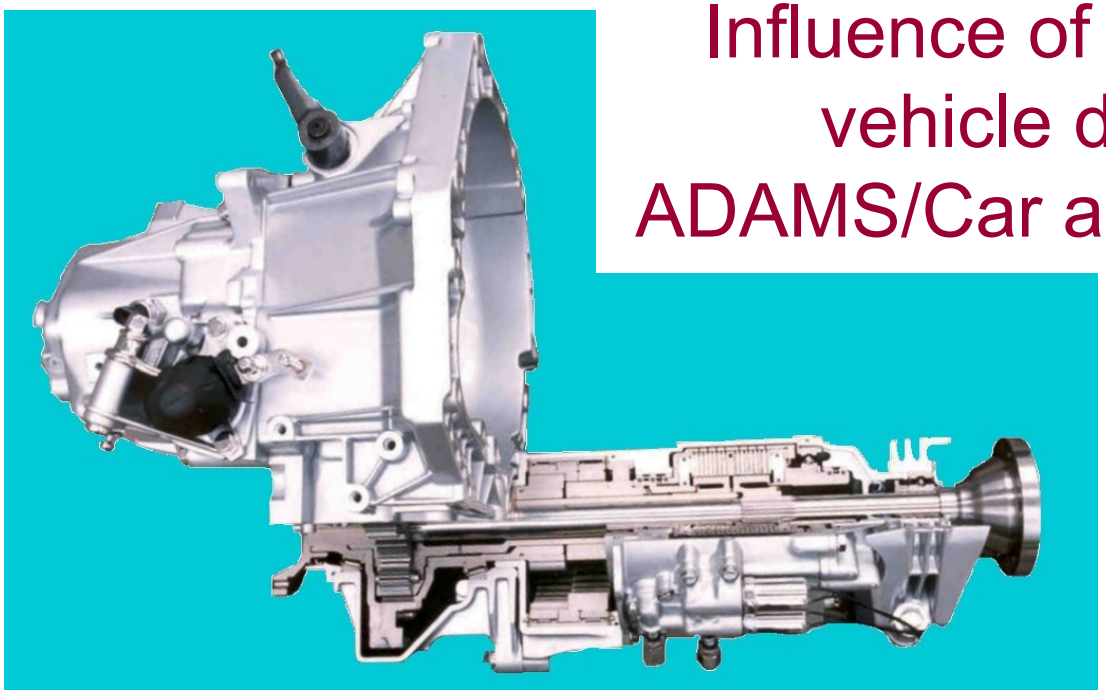

Influence of active systems on vehicle dynamics using ADAMS/Car and ADAMS/Controls

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Salvatore Frediani (FIAT Research Centre)

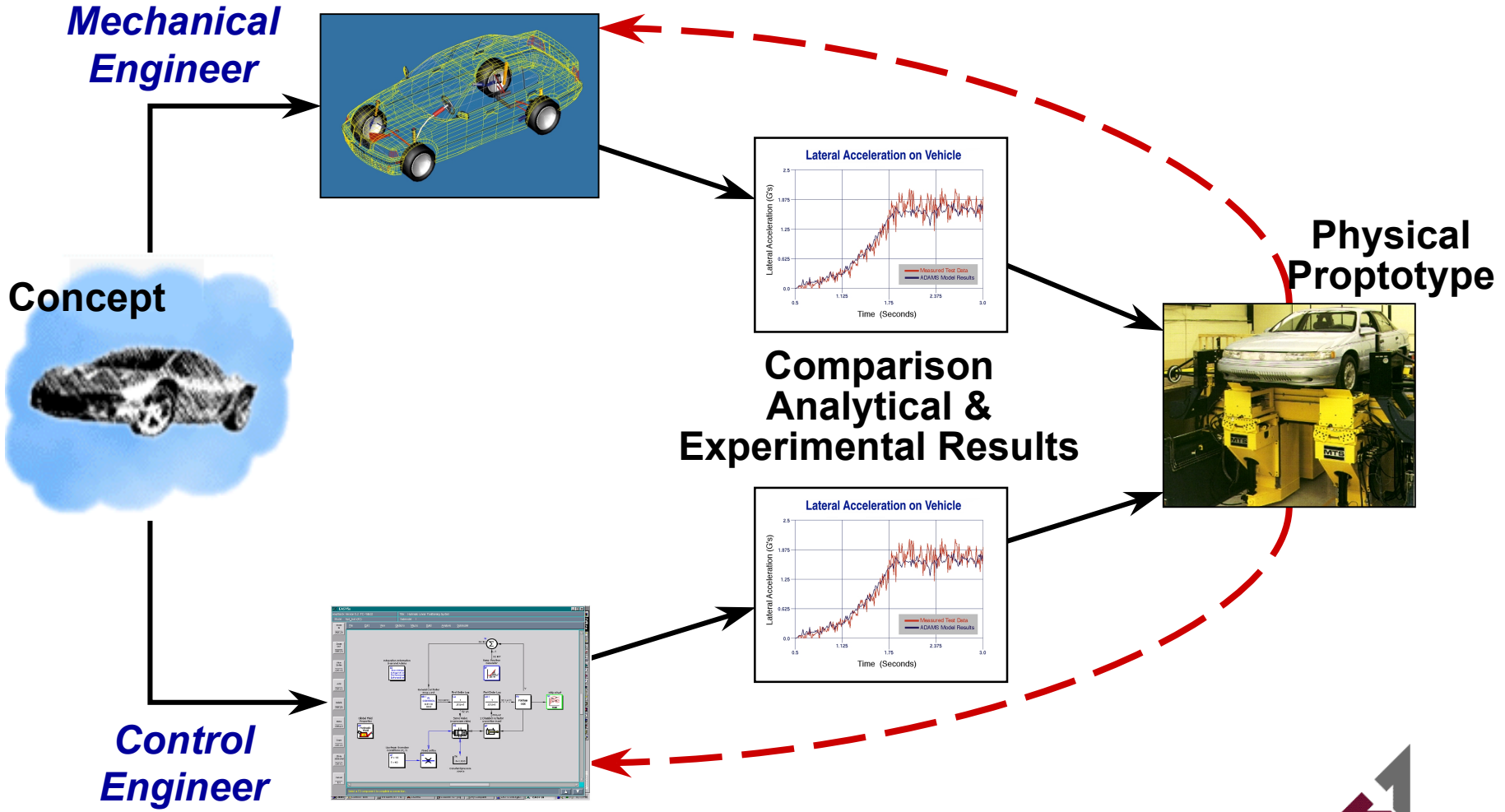
Guido Bairati (Mechanical Dynamics Italy s.r.l.)

