Advanced Track and Tire Modeling using SIMPACK User Routines

Werner Krantz, Jens Neubeck

Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren Stuttgart

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SIMPACK User Meeting 2003

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- **Introduction**
- **Continuous Track Model**
- **Implemented SIMPACK User Routines**
  - **6 DOF Track Joint**
  - **Track Sensor**
  - **Tire Model**
- **Summary and Perspective**

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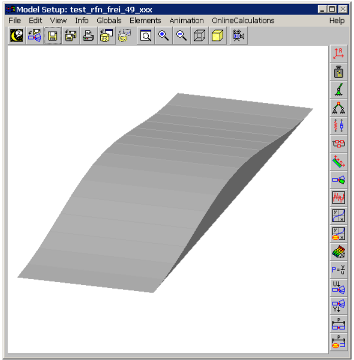
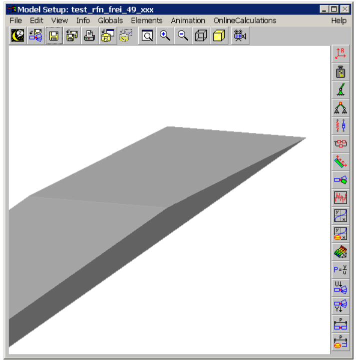
Track Models in SIMPACK



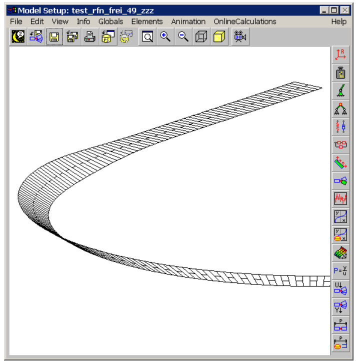


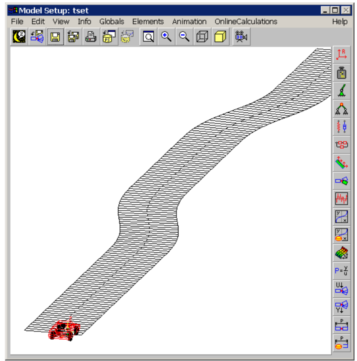
"Road Surfaces"

- SIN-Obstacle
- Ramp
- ...

"Tracks"

- Simple Track
- Measured Track
- ...





Associated elements: Track Joint, Track Sensor

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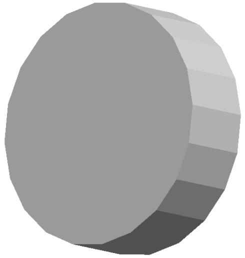
Tire Models in SIMPACK

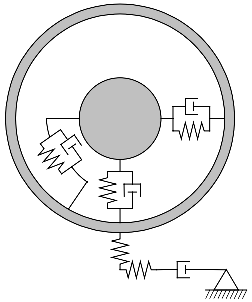


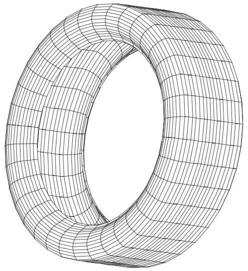
Standard Tire Models

- HSRI-Model
- Pacejka Magic Formula
- Pacejka Similarity Method

Non Standard Models

- Delft MF-Tire
- Delft SWIFT-Tire (v8.5)
- RMOD-K (v8.5)





Tire Interfaces

- SIMPACK User Tire
- Standard Tire Interface STI

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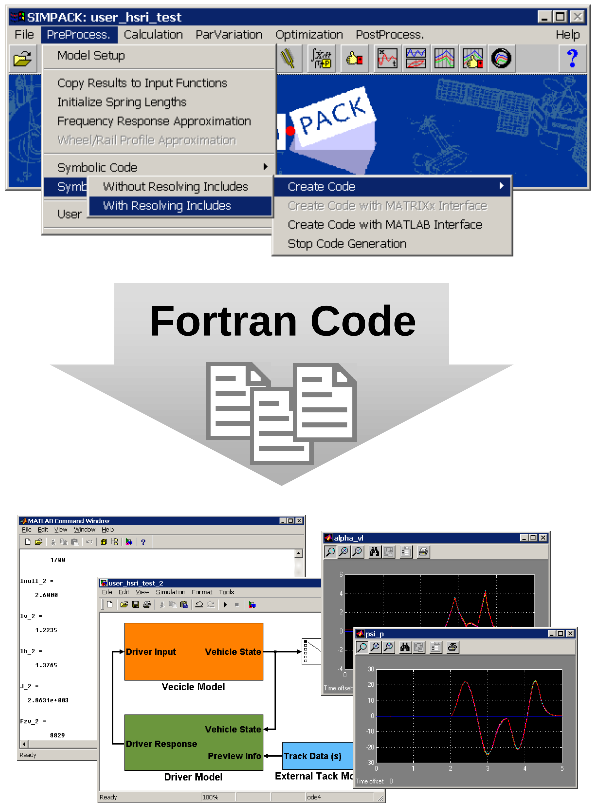
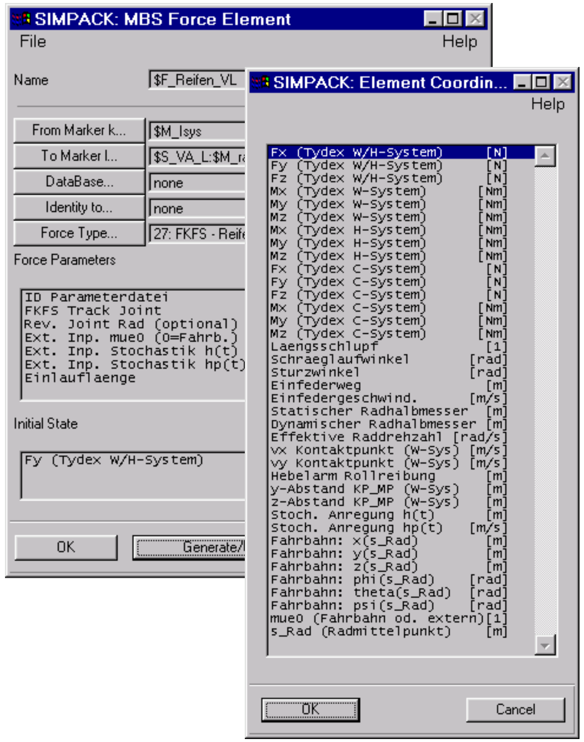
Track and Tire Modeling using User Routines

- Full availability in Symbolic Code (v8.0)



