

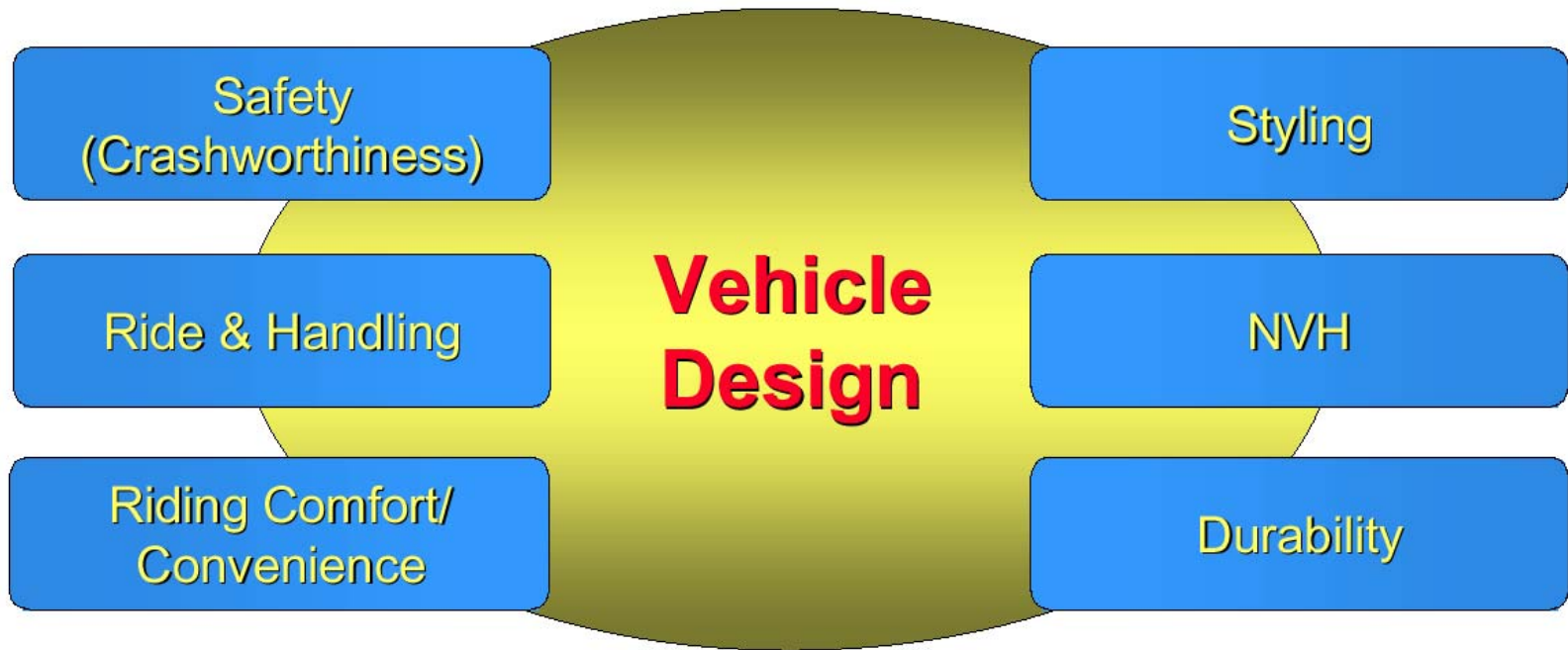
# Virtual Prototyping with Multibody Dynamics Software in Vehicle Development Process

**Sang-Sup Kim**

**Graduate School of Automotive Engineering  
Kookmin University**

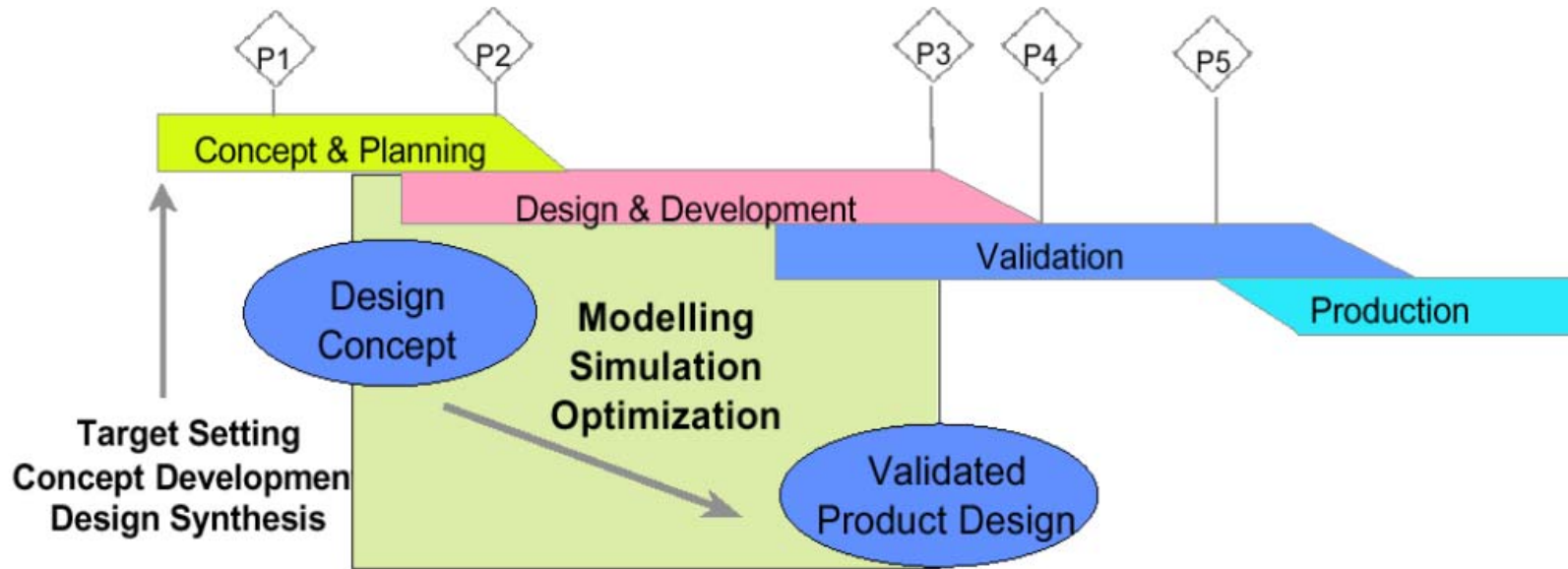
# Vehicle Design

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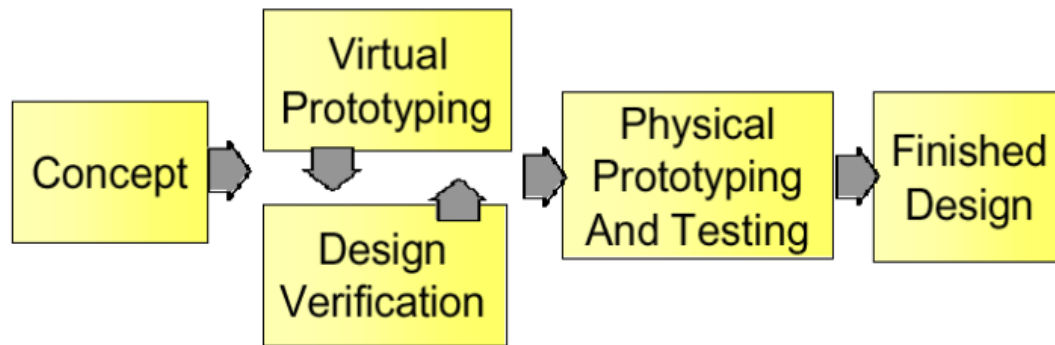
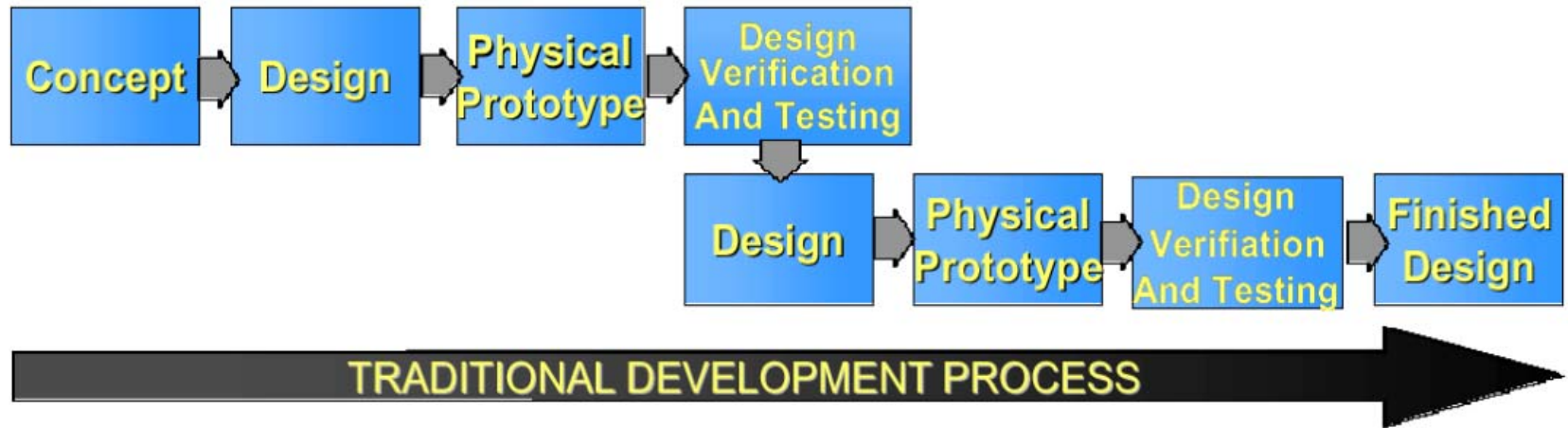
By D. S. Lee