Mechanical Dynamics

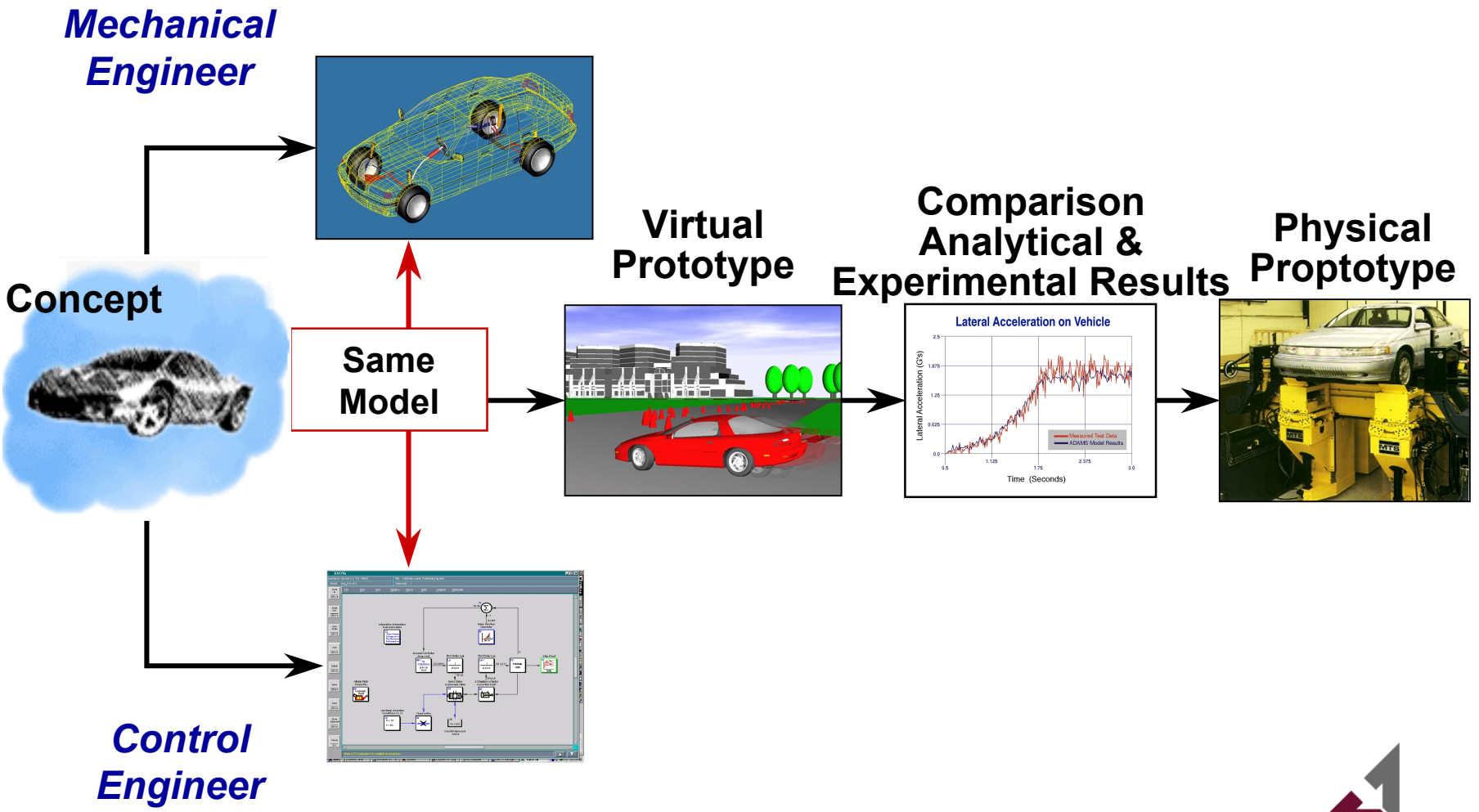
Agenda

- Why using ADAMS/Car and ADAMS/Controls
- Integrating a multibody model with a control system developed with SIMULINK
  - active differential
  - the model
  - results
- Conclusions

Typical Design Process



Design Process using ADAMS/Controls



Why does FIAT Research use ADAMS/Controls?

- There are more and more active system of today's cars such as ABS, VDC and ESP
- We have, in this way, the possibility to use same models as other departments. We don't want to focus on the building of the model but we want to develop good controls which fit well in our cars
- Developing a car model in MATLAB is time-consuming and very difficult
- Easiness in reproducing different test conditions:
  - environmental (friction, tire slip, …)
  - car set-up (bushing, spring, damper, ride heights)

Problem

- **Studying the influence of an active differential on the dynamic behavior of the car**

ADAMS/CAR

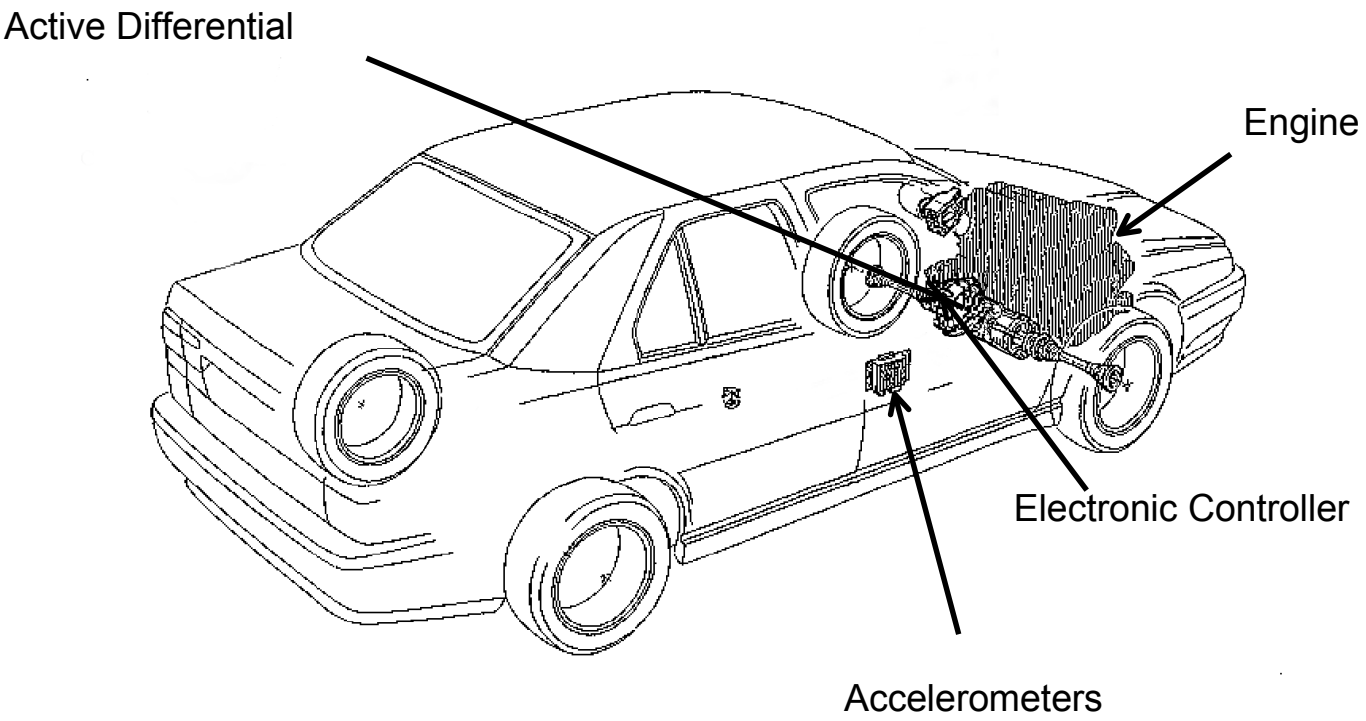
- 1st Phase: the model is built in ADAMS/Car
- 2nd Phase: Model Validation
  - Suspension Analyses
  - Dynamic analyses
- 3rd Phase: Integration of the control model with the multibody model

