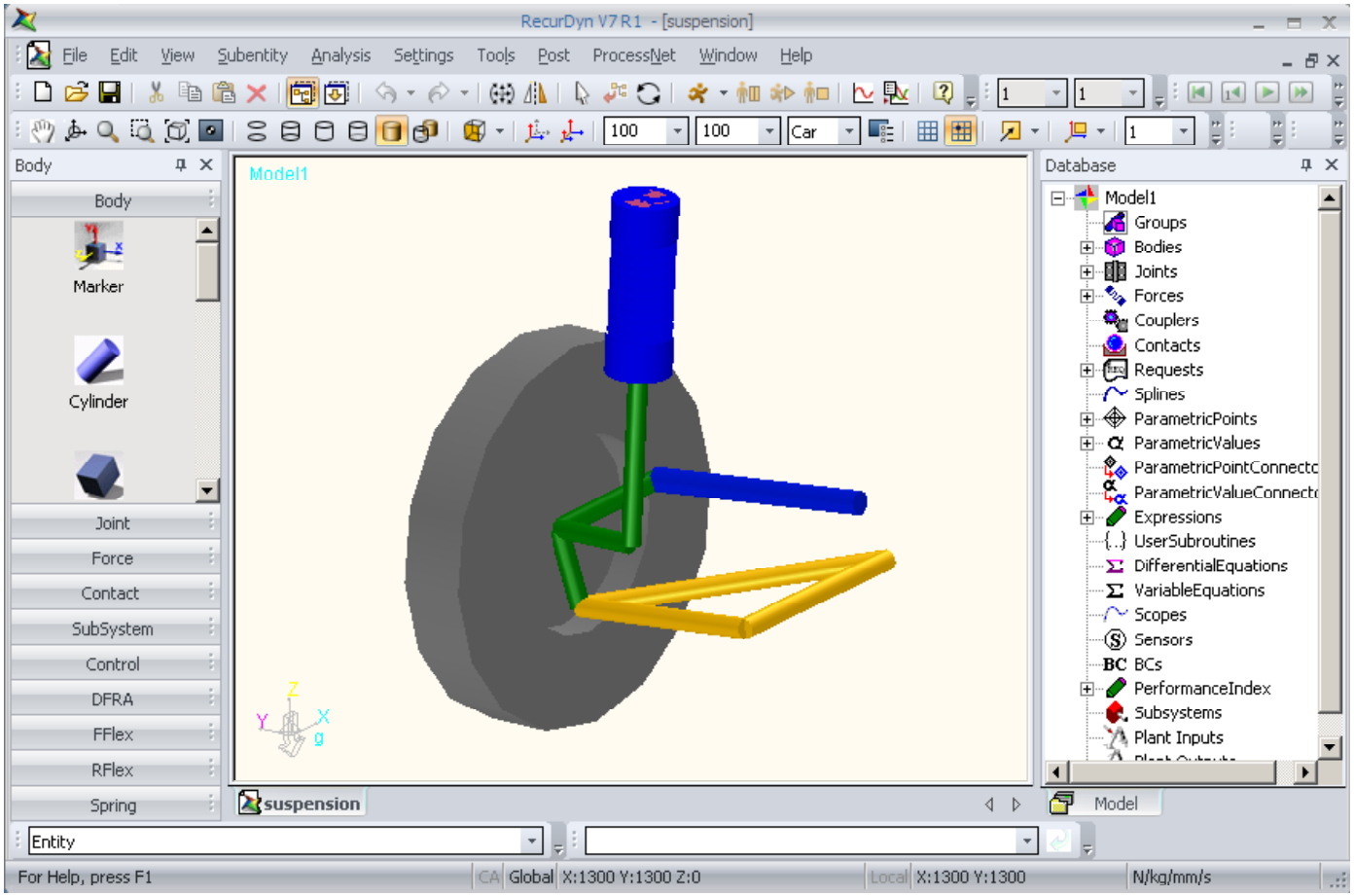
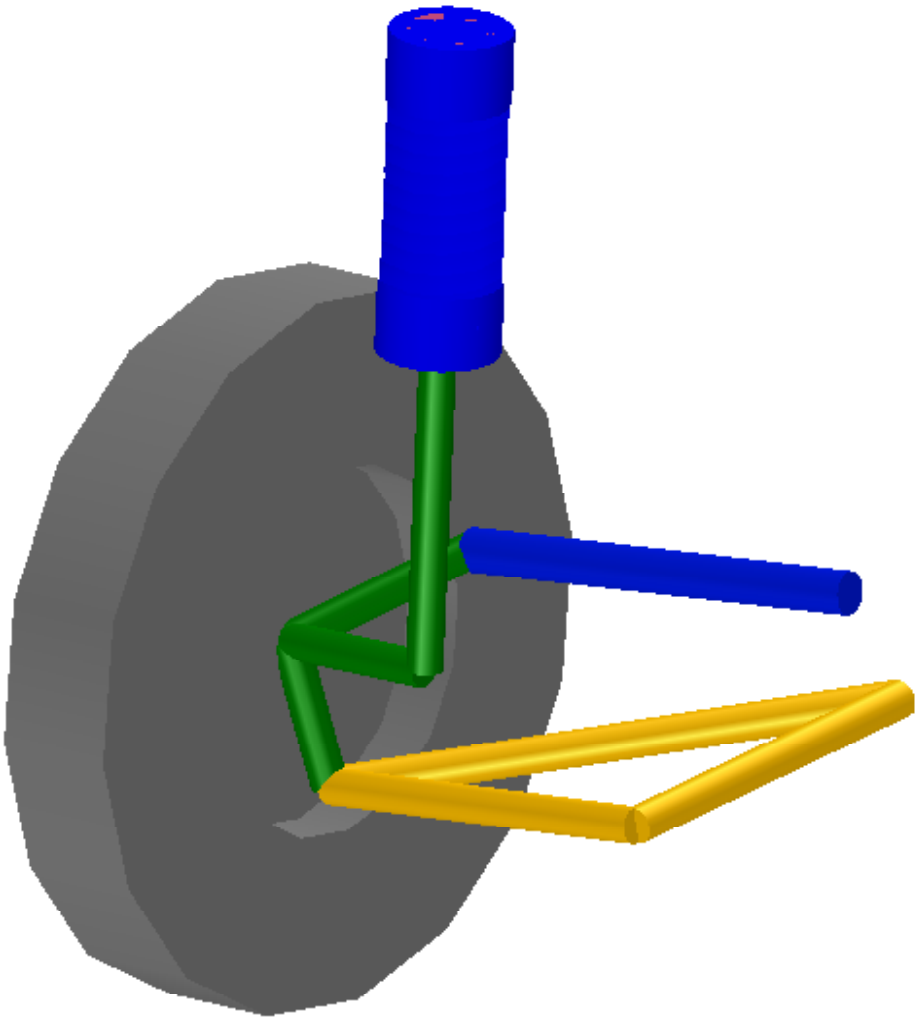
Sensitivity Study, Design Optimization and Tolerance Analysis of a Car Suspension in RecurDyn