# Vehicle Development Process Using CAE



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# Virtual Prototyping

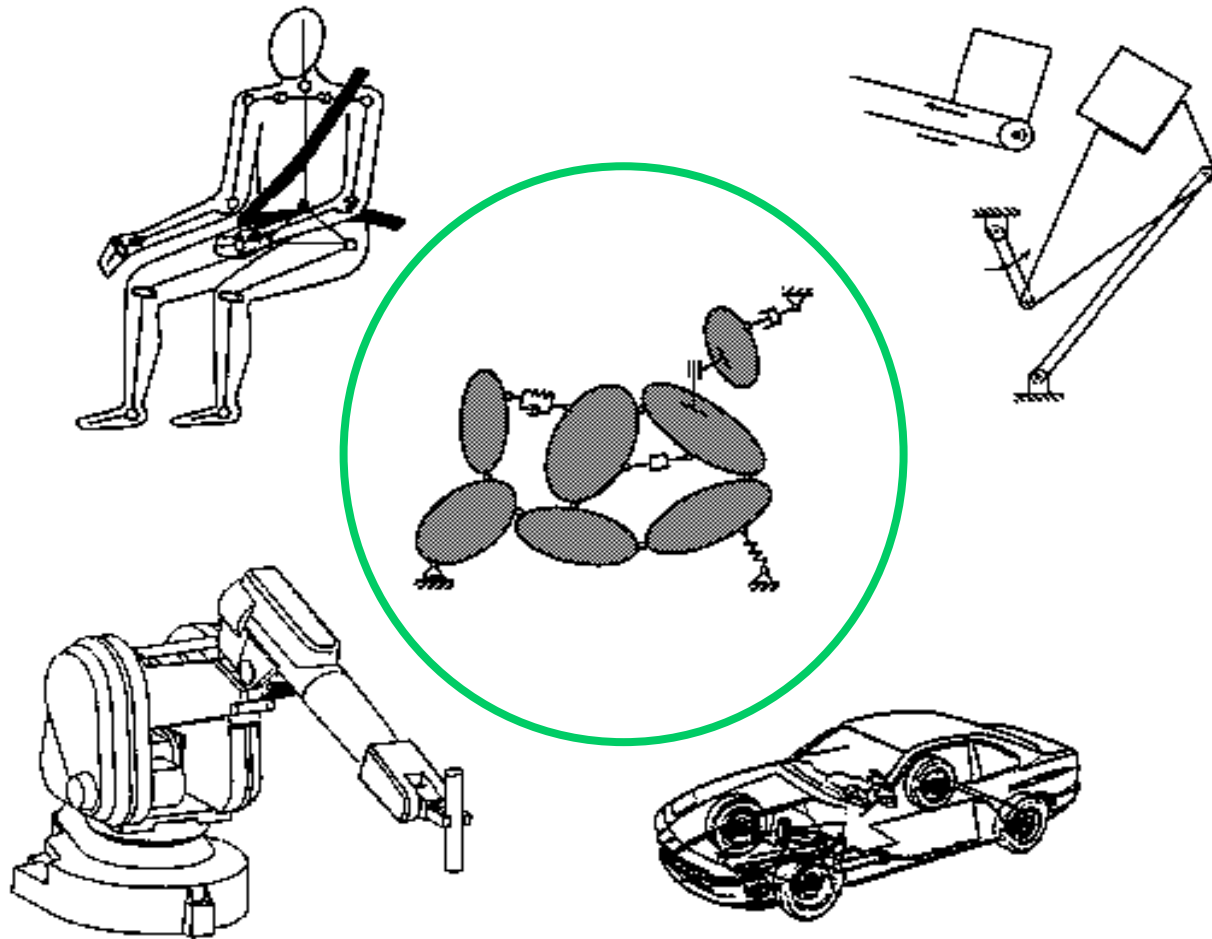


TIME SAVINGS

By D. S. Lee

# Multibody Dynamic Systems

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# Multibody Dynamics

## Components of MBS

Rigid or Flexible Bodies

Kinematic Joints

Force Elements

- ✓ **Spring**
- ✓ **Damping**
- ✓ **Tire**
- ✓ **Actuator**

Physical  
Laws



Assumptions

## Equation of Motion

$$M \ddot{q} + \Phi_q^T \underline{\lambda} = Q$$

$$\Phi(q, t) = 0$$

$$\Phi_q \dot{q} = v$$

Initial Condition

$$q(t_0) = q_0$$

$$\dot{q}(t_0) = \dot{q}_0$$

# Multibody Dynamic Software

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The multibody dynamics tool is a key technology in virtual engineering of integrated vehicle development ;

- Automatically generate the equations of motion
- Solve the equations of motion
- Display the results (plot & animation)

