



# Acusolve CFD MULTIPHYSICS solutions for HPC applications: Better Model Reality Using Co-simulation



Maurizio Sperati | Country Manager Italy



# Altair Numbers

30+ years driving innovation

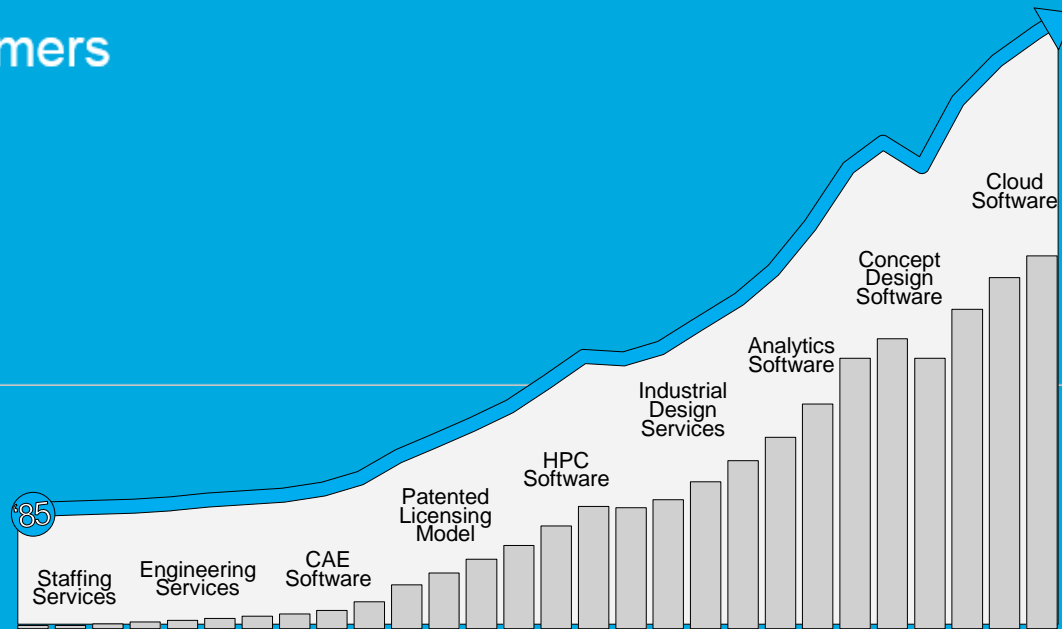
\$300+ million in revenue

45+ offices in 22 countries

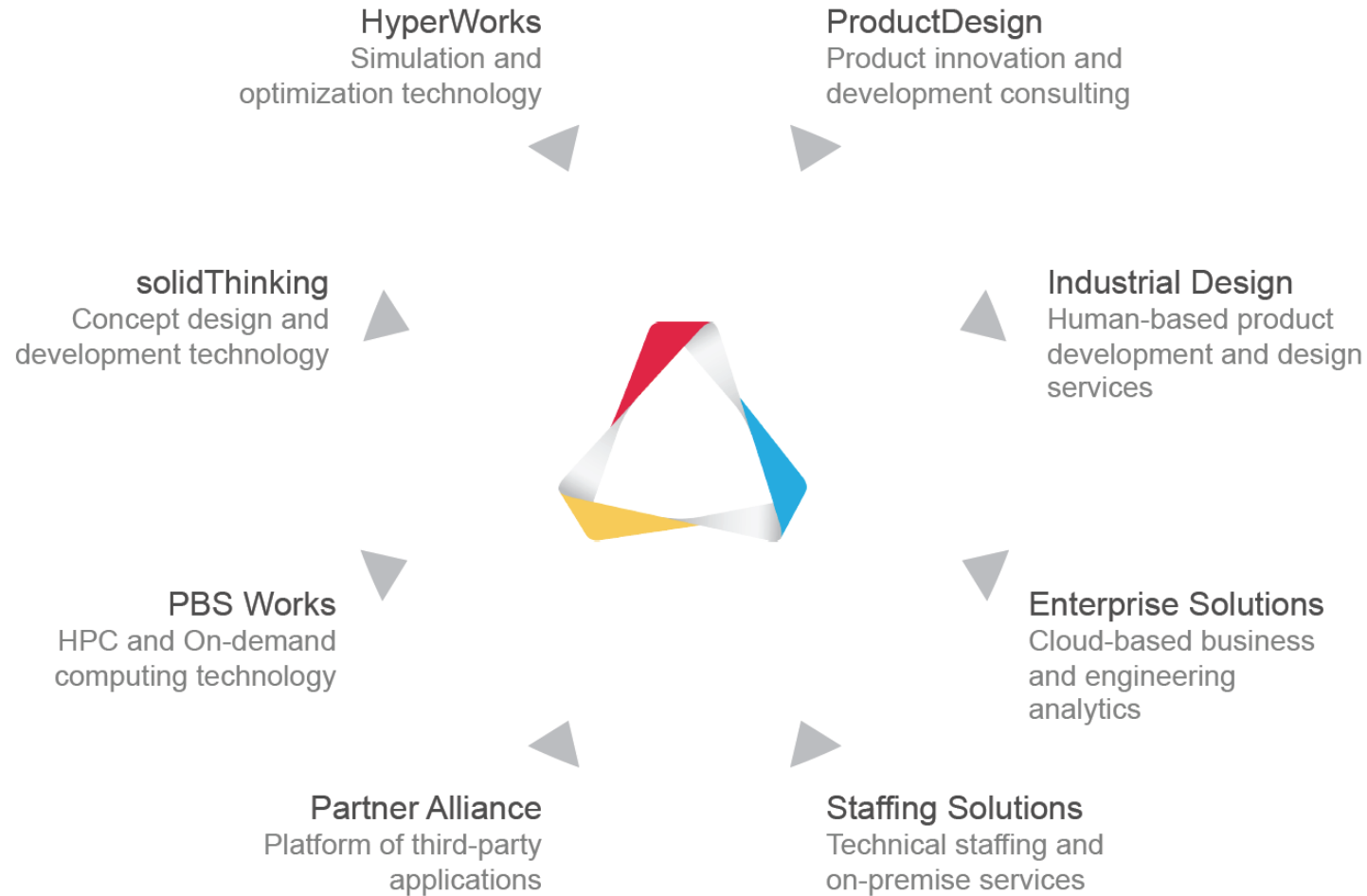
2,600+ creative designers, engineers, scientists, and developers

150+ technology and business partners

5000+ customers



## Altair - A Unique Blend of Software and Services



# Synergy @ ALTAIR



## ProductDesign

A global engineering and design business delivering innovation to our clients



## HyperWorks

Industry's broadest integrated Simulation Software Suite (Model Builders, Solvers, Optimisers Visualization)



# LET'S TALK ABOUT MASSIVE CO-SIMULATION: MULTIPHYSICS



# IN THE NEXT 20 MINS. LEARN

## WHY

use co-simulation

## HOW

MBS-CFD co-simulation can be applied

## WHAT

is the relevance of MBS-CFD co-simulation for drivability



# LET'S START WITH WHY

**WHY**

use co-simulation

HOW

MBS-CFD co-simulation can be applied

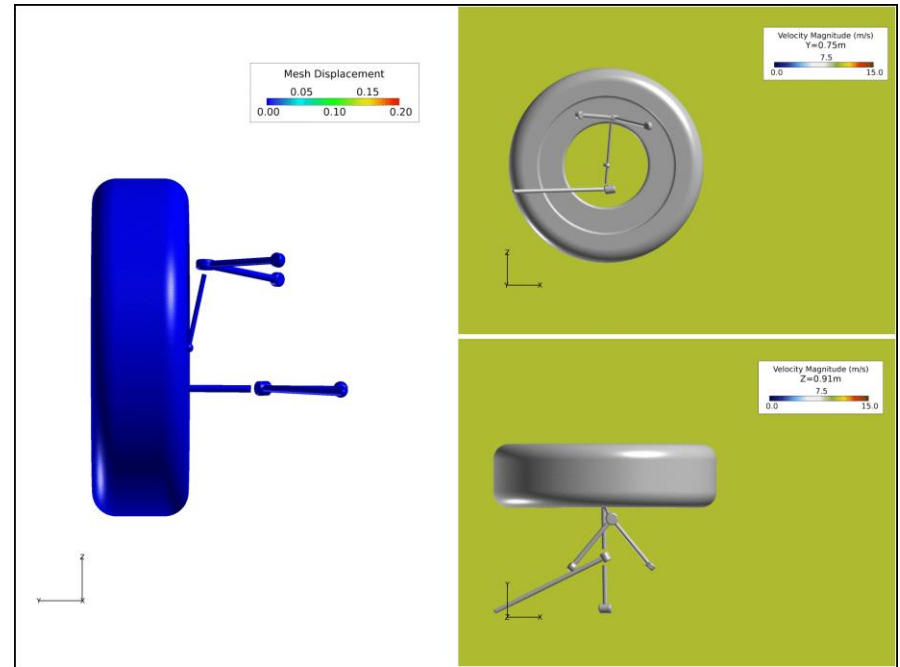
WHAT

is the relevance of MBS-CFD  
co-simulation for drivability



# WHY use co-simulation .....

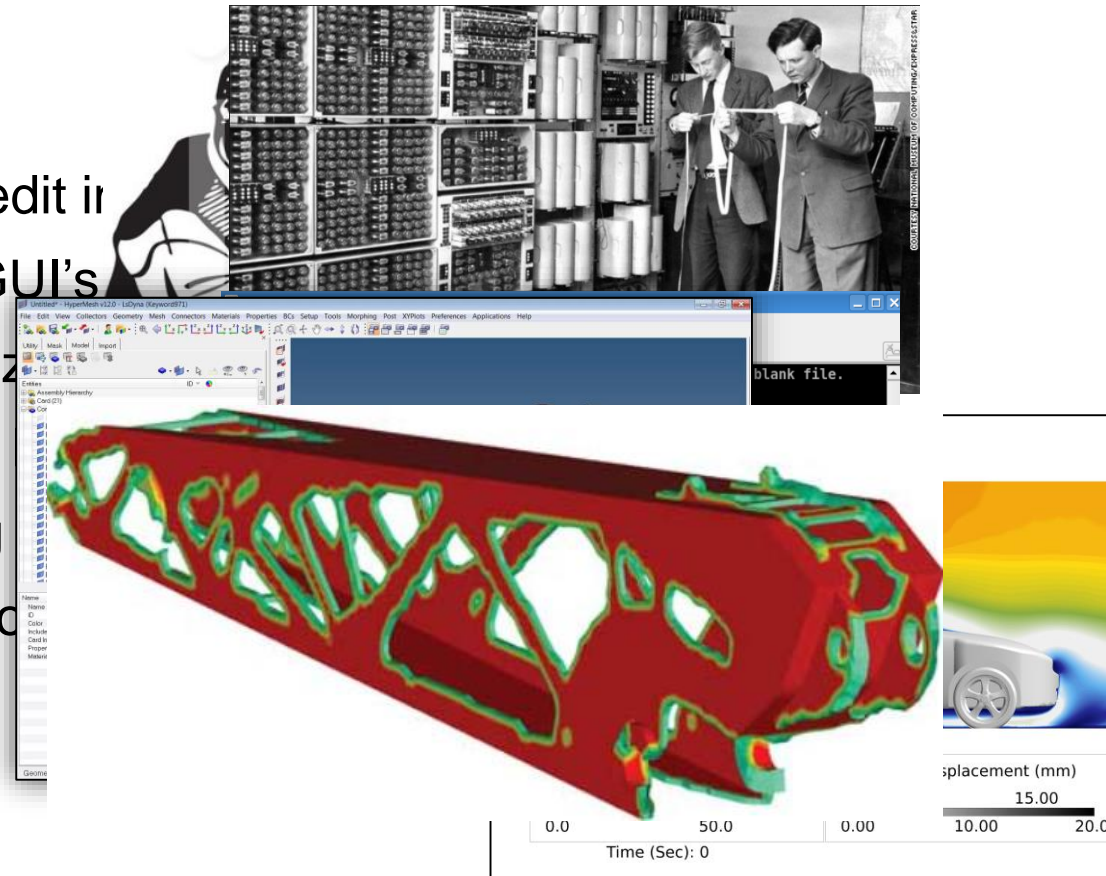
- CAE drives the design more today than ever before.
- Therefore, it is vital that simulation represent reality to the maximum extent possible.
- Multiphysics simulation provides the opportunity for significantly improved accuracy.



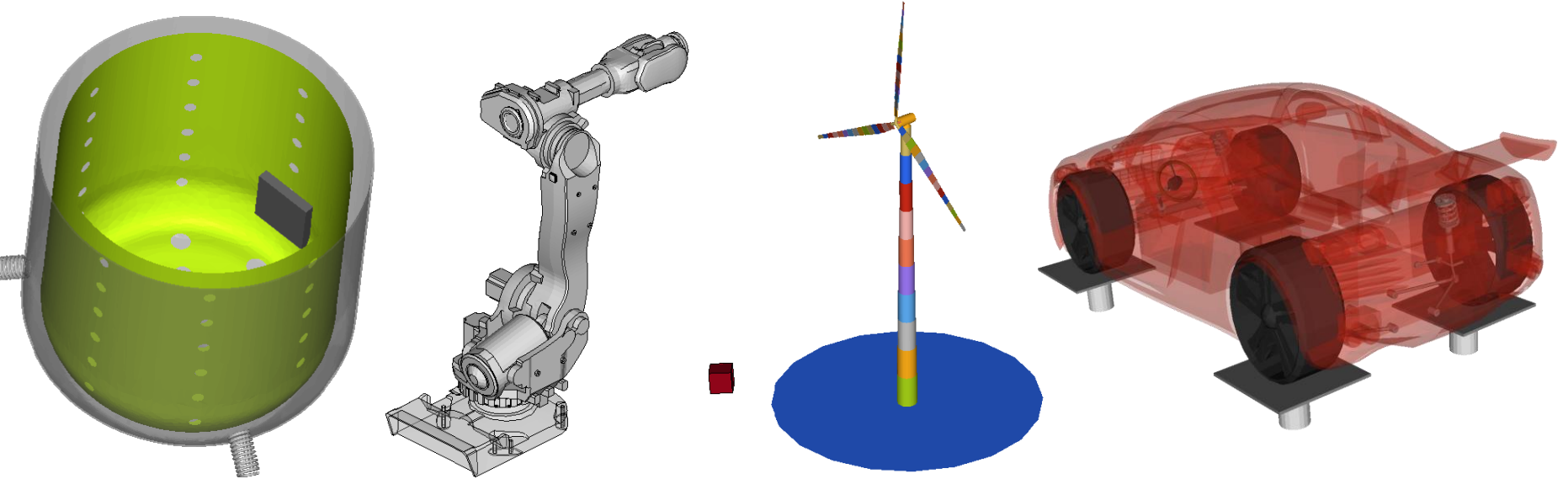


## Let's look at a brief history of engineering & simulation:

- 1950's & Earlier: "Build & Test" was the norm; Pen & Paper calcs
- 1960's: The CAE age begins
- 1970's: Solvers emerge; Text edit in
- 1980's: Solver use common; GUI's
- 1990's: GUI's common; Optimiz
- 2000's: Optimization common;
- 2010's: Multiphysics becoming
- Future: Multiphysics optimization



# WHY DO MULTI-PHYSICS SIMULATION?

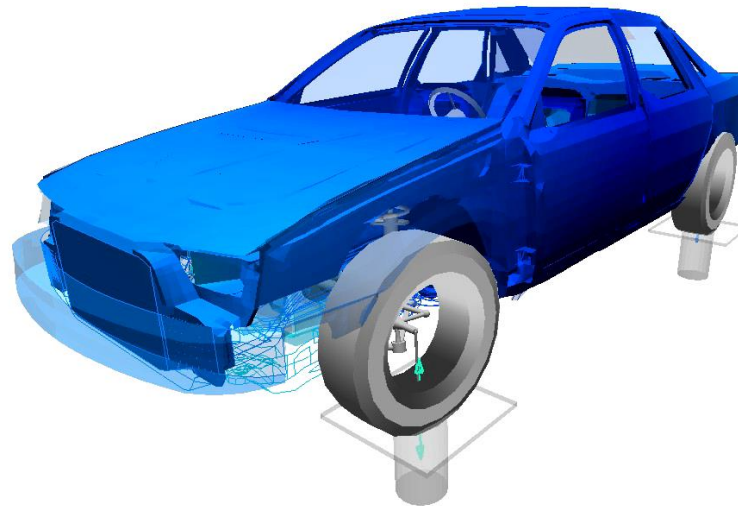
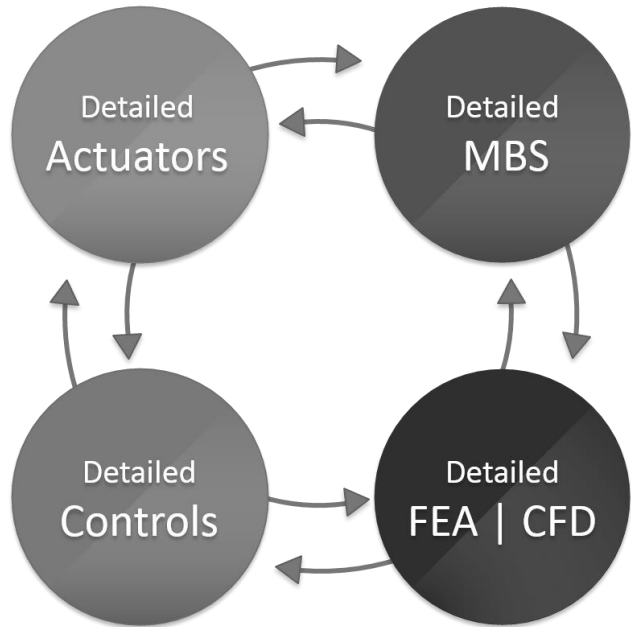


Take better design decisions by accurately  
simulating interaction between different physics

MBS | Controls | FEA | CFD | Actuators



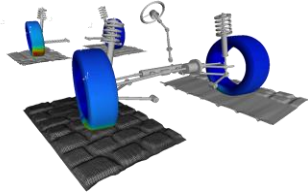
# WHY DO CO-SIMULATION?



Co-simulation empowers you to do multi-physics simulation **WITHOUT** any model simplification



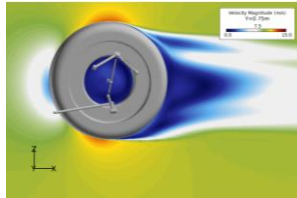
# THE GOAL



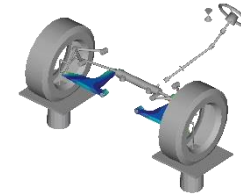
High-fidelity components



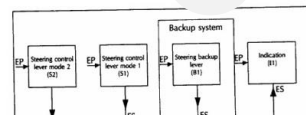
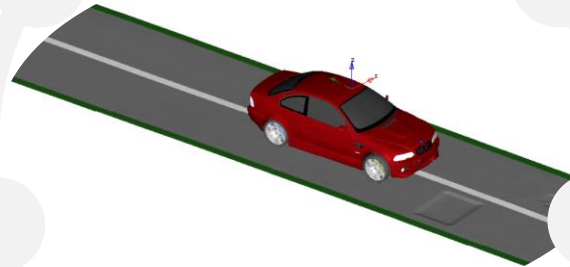
Detailed kinematics



Computational Fluid Dynamics



Structural flexibility



Controls & Actuators

## Simulate combined system behavior before creating physical prototypes

UNDERSTAND BEHAVIOR | IMPROVE DESIGNS | DECREASE COSE & REDUCE RISK



# LET'S REVIEW SOME APPLICATIONS

WHY

use co-simulation

HOW

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WHAT

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Altair

# F1 Wing Drag Reduction System

MBS-CFD CO-SIMULATION



Velocity Magnitude (m/s)



Surface Pressure (Pa)



# Altair

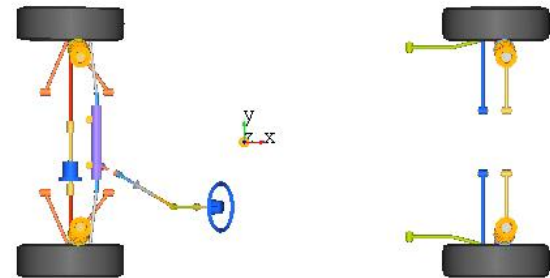
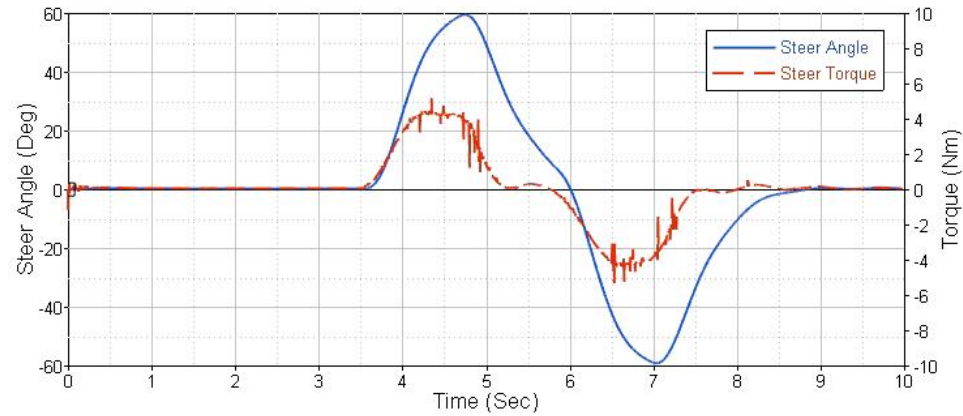
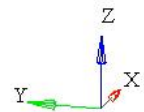
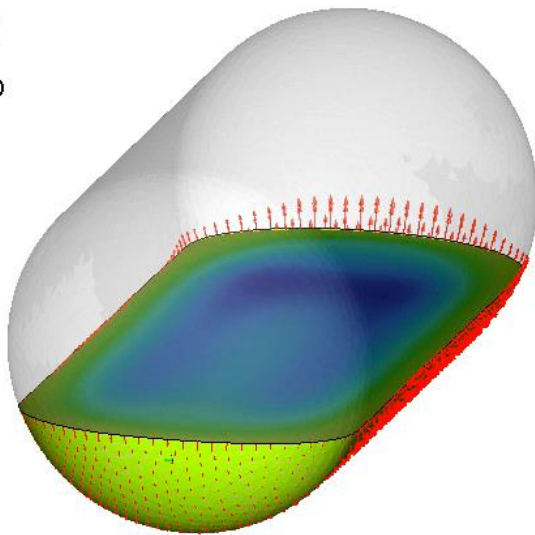
## Sloshing Tanker Truck

### MBS-CFD CO-SIMULATION

Contour Plot  
Velocity (Mag)  
Analysis system

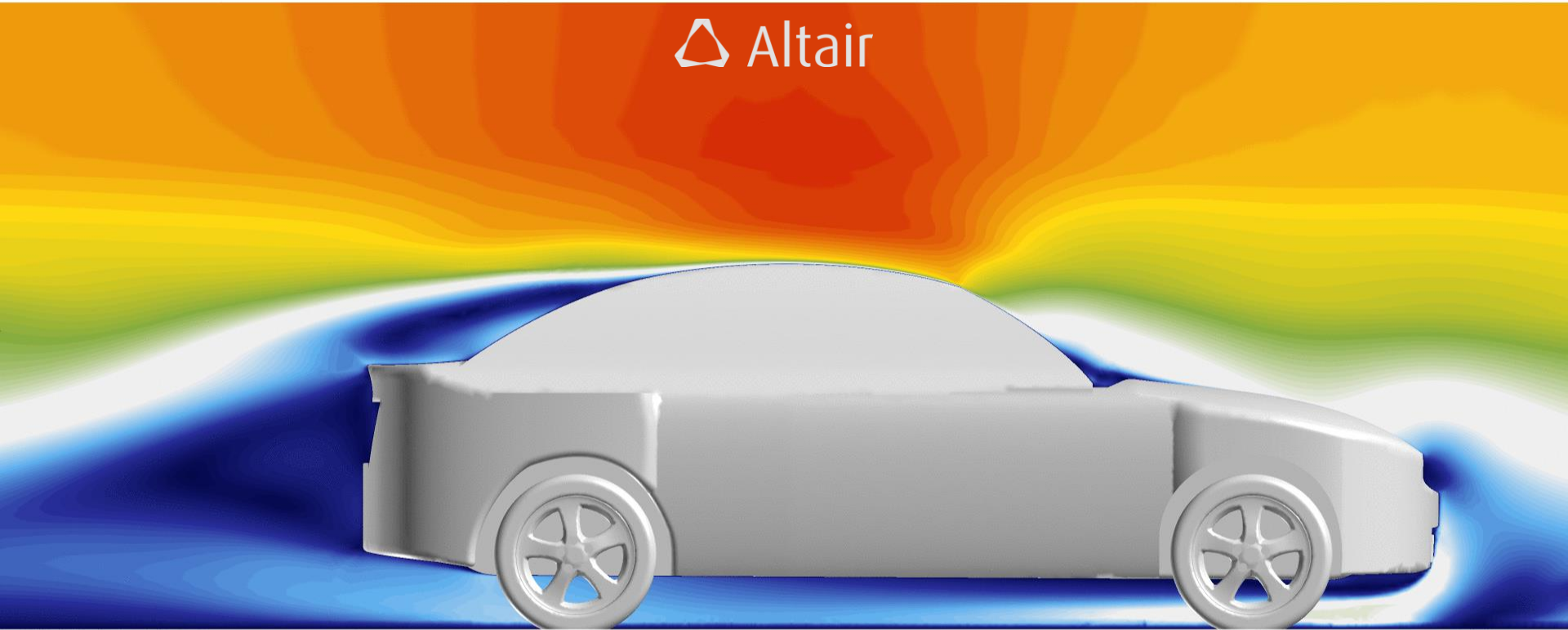
Vector Plot  
Wall\_shear\_stress(X+Y+Z)  
Analysis system

6.842E+00	5.00E-01
6.788E+00	4.38E-01
6.734E+00	3.75E-01
6.679E+00	3.13E-01
6.625E+00	2.50E-01
6.571E+00	1.88E-01
6.516E+00	1.25E-01
6.462E+00	6.25E-02
6.408E+00	0.00E+00
6.353E+00	
No result	



# Full Vehicle Ride Performance

MBS-CFD CO-SIMULATION



Velocity Magnitude (m/s)

25.0

75.0

0.0

50.0

Mesh Displacement (mm)

5.00

15.00

0.00

10.00

20.00

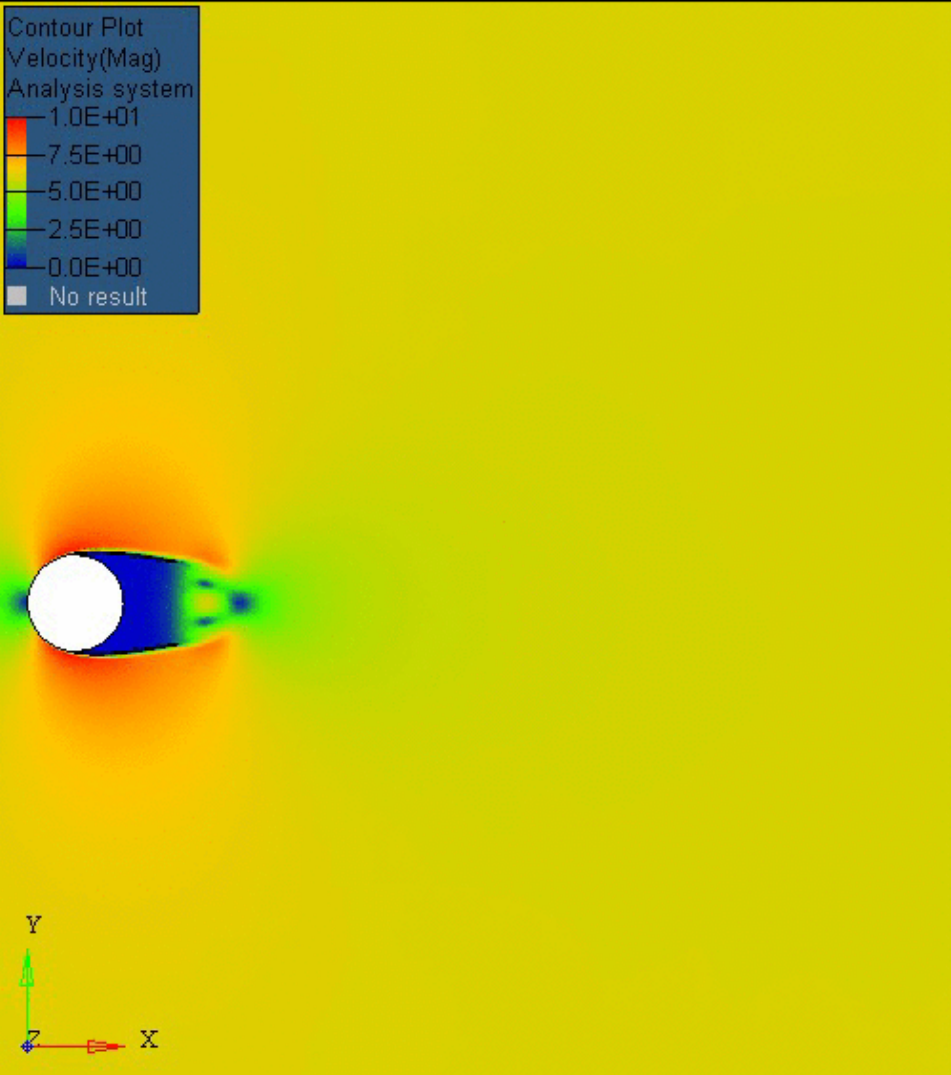
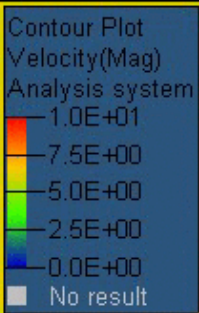
Time (Sec): 0



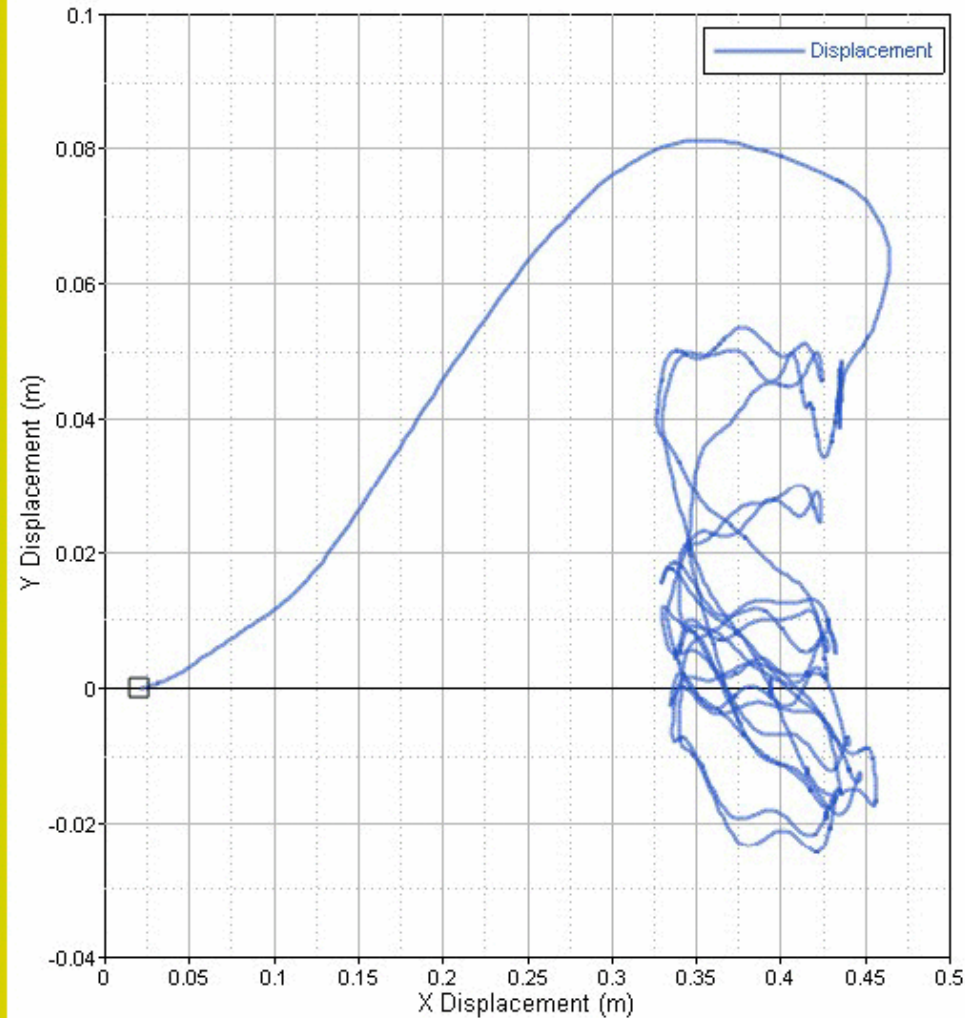


# Offshore Riser/Fairing Simulation

## MBS-CFD CO-SIMULATION



### Fairing Displacement



# VEHICLE STEERING STABILITY CO-SIMULATION

WHY

use co-simulation

HOW

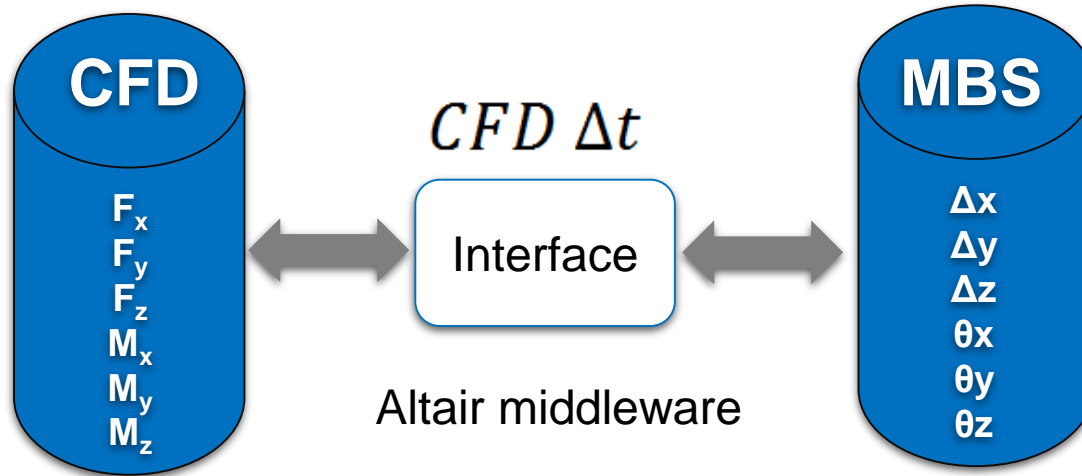
MBS-CFD co-simulation can be applied

**WHAT**

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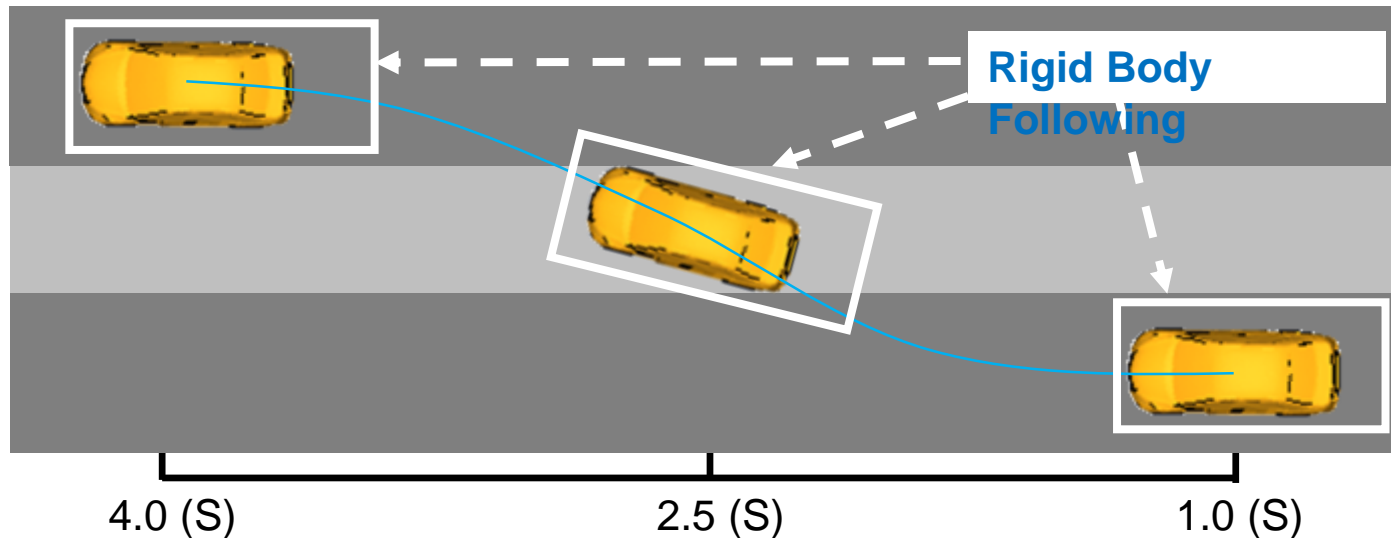
# MOTIONSOLVE (MBS) – ACUSOLVE (CFD) CO-SIMULATION



- ✓ MBS & CFD solvers send/receive info via TCP socket communication
- ✓ Altair middleware application communicates information between solvers
- ✓ Information is exchanged at the CFD time increment
- ✓ Middleware manages runtime and licensing



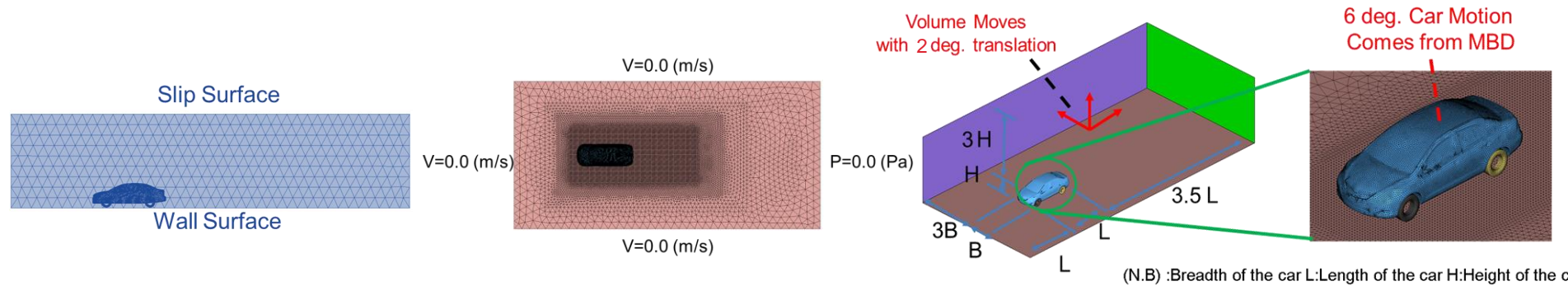
# GOAL: INVESTIGATE VEHICLE STABILITY UNDER LANE CHANGE



- ✓ Accurately predict actual driving conditions
- ✓ Simulations at 90 km/hr (56 mph) performed
- ✓ Lane change maneuver takes place over a 4 second period
- ✓ Fluid domain follows vehicle body in horizontal plane



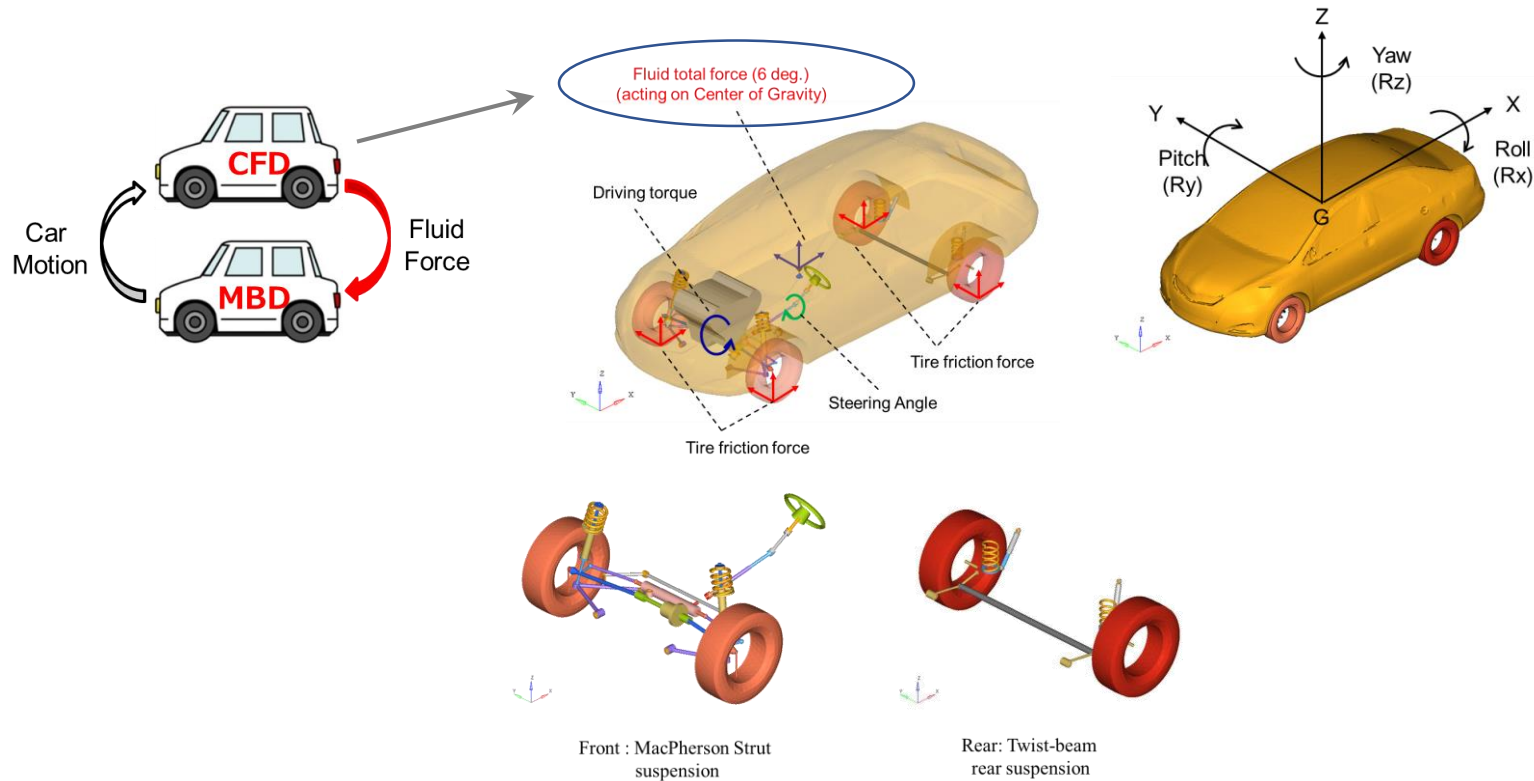
# CFD MODELING HIGHLIGHTS



- ✓ Transient Simulation (Delayed Detached Eddy Simulation)
- ✓ Single body forces/moments displacements/rotations transferred between MBS & CFD solvers
- ✓ To enable lane change in CFD, the entire fluid is translated according to the motion of the body in MotionSolve (MBS)



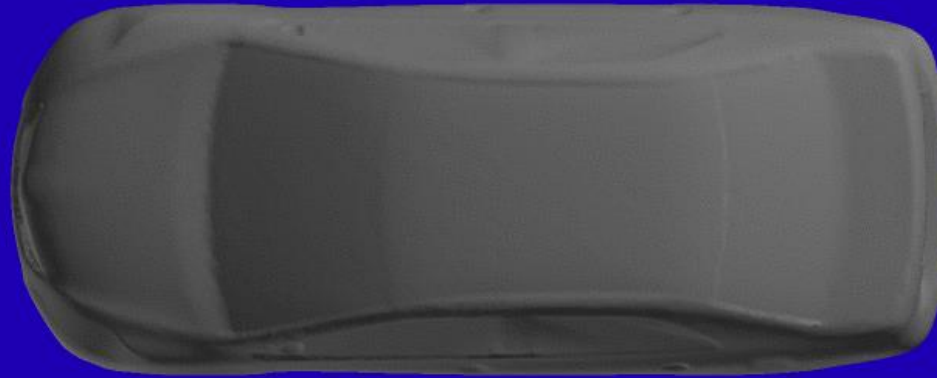
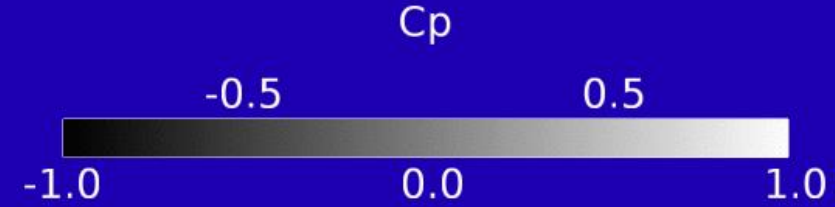
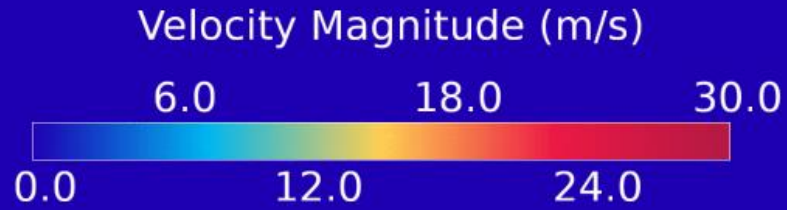
# MBS MODELING HIGHLIGHTS



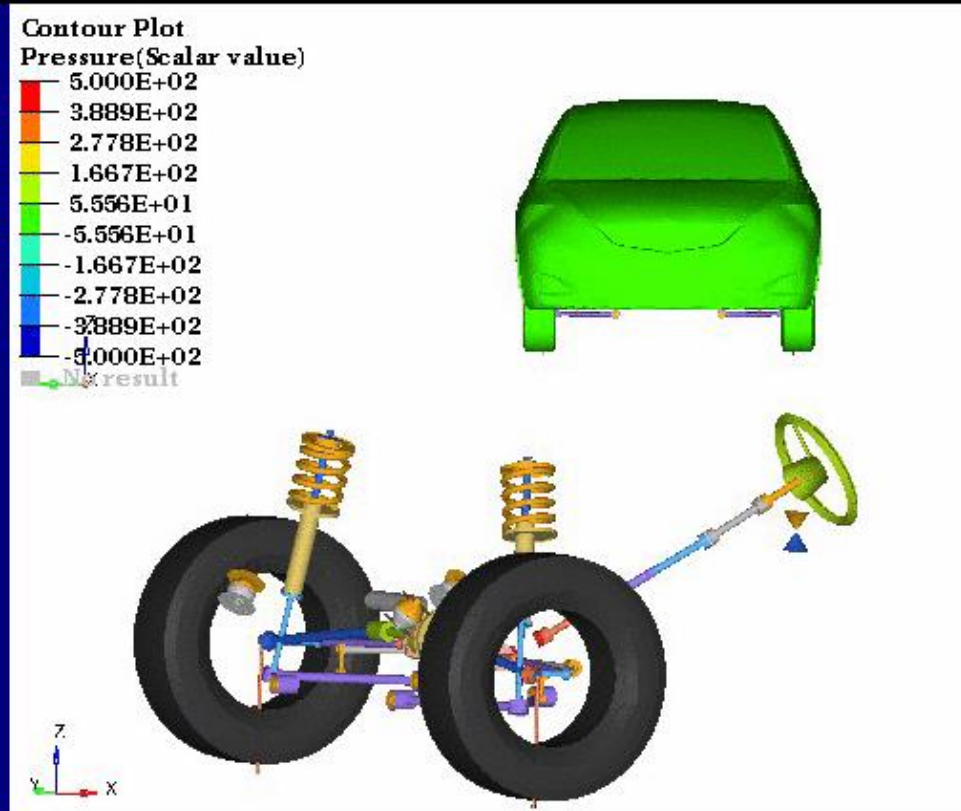
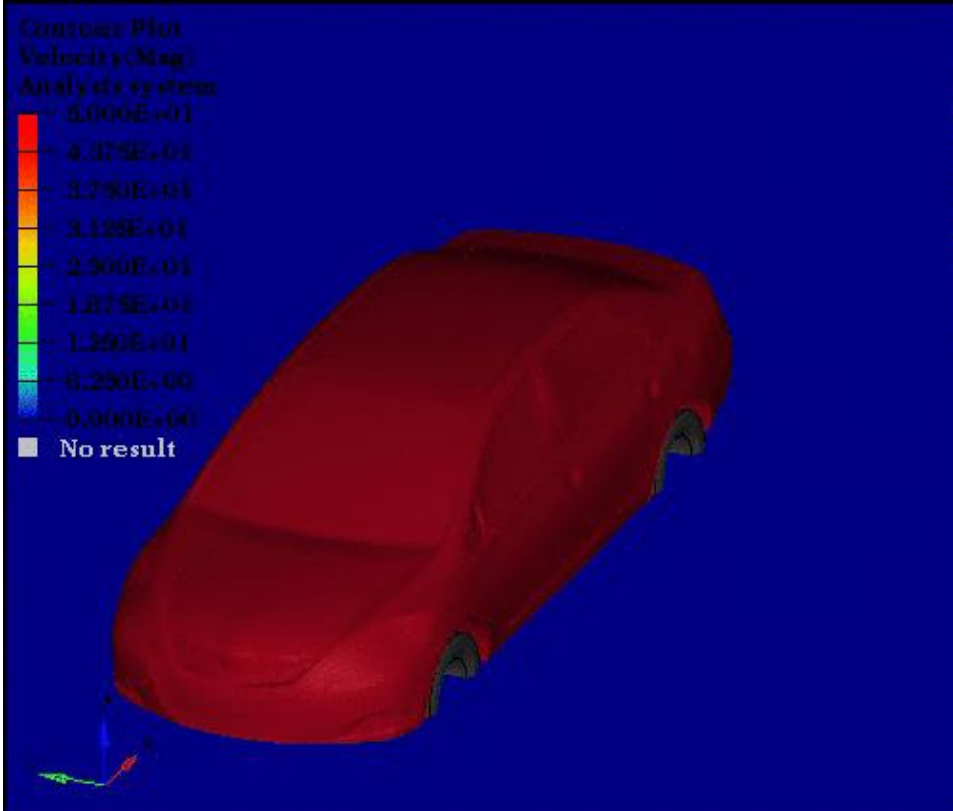
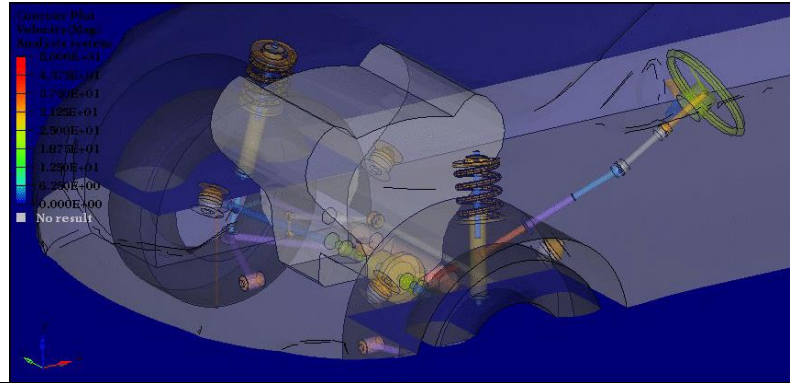
Detailed Full Vehicle model built in MotionSolve (MBS) including the external forces coupling from the CFD analysis (AcuSolve)



# SIMULATION RESULTS: AERODYNAMICS

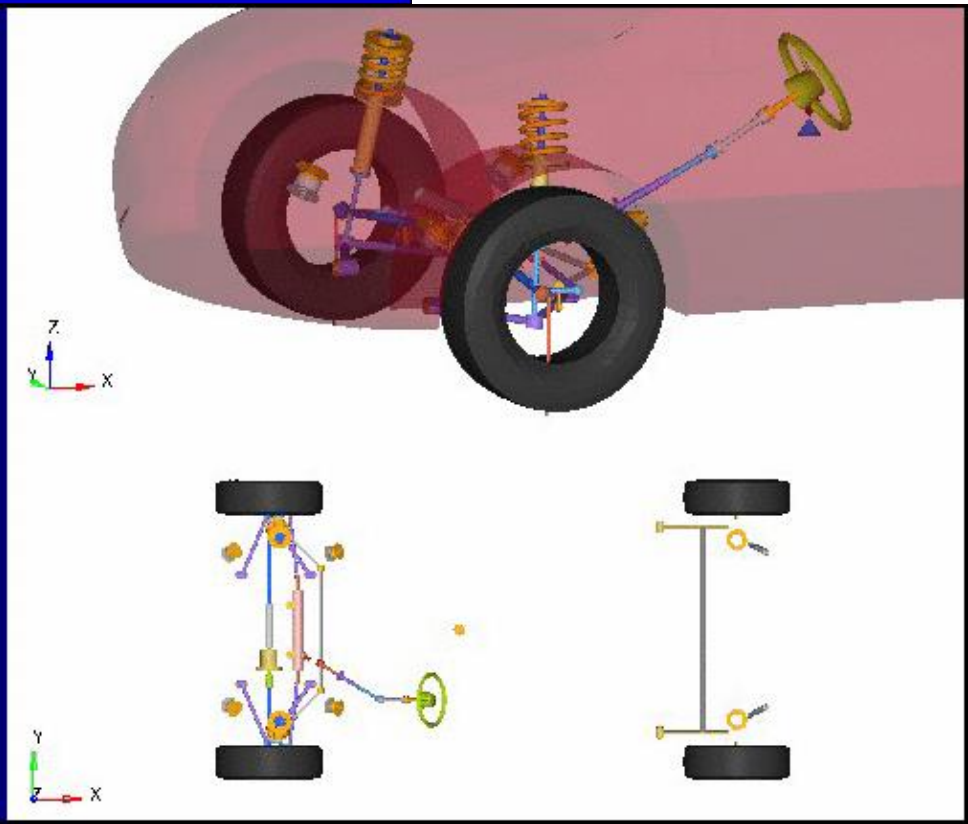
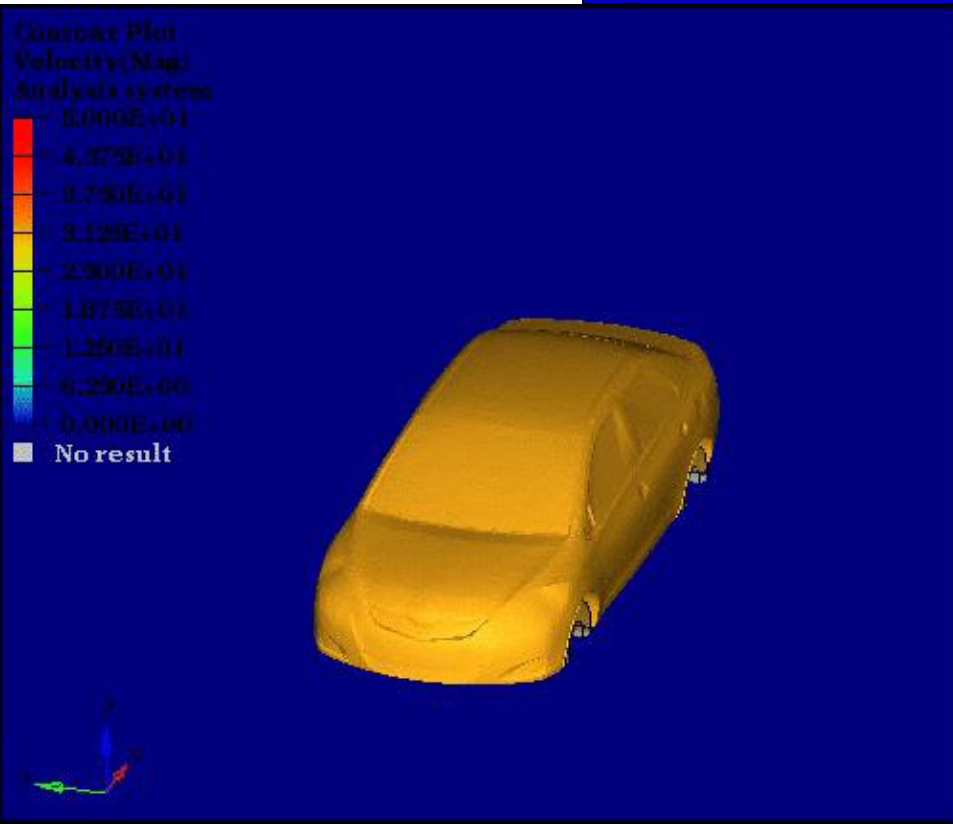
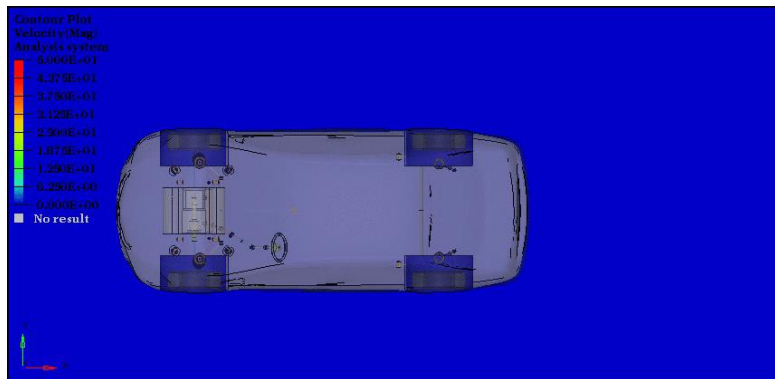


# SIMULATION RESULTS: COMBINED

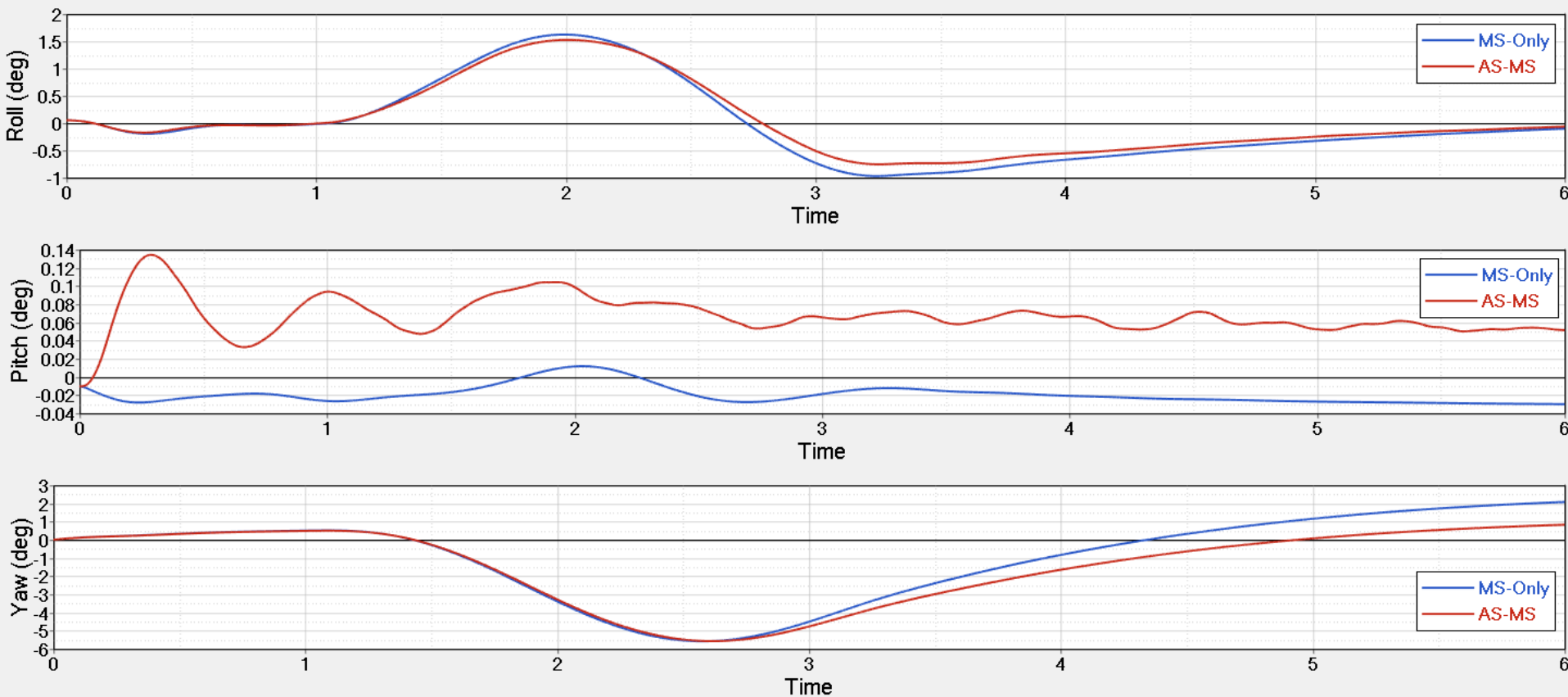




# SIMULATION RESULTS: COMBINED



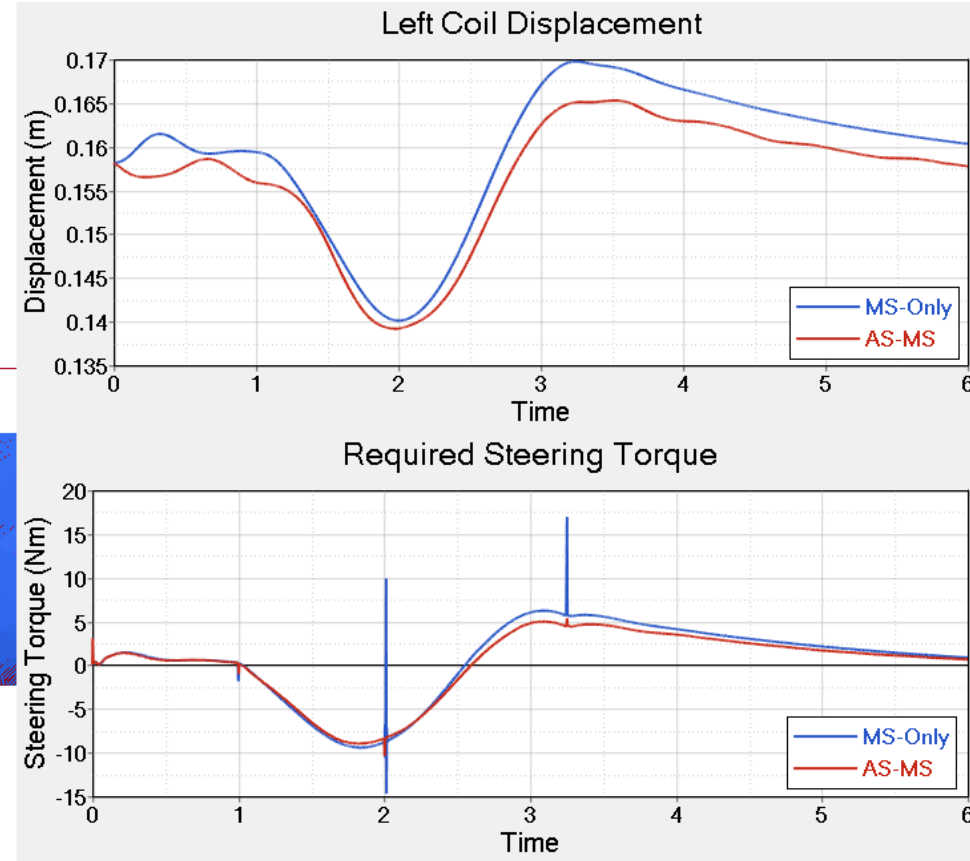
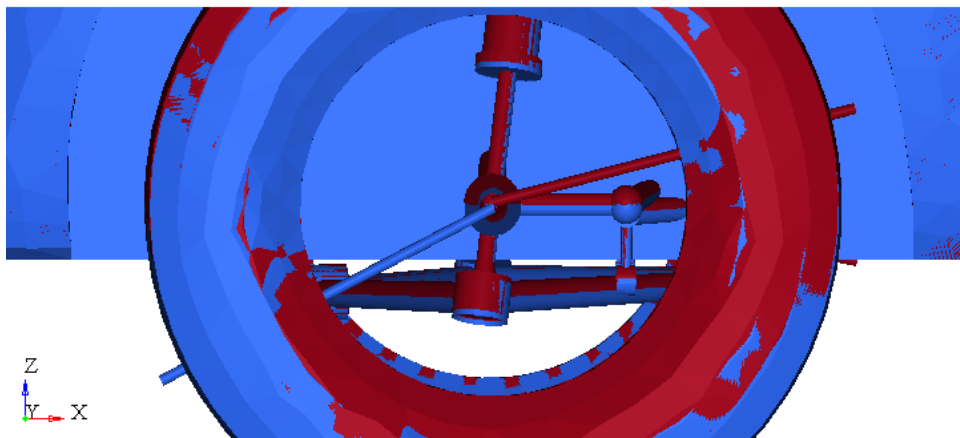
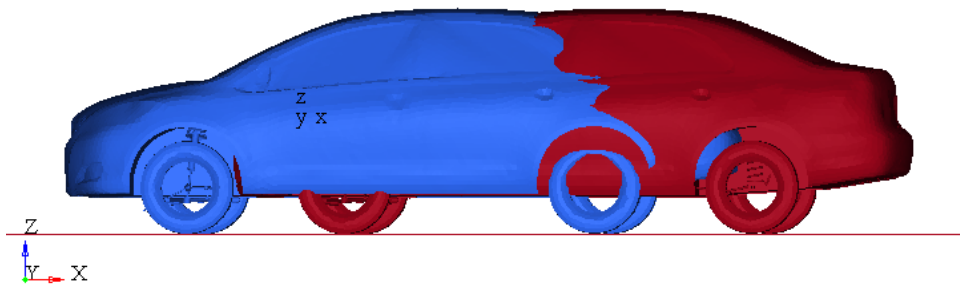
# SIMULATION RESULTS: ANGULAR DISPLACEMENT



Speed = 90km/hr; results for MotionSolve Only and AcuSolve-MotionSolve Coupling; Not a significant difference in terms of angular motion