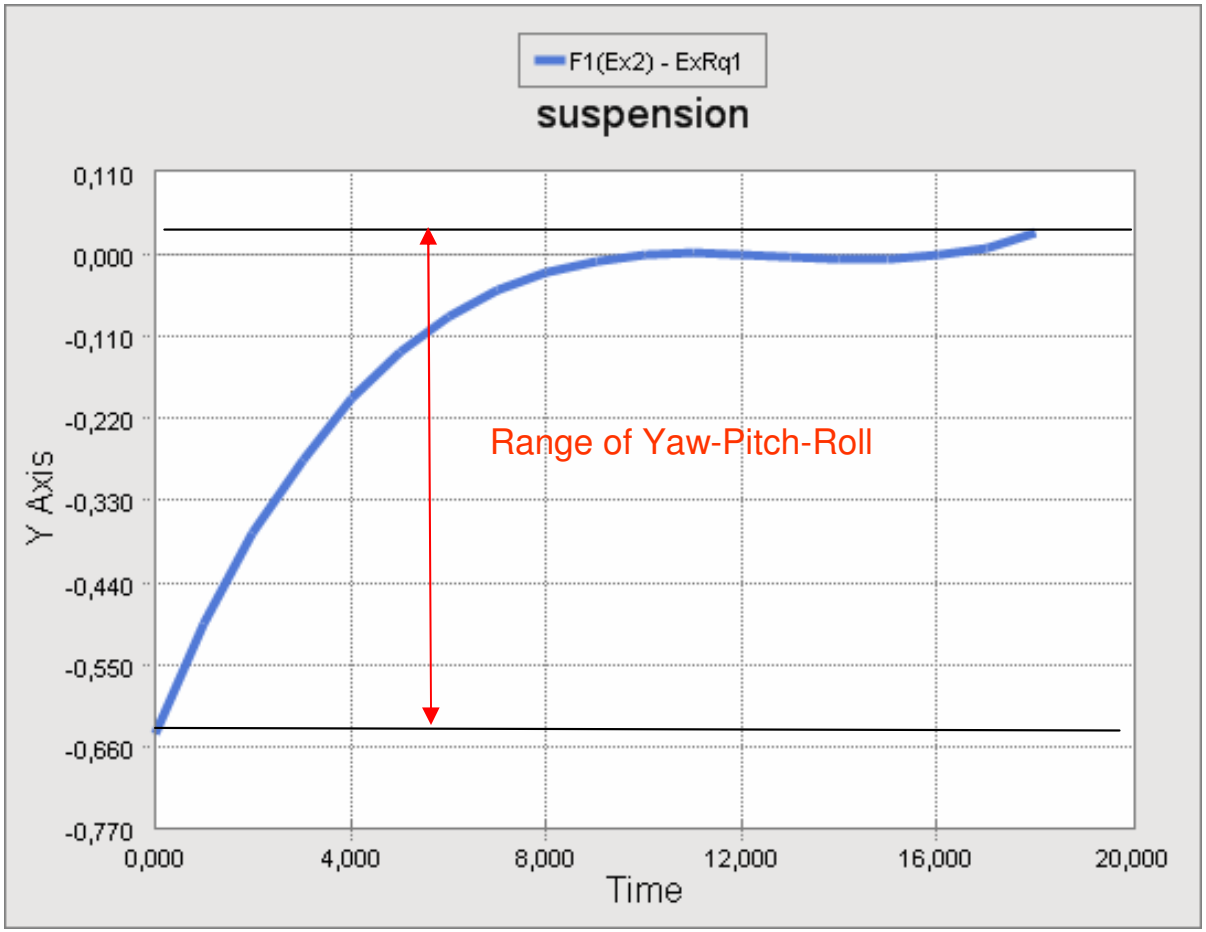


Car Suspension System



- The suspension system contains the arm, tie rod, knuckle, tire and damper
- The design parameters are geometric joint coordinates.
- Dynamic Simulation shows the damping process and motion of the tire

