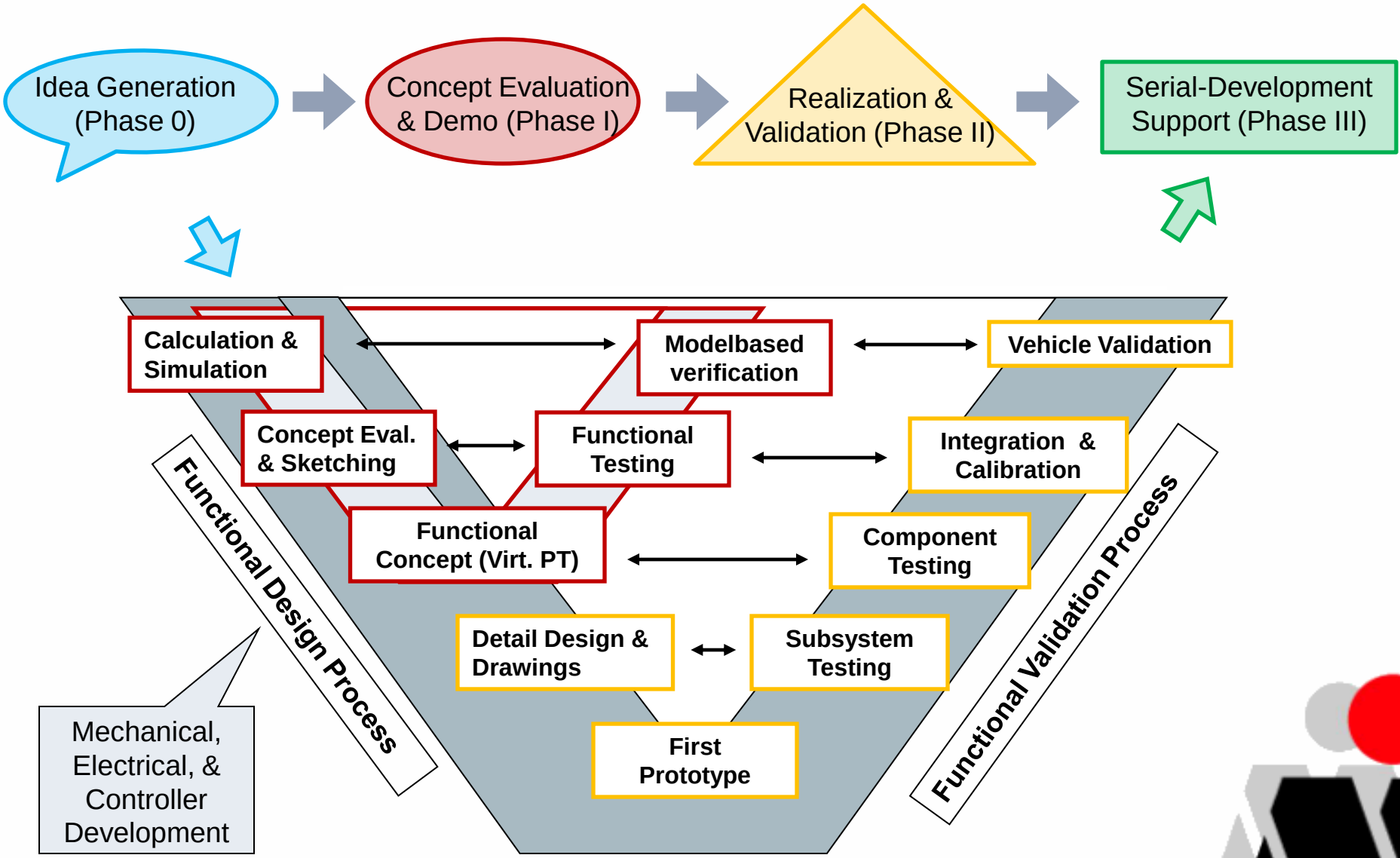
PROJECT HOUSE – Main Goals

- **The Project House is a cooperation of Magna Steyr, Magna Powertrain and Magna Electronics.**

- **Goals**
  - Identification of new products for the participating Magna groups
  - Pre-development of prioritized projects
  - Design and assembly of the first prototypes
  - Concept proof

  After concept proof, the Project House will hand-over the product to the MAGNA group, which will do the serial development and production of this product.

Functional Development PH



Idea Generation – Customer-Oriented Chassis Development

Idea Generation (Phase 0)

Customer Requirements / Brand Philosophy

- Ride comfort, driving safety, handling
- Costs, Package
- Environmental friendly, CO_2 Reduction, Weight

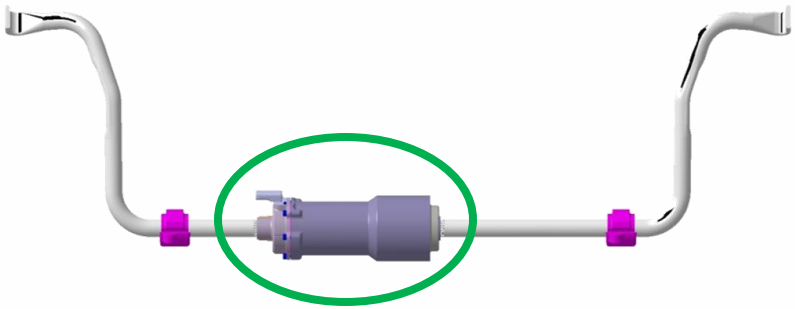
Vehicle Dynamics / Vehicle Requirements

- Roll angle control, yaw behavior control: over- / understeering
- Package requirements, same parts, 12V on-board electrical system
- Less energy consumption, weight