## Commercial Software Tools

**ADAMS**

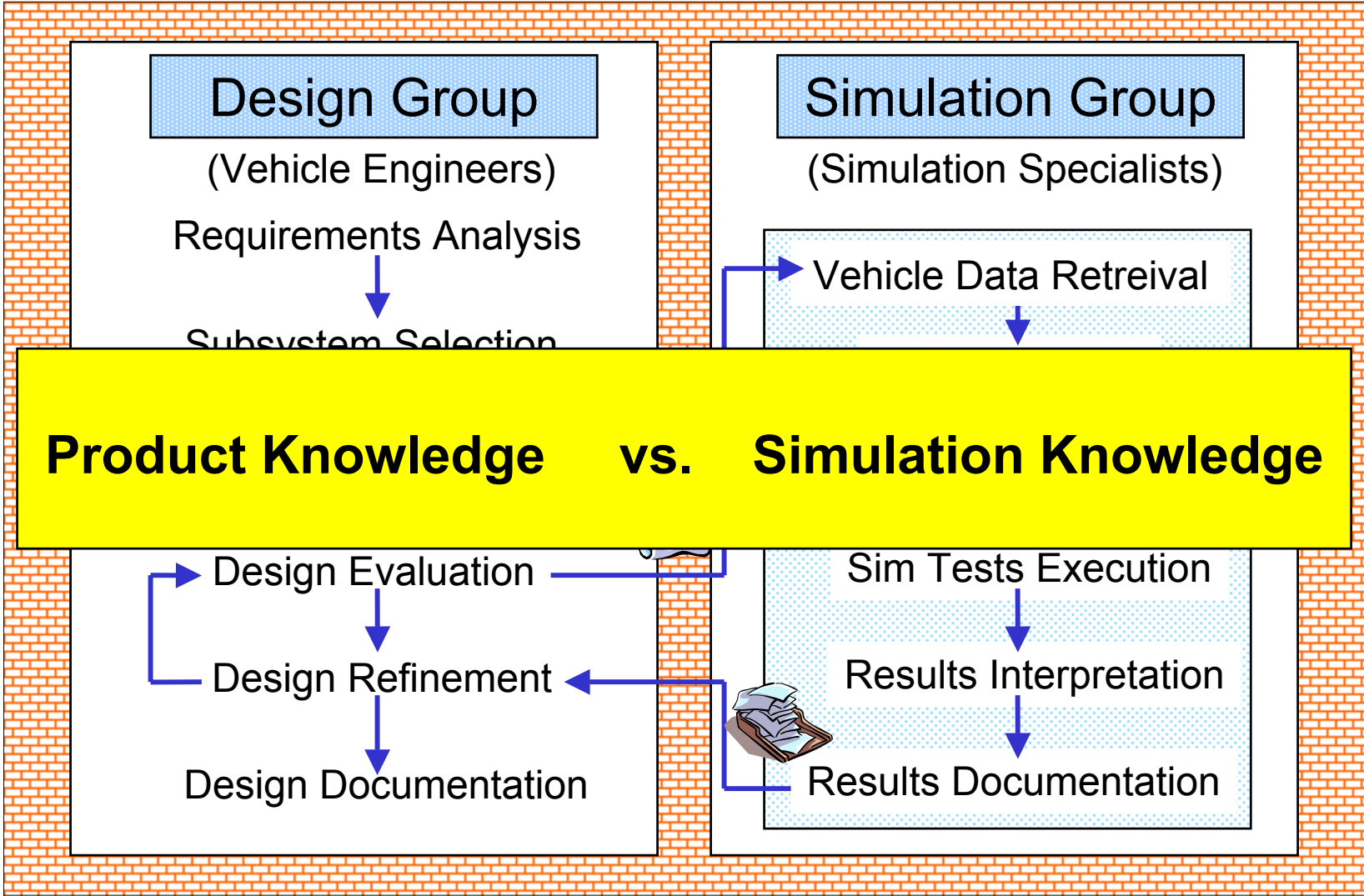
**DADS**

**SIMPACK**

**RecurDyn**

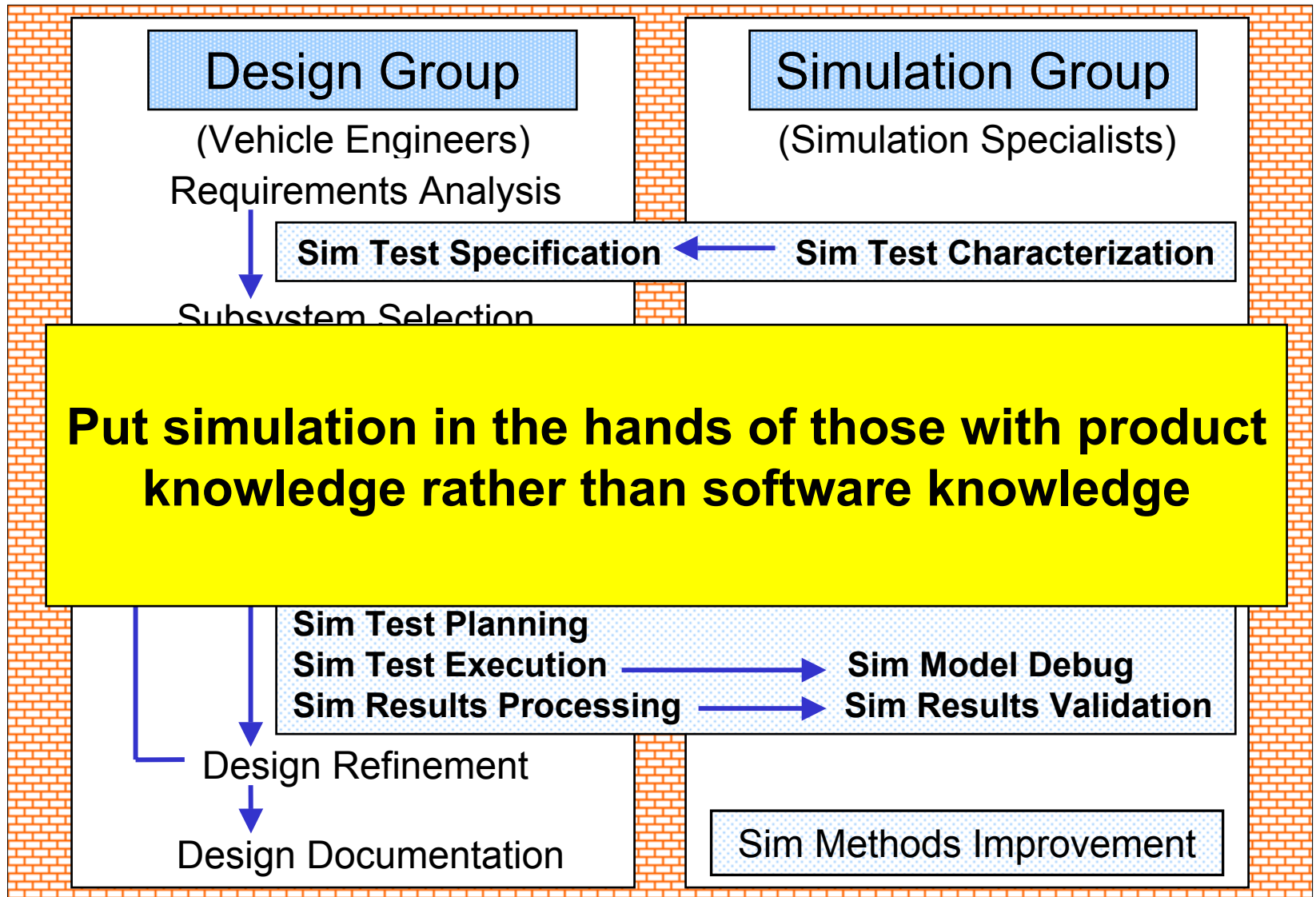
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# Traditional Simulation Process in Design





# An Improved Simulation Process in Design

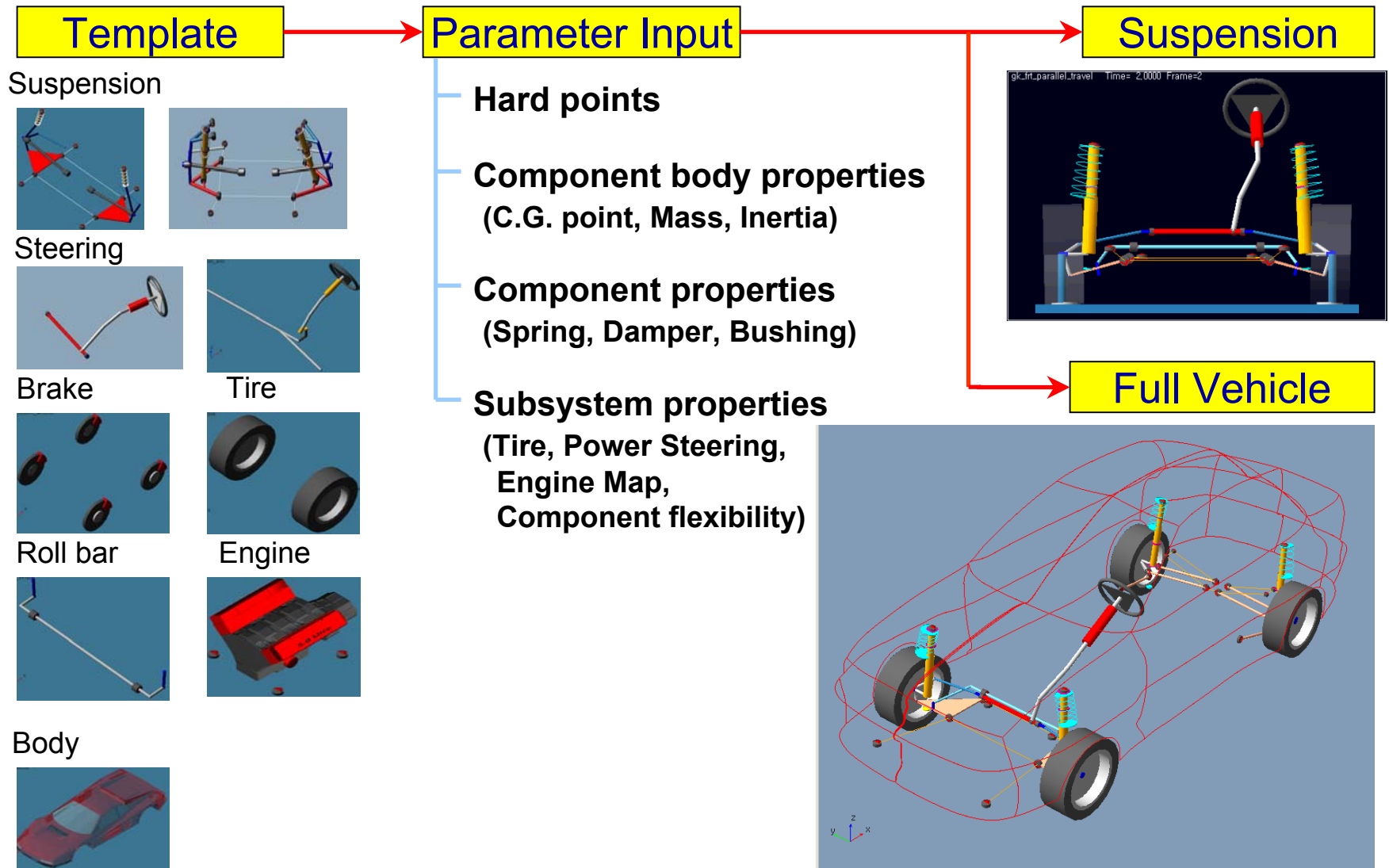


# What to do ?

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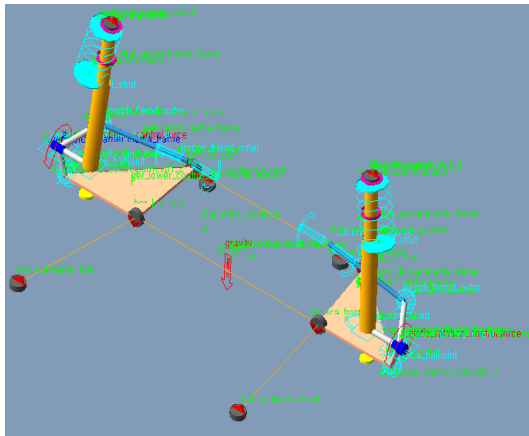
- ❑ Decouple solution seeking from modeling efforts
- ❑ Tool-oriented problem solving
- ❑ Template-based model building
  - Simulation experts create subsystem templates and simulation scenarios
  - Design engineers choose parameters and execute the model for design evaluation