ADAMS/Controls

SIMULINK

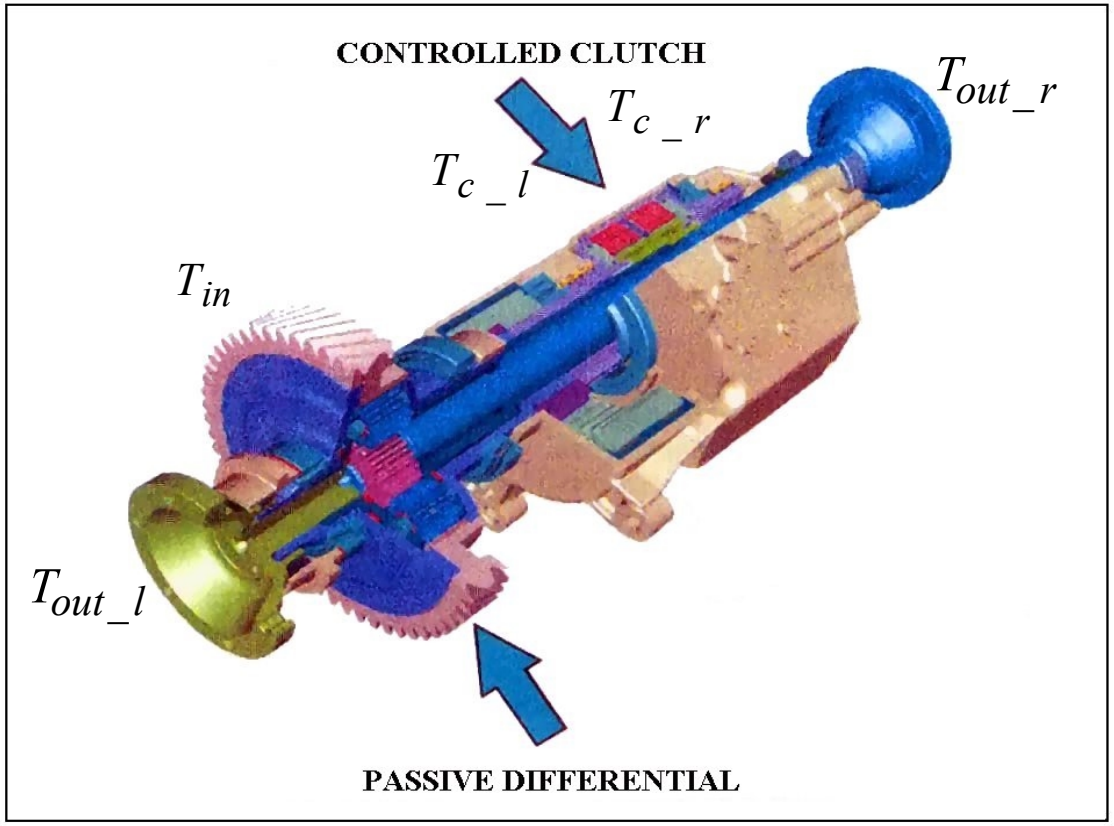
- Phase 0: Both Car and Control modelled in SIMULINK for a preliminary study
- 1st Phase: building the SIMULINK model of the control system

The Active Differential



OBJECTIVES:
- Yaw dynamic stabilization
- Understeer Regulation according to driver's personal feeling
- MAX Cornering Traction Increment
- ***Active Safety*** increment

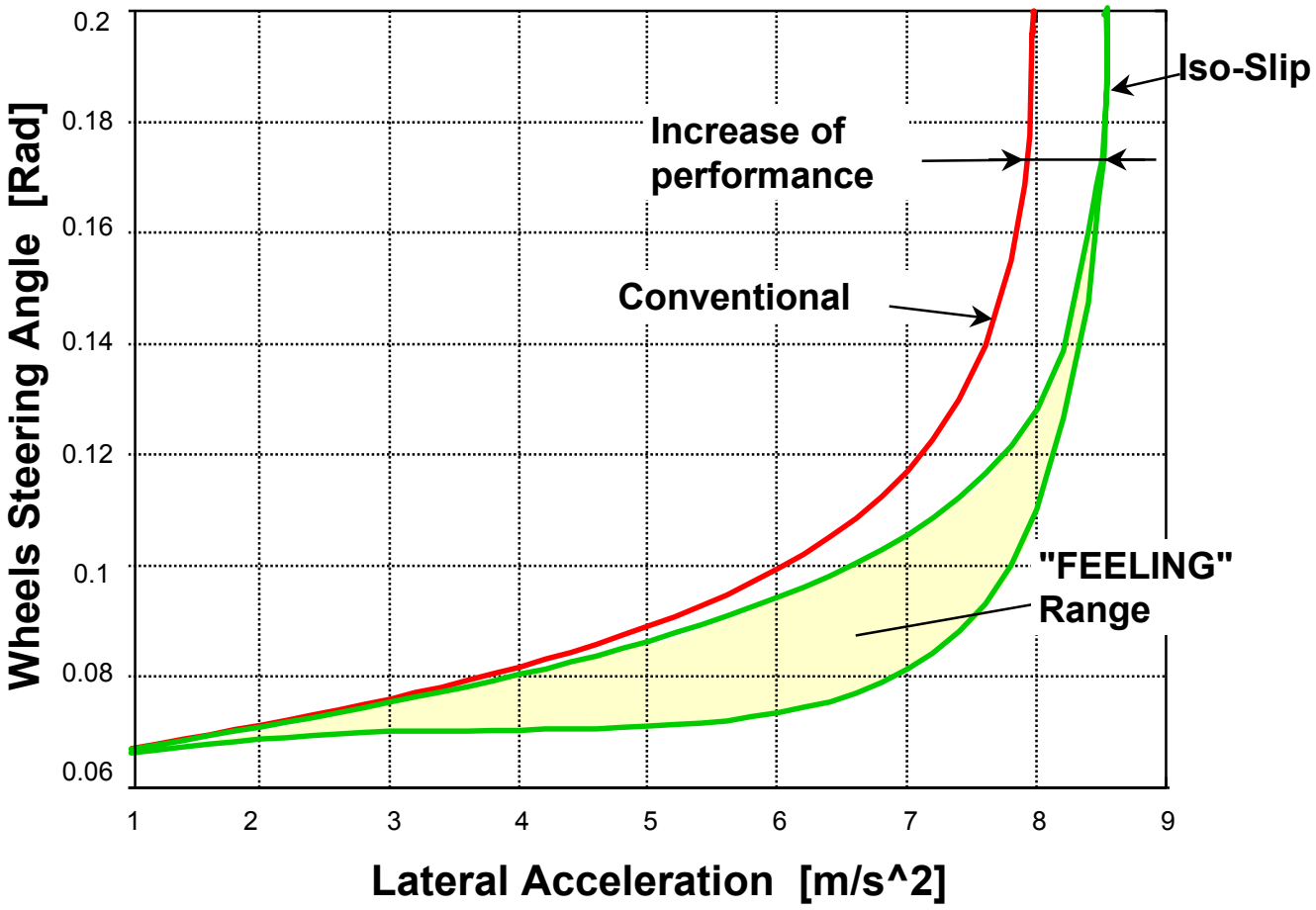
The Active Differential



$$T_{out\_l} = T_{in} + T_c \frac{2-\tau_c}{2}; \quad T_{out\_r} = T_{in} - T_c \frac{\tau_c}{2};$$

$$T_{yaw} = (T_{out\_l} - T_{out\_r}) \frac{c}{2R_w} = (T_{c\_l} - T_{c\_r}) \frac{c}{2R_w};$$