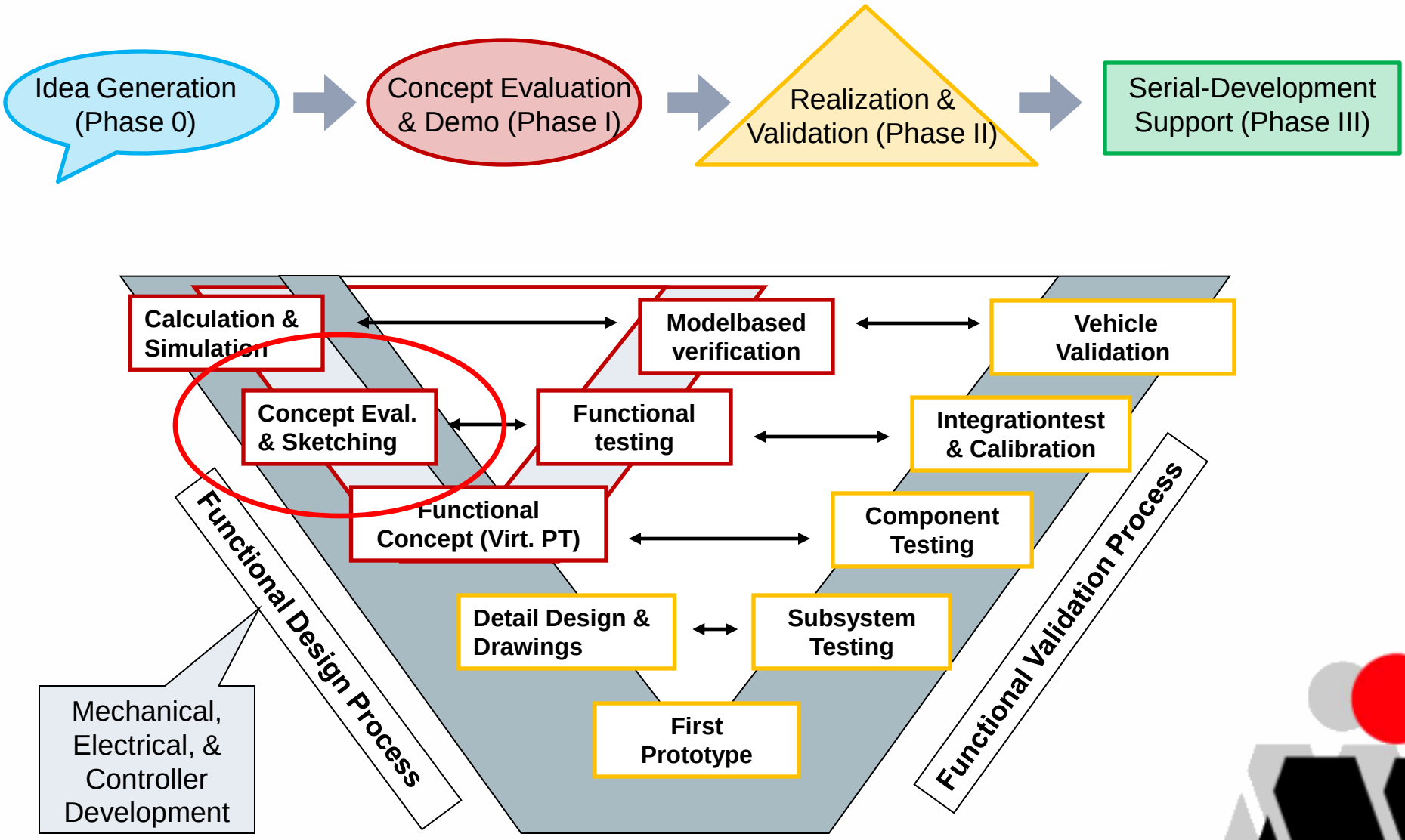
Component Specifications

- Full active suspension control
- Anti-Roll-Stabilizer

electric



Concept Evaluation



Concept Evaluation

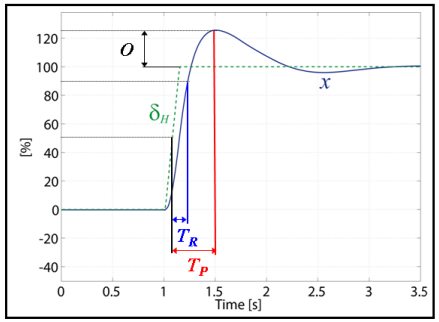
Requirement specification
- Max. Torque
- Dynamics
- Energy consumption

Benchmark
OEM Specifications
Full Vehicle Simulation

Concept Evaluation & Demo (Phase I)

Validation
- Component based
- Full vehicle based

Tast cases
Driving maneuvres
MAGNA rating matrix



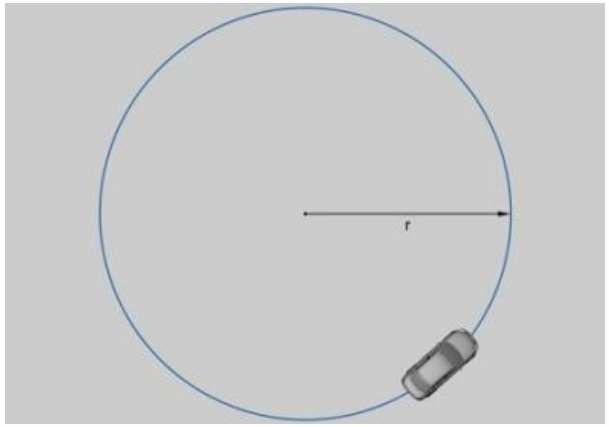
results in

Optimized + verified Concept
- Hardware (e.g. active stabilizer)
- Software (Functional SW & VDC Controller)

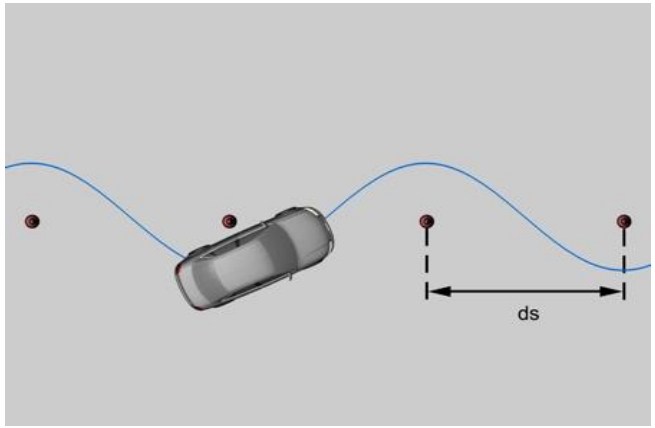
eARS VDC Simulation

- Simulation Environment: TESIS veDYNA
- Vehicle: SUV R6 2.5 Otto
- Active Vehicle: Active Roll Control
- Active Stabilizer Torque Distribution
- veDYNA driver