# ADAMS/Car : Template-based Vehicle Modeling Tool

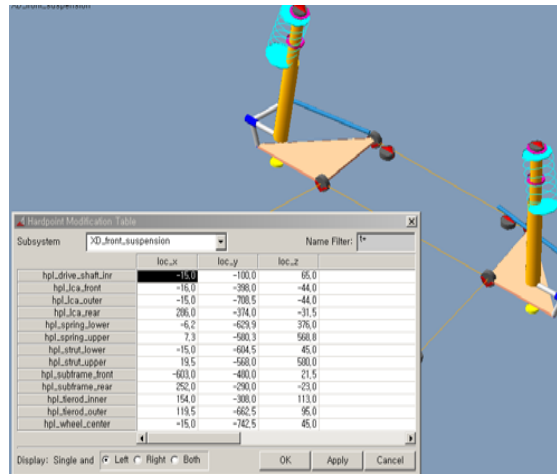


# Front suspension model

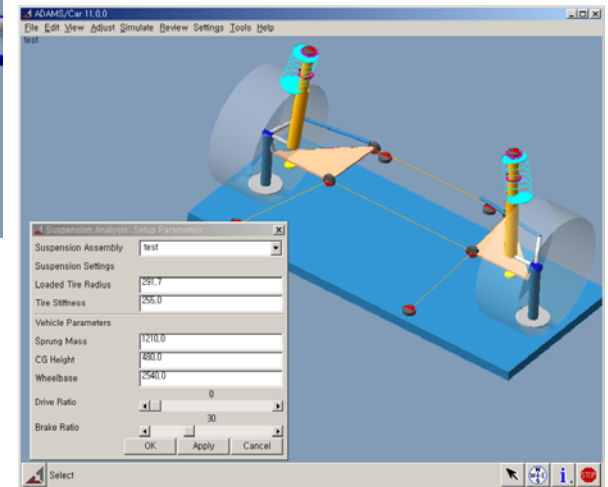
Template → Subsystem → Front Suspension test assembly



MacPherson Strut  
Template



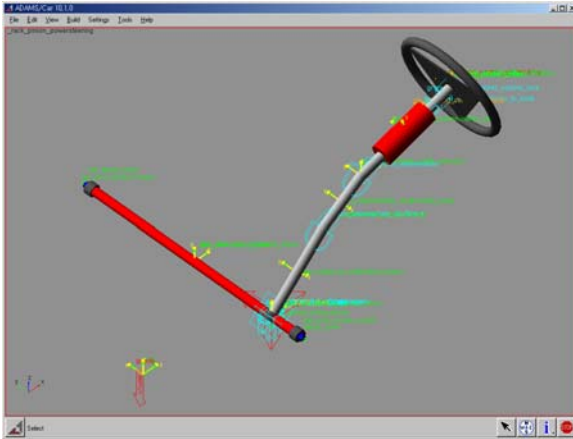
Parameter Input



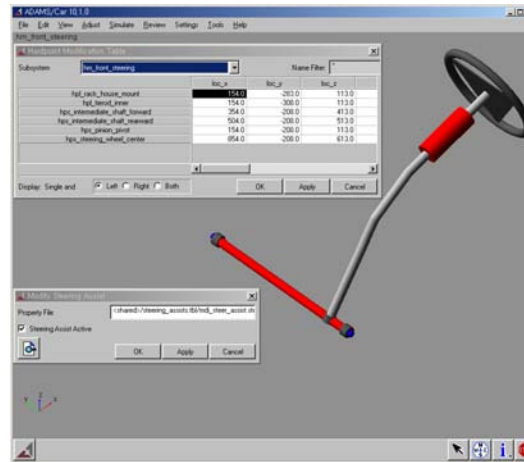
Test Rig

# Steering model (Rack & Pinion)

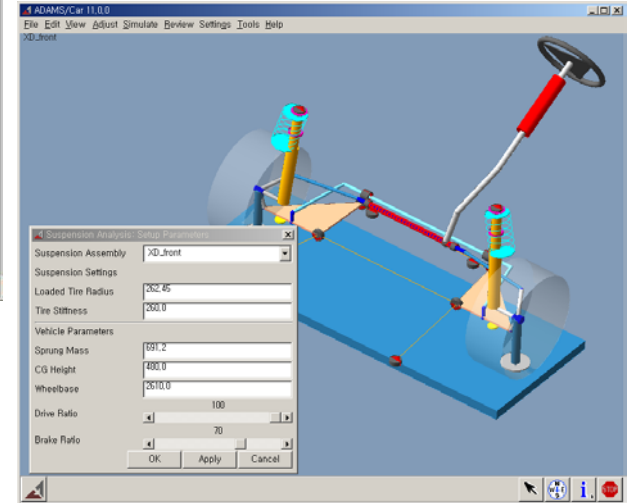
□ Template → Subsystem → Front test assembly



Rack & Pinion  
Template



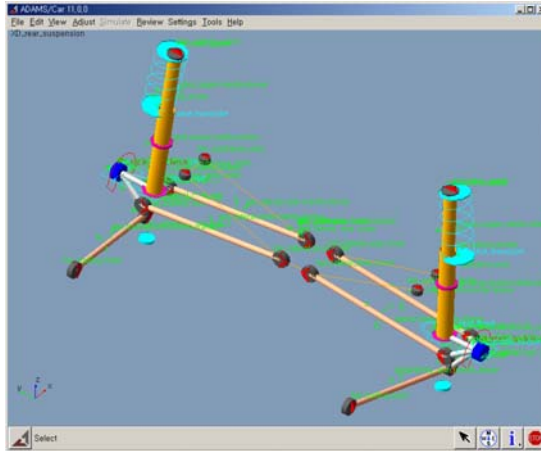
Parameter Input



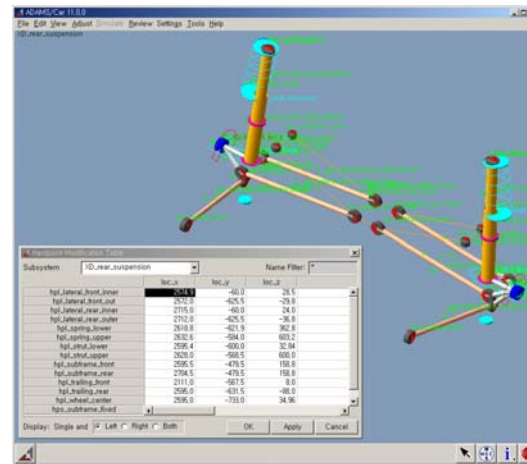
Front Suspension  
Test Rig

# Rear suspension model

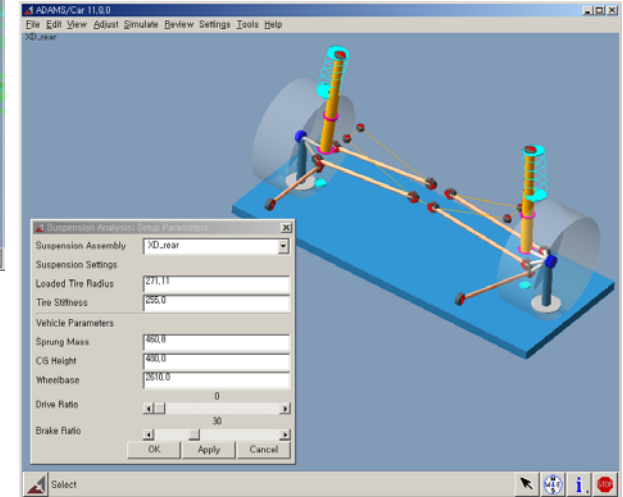
□ Template → Subsystem → Rear Suspension test assembly



Dual Link Template

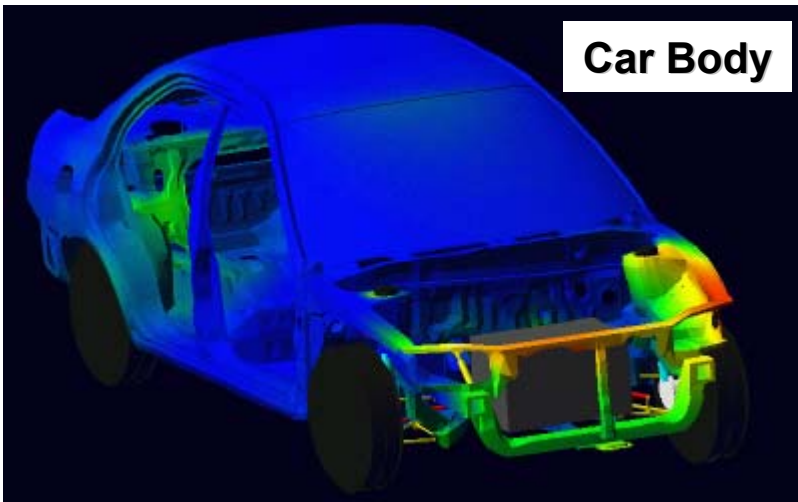
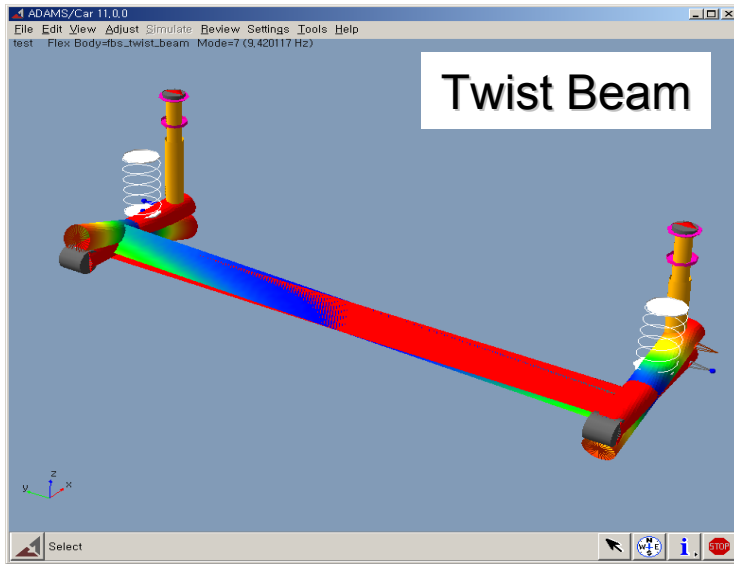