- Flexible definition of tire parameters and output values



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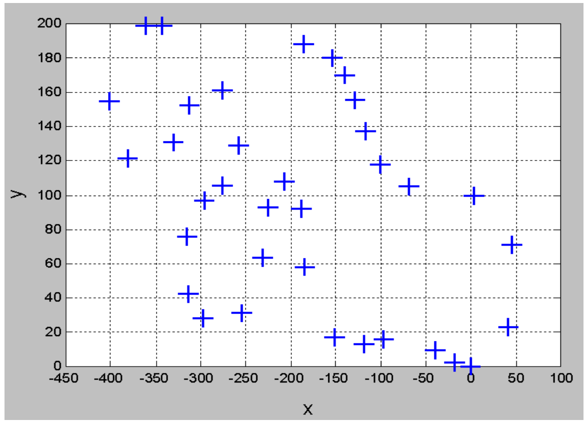
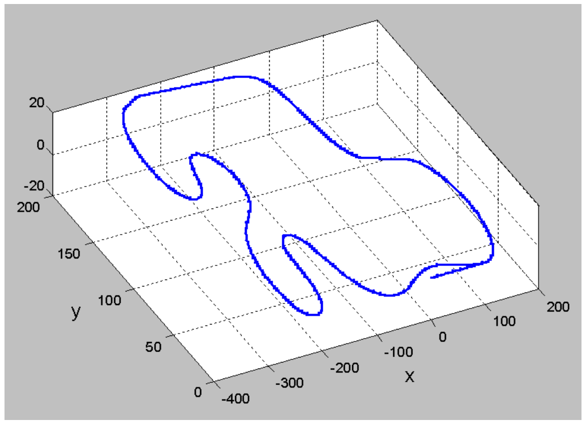
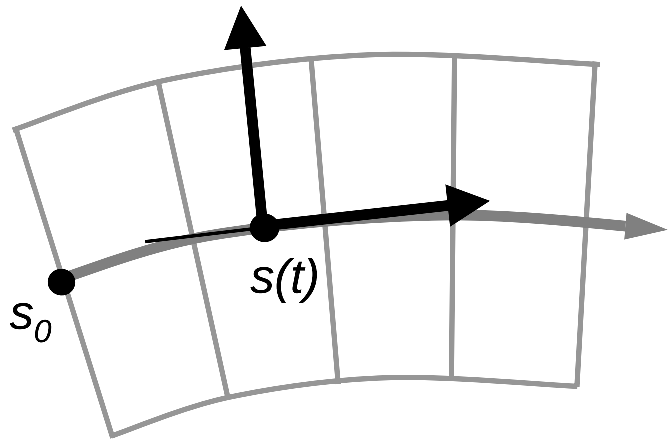
Continuous Track Model





- Generated from measured data in a preprocessing step (MATLAB)
- Continuous approximation using splines



$\Rightarrow x_{Tr}(s), y_{Tr}(s), z_{Tr}(s), \alpha_{Tr}(s)$

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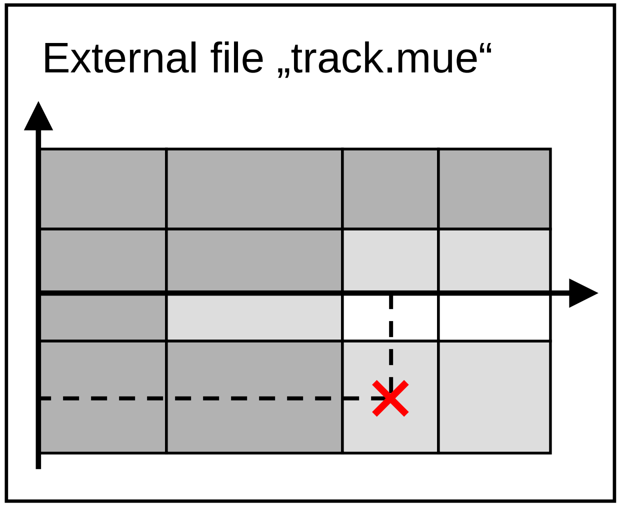
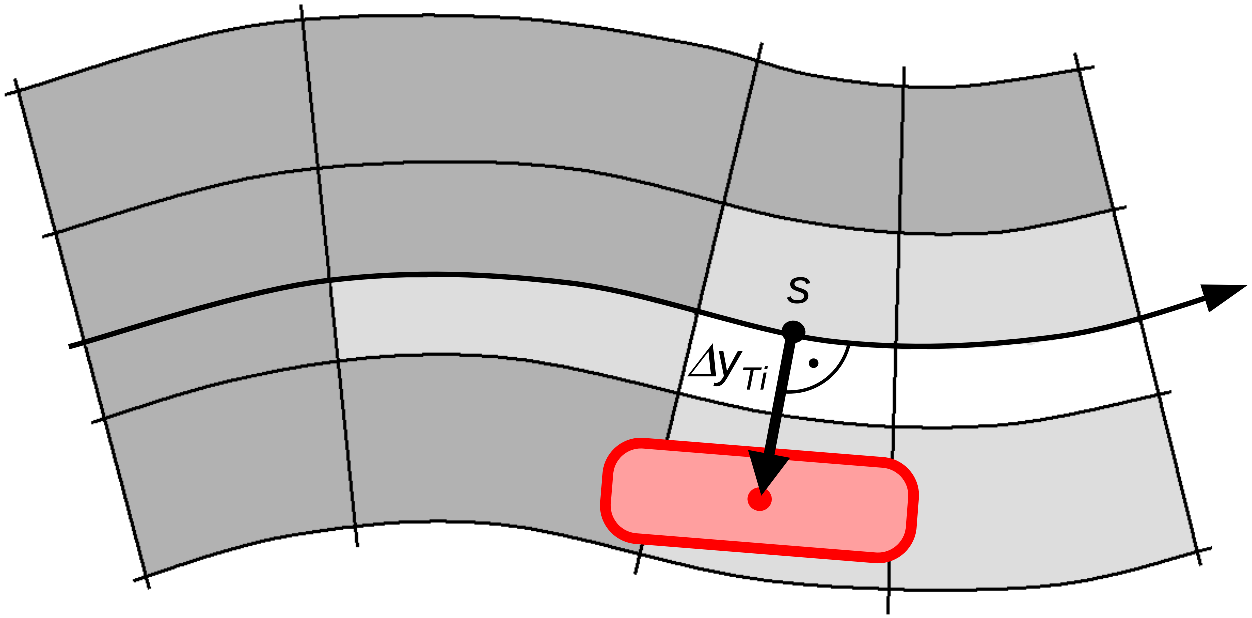
Friction Coefficient