Concept Evaluation & Demo (Phase I)



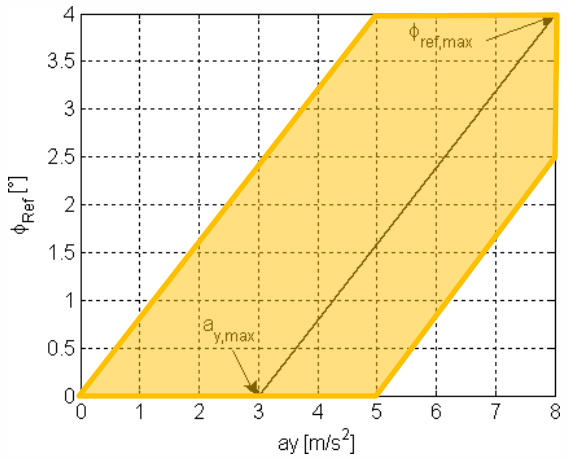
Steady State Cornering

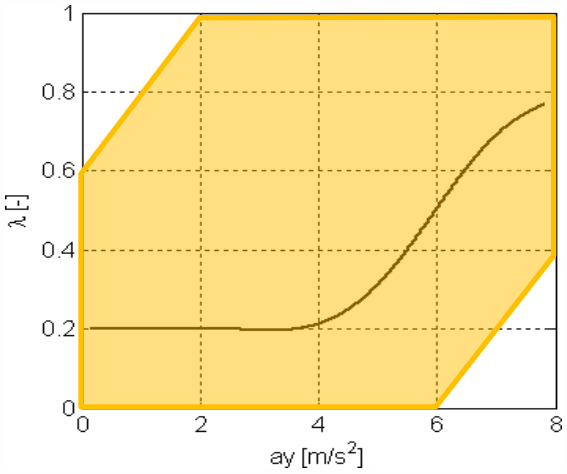


Slalom

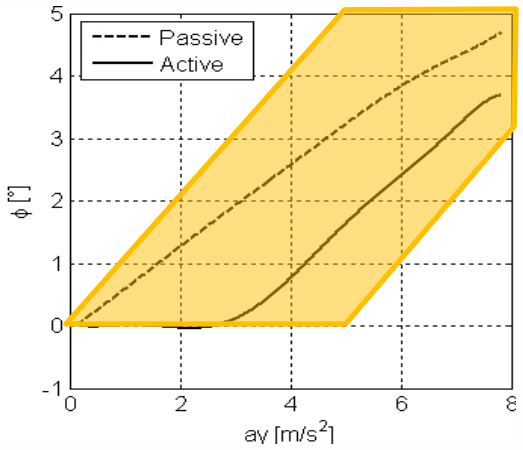
eARS VDC Simulation – Steady State Cornering

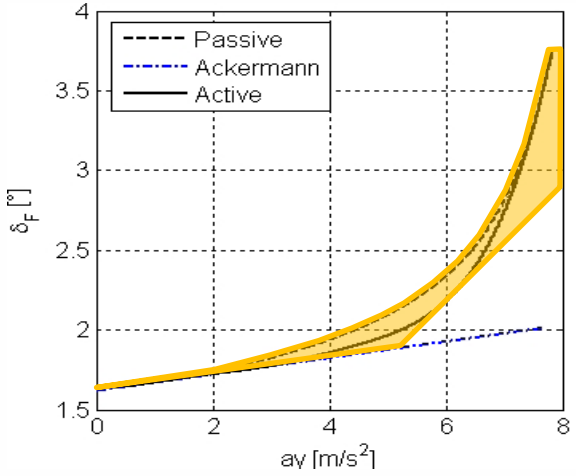
Reference Values:





Results:





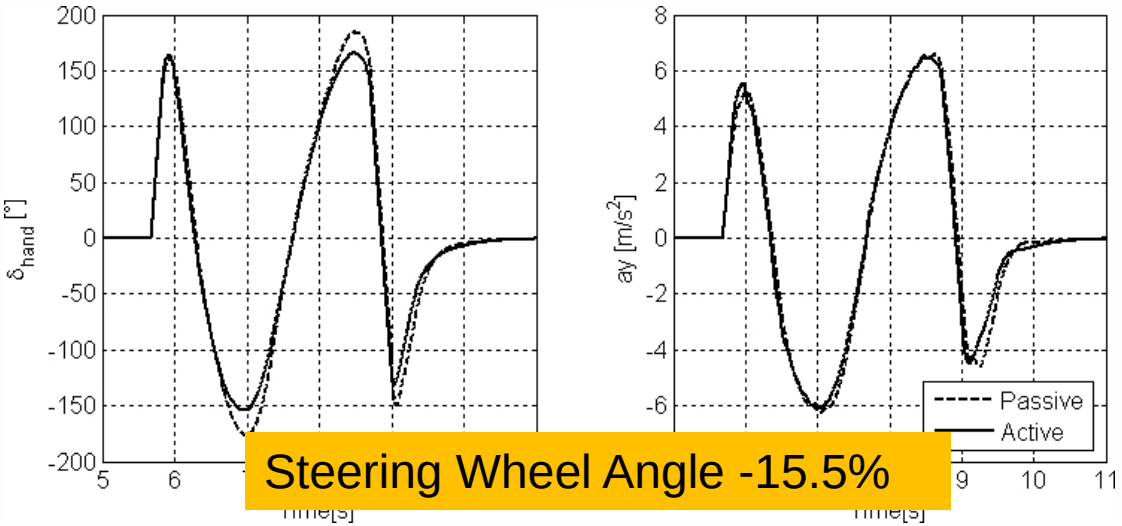
Concept Evaluation & Demo (Phase I)