Parameter Input

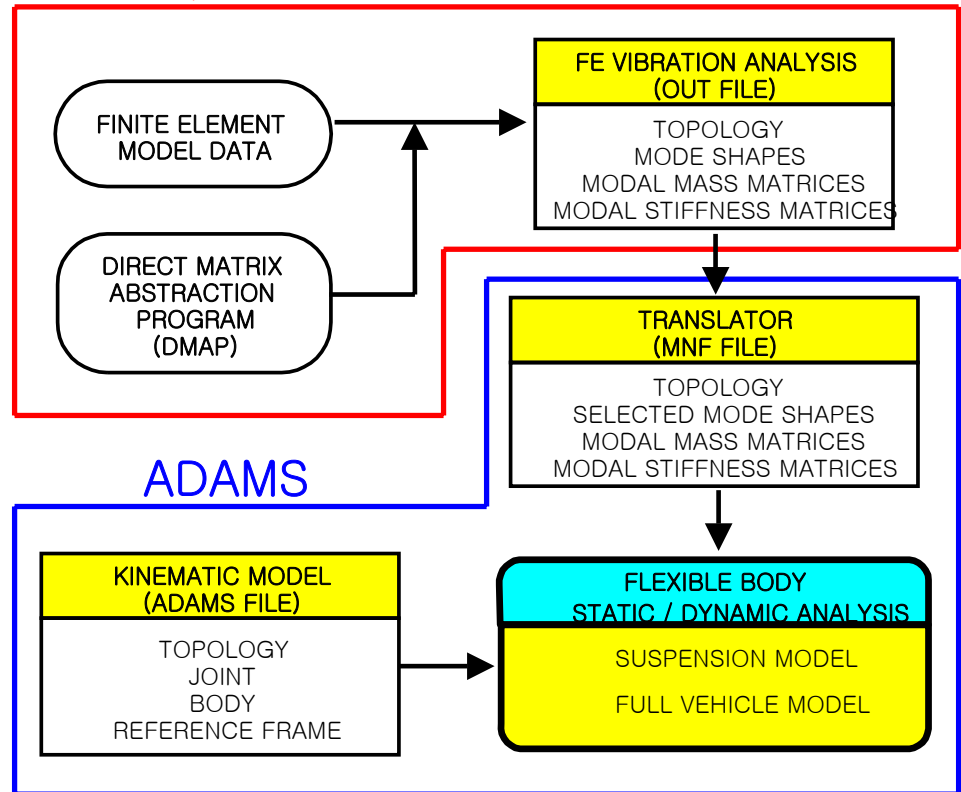


Rear Suspension Test Rig

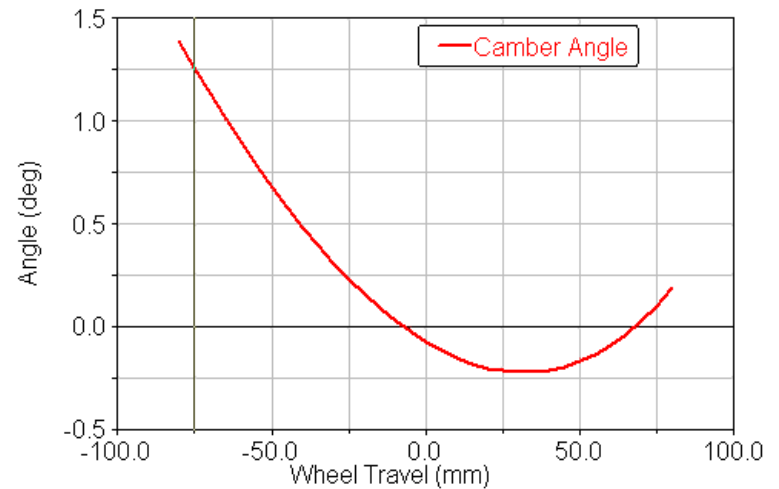
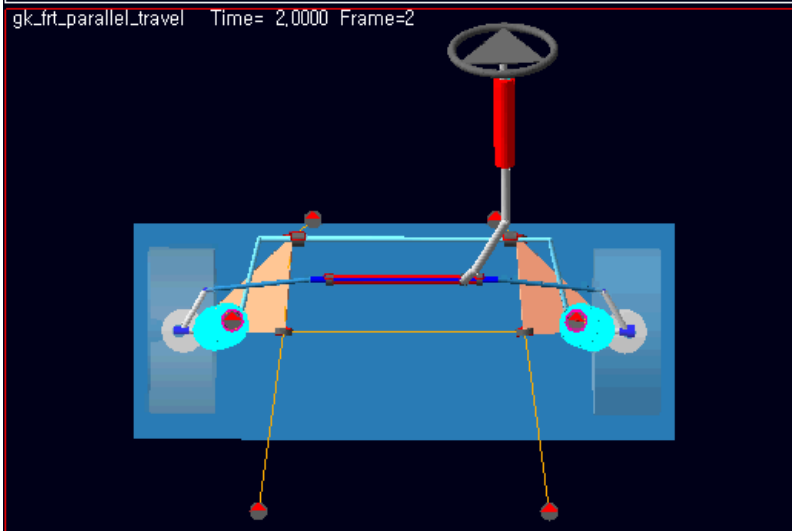
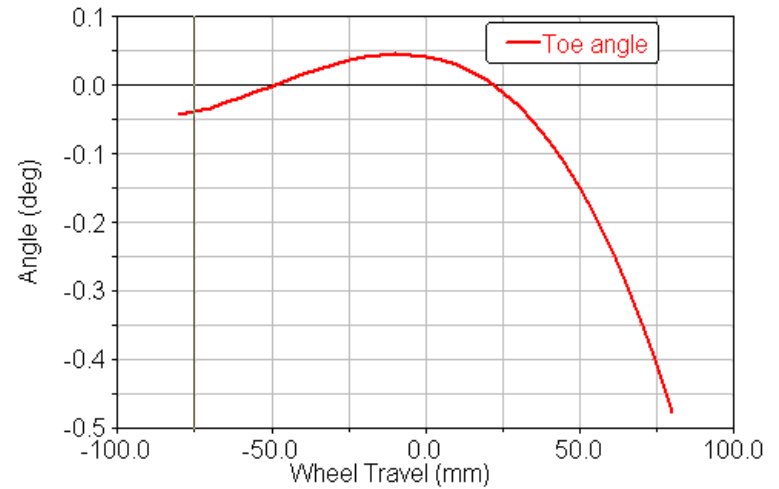
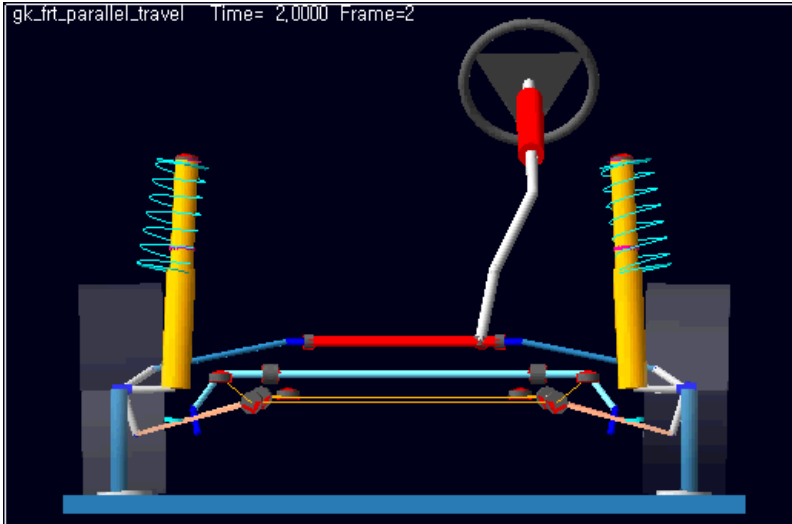
# Flexible Body Modeling



## MSC/NASTRAN



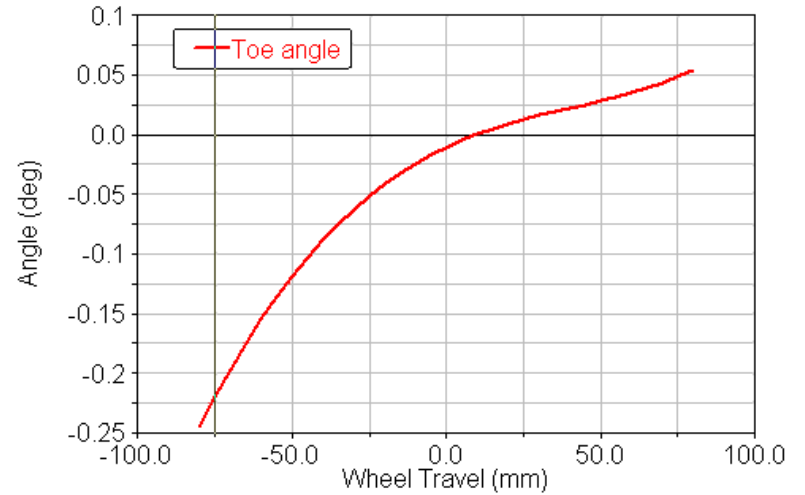
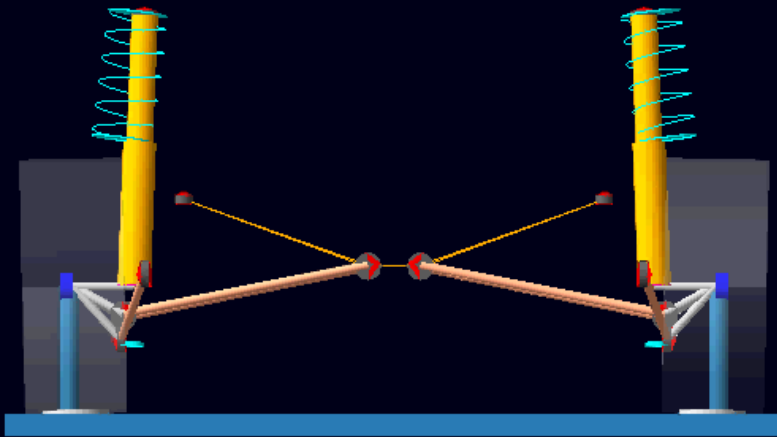
# Front Suspension Ride Analysis