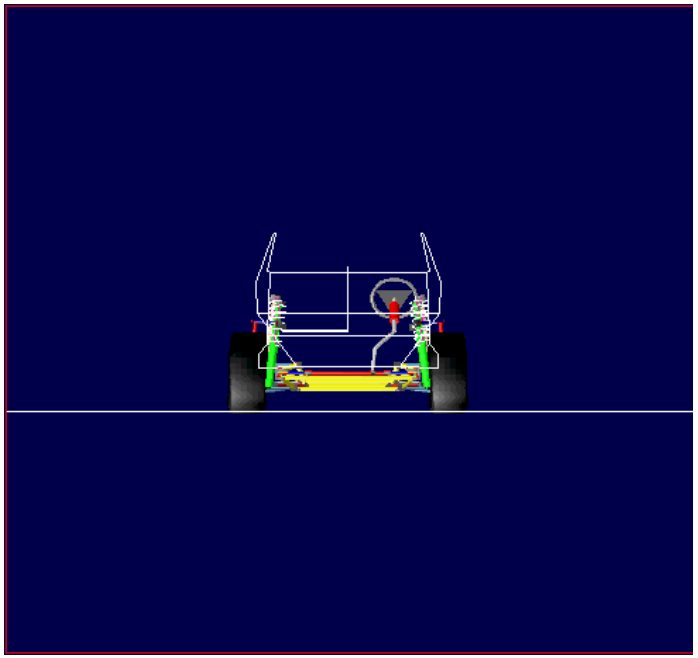
Steering Pad - 40 m Radius



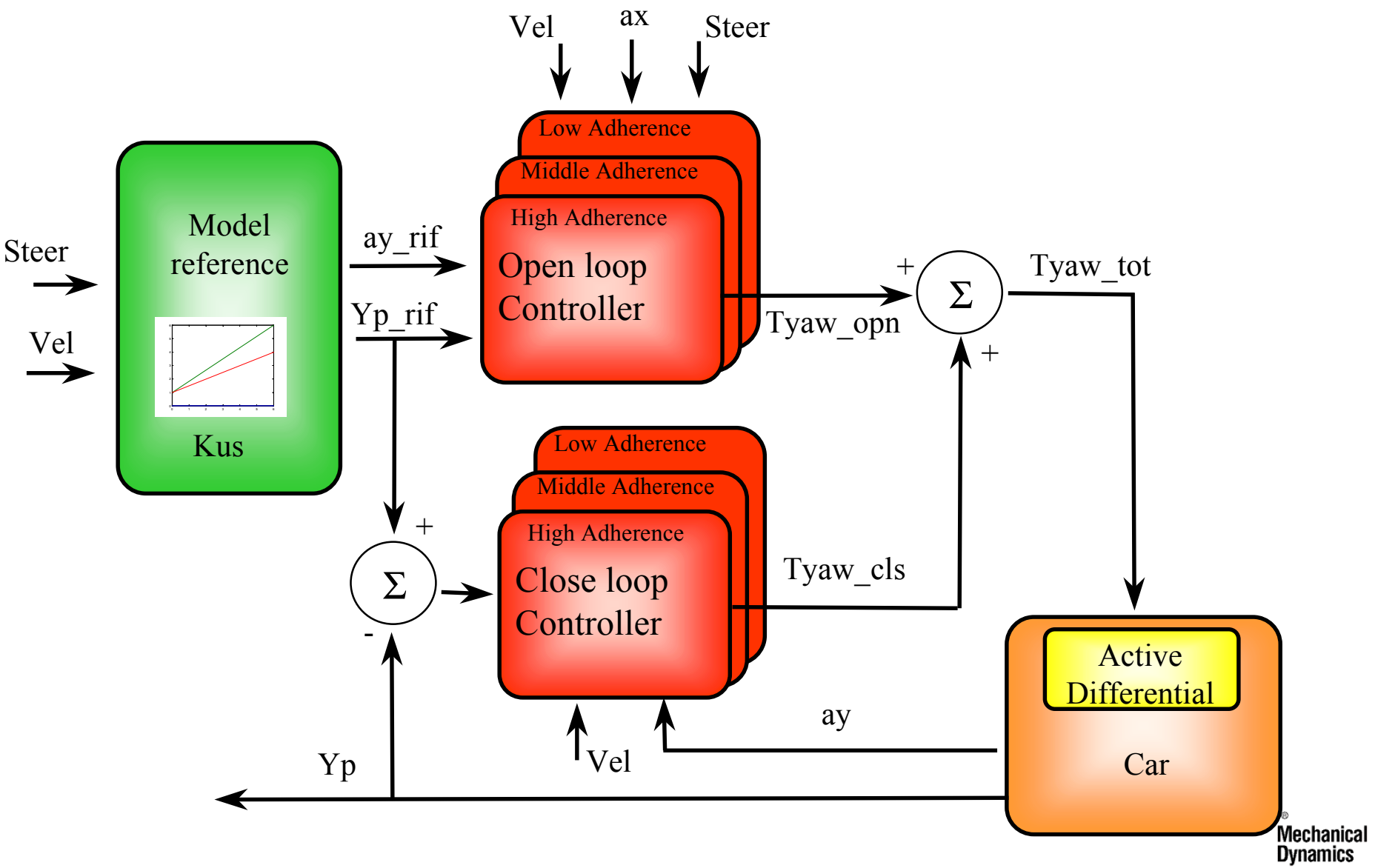
Control Logics

- **Input:**
  - Steering Angle [deg]
  - Wheel Angular Velocity (Front/Rear, Left/Right) [rad/sec]
  - Longitudinal Velocity [m/sec]
  - Lateral and Longitudinal Acceleration [m/sec^2]
  - Yaw Velocity [rad/sec]
  - Feeling Factor

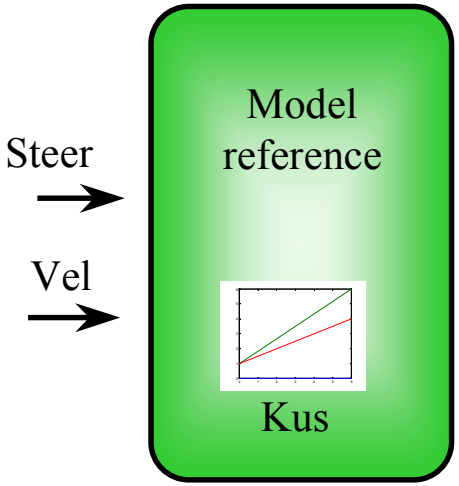
    (personal driving style)
- **Output:**
  - Additional Torque at Left Driveshaft [Nm]
  - Additional Torque at Right Driveshaft [Nm]