Different Reference Curves: Potential Analysis

OEM Specification

Define Brand Specific Characteristics

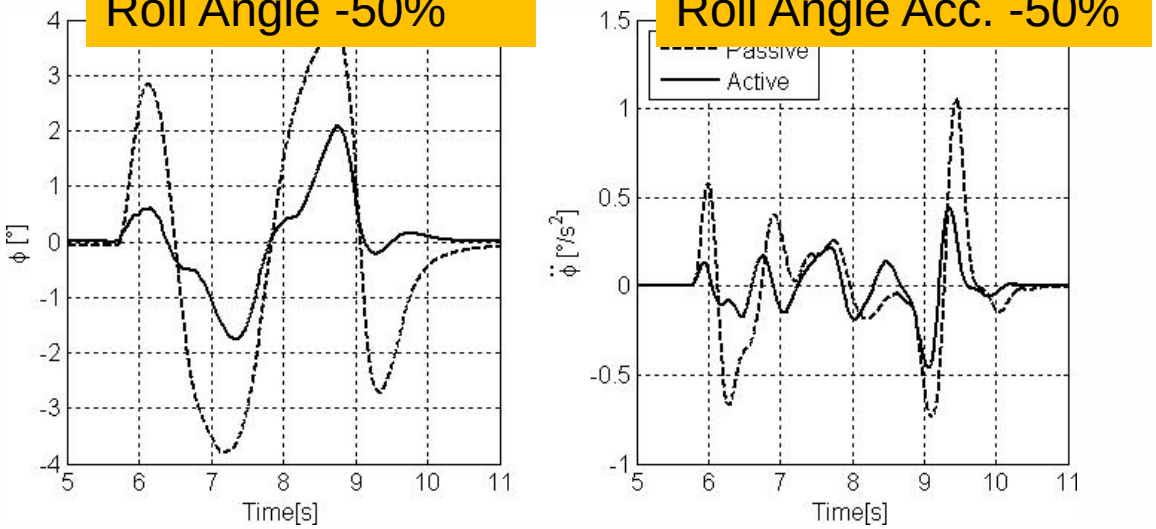
eARS VDC Simulation – Slalom



Steering Wheel Angle -15.5%

Roll Angle -50%

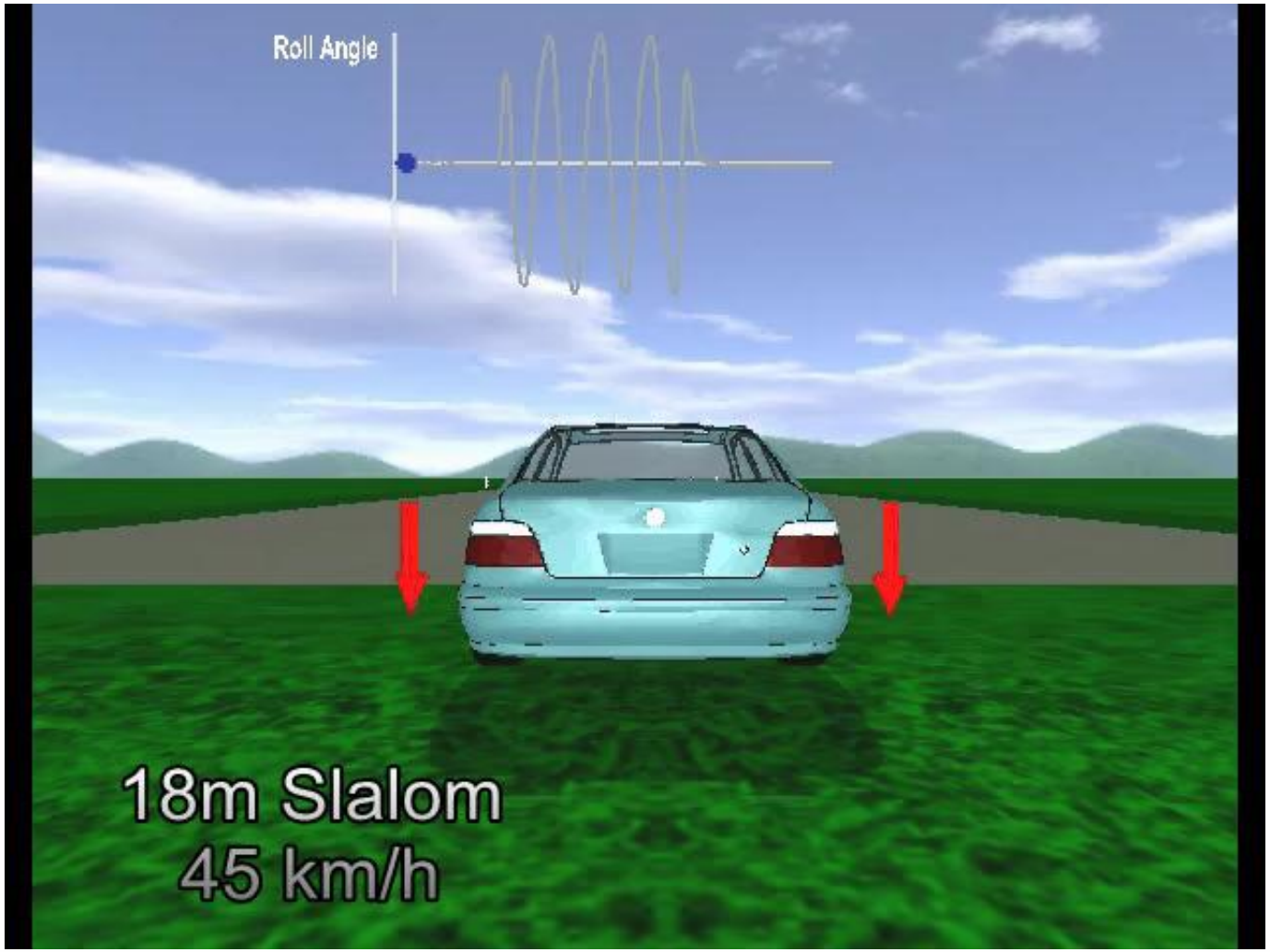
Roll Angle Acc. -50%



Concept Evaluation & Demo (Phase I)