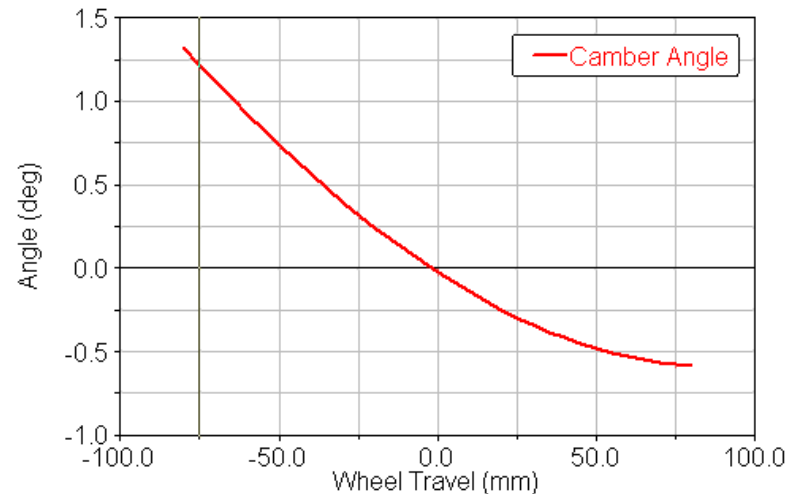
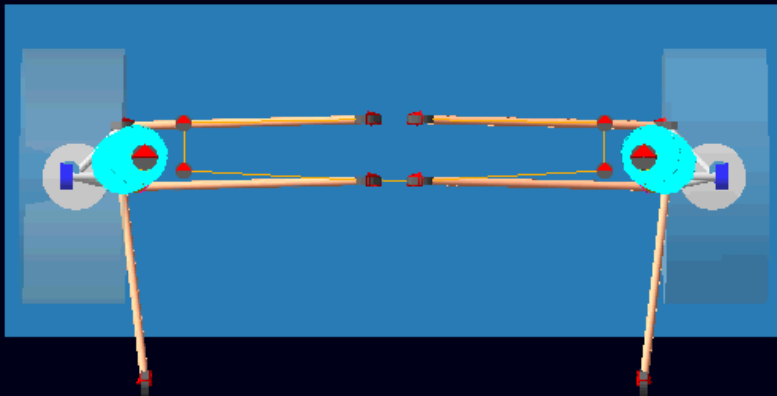


# Rear Suspension Ride Analysis

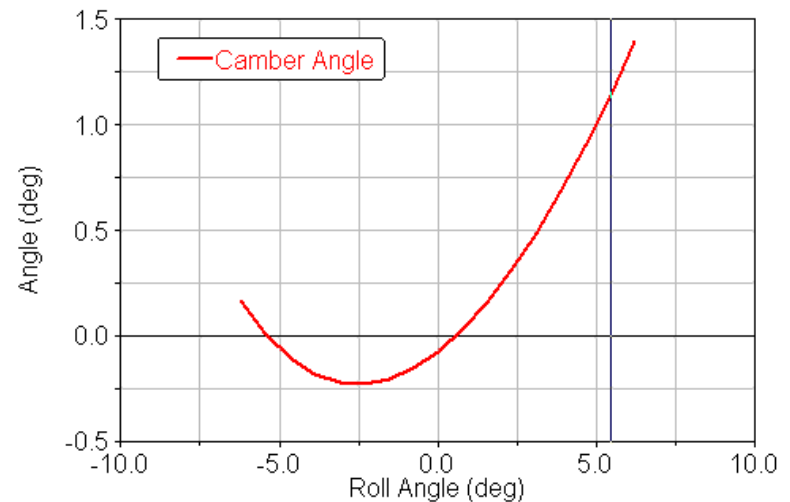
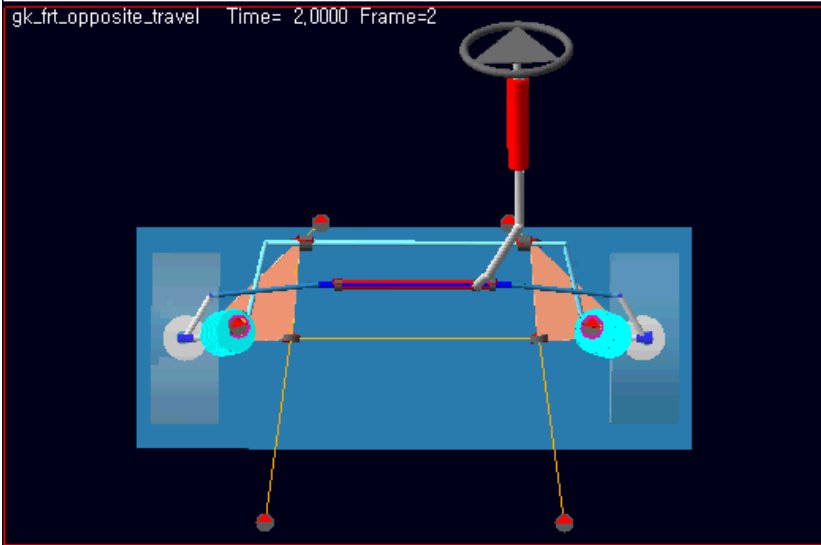
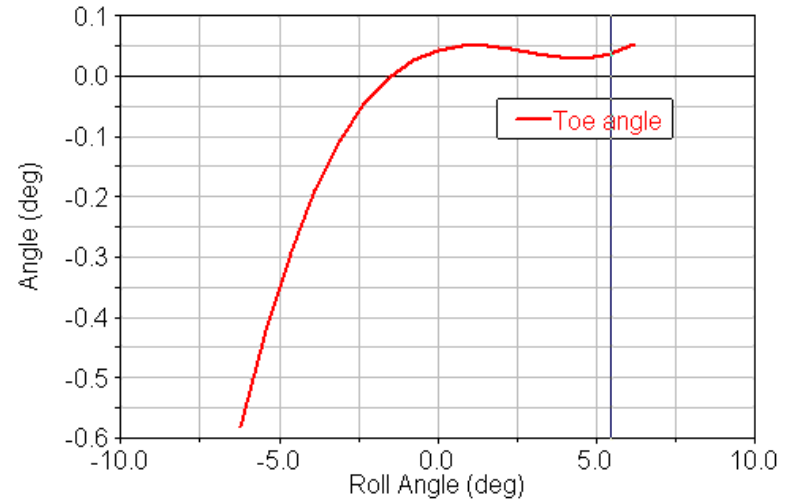
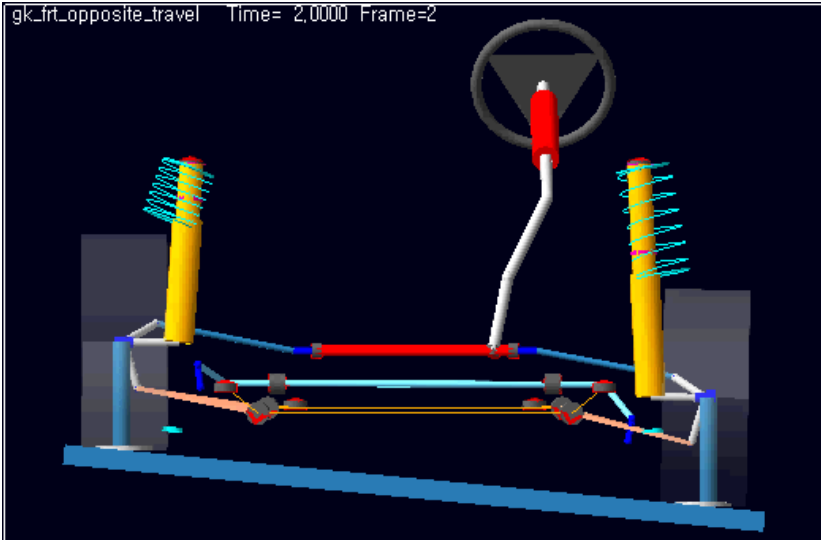
rr\_parallel\_travel Time= 2,0000 Frame=2