- µ-definition by rectilinear grid
- Grid mapped to track surface or xy-plane of earth coordinate system





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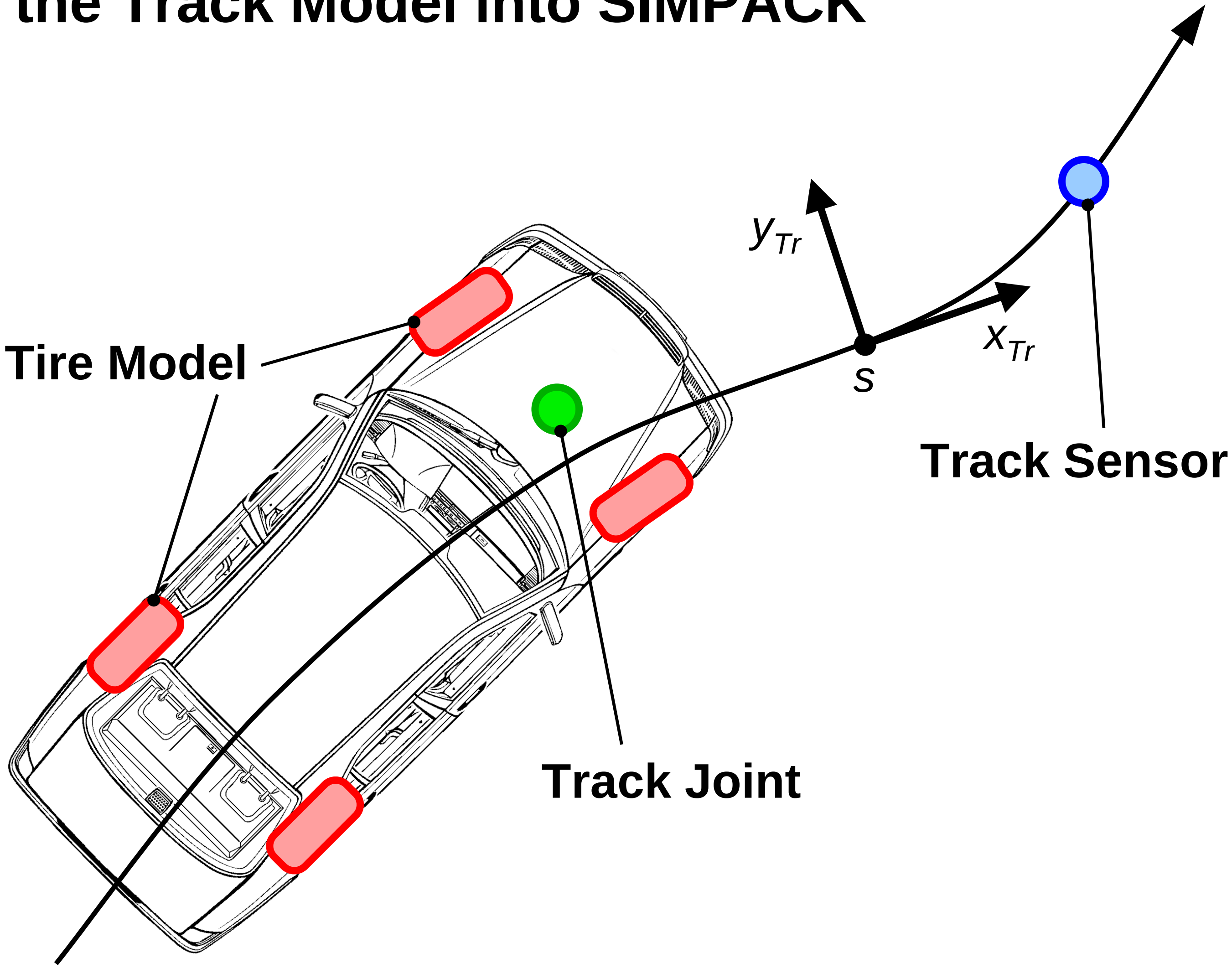
Implemented User Routines - Integration of the Track Model into SIMPACK



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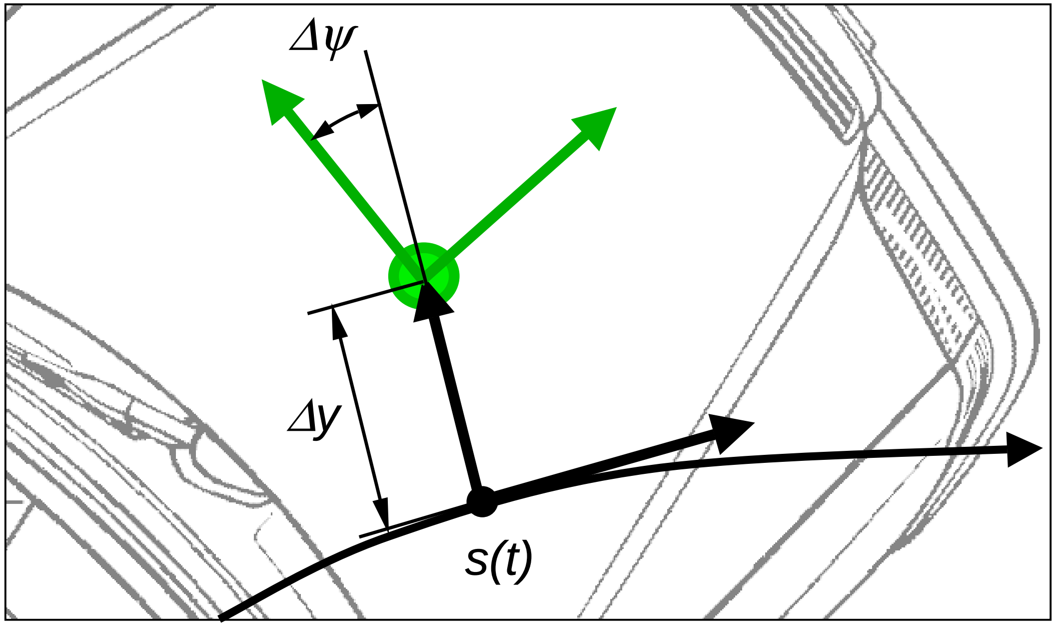
6 DOF Track Joint



- **States provide vehicle position and movement relative to track**
- **Serves as reference element for tire and track sensor**