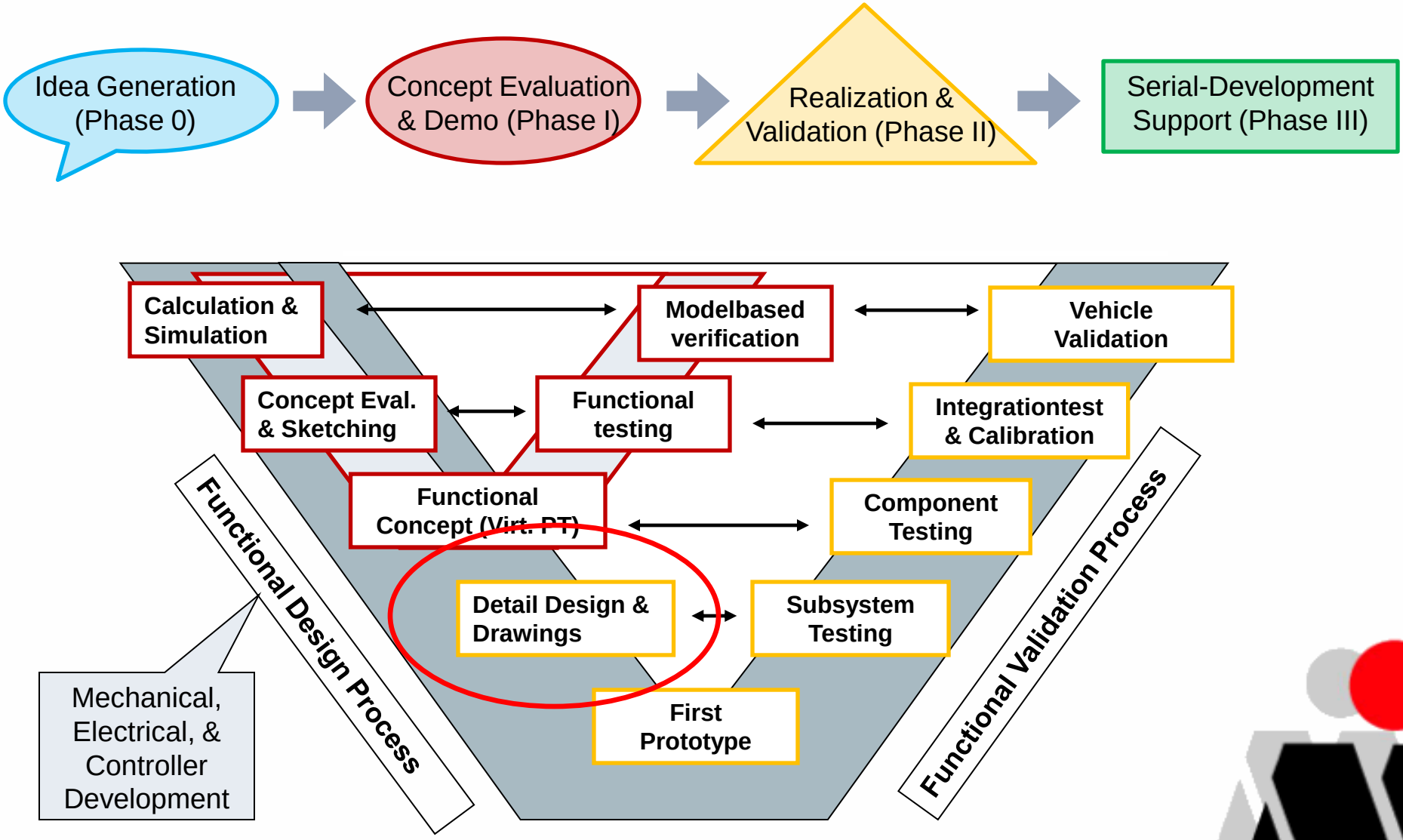
- Vehicle Velocity ~80km/h
- Lateral Acceleration: 6m/s2
- Improvement in Safety and Comfort

eARS VDC Simulation – Slalom



Concept Evaluation & Demo (Phase I)