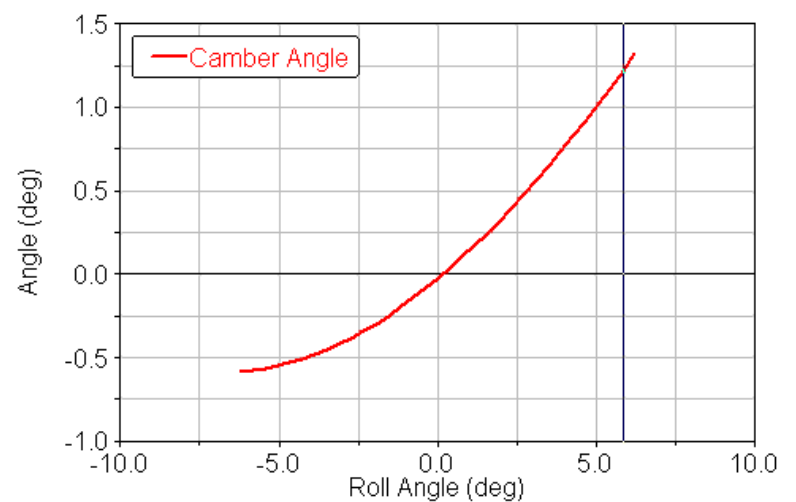
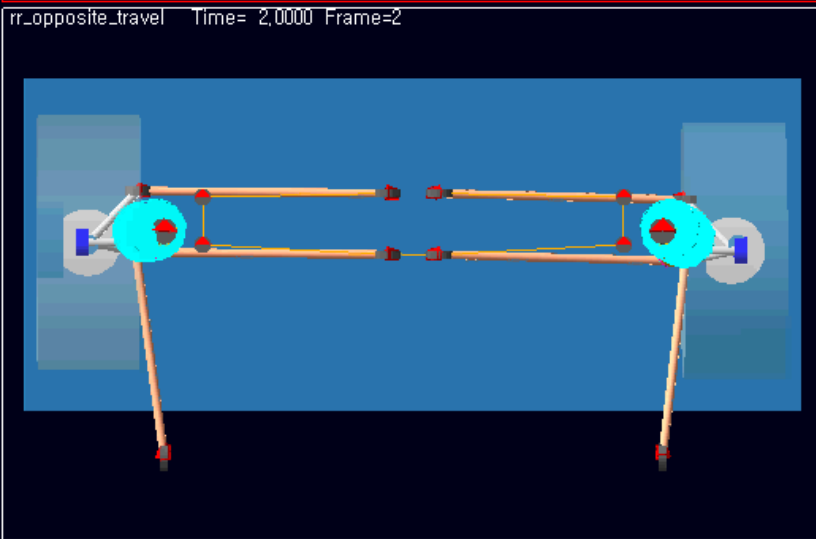
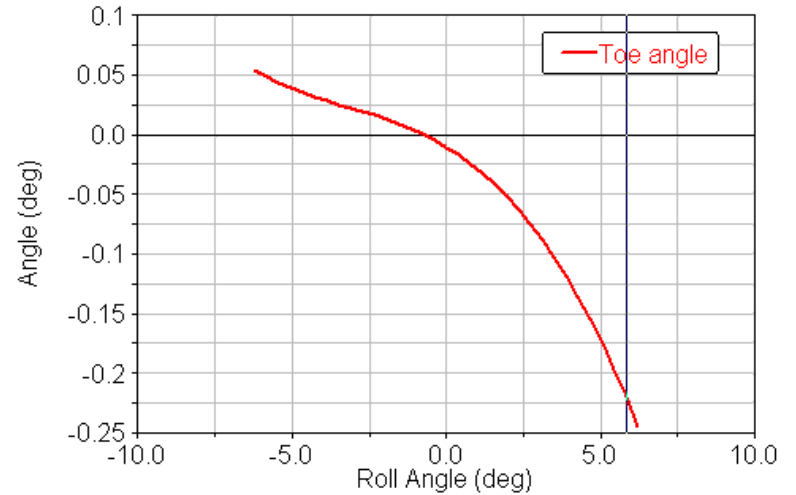
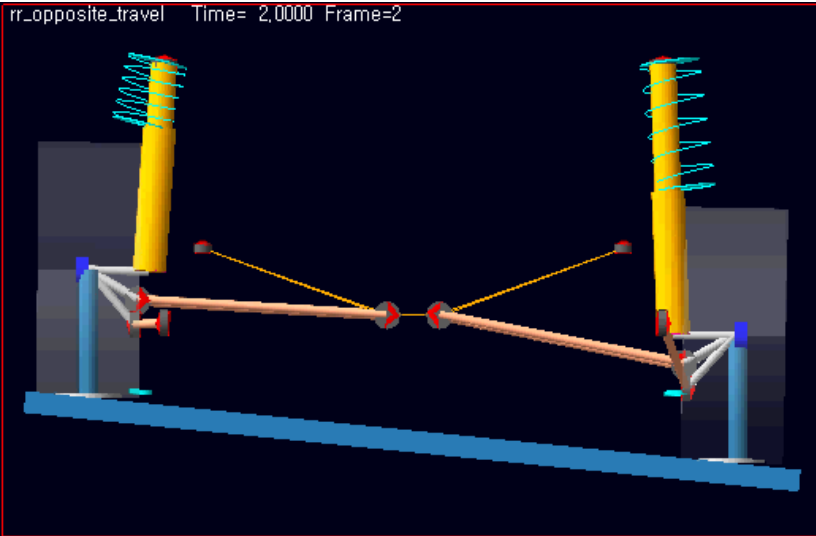
rr\_parallel\_travel Time= 2,0000 Frame=2



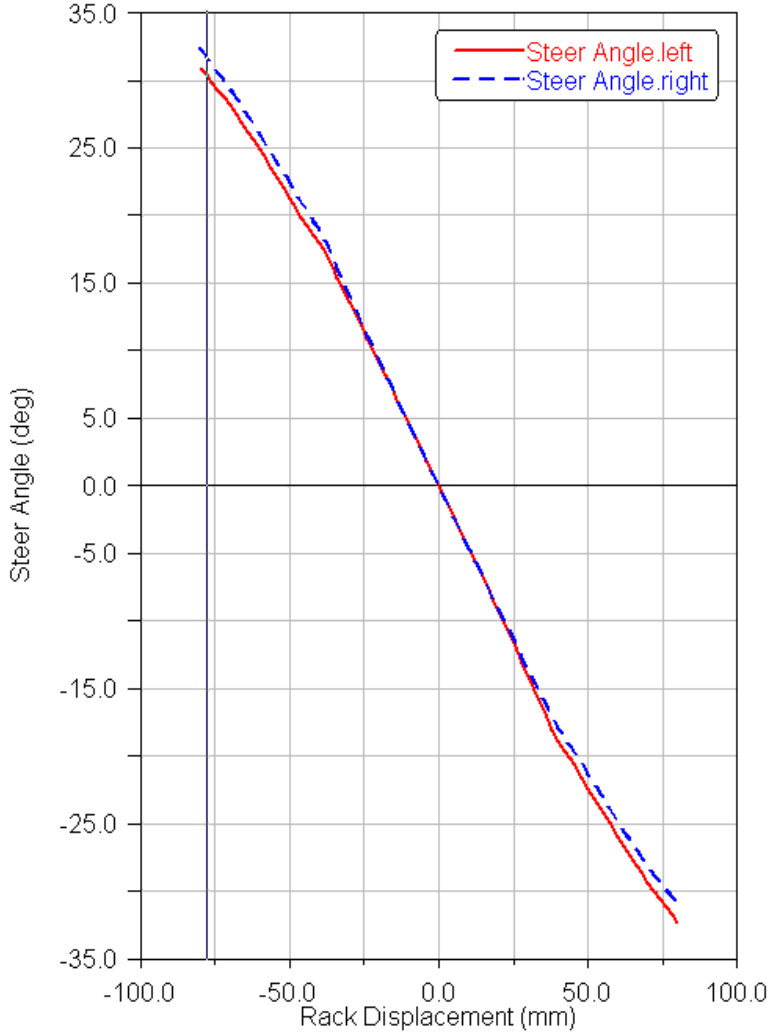
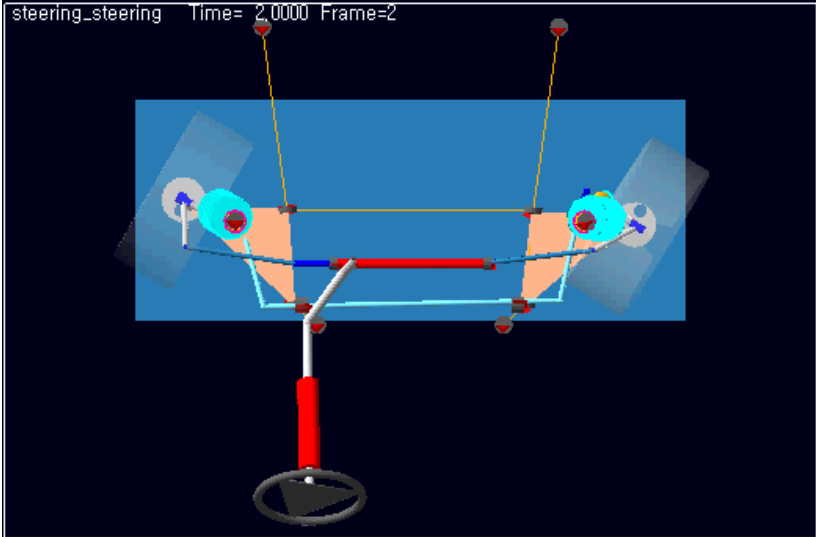
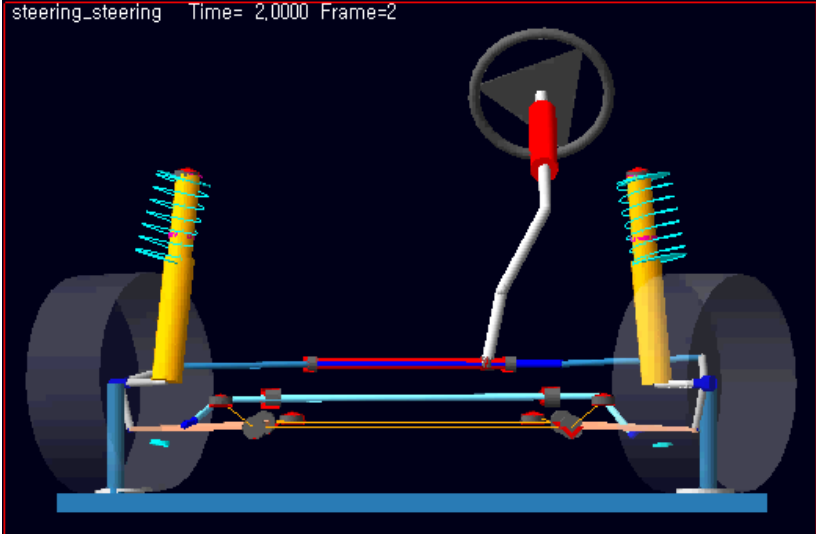
# Front Suspension Roll Analysis