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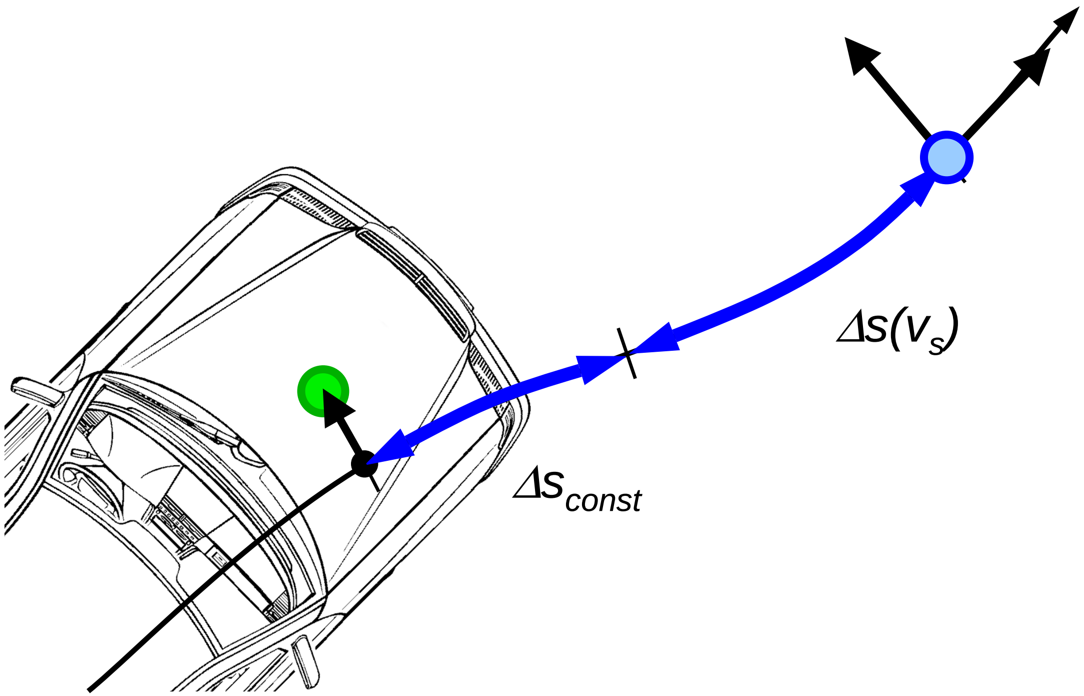
Track Sensor



- Allows preview relative to Track Joint position
- Preview distance modeled with constant and velocity dependent part

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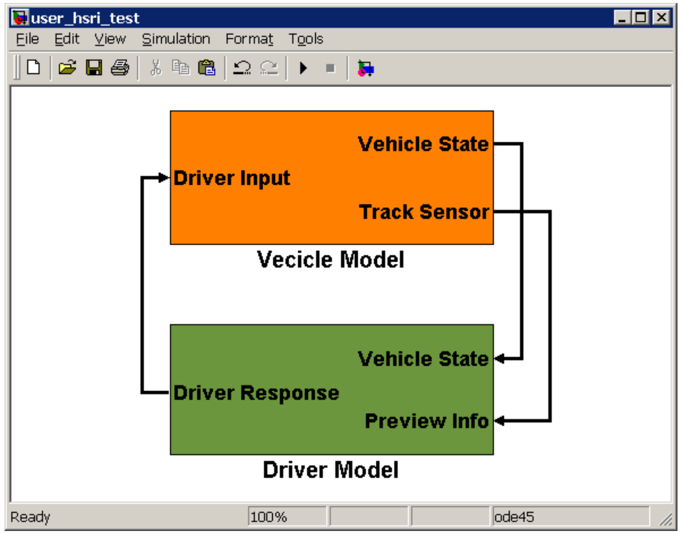
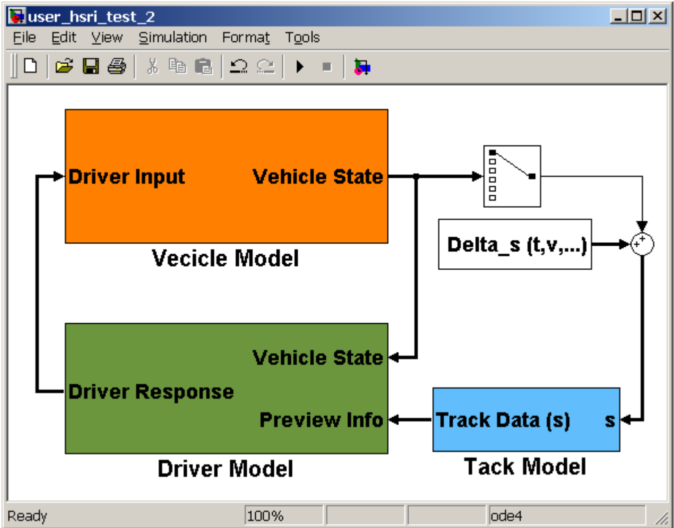
Implemented User Routines - Track Sensor



- **SIMULINK example: Controller using Track Sensor data**



- **SIMULINK track model for advanced controller concepts**

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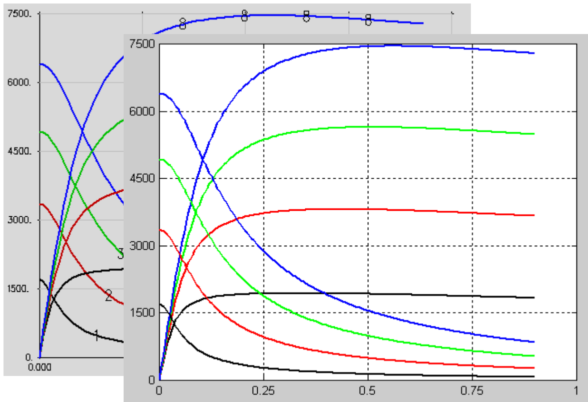
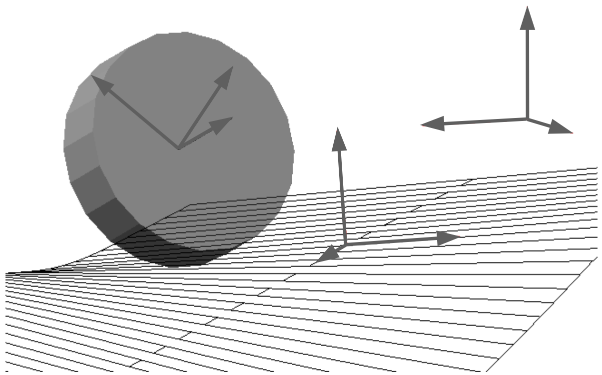
Tire Model



Tire Forces:

- **HSRI-Model**
- **Other models can easily be implemented**



Tire Kinematics:

- **Tire position relative to track**
- **Contact point, camber angle and slip values**

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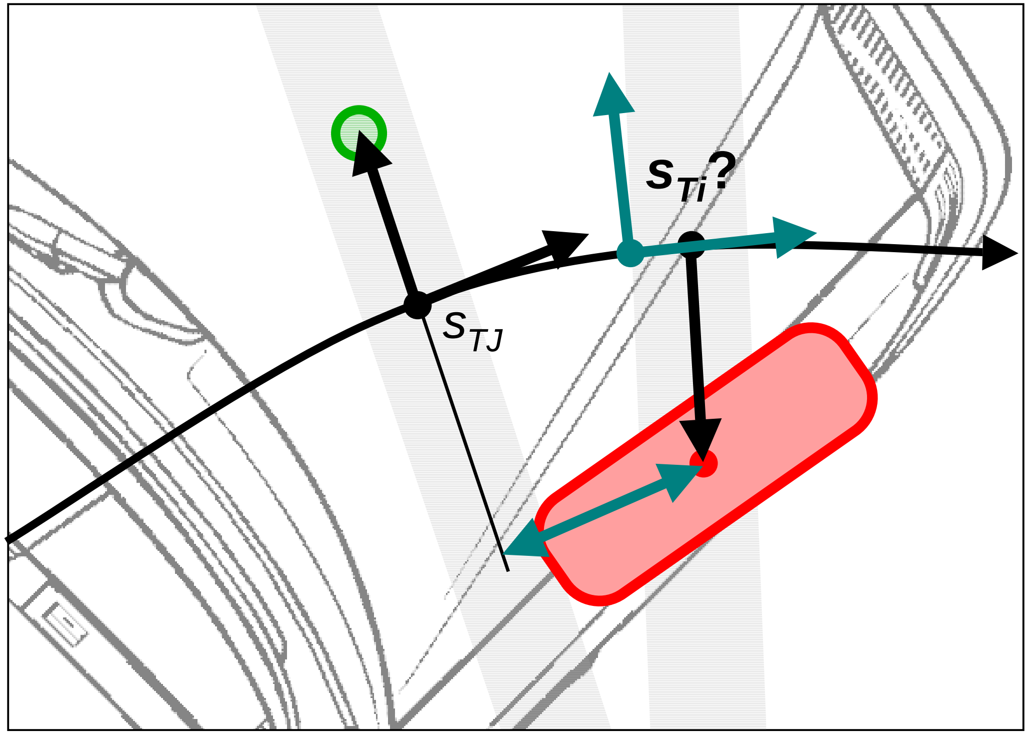
Tire Position Relative to Track

- Track definition: $x_{Tr}(s)$, $y_{Tr}(s)$, $z_{Tr}(s)$, ...
- Current tire position: x_{Ti}, y_{Ti}, z_{Ti}, ...



➨ Iteration: s_{Ti} (x_{Ti}, y_{Ti}, z_{Ti})

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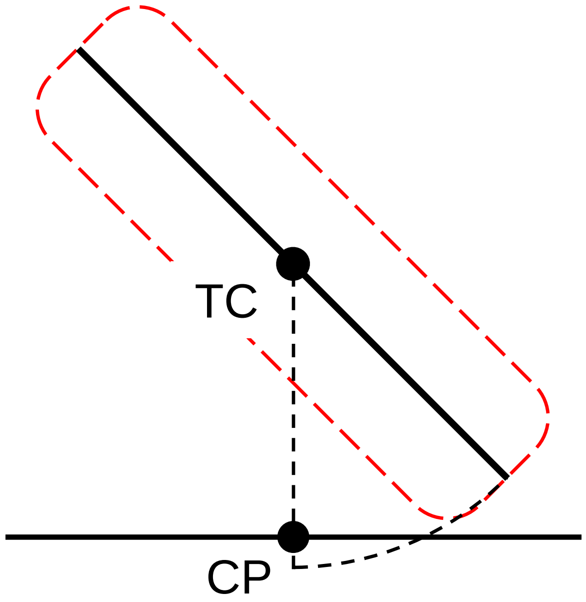
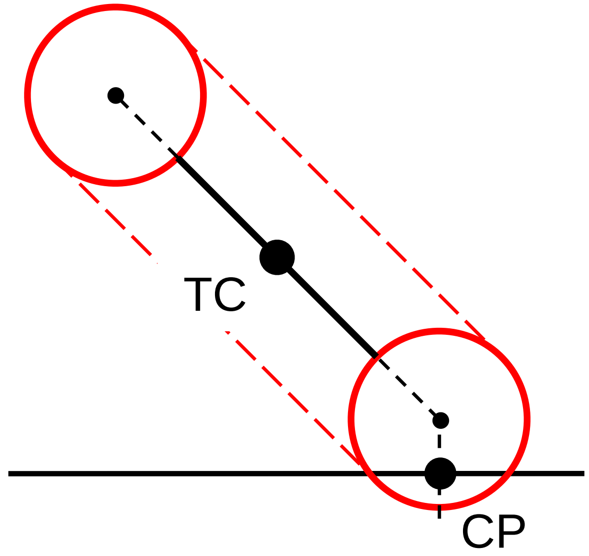
Contact Point Determination



SIMPACK Standard Tire ?