Subsystem Development



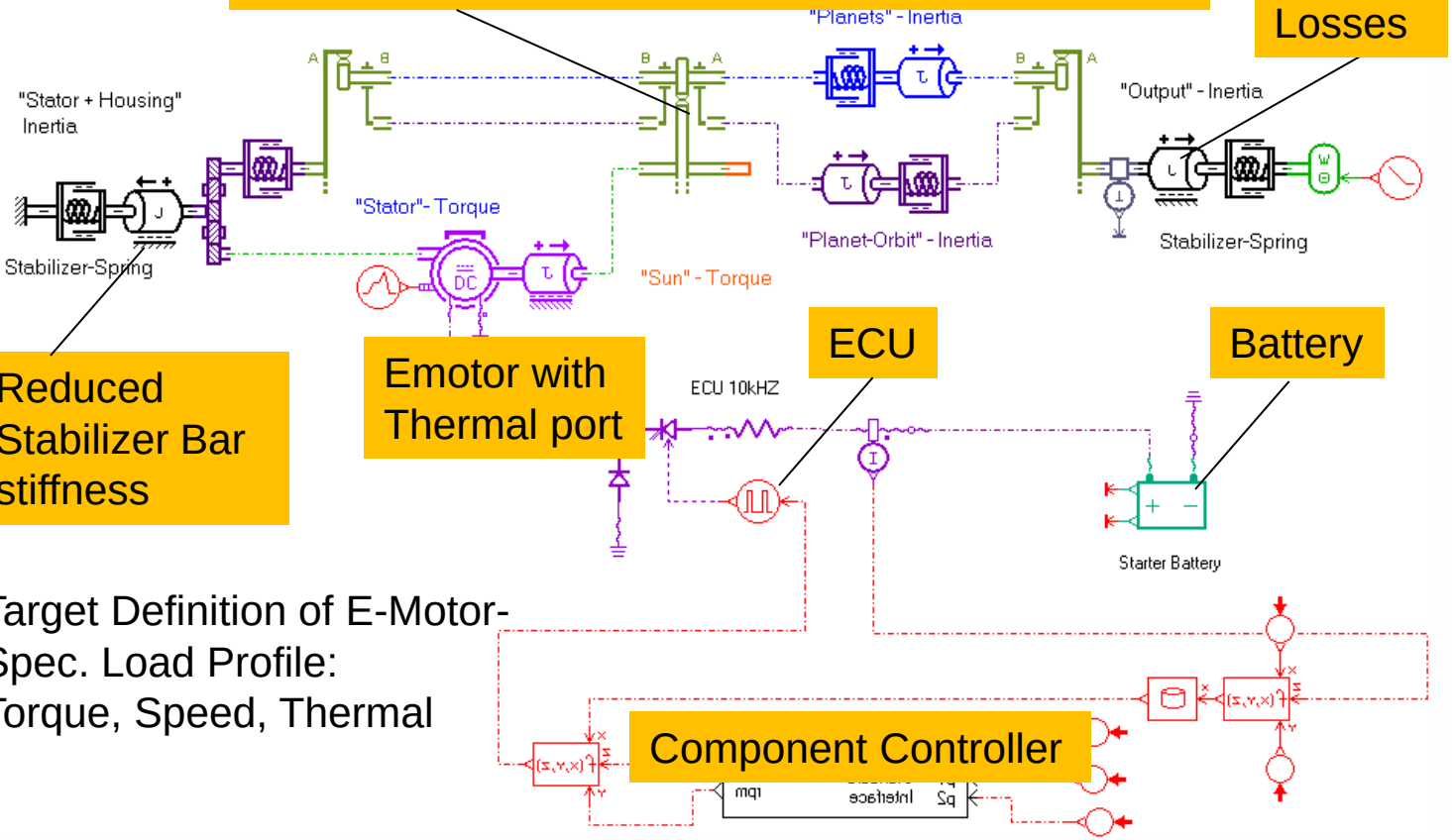
Sub-System-Development: BLDC-Motor

EMotor: AMESim - System-Simulation

Realization & Validation (Phase II)

Planet Gears with Inertia, Coulomb Friction, Viscous friction torque, Stiction Torque and Tooth & Bearing Losses

Bearing Losses



Reduced Stabilizer Bar stiffness

Emotor with Thermal port

ECU

Battery

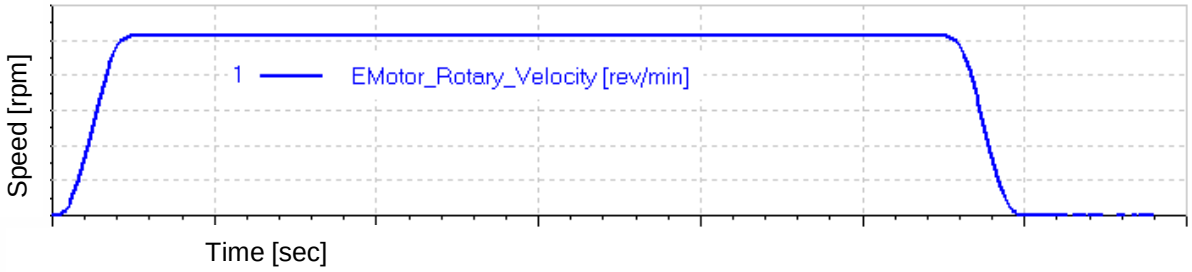
Target Definition of E-Motor-Spec. Load Profile: Torque, Speed, Thermal

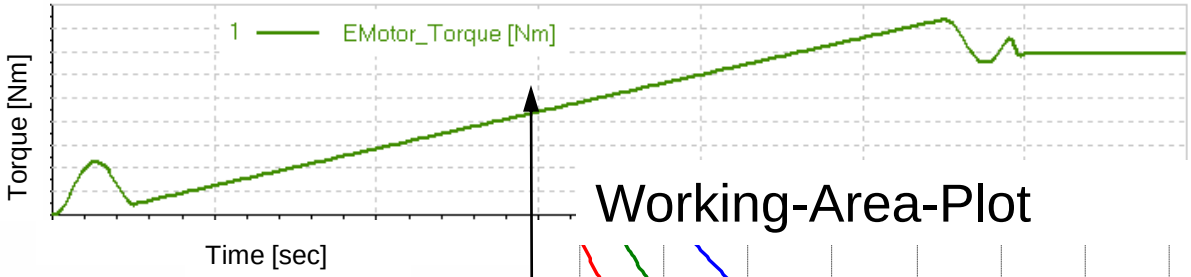
Component Controller

Sub-System-Development: BLDC-Motor

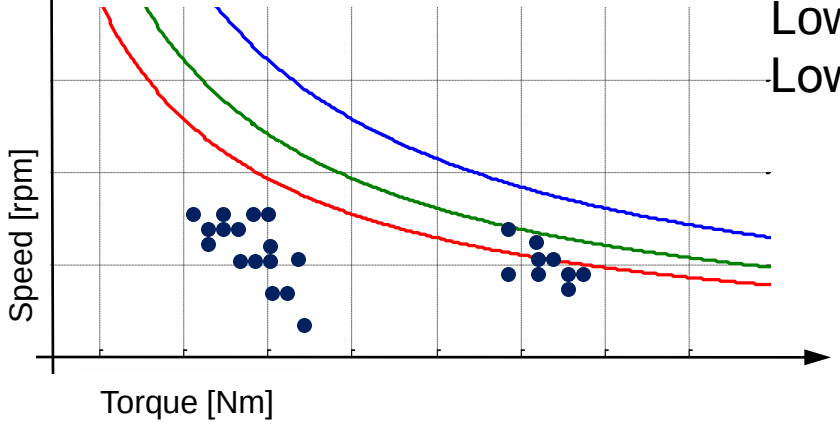
Result-Sheets:

EMotor: ramp-up with symmetric profile





Working-Area-Plot

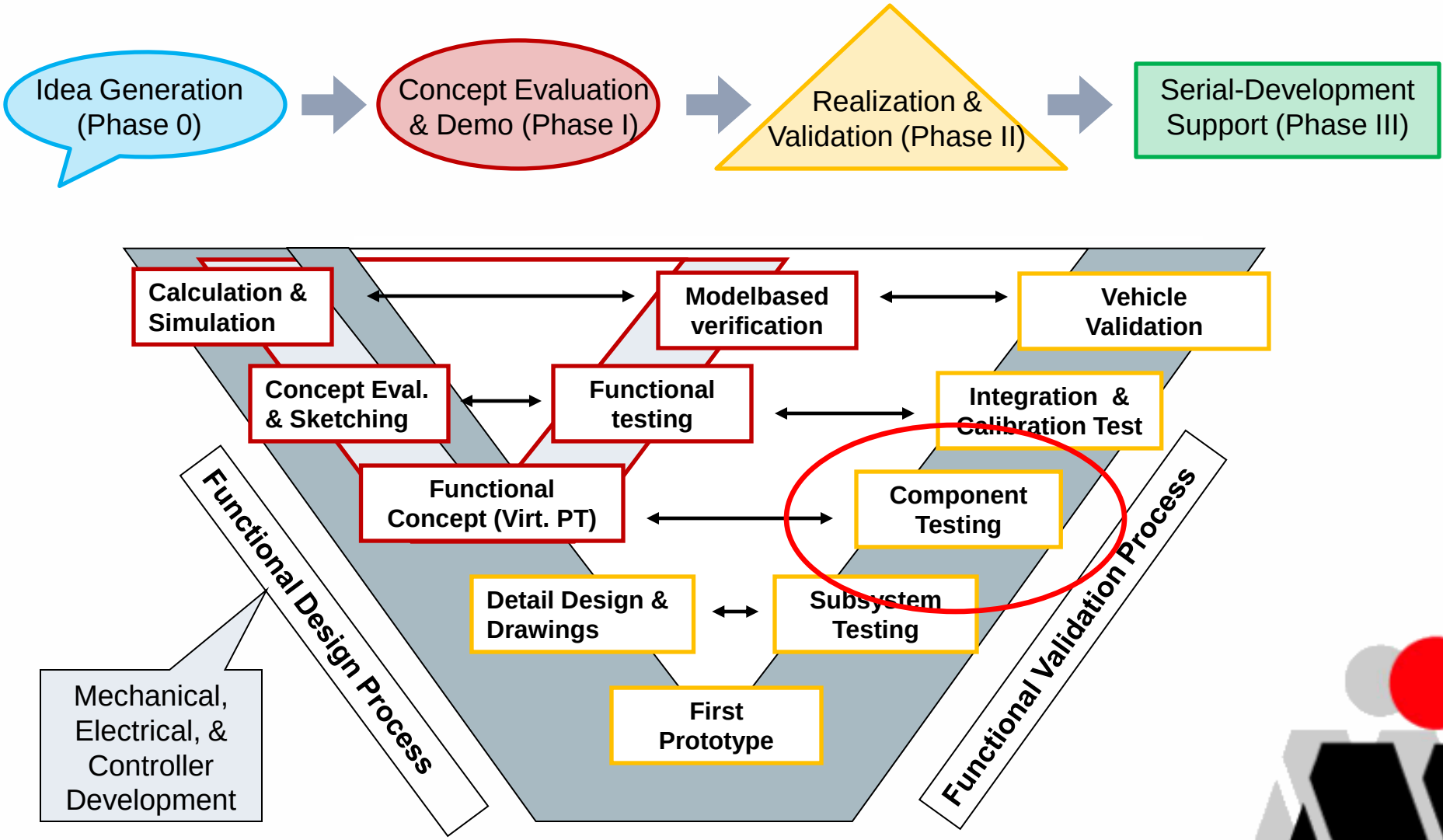


Realization & Validation (Phase II)

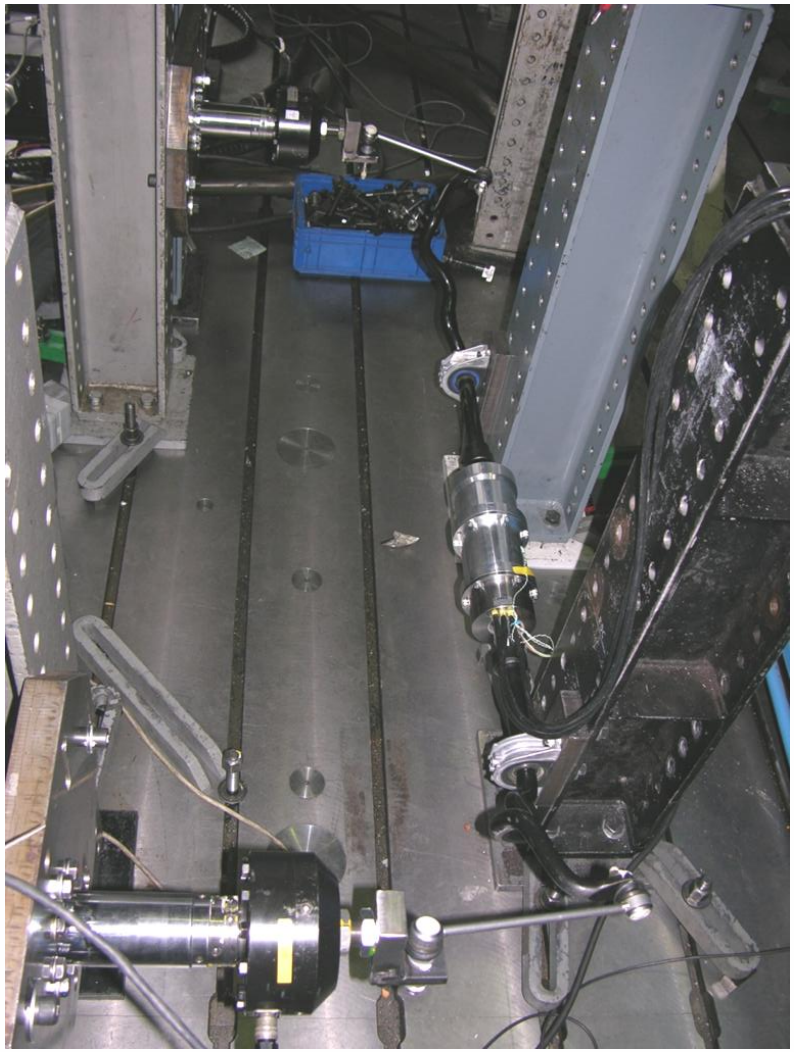
BLDC-Motor Development:

- Specification from Component Simulation & CAD
- Optimization of Geometry
- High Dynamics, Low Inertia, HighEfficiency, Low Torque Ripple, …