# Rear Suspension Roll Analysis



# Steer Analysis



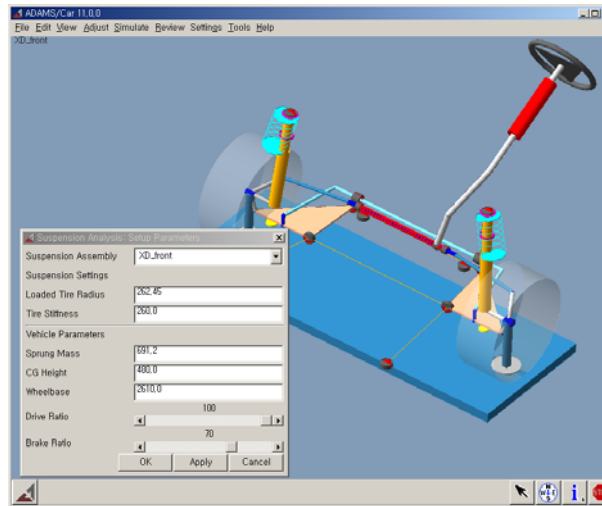
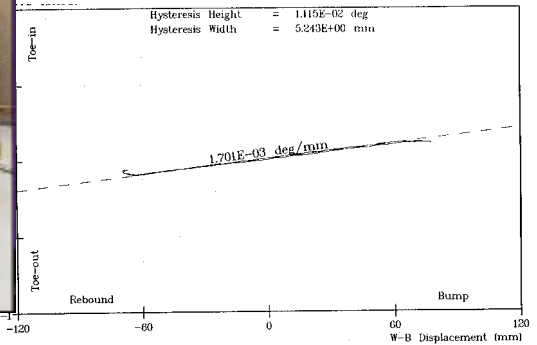
# Model Validation with K&C Test Results

## □ Kinematics

- Ride
- Roll
- Steer

## □ Compliance

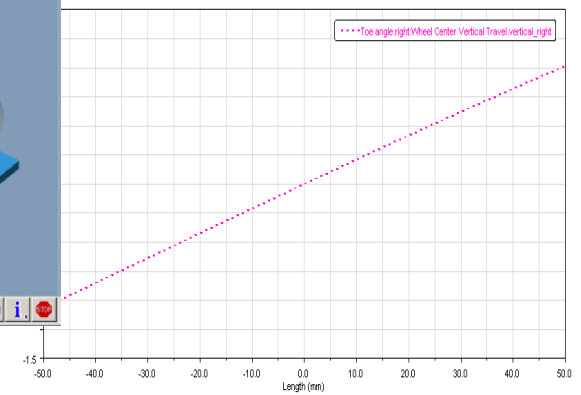
- Force
- Moment



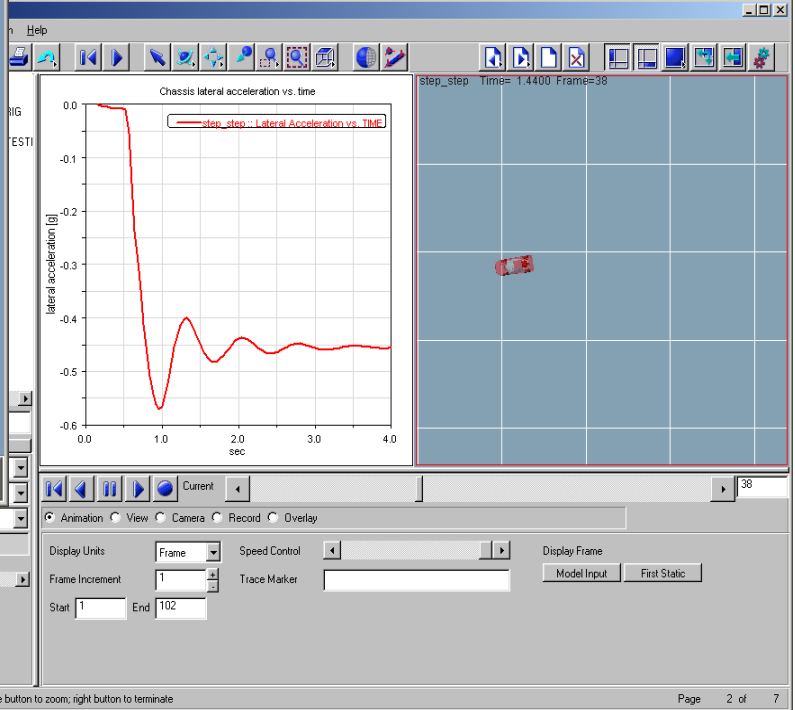
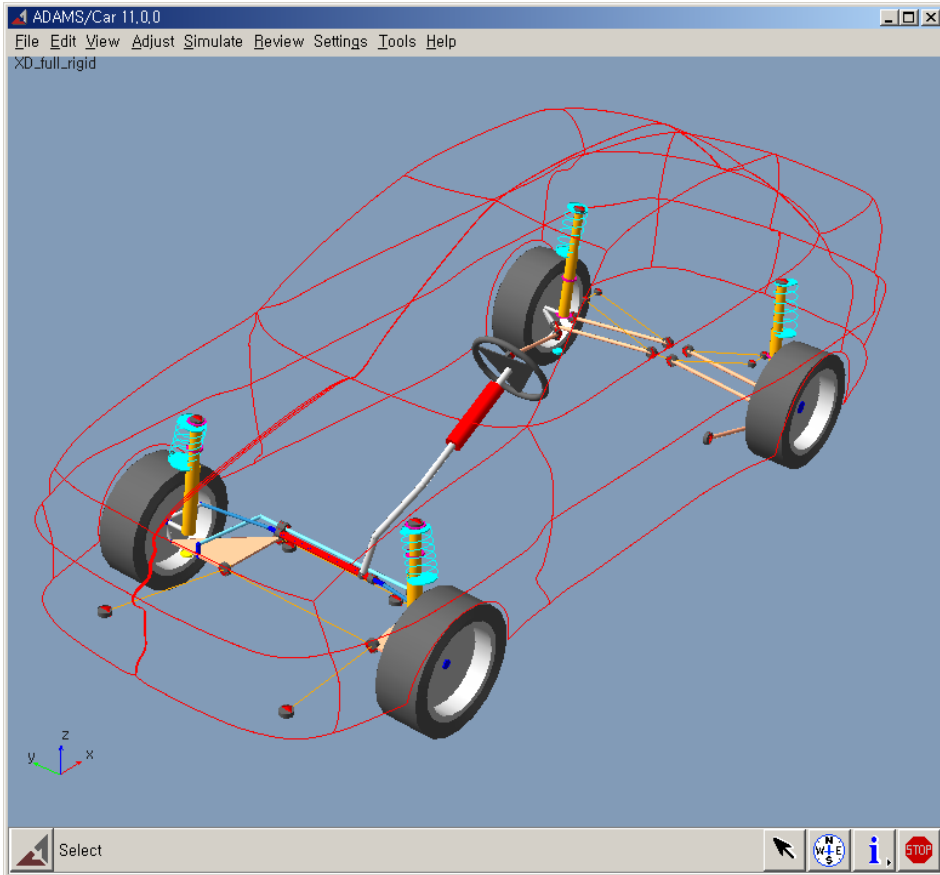
Vertical Test

Steer  
Ice A : Standard Kinematics  
PF : Test #1 of 3

Rear LH Wheel



# Full Vehicle Model & Handling Simulation



# Conclusions

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- ❑ CAE Tools have changed the best practice in vehicle product development.
- ❑ Multibody dynamic software is a key technology in virtual prototyping of vehicle dynamic systems.
- ❑ The template-based multibody modeling tool is very effective for design engineers' involvement in simulation tasks.