User Routine Tire

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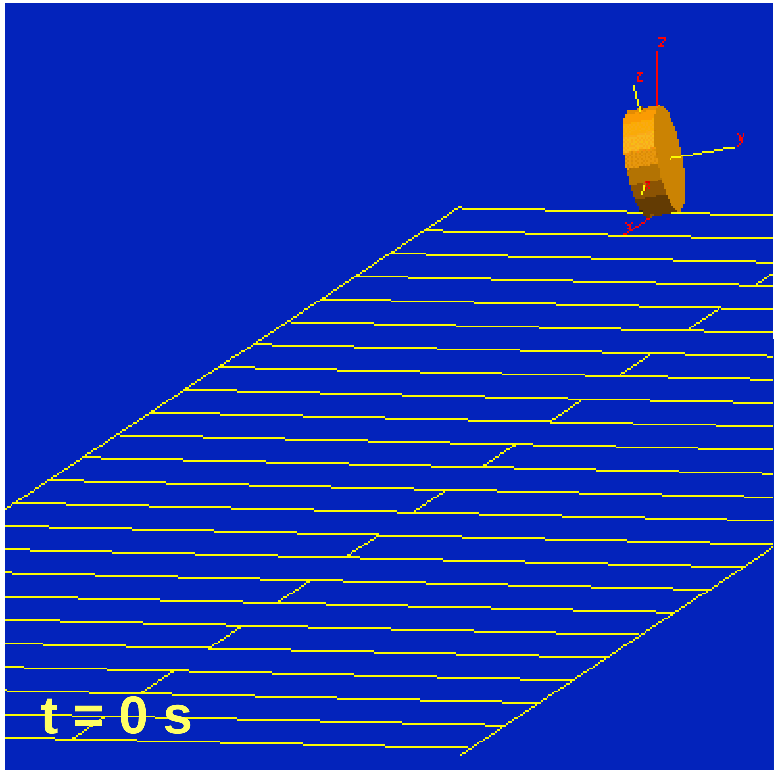
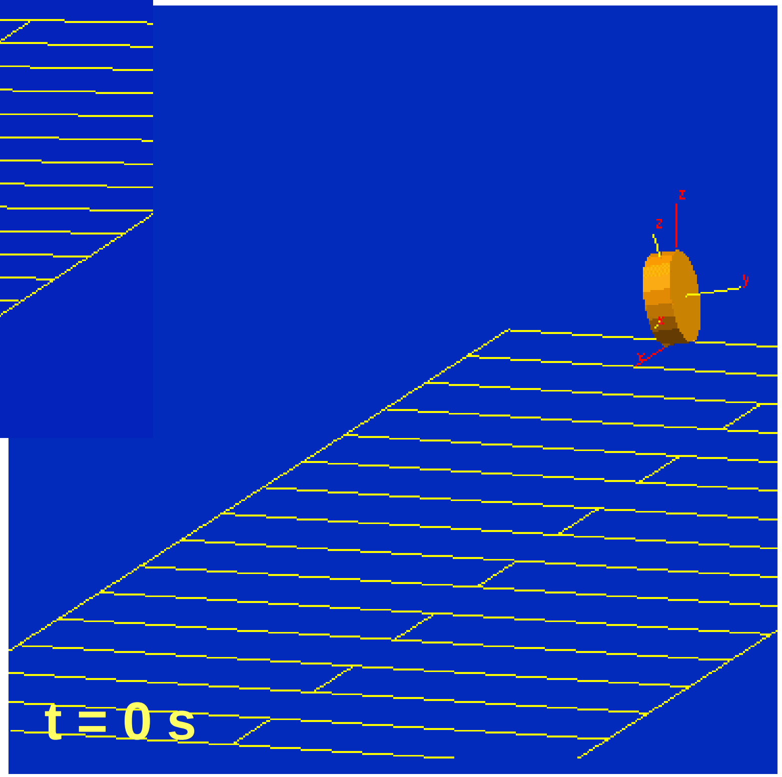
Implemented User Routines - Tire Model



SIMPACK Standard Tire (HSRI)

User Routine Tire



Krantz

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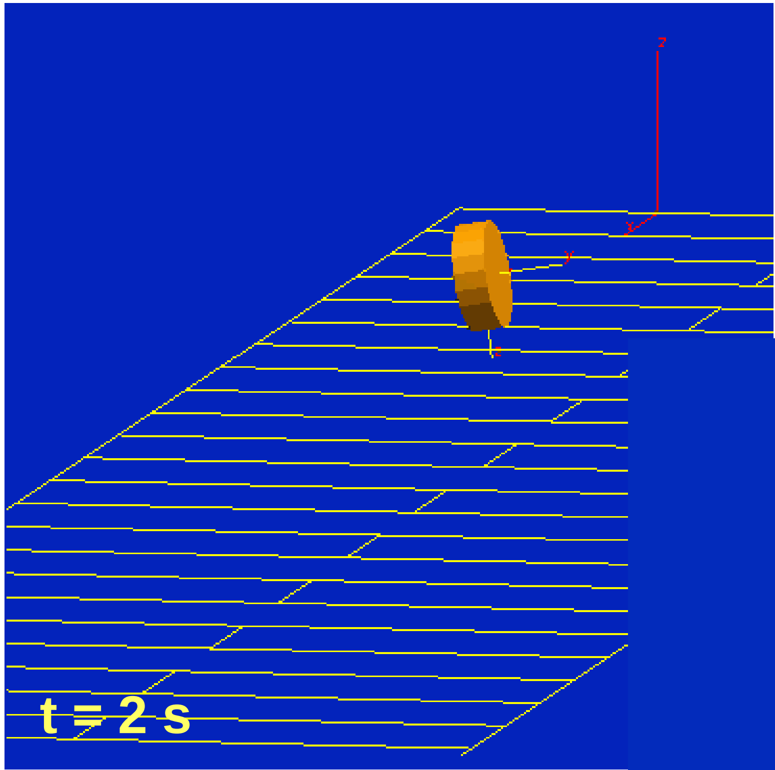
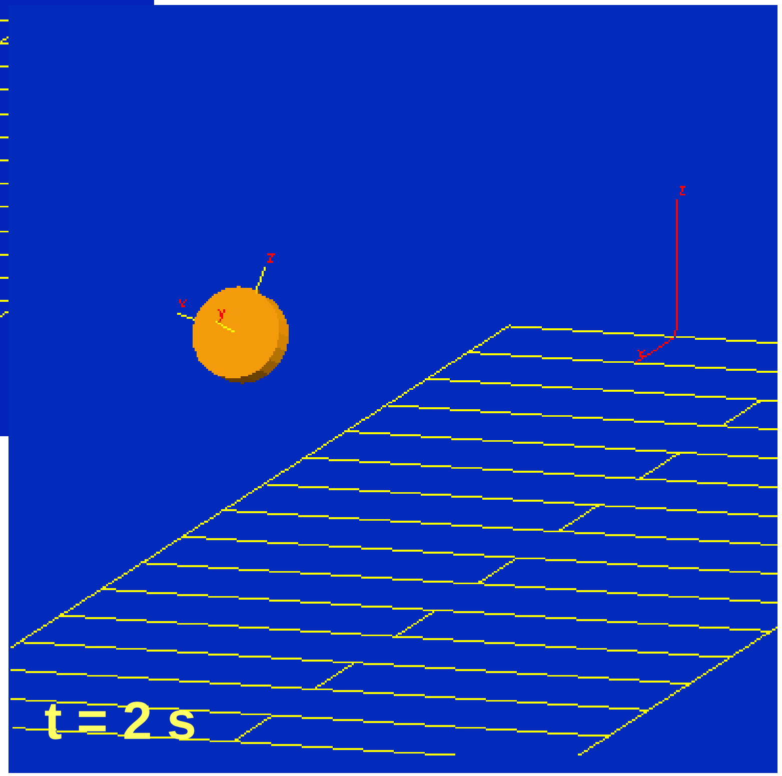
Implemented User Routines - Tire Model