Component Testing



eARS Test Bench Lay-Out

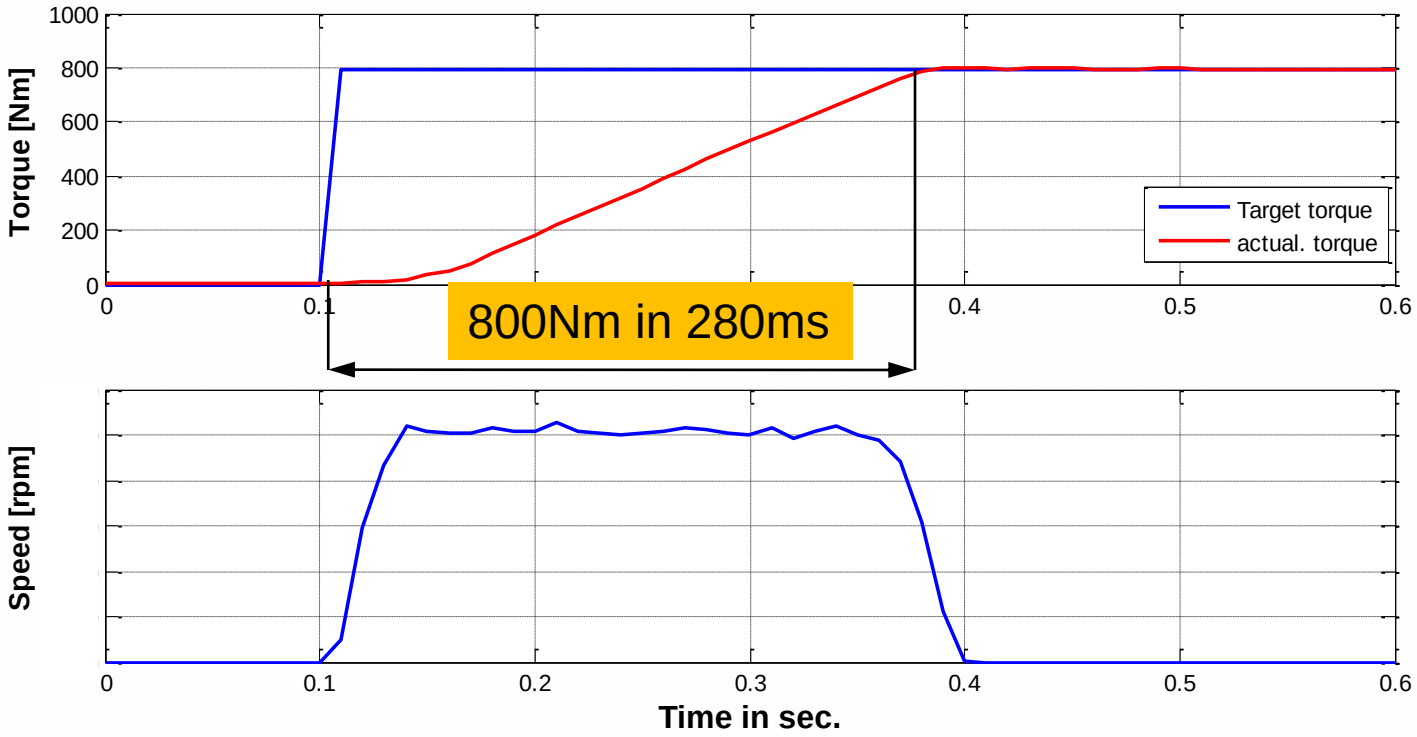


Realization & Validation (Phase II)

- Stabilizer Bars from SUV
- Voltage Supply: 12V from Battery
- Force Sensors, Temperature Sensors, …
- Testing Procedures:
  - Static Testing
  - Dynamic Testing
  - Thermal Testing

eARS Test Bench Results

Torque Step Input



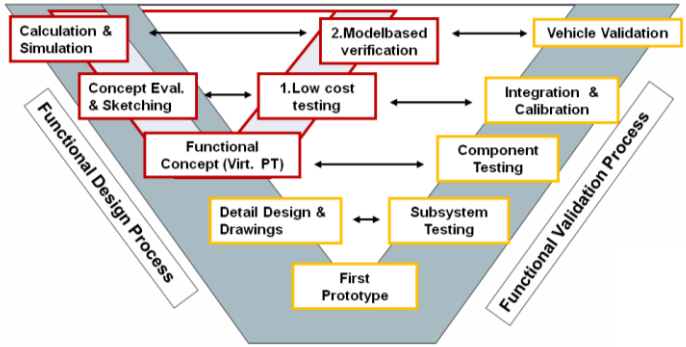
Realization & Validation (Phase II)

BLDC-Motor Development:

- Ramp-Up Profile
- Optimization of Geometry
- High Dynamics, Low Inertia, High Efficiency, Low Torque Ripple, …

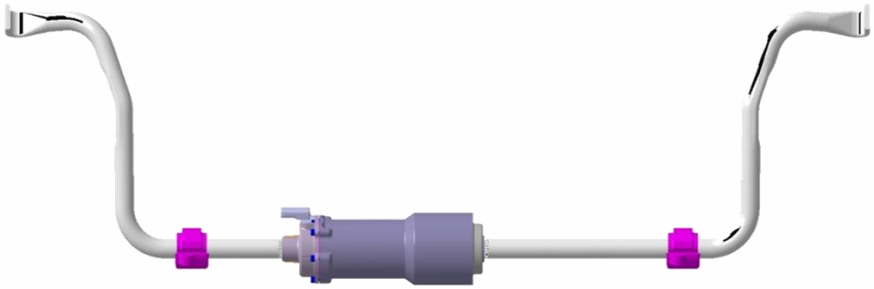
Conclusion and Outlook

Functional Development Process



- ✓ Optimized + verified Concept
  - Hardware
  - Software → VDC Controller

electric Anti-Roll-Stabilizer eARS



- ✓ Functional Targets:
  - Actuation Torque: 800Nm
  - High Dynamics: 300ms
  - Improved Response Time
  - Fail Safe Mechanism
- ✓ Optimum of Package & Weight
- ✓ Cost Effective & Energy Efficient
- ✓ Target Vehicle Segments: Upper Middle, Premium Class, SUV

Outlook

- On-Vehicle tuning and testing (VDC → subjective rating)
- Serial Development SOP 2012 possible