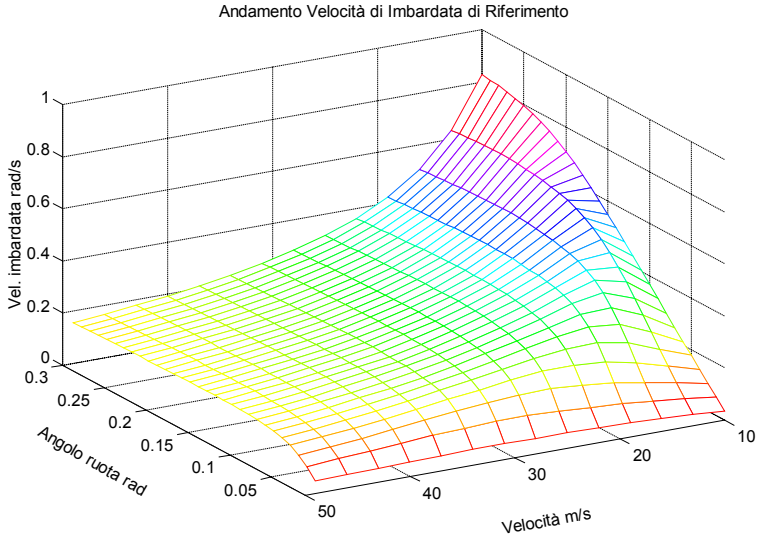


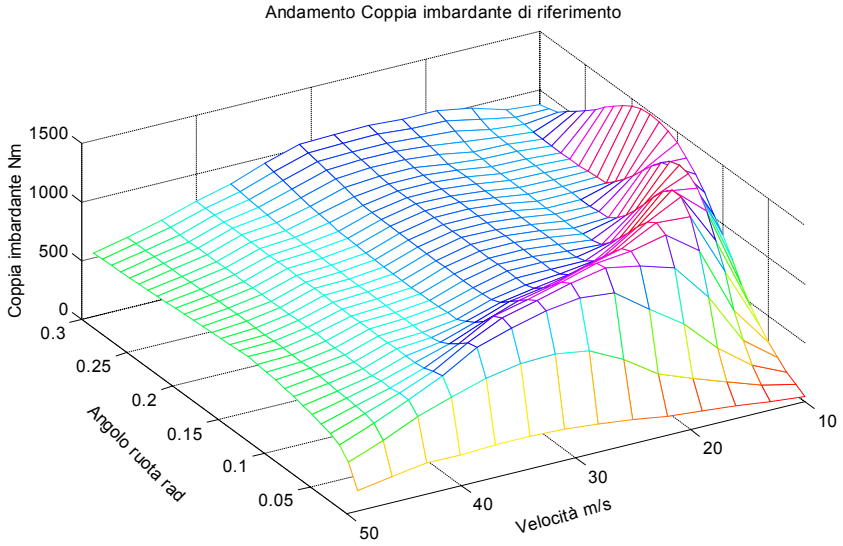
Control Structure



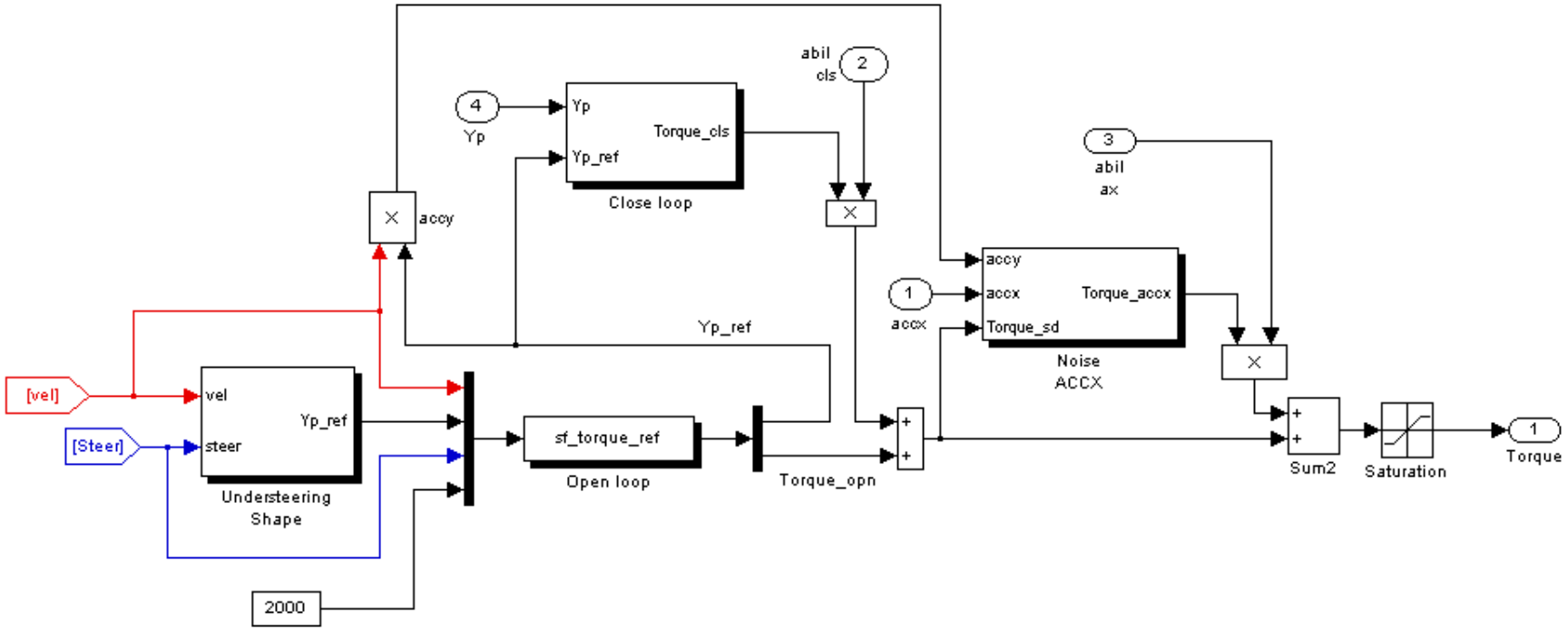
Control Structure







The SIMULINK Model



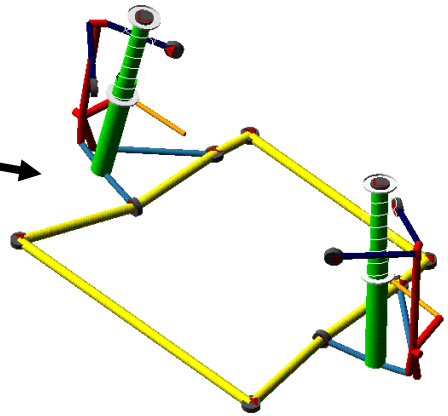
CONTROLLER

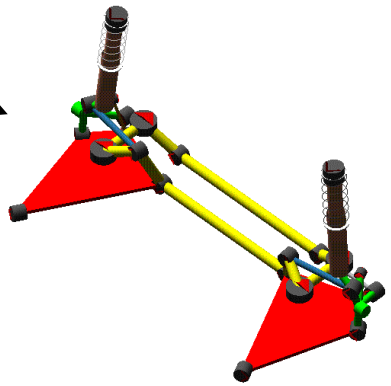
The ADAMS/Car vehicle model

- **The model includes:**
  - Front Suspension

    (double wishbone with virtual steering axis)
  - Rear Suspension

    (MultiLink)
  - Chassis
  - Steering System
  - Front/Rear AntiRoll Bar
  - Front/Rear Tires
  - Differential (from MATLAB)