SIMPACK Standard Tire (HSRI)

User Routine Tire



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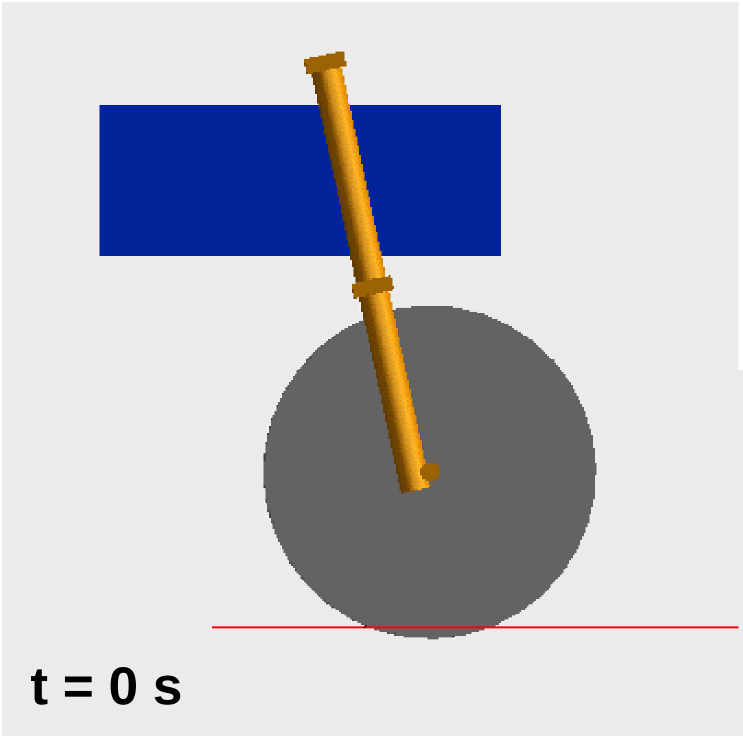
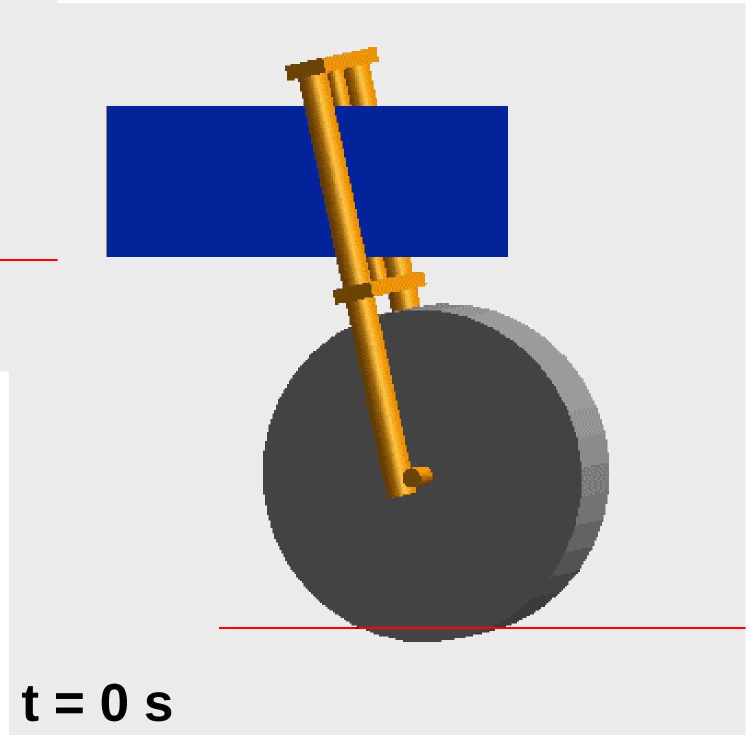
Implemented User Routines - Tire Model



SIMPACK Standard Tire

User Routine Tire



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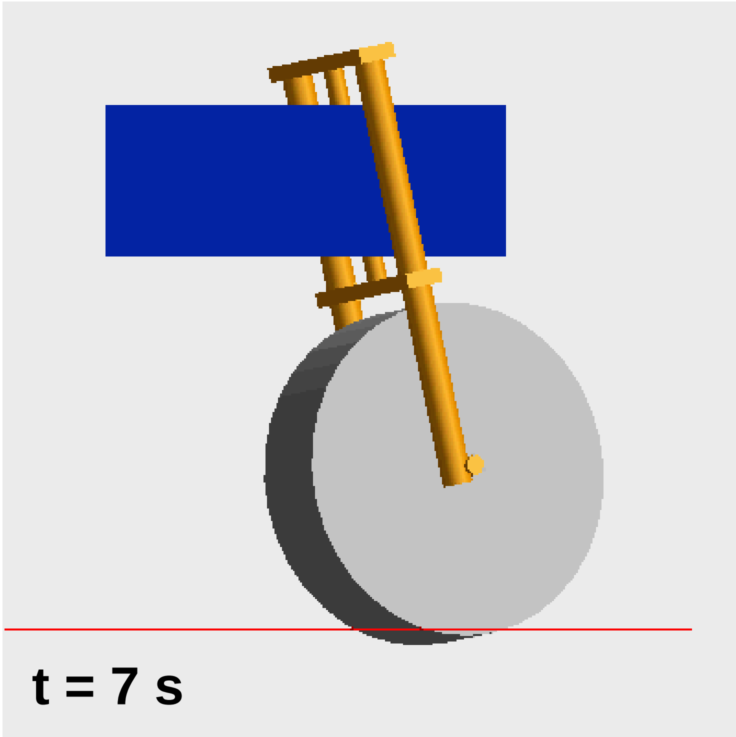
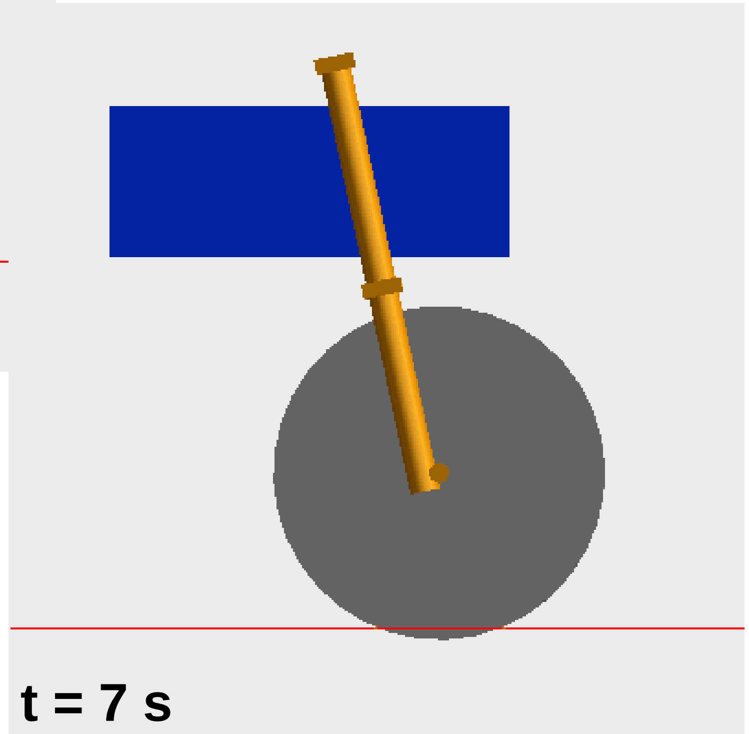
Implemented User Routines - Tire Model