Simulation of the first Solution

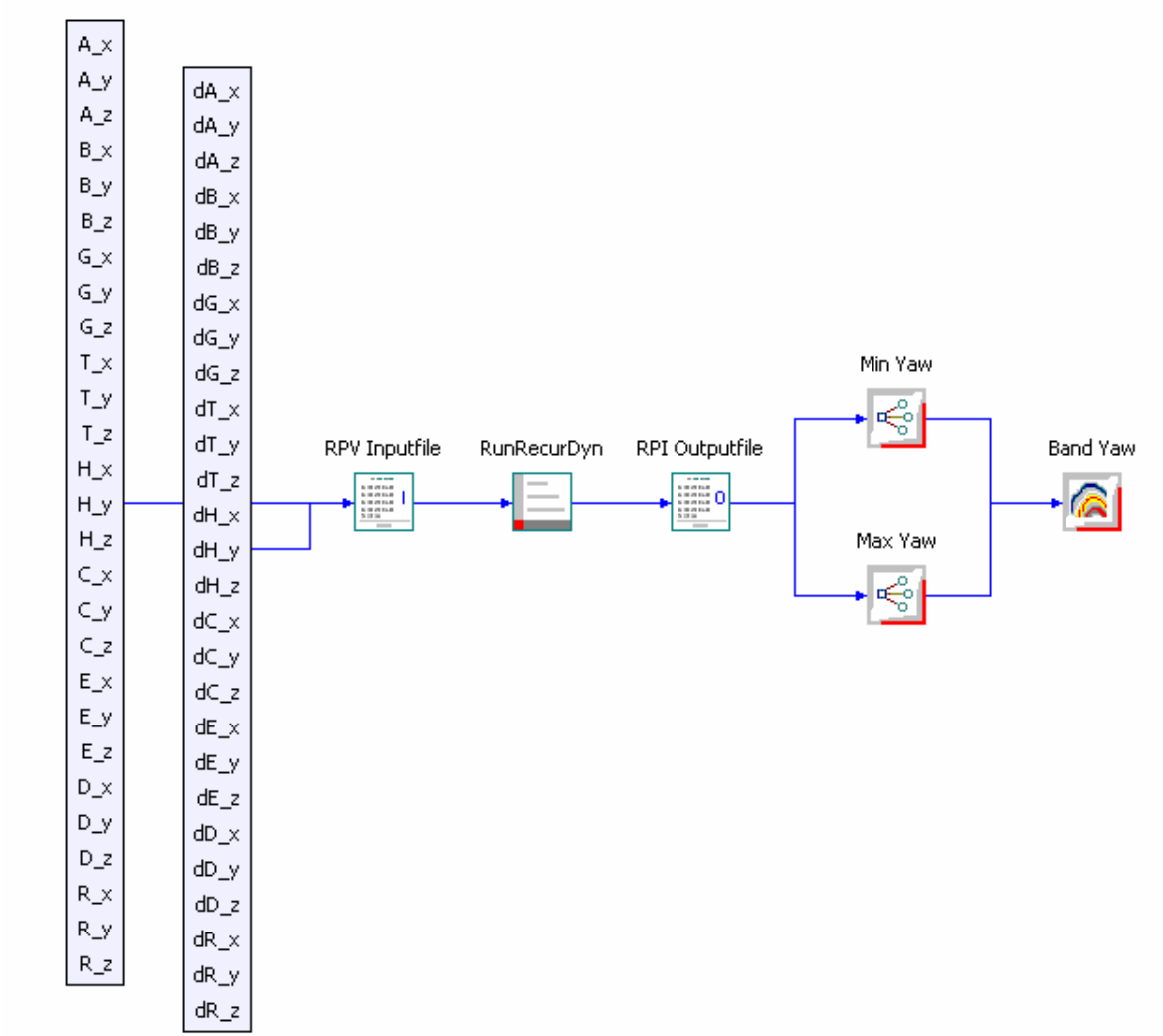


- The performance index is the first rotational Yaw-Pitch-Roll of the tire

- The performance and comfort of the car is characterized by minimal range between min and max Yaw-Pitch-Roll