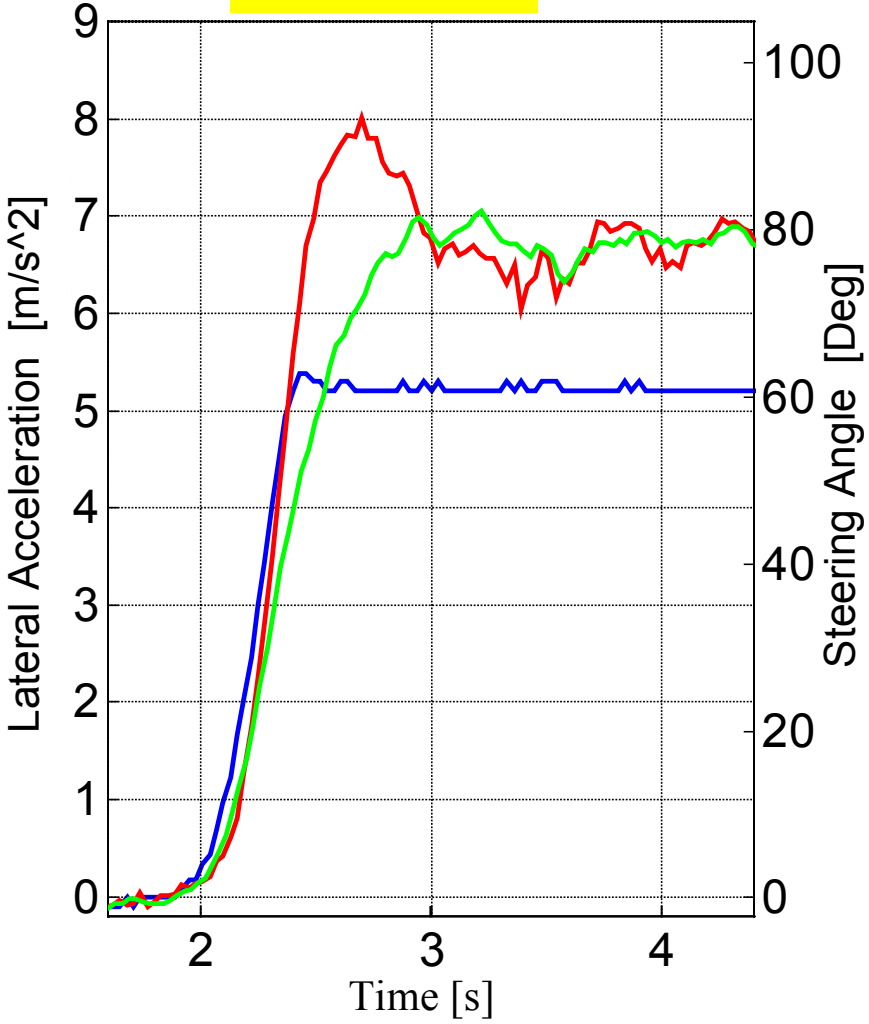


FIAT RESEARCH

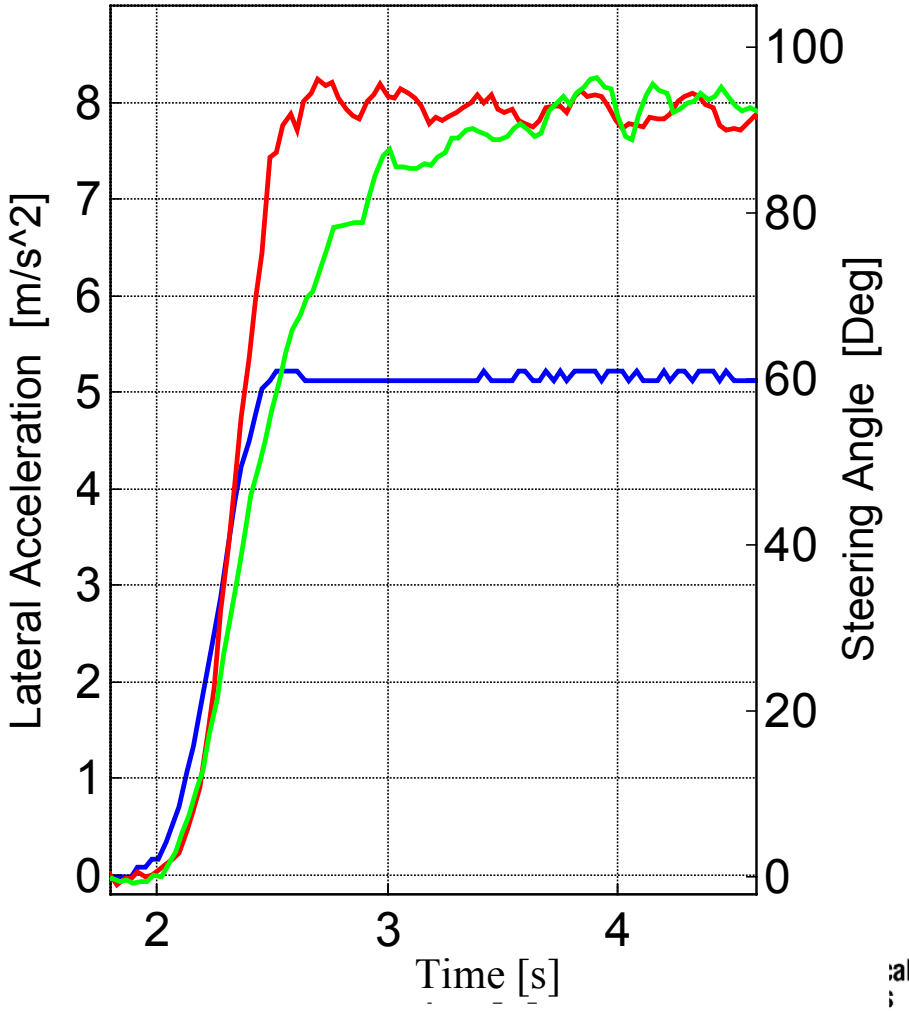
Active Control Behavior

Experimental Results

Passive Car



Active Car

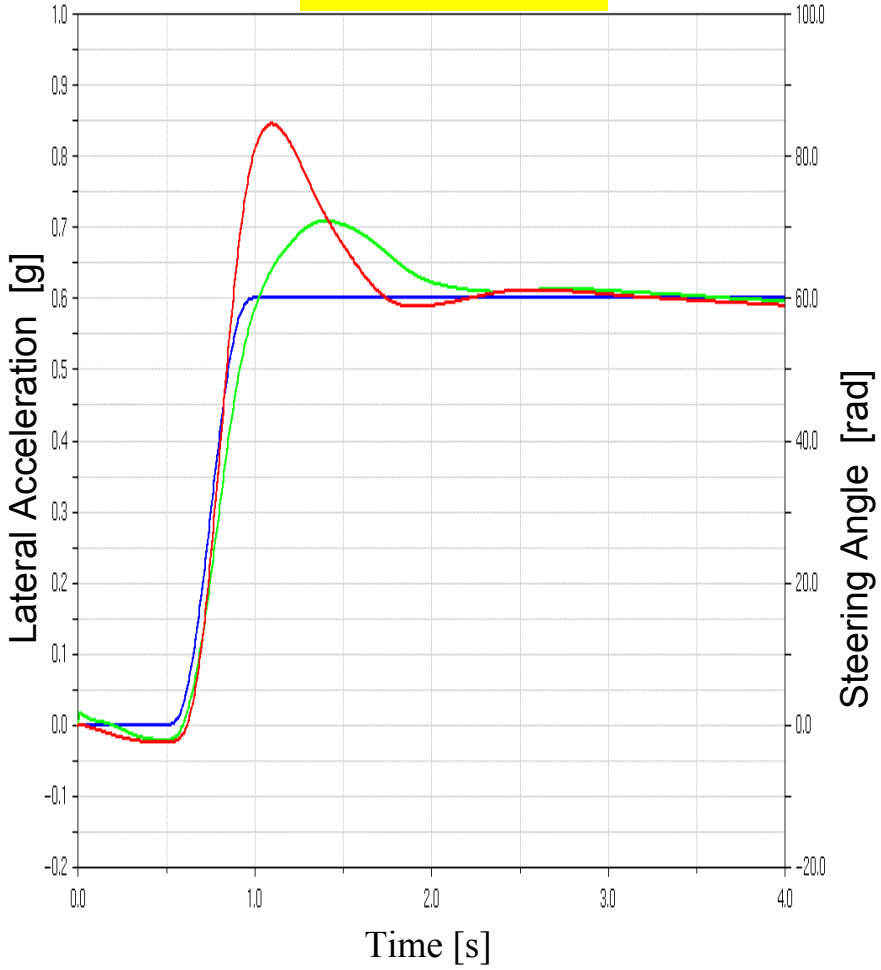


FIAT RESEARCH

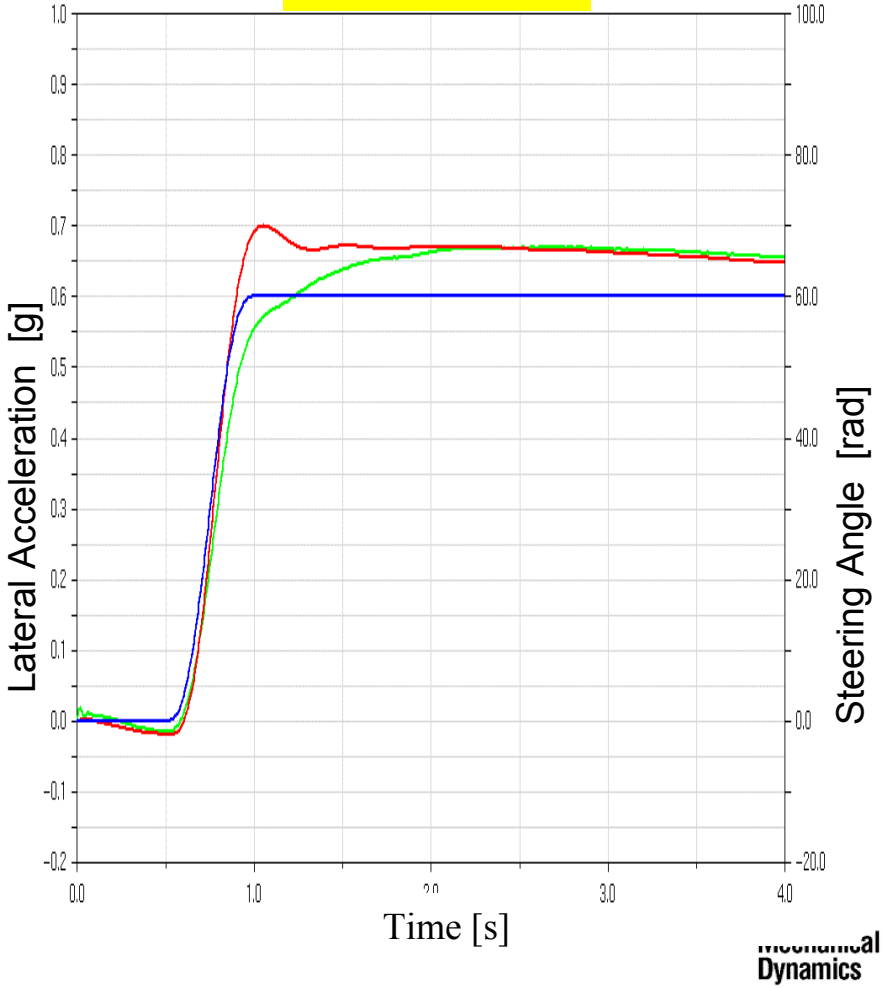