SIMPACK Standard Tire

User Routine Tire



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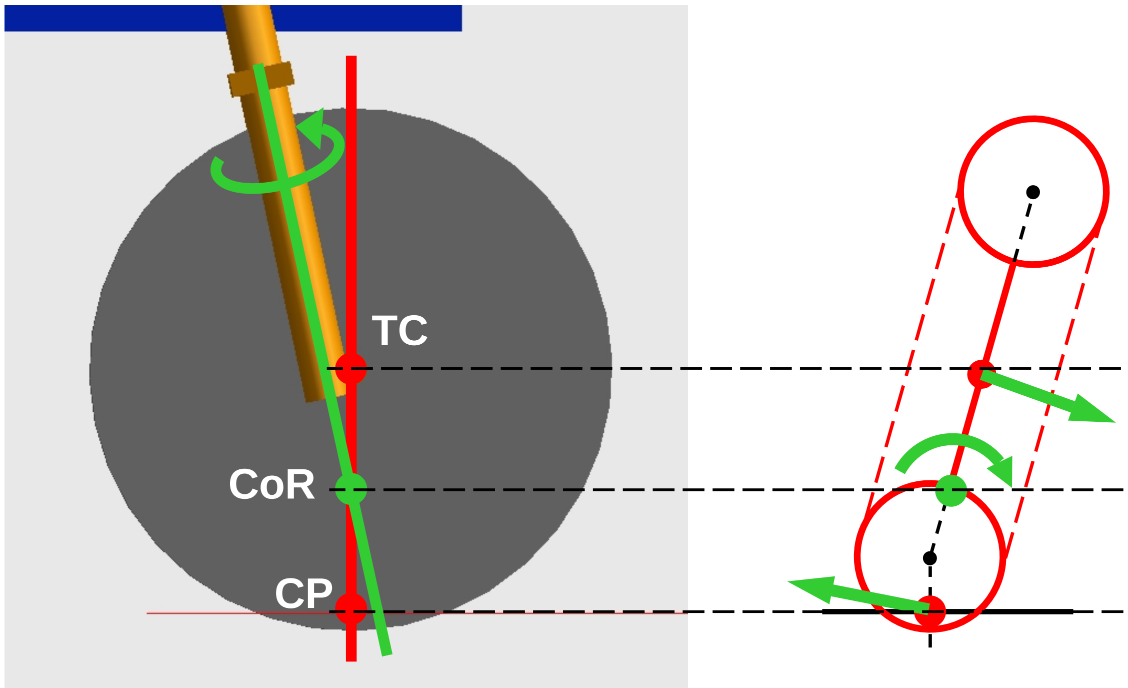
Implemented User Routines - Tire Model



- **Camber velocity induces slip angles**

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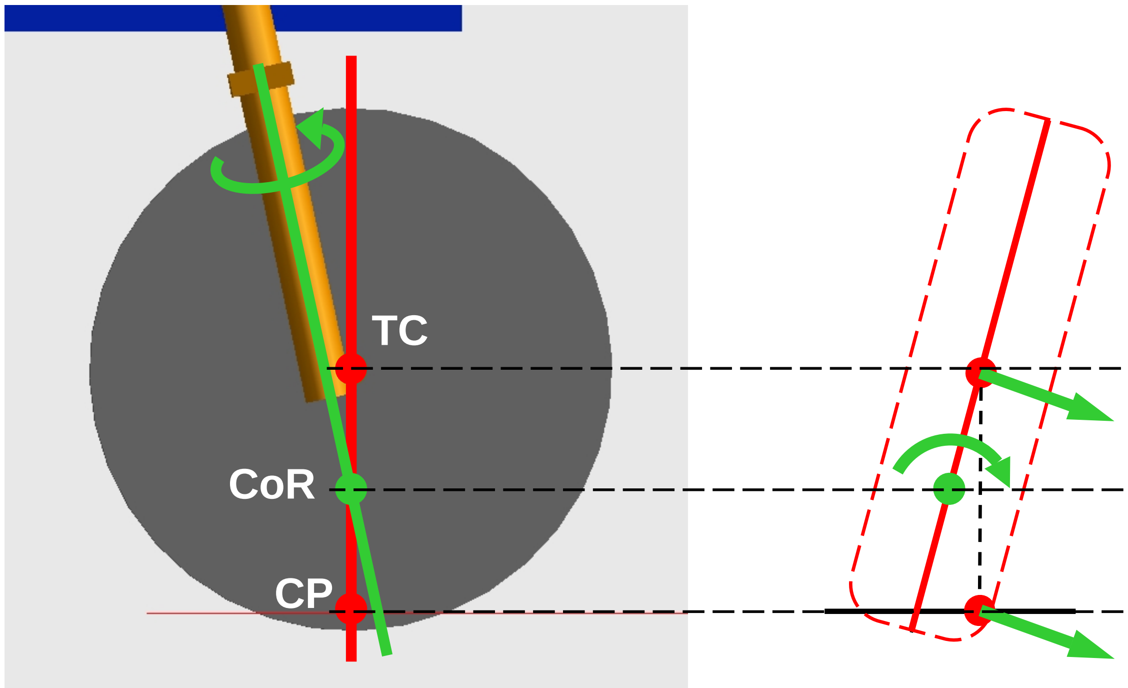
Implemented User Routines - Tire Model



- **Camber velocity induces slip angles**
- **Resulting lateral forces may excite system when using simple algorithm**

Summary

- Track and tire model now available for Symbolic Code Export
- Proved Track Joint concept is retained
- Improved contact point determination

Perspective

- Integration of superior tire models
- Enhanced pre- and postprocessing
- Porting to SIMPACK v8.5