- There are **27 design parameters** of joint coordinates

OptiY Workflow for Sensitivity Analysis



The Design Parameter Space

- 27 parameters
- Nominal Values ± 10 mm

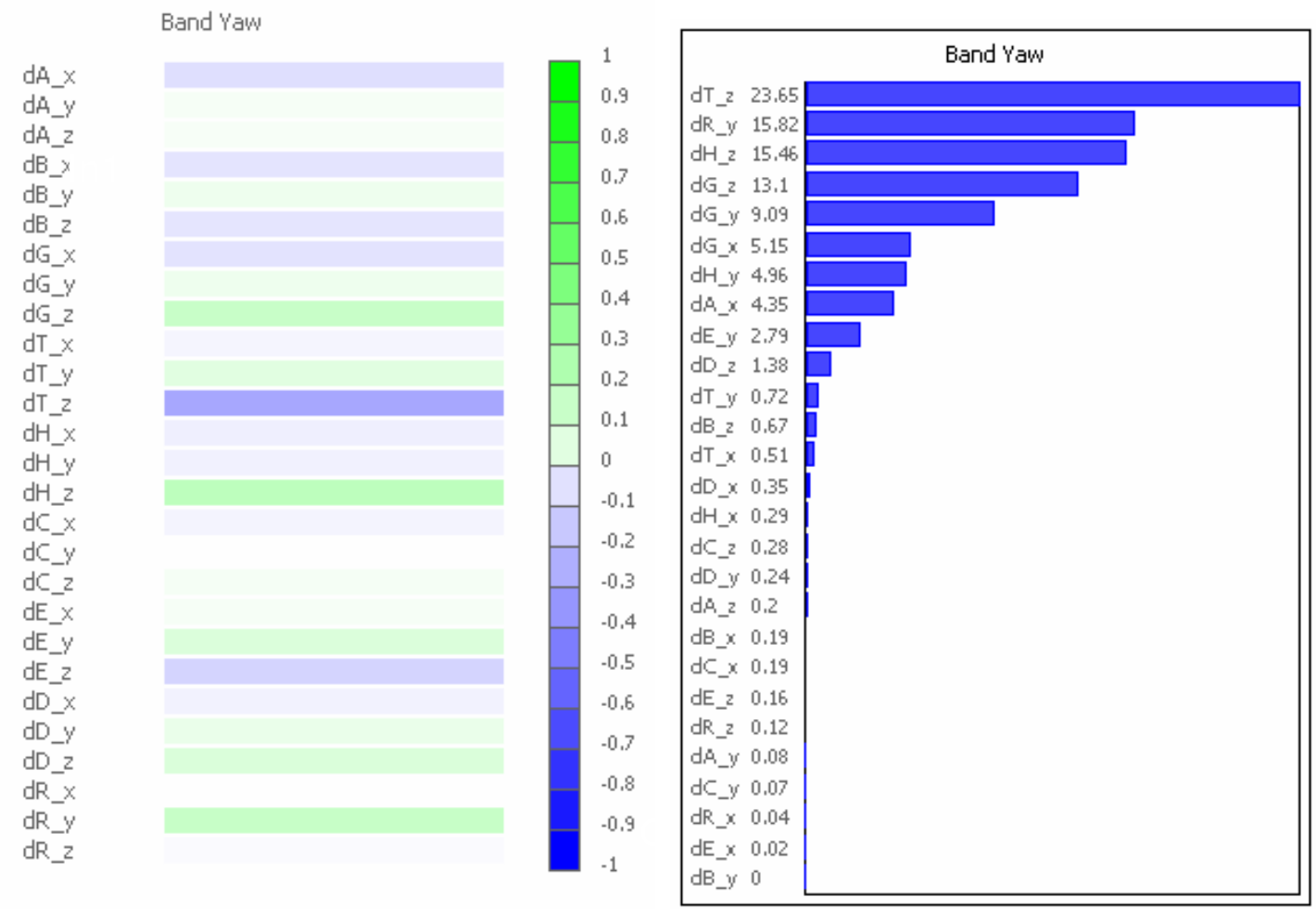
The Goals

- Reduce complexity
- Identify important parameters
- Identify insignificant parameters being ignored

DOE Method

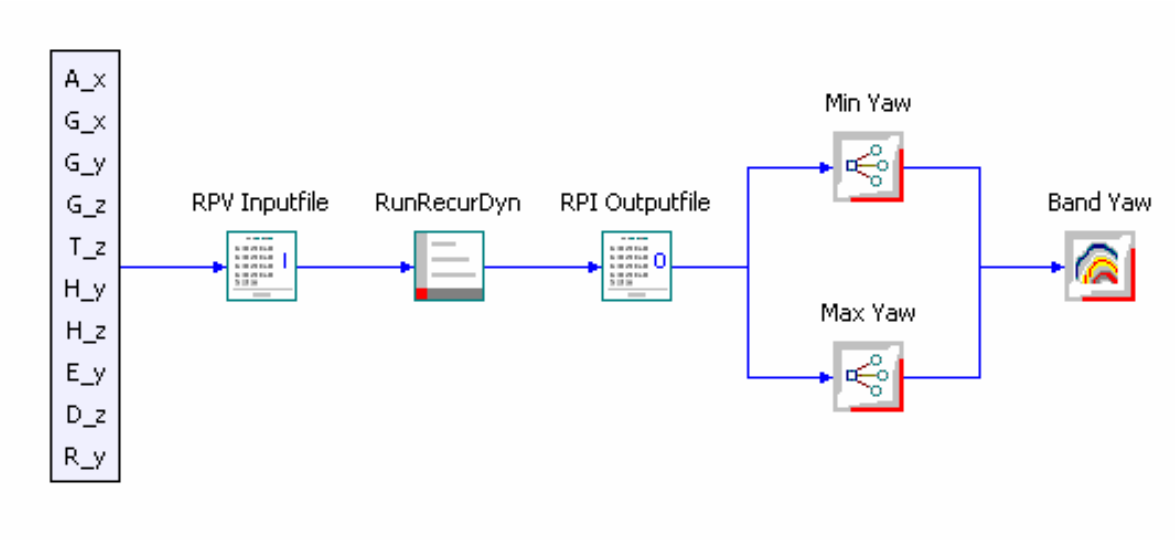
- Latin Hypercube Sampling with 100 sample size
- First order approximation

Sensitivity Study



- Linear correlation matrix and variance based sensitivity Sobol index
- Local = global (linear)
- Identify 10 important parameters being investigated
- Other 17 insignificant parameters can be ignored

OptiY Workflow for Design Optimization



The Design Parameter:

- Only 10 important parameters
- Nominal Values ± 10 mm

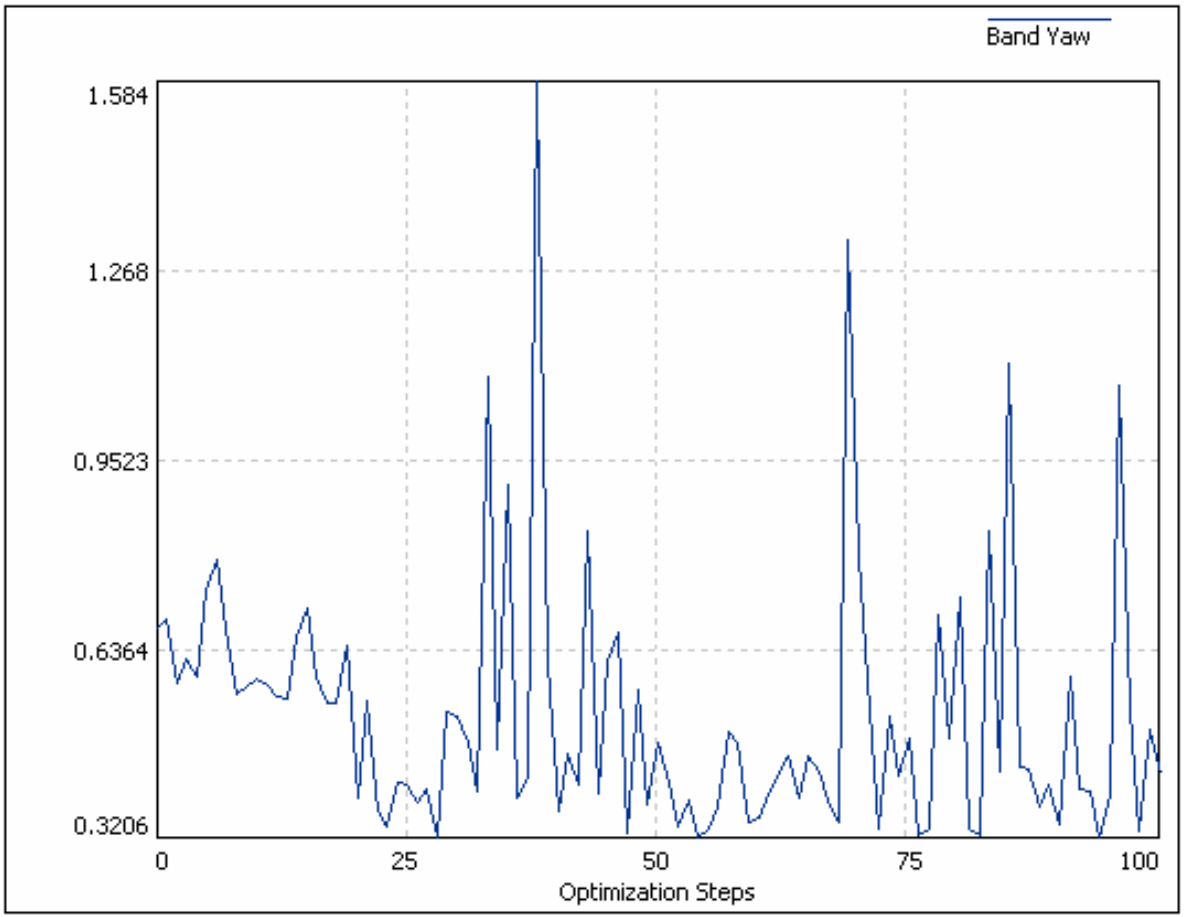
The Goal:

- Reduce the range between min. and max. Yaw-Pitch-Roll of the tire

Optimization Method

- Hooke-Jeeves
- 100 Steps
- Standard Step Control

Optimization Process

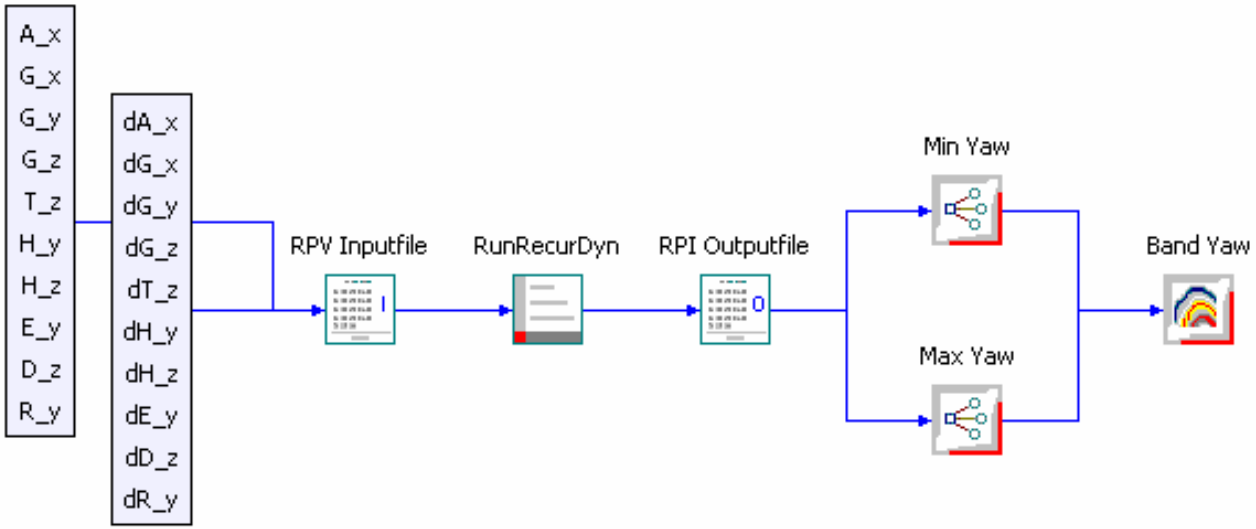


- The Range between min. and max. Yaw-Pitch-Roll of the tire reduces:

- First Value: 0.673
- Optimal Value: 0.320

- Improvement: 52%

OptiY Workflow for Tolerance Analysis

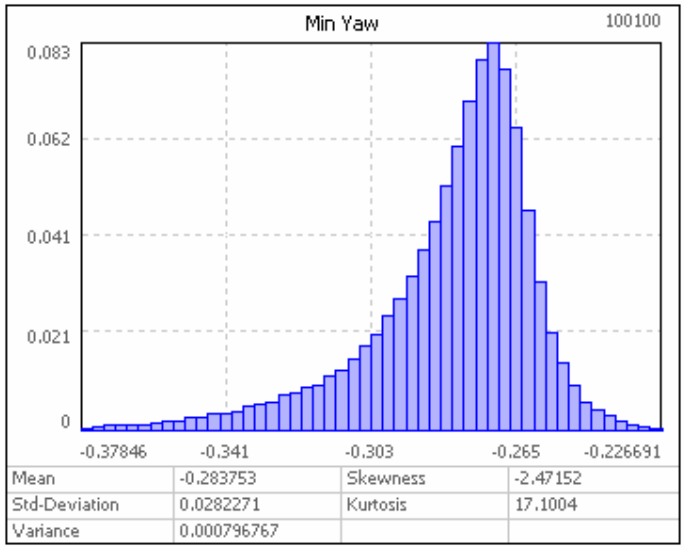


DOE-Method:
- Sobol Sampling
- 100 Sample size
- 100000 virtual sample size
- Second order approximation

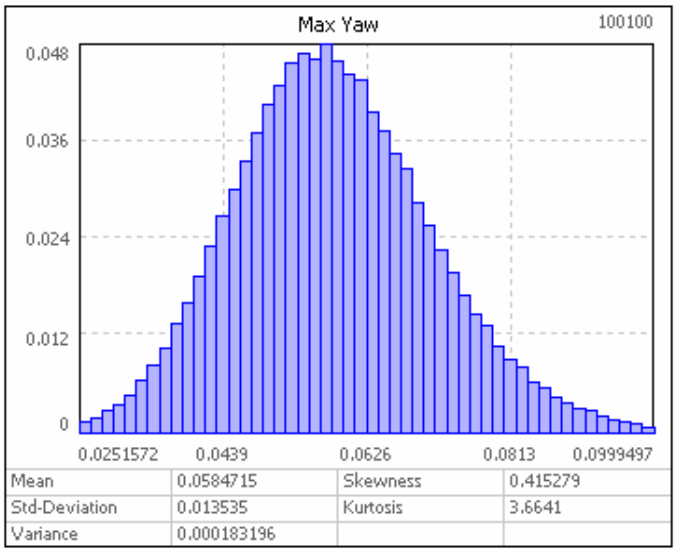
All Design Tolerances :
- Tolerance Value = 1 mm
- Normal Distribution

The goal is to explore the optimal design point
- Worst Case
- Best Case
- Sensitivity

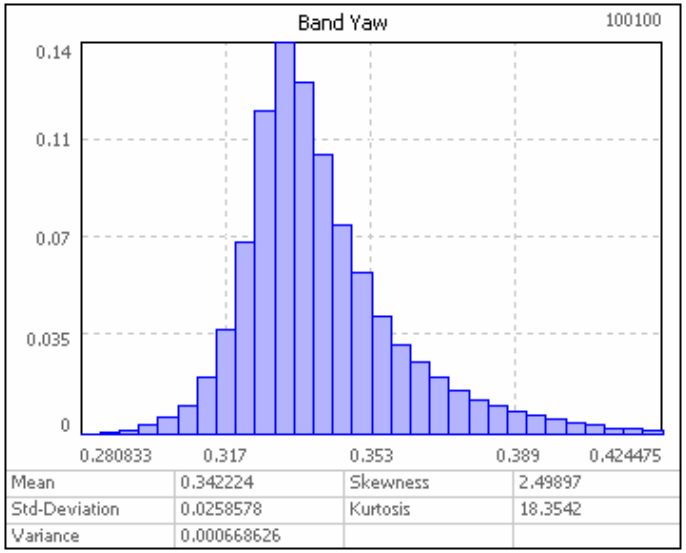
Statistical Distributions of Yaw-Pitch-Roll



Min Yaw-Pitch-Roll
(-0.378) – (-0.226)