Active Control Behavior

ADAMS/Car - SIMULINK Co-Simulation

Passive Car



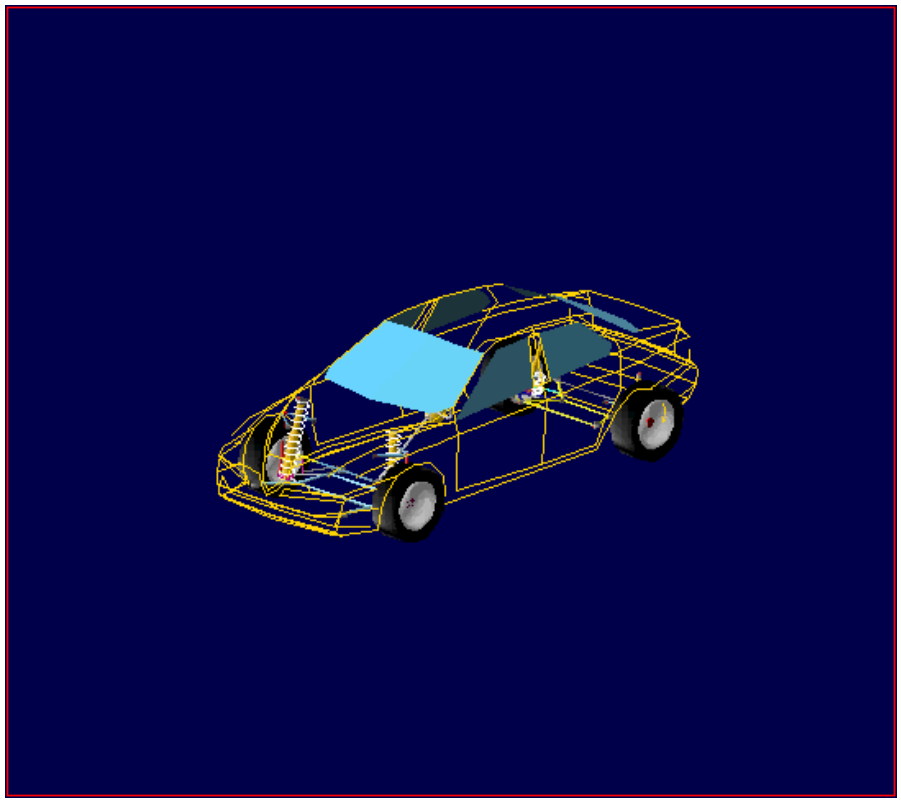
Active Car

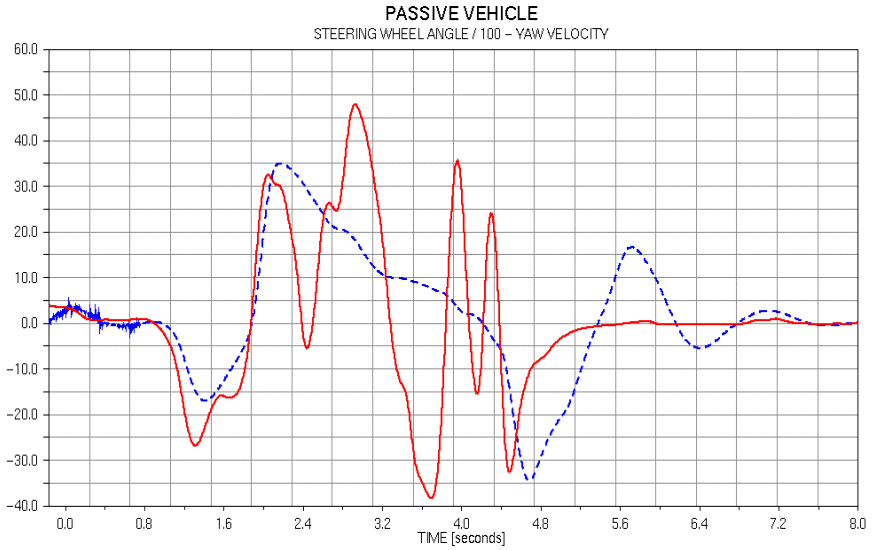


Dynamics

Active Control Behavior: ISO Lane Change

Front and Rear Tires on a same friction surface ($\mu = 1$)

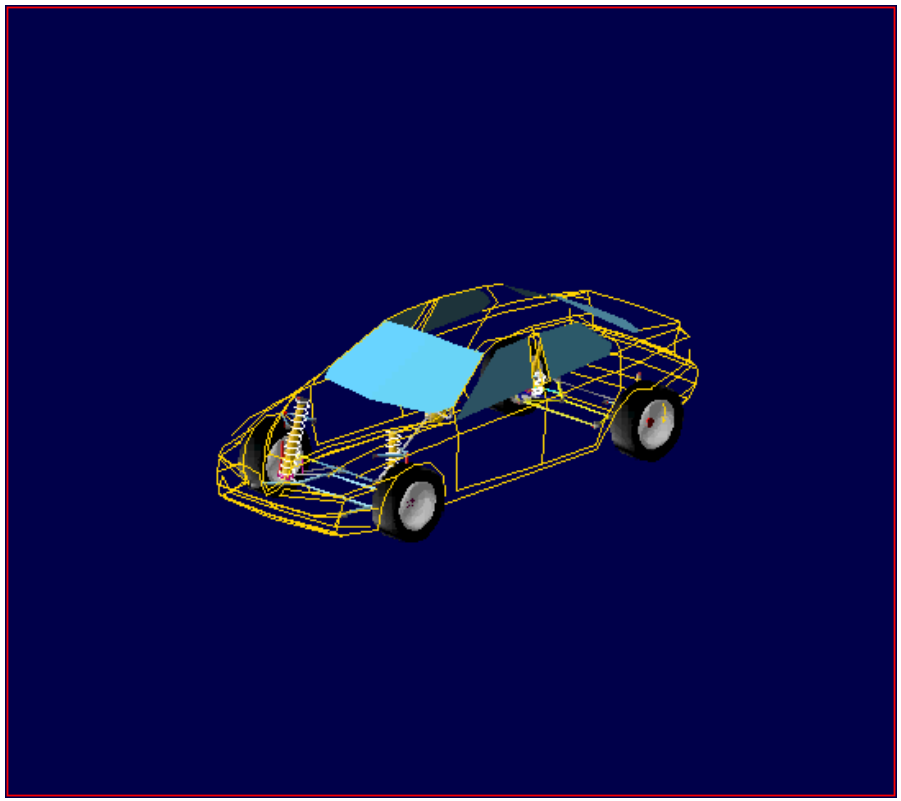


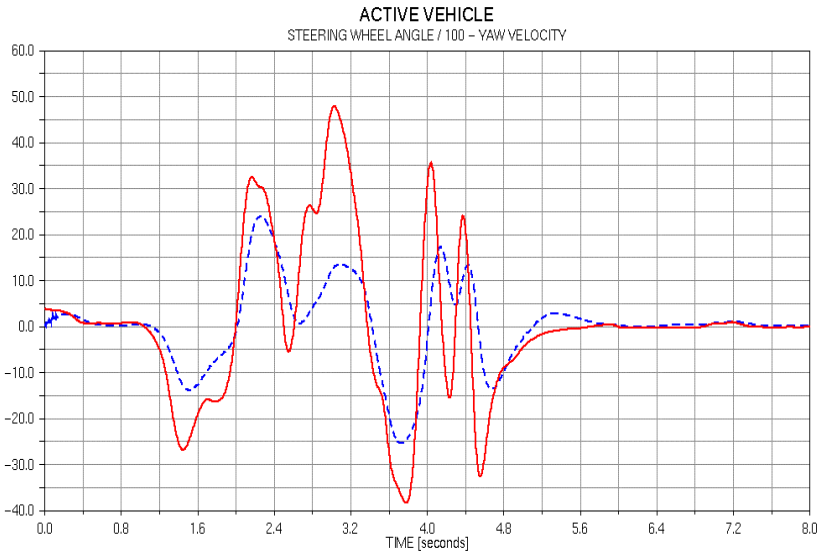


FIAT RESEARCH

Active Control Behavior: ISO Lane Change

Front and Rear Tires on a same friction surface ($\mu = 1$)

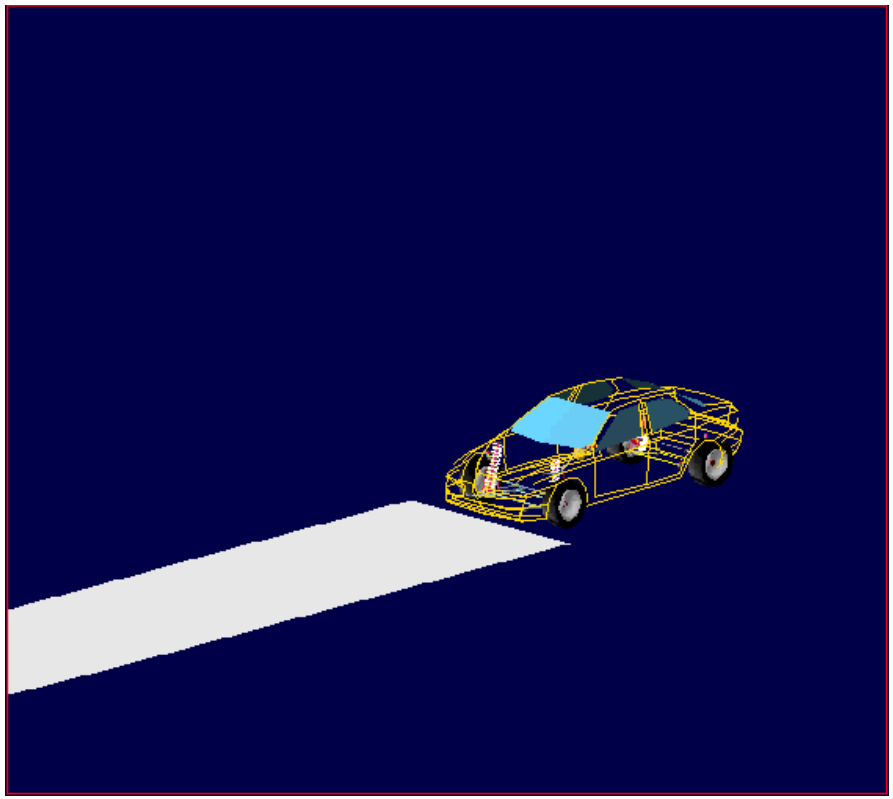


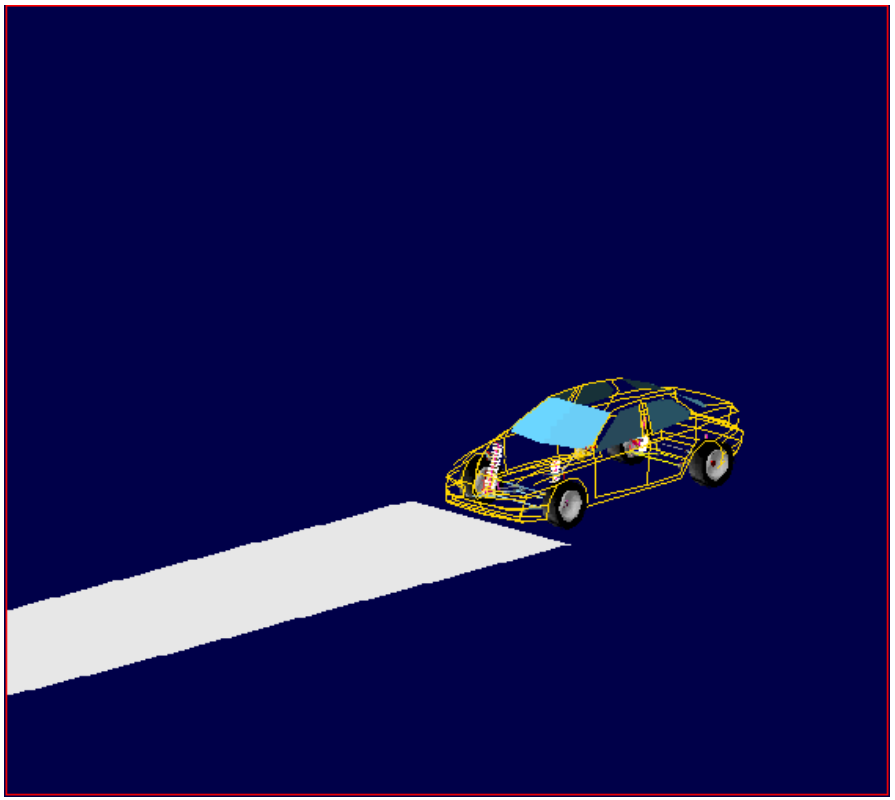


Mechanical Dynamics

Active Control Behavior: Step Steer

Rear Tires on a low friction surface ($\mu = 0.85$)





Conclusions

ADAMS/Car

- The virtual model makes it easy to test maneuvers difficult to be run on the test track (ice, rain, ..)
- Separates different effects
- ADAMS/Car allows to change all different inputs
  - sensitivity studies
- Possibility to test different car configurations

CONTROL

- The control allows to increase vehicle performances:
  - lateral acceleration
  - longitudinal acceleration
  - guidability e driving style personalization
  - *Active Safety*
    - Increased stability in all different working conditions

Future Developments

- Use ADAMS/Car - ADAMS/Driver - ADAMS/Controls to test how the driver model interacts with controls in maneuvers such as:
  - ISO Lane Change
  - Test Track Simulation