Driving Dynamics Modelling with Modelica

Johan Andreasson, Division of Vehicle Dynamics
Royal Institute of Technology, Sweden
Outline

• Aim with the Car.mo library
• From the top to the bottom!
• Library contents
• Examples
• Related libraries
• Future improvements
Aim with the Car.mo library

- Driving Dynamics evaluation
  - Critical manoeuvres
  - Lateral performance
  - Longitudinal performance
  - Comfort
  - Etc.
From the top to the bottom!

Focus on chassis
A car model

- Road
- Environment
- Chassis
- Trailer
- Driver
- Power train

Johan Andreasson, Division of Vehicle Dynamics, KTH
Chassis interface

- body frame
- steering flange
- drive shafts

Tyre-road interaction as a field
Chassis model

- BGR
- wheel_2
- MacPherson
- frontSuspension
- left
- flange_SW
- wheel_1
- flange_1
- ground
- freeMotion
- wheel_3
- flange_3
- wheel
- TwistBeam
- rearSuspension
- left
- body
- rear suspension
- front suspension

Johan Andreasson, Division of Vehicle Dynamics, KTH

Driving Dynamics
Suspension Interface

MacPherson

left

wheel connectors

connection to body

(steering flange)
Suspension model (MacPherson)

- Suspension parameters
- Anti-roll linkage
- Data
- MacPherson linkages
- Steering
- Frame_U_1
- Frame_U_2
- Frame_C
- Flange_SW
Suspension model (MultiLink4)

- Suspension parameters
- Anti-roll linkage
- Multi-links
- Struts

Data flow diagram showing connections between different components of the suspension model.
Linkage model (MacPherson)

- frame_C
- frame_U
- wish-bone (A-arm)
- MacPherson strut

forceTable
\[ f_s = f(s) \]
\[ f_d = f(\text{der}(s)) \]
Component model (MacPherson strut)

\[ f_s = f(s) \]
\[ f_d = f(\text{der}(s)) \]
Hierarchy

Vehicle model
Hierarchy

Vehicle model
Chassis model
Vehicle model
Chassis model
Suspension model
Vehicle model
Chassis model
Suspension model
Linkage model
Vehicle model
Chassis model
Suspension model
Linkage model
Component model
Library contents
Library contents

- Car.Examples
- Car.Chassis
- Car.Chassis.Suspensions
- Car.Chassis.Components

Vehicle models
Chassis models
Suspension models
Linkage models
Component models
Usage
Usage – Existing examples

- Chassis Library
- Wheels Library
- Drivers Library
- Examples Library
- Utilities Library
- Environments Library
Usage – Own models

- MyCar Model
- Chassis Library
- Wheels Library
- Drivers Library
- Examples Library
- Utilities Library
- Environments Library
Usage – With other libraries

- PowerTrain Library
- HevLib Library
- MyCar Model
- Chassis Library
- Wheels Library
- Drivers Library
- Examples Library
- Utilities Library
- Environments Library

Johan Andreasson, Division of Vehicle Dynamics, KTH
Usage – Visualised performance
Usage - Suspension mapping
Usage - Comfort issues
Related libraries
Summary

– Chassis modelling
– Driving dynamics simulation
– Interfacing other Modelica libraries
Future Improvements
Evaluation aids

• Related models
  – Drivers
  - Automatic test rigs
  - ...

• Motion constraints
  – Constant speed manoeuvres
  – Constant radius turns
  – ...

Extended flexibility

- With/without bushings
- Linear/nonlinear spring-dampers
- Swapping tyre models
- 1D-2D-3D geometries and combinations
Extended flexibility

• Different models share same interface.
  – Model focus/viewpoint can be changed easily!
Different models share same interface
Different models share same interface
Extended flexibility

- Different models share same interface.
  - Model focus/viewpoint can be changed easily!
  - Higher requirements on interfaces!
Suitable interfaces?

four wheel steering?

Active suspension?
Extended flexibility

• Different models share same interface.
  – Model focus/viewpoint can be changed easily!
  – Higher requirements on interfaces!
  – Over-all model structure that is suitable!
Suitable structure

X-by wire?

Fuel cell technology?

Vehicle dynamics control systems?

Energy management?
Extended flexibility

• Different models share same interface.
  – Model focus/viewpoint can be changed easily!
  – Higher requirements on interfaces!
  – Over-all model structure that is suitable!
  – Sub-models must know their limitations!
Model limitations!

- Magic Formula
- Linear model
Acknowledgements

• Dynasim AB
• DLR
Contact

johan@fkt.kth.se