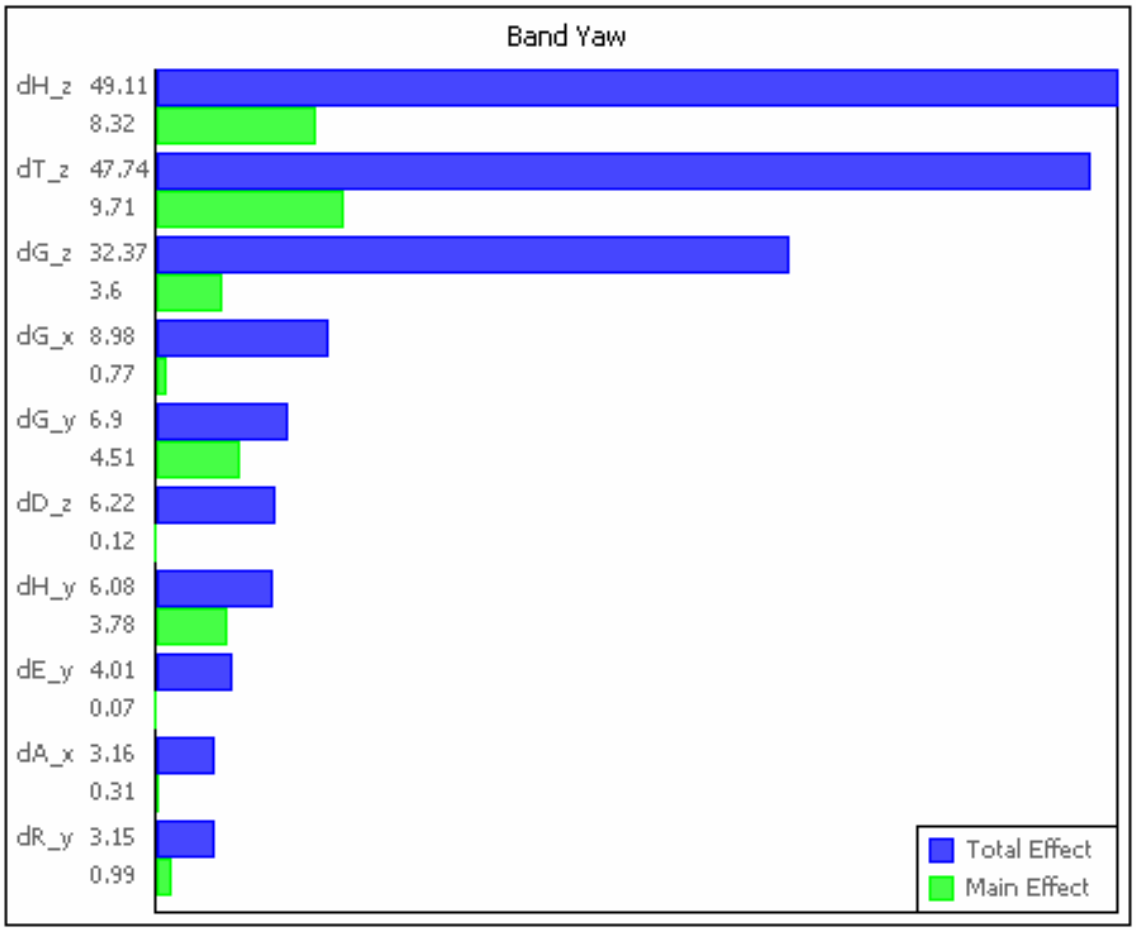


Max. Yaw-Pitch-Roll
0.025 – 0.099



Range Yaw-Pitch-Roll
0.28 – 0.42

Global Sensitivity

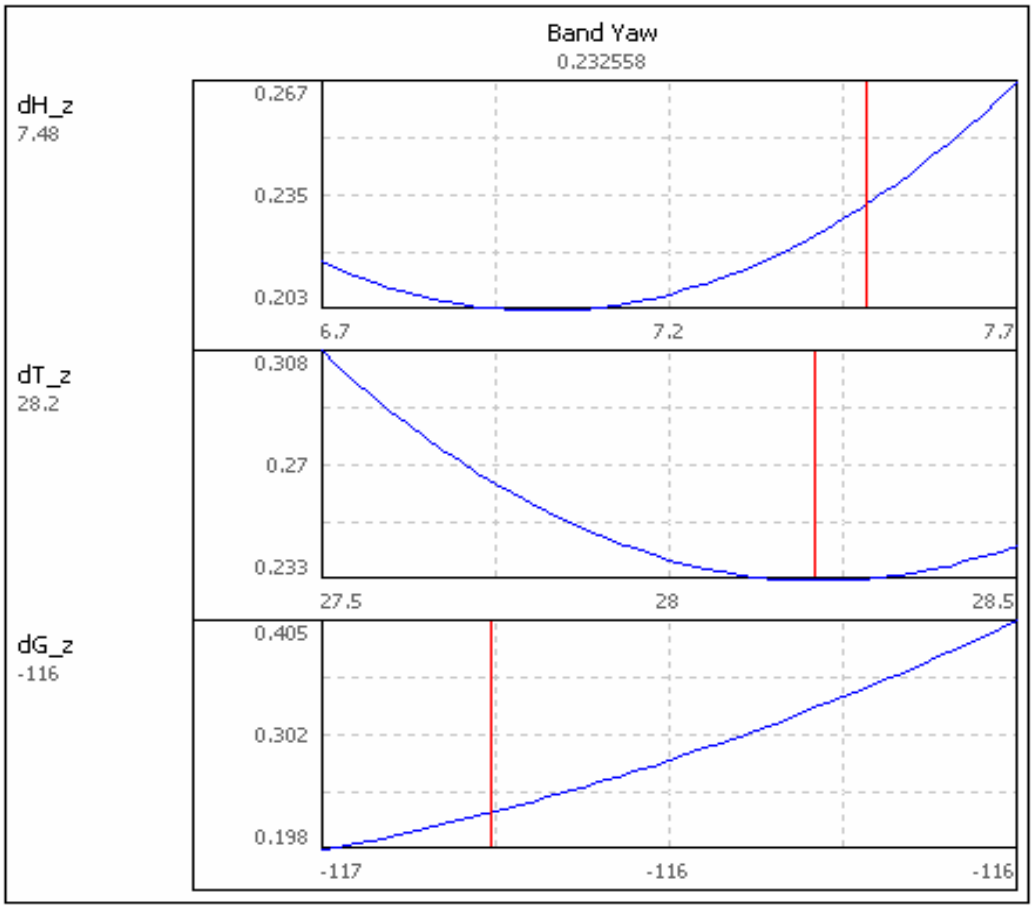


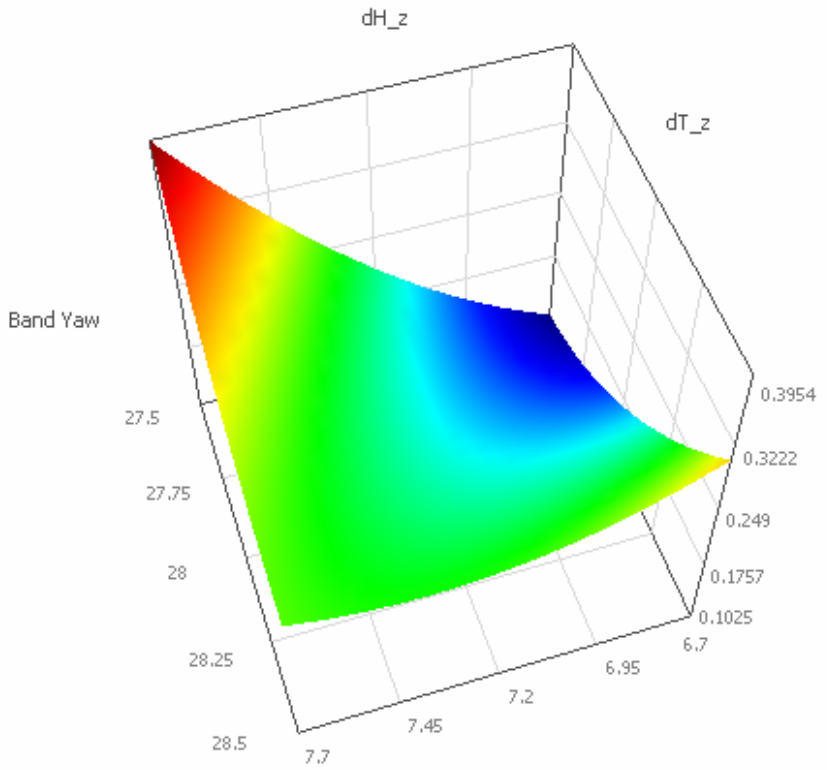
- The z-coordinates tolerances contribute the most to the variablity of the range Yaw-Pitch-Roll

- There are strong interactions between tolerances

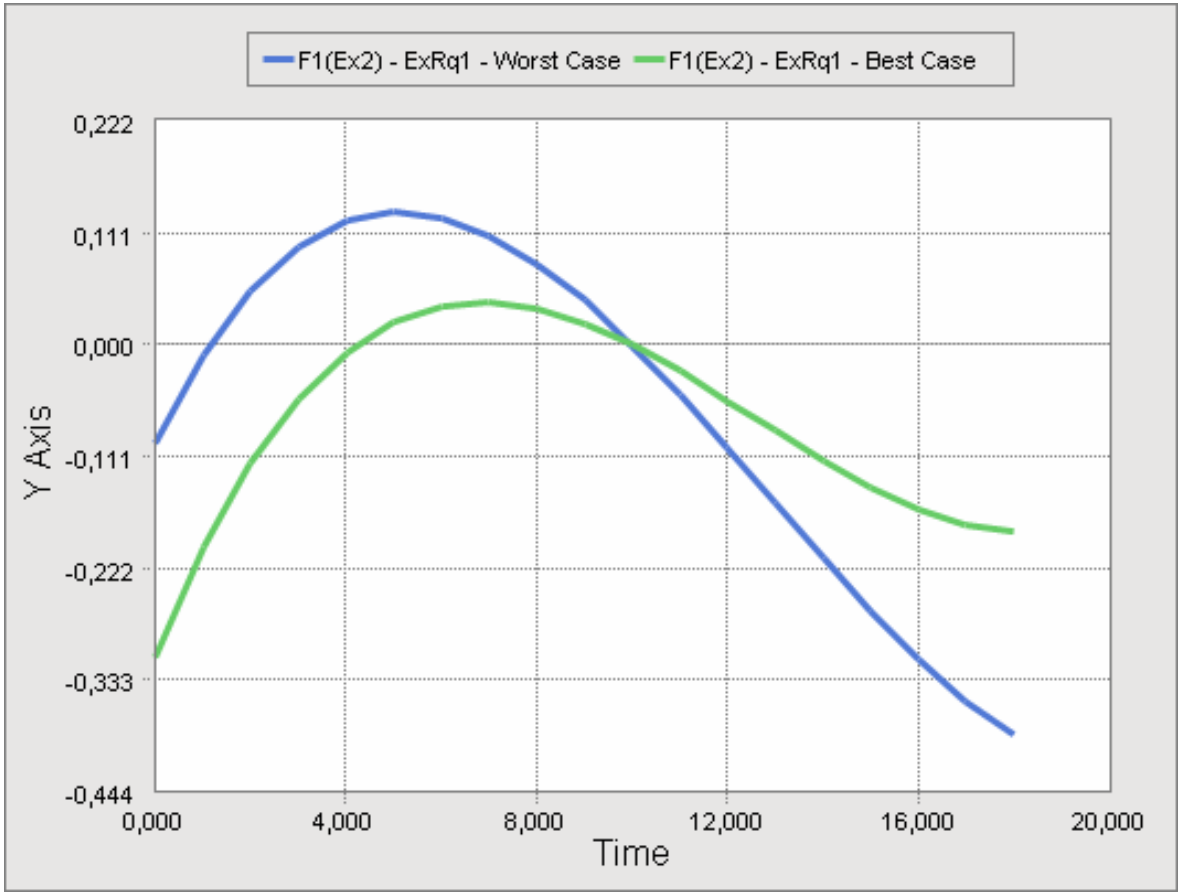
Response Surface

- Graphical 2D and 3D Diagrams of the Taylor-series are shown
- Approximation to the surrogate model
- Optimization with the surrogate model
- Best- and Worse-Case Simulation





The Worse- and Best-Case Simulation



- The best- and worse-case solution within the tolerance space at the optimal design point
- The design parameter combinations for both cases are also available