Electric Active Roll Control (EARC)

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22 June 2010

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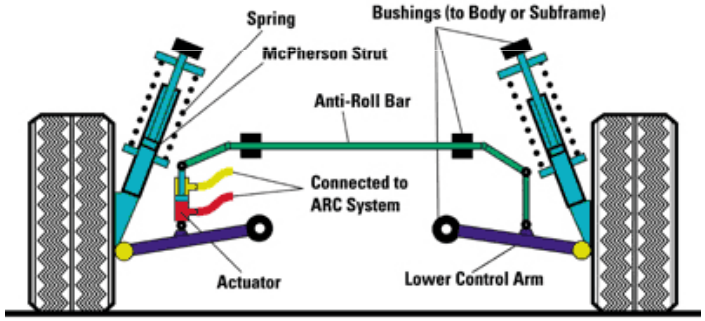

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About Us

Cranfield UNIVERSITY

YEAR 2010
The Young European Arena of Research
Silver Medal Award

50 YEARS
AUTOMOTIVE PRODUCT ENGINEERING MSc

- Students at Cranfield University School of Engineering
- Pursuing MSc in Automotive Product Engineering
- This presentation represents our ongoing thesis research in the area of Active Roll Control
- Expected accomplishment in September 2010

Background

Source: First Mustang Club Of Germany

The Problem:

- Body roll is caused by lateral acceleration
- Too much roll causes passenger discomfort
- Also result in roll steer effects
- Adversely influences the driver's control responses

The Solution:

- Reduce the roll angle (θ) using Active Roll Control (ARC)

Types of ARC Control

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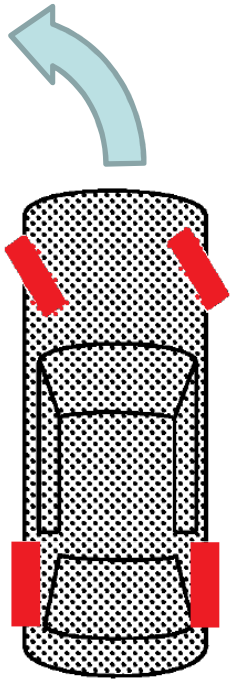
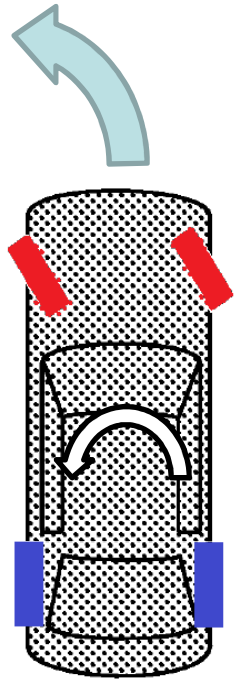


Single Channel



Dual Channel

ARC Configuration	Roll Control	Yaw Control
Front + Rear (single channel)	✓	✗
Front + Rear (dual channel)	✓	✓

Yaw Rate Control

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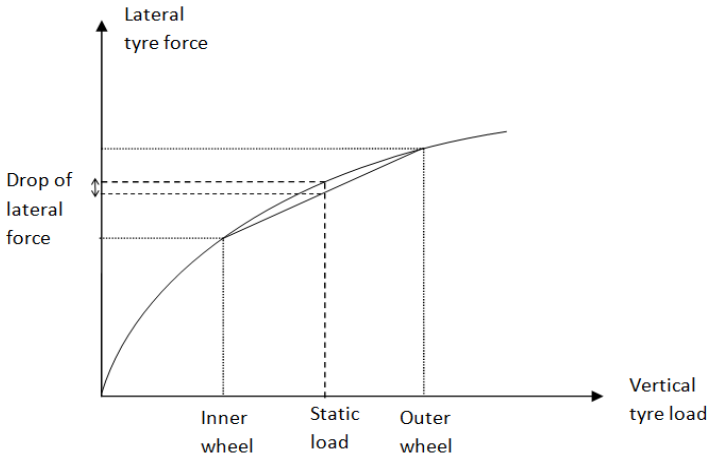
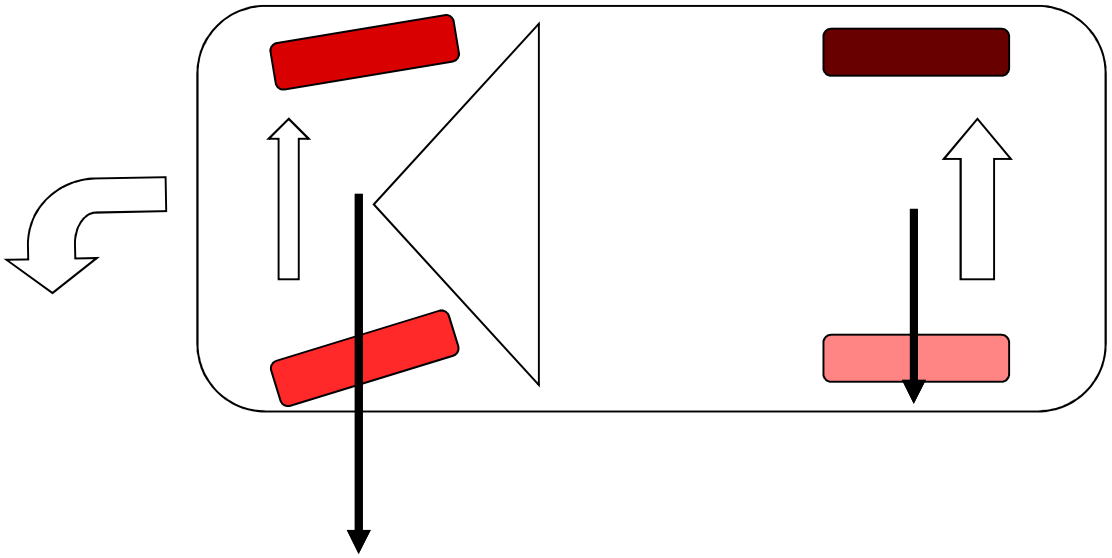
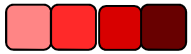
Non linearity of the lateral force capability:



More oversteering:
increasing weight transfer to the rear

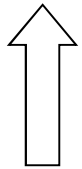


Normal load:



Small big

Roll moment:



Lateral forces:

Yaw Rate Control

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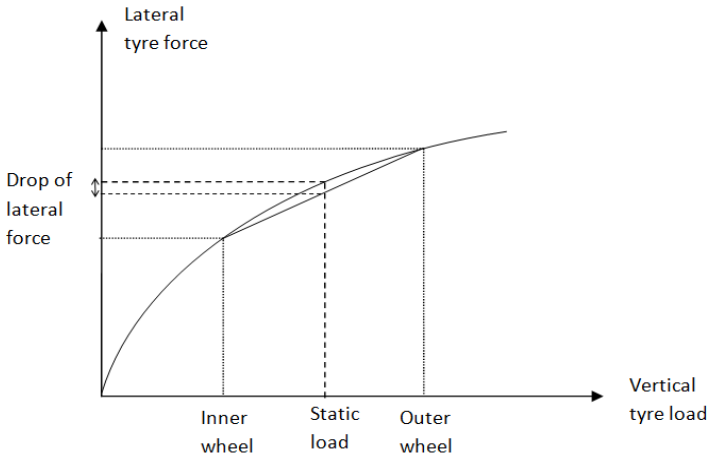
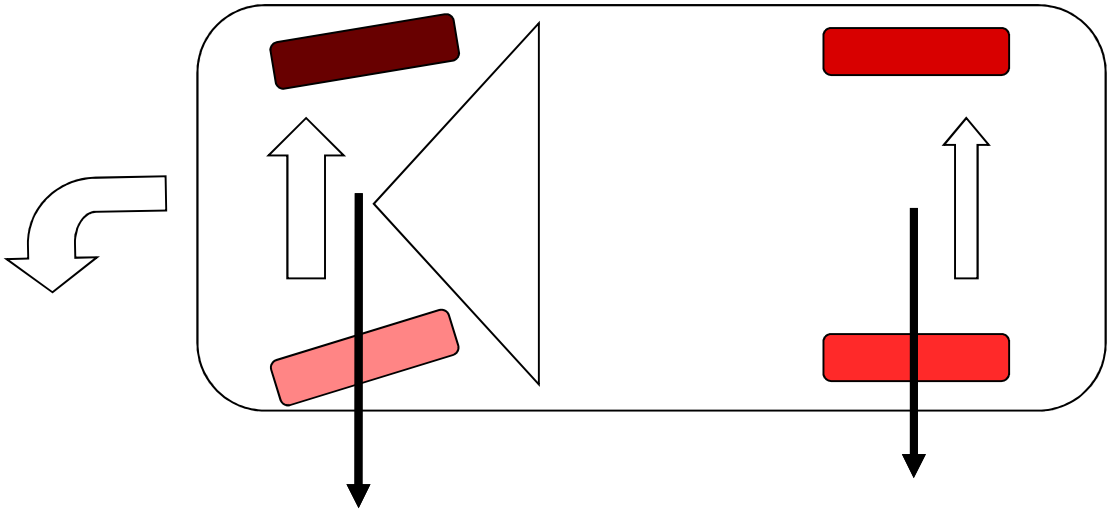
Non linearity of the lateral force capability:



More understeering:
increasing weight transfer to the front



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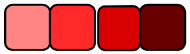
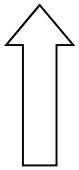


Small big

Roll moment:



Lateral forces:

Single Channel Control System

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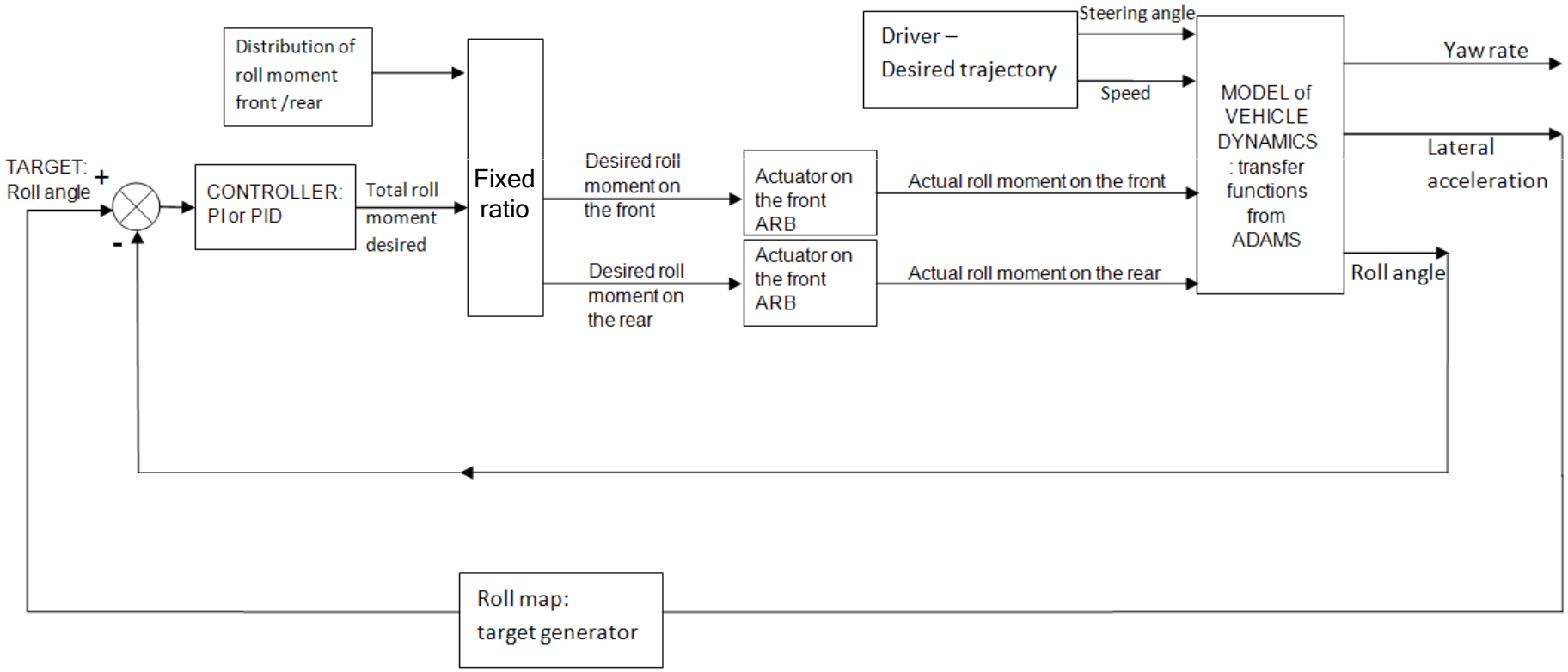

Dual Channel Control System

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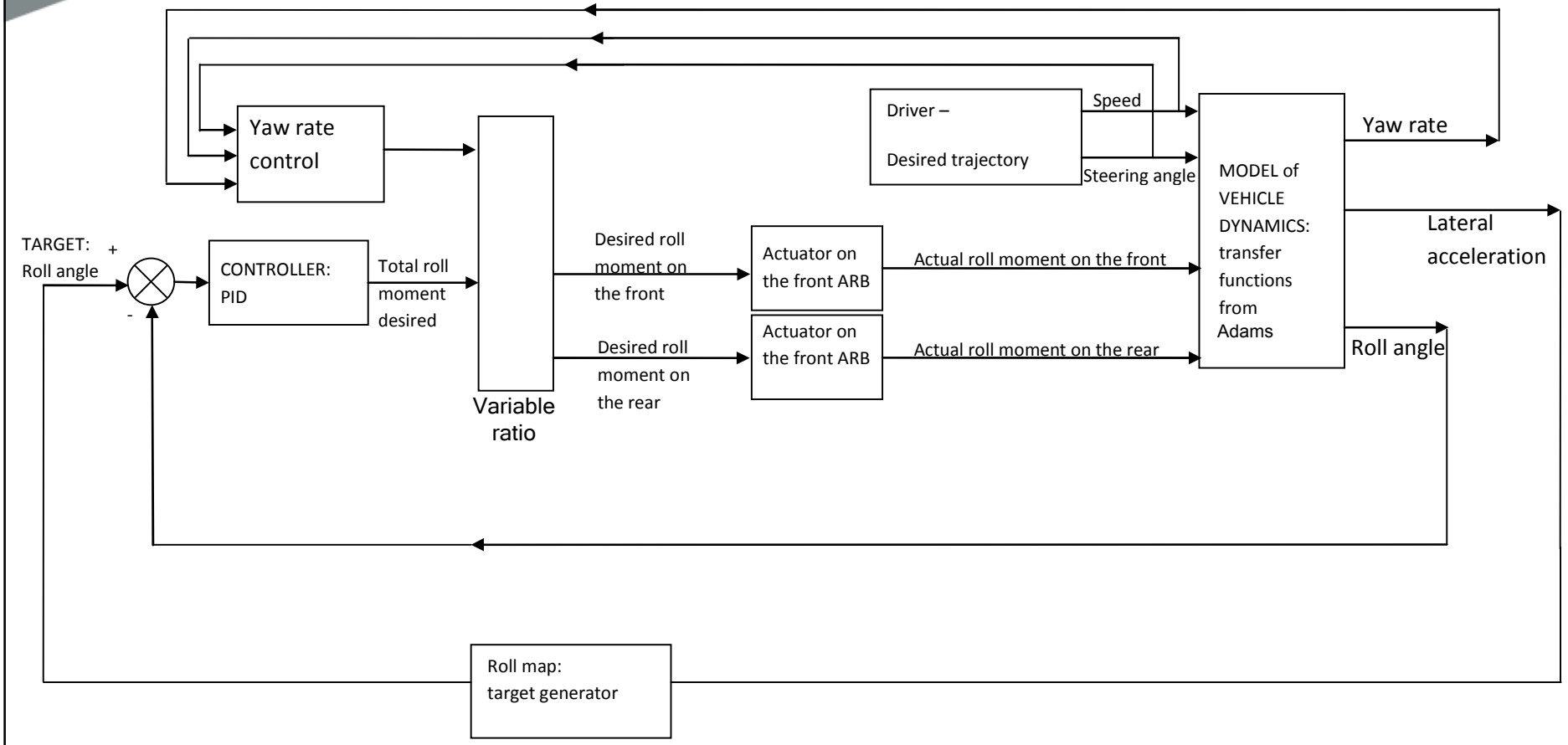

Electric vs Hydraulic

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	Hydraulic ARC	Electric ARC
Response	Slow	Quick
Cost	Expensive	Cheaper
Design	Complex	Simple
Maintenance	Difficult	Easier
Adaptability	Difficult	Easier

EARC also offers fuel consumption reduction of 1 – 2% compared to HARC*

*Source: ZF Sachs

Aims and Objectives of Research

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1. Simulation of single channel HARC
2. Simulation of single channel EARC
3. Compare single channel HARC vs EARC

4. Simulation of dual channel HARC
5. Simulation of dual channel EARC
6. Compare dual channel HARC vs EARC

Research Strategy

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Electric Active Roll Control (EARC)

Modeling (MSC-Adams)

- Creation of detailed vehicle model and ARC mechanisms using Adams/Car and Adams/Mechatronics
- Sizing and physical location of EARC and HARC components
- Specifying suspension parameters:
  - Tire model
  - Suspension kinematics
  - Spring rates

- Roll Angle
- Lateral Acceleration
- Steering Angle (dual channel)
- Yaw Rate (dual channel)
- Vehicle Speed (dual channel)

- Front and rear roll moments

Controls (Matlab/Simulink)

- Creating control strategy for both single channel (roll angle) and dual channel (roll angle + yaw rate) using Simulink
- Tune controller parameters (PI and PID)
- Analyze the vehicle dynamics response of an EARC system and compare it to that of a HARC system

Current Hydraulic ARC Mechanisms

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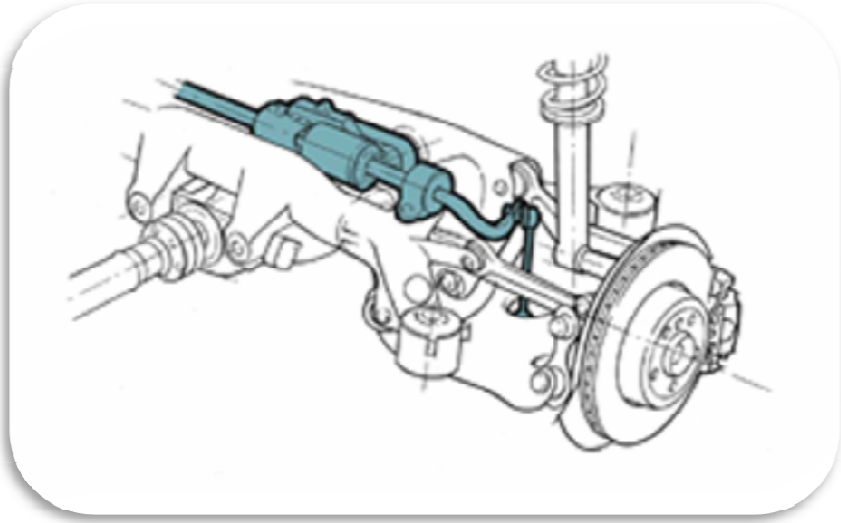
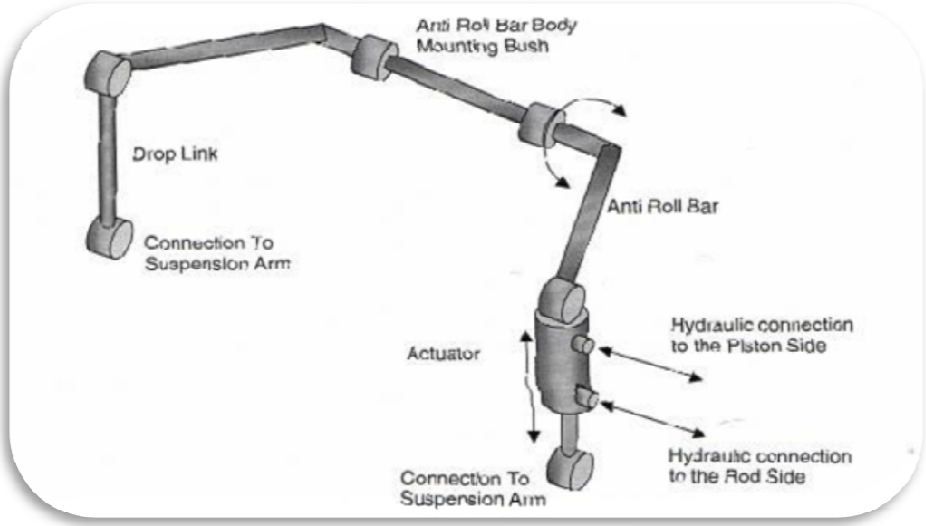
Rotary Actuator



Source: Bayerische Motoren Werke AG

Linear Actuator



Source: TRW Automotive

Electrical ARC Mechanisms

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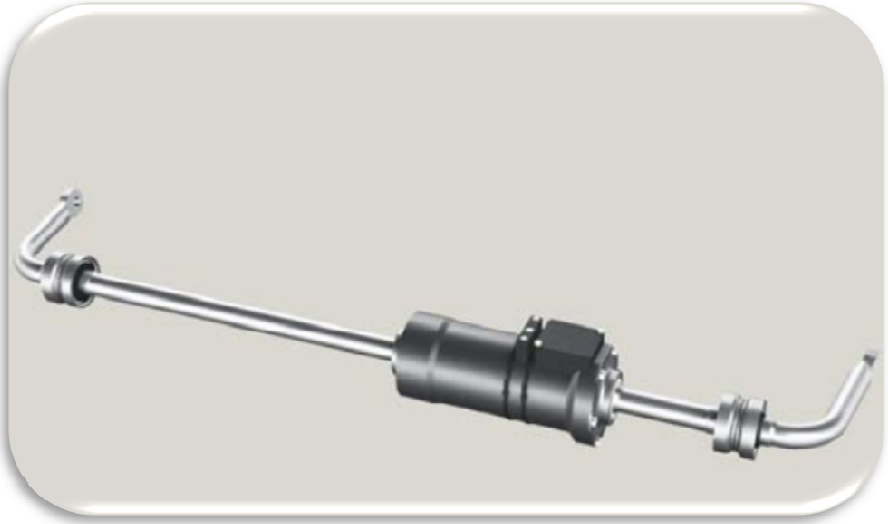
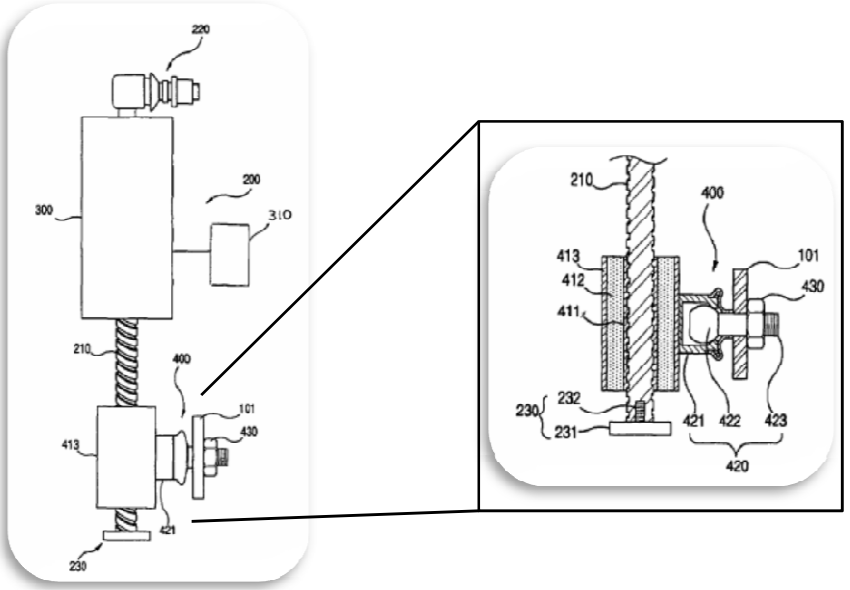
Rotary Actuator



Source: ZF Sachs

Linear Actuator



Source: Hyundai US Patent #7,427,073 B2

Modelling in Adams/Car

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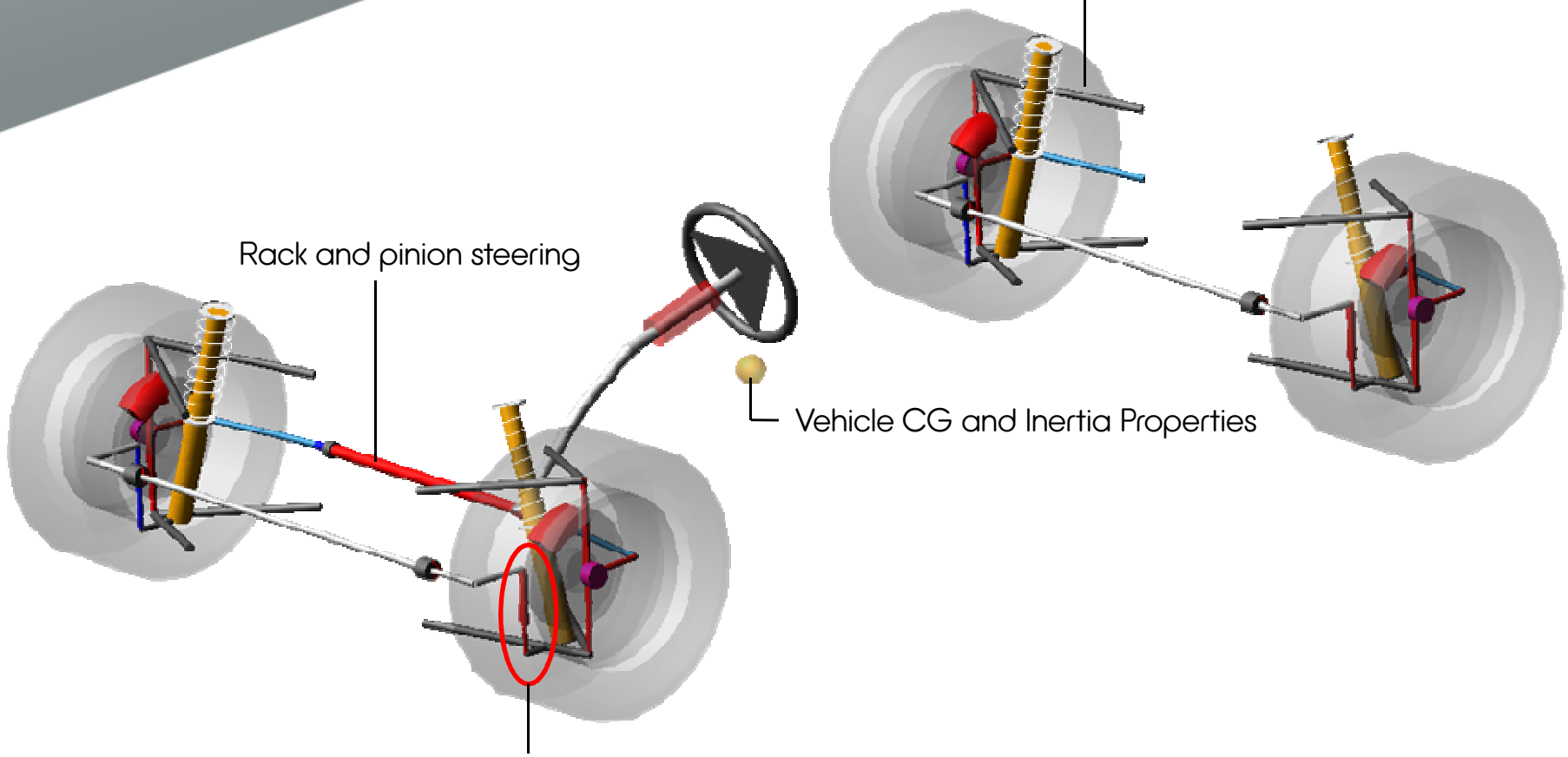

Electrical ARC Mechanism

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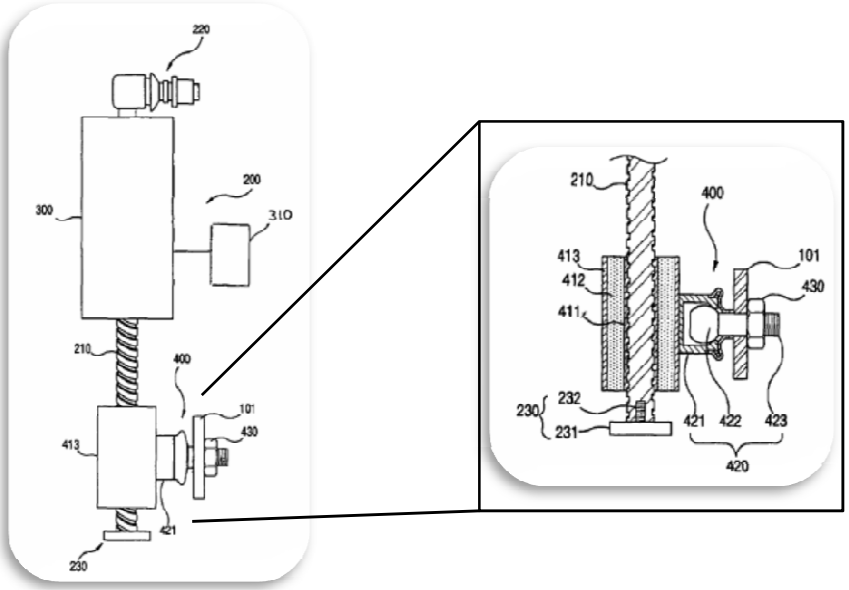

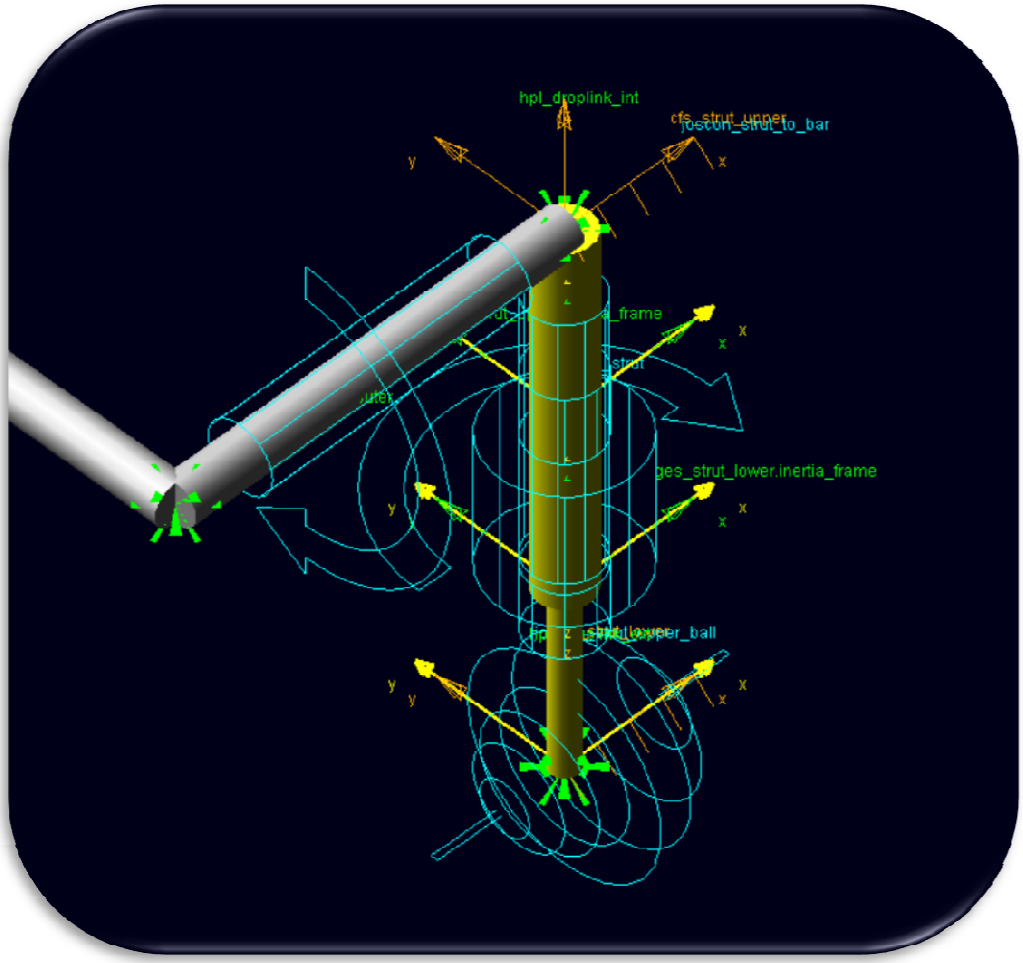

Co-simulation between Adams and Simulink

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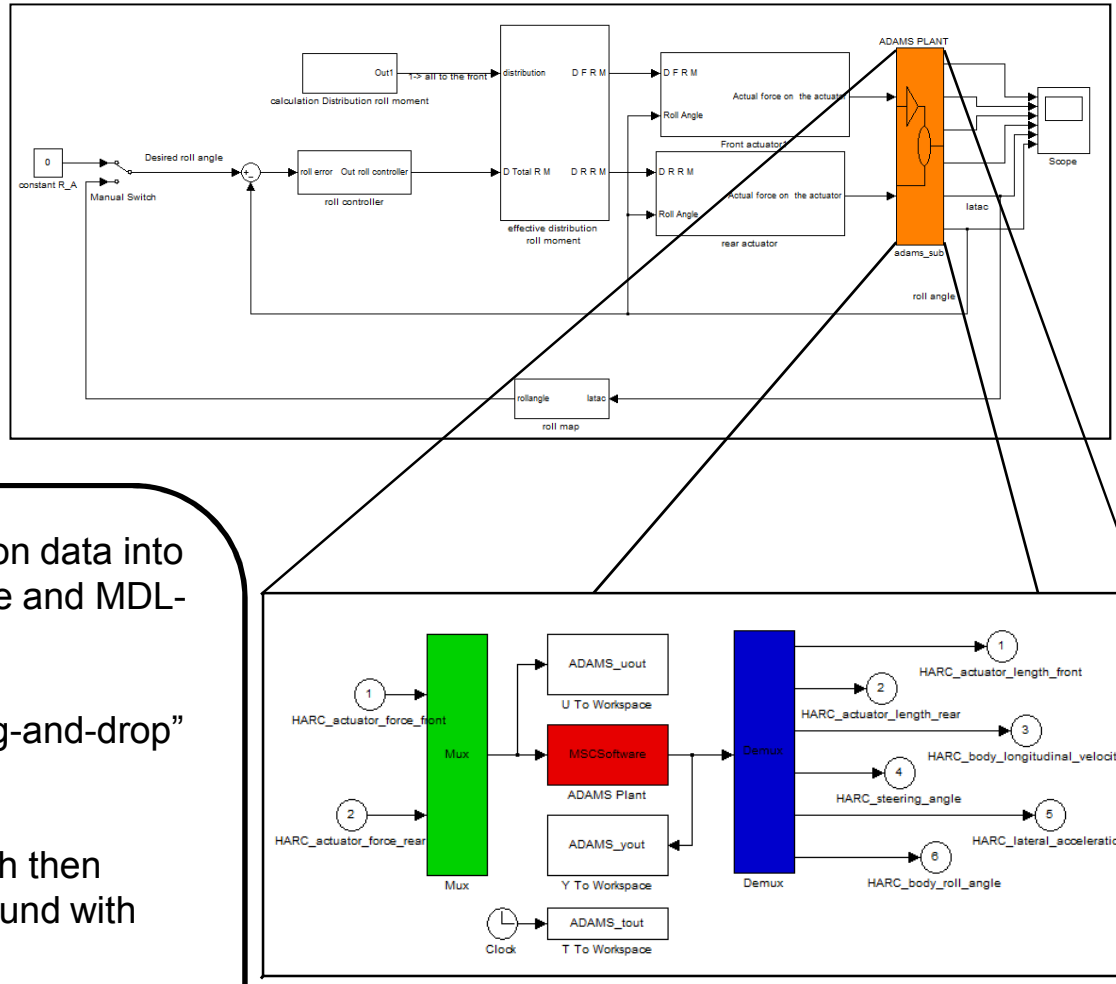

- Adams/Car outputs variables and simulation data into MATLAB/Simulink environment via an M-file and MDL-file respectively
- MDL-file contains a function block for “drag-and-drop” into Simulink control system
- Simulation is initiated using Simulink, which then carries out the co-simulation in the background with Adams/Solver
- Adams/Car and Adams/PostProcessor used for viewing simulation results

Results

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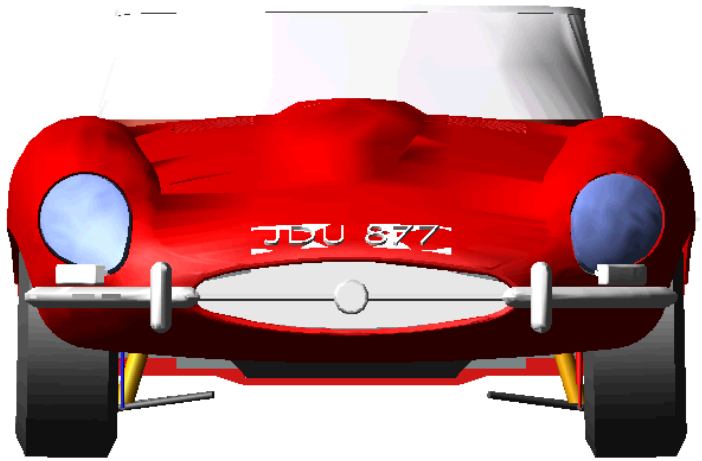
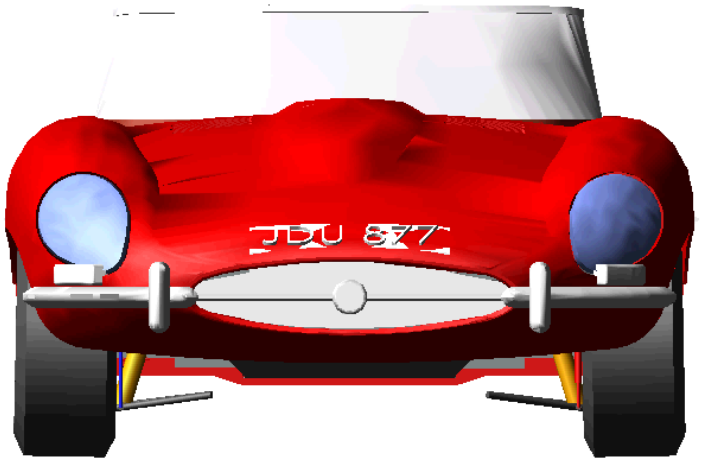
Without ARC

ish_hook_pac89_tires_fho Equilibrium Frame=001



With ARC

fishhookpac89tires_fho Time= 0.0100 Frame=001



Results

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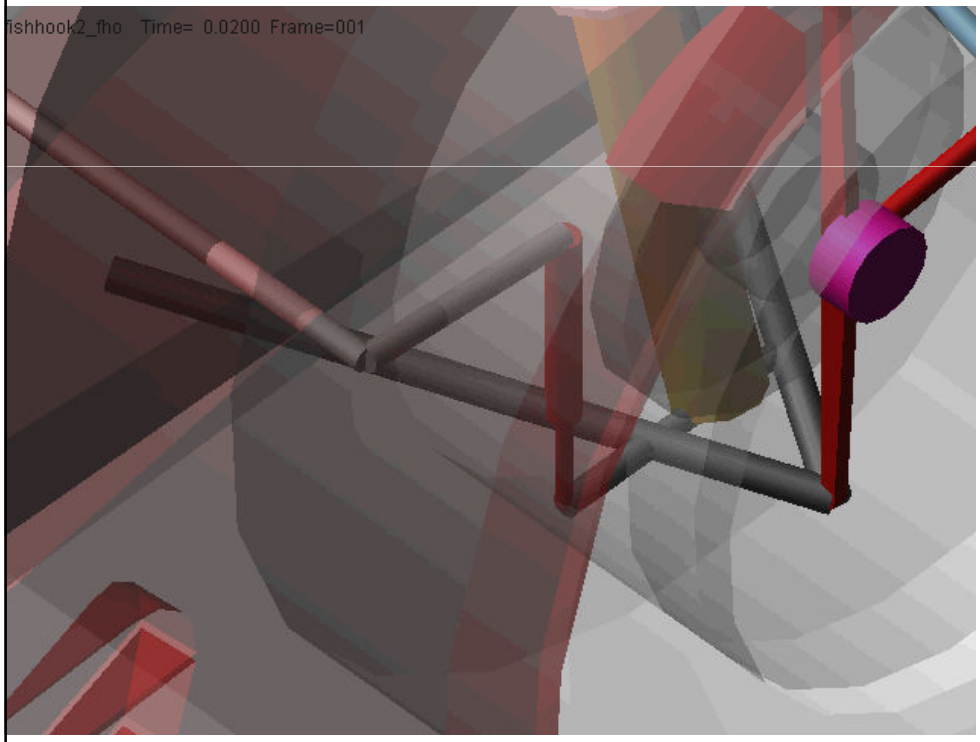

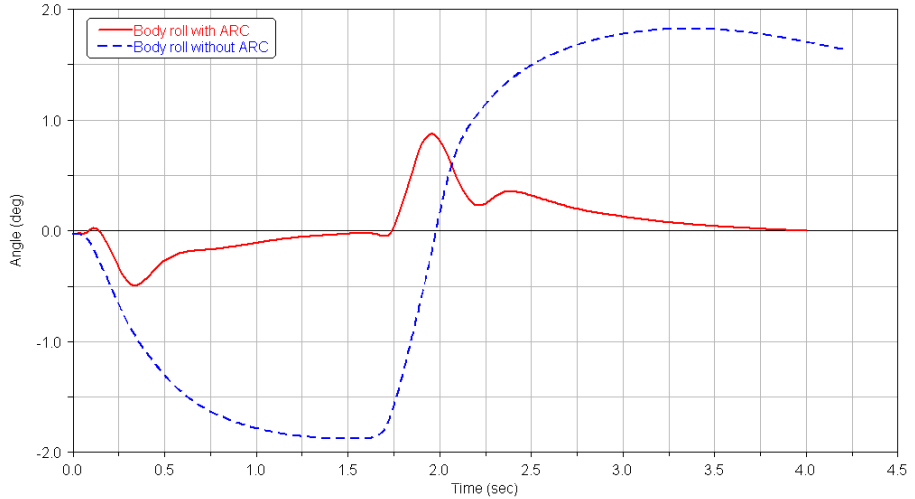

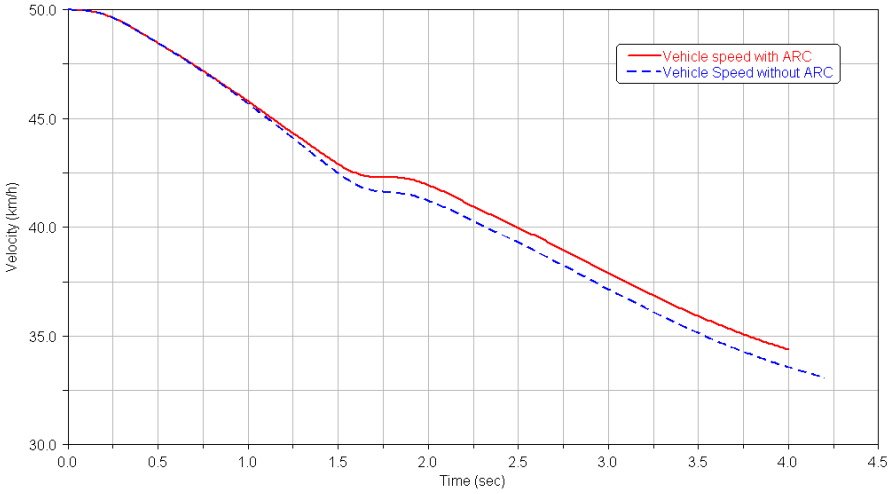

Dual channel ARC: influence of the roll distribution

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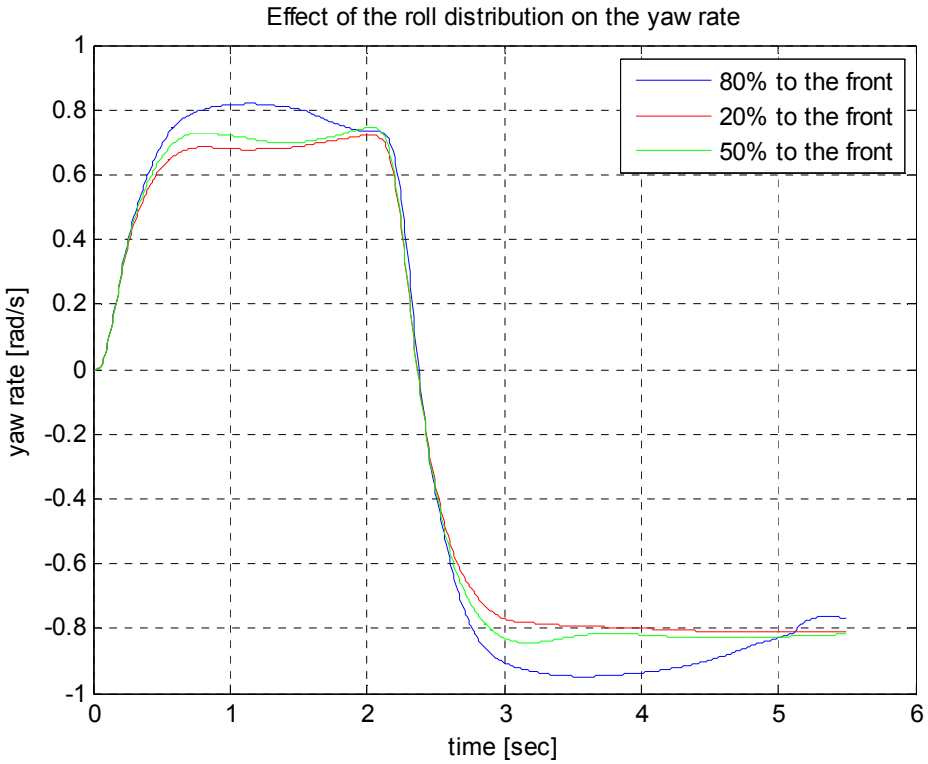
Multiple Runs Time= 0.0100 Frame=001



Dual channel ARC: Safety Improvement

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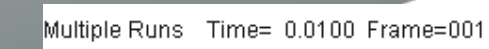

Conclusion

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- Active Roll Control offers potential to reduce body roll and increase stability
- Higher average vehicle speeds attainable via ARC
- Electric ARC systems offer easier implementation in full electric and hybrid vehicles
- Impact of Electric ARC systems to be investigated further
- Passive suspension can be tuned for increased comfort for vehicles with ARC systems

Thank You

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Questions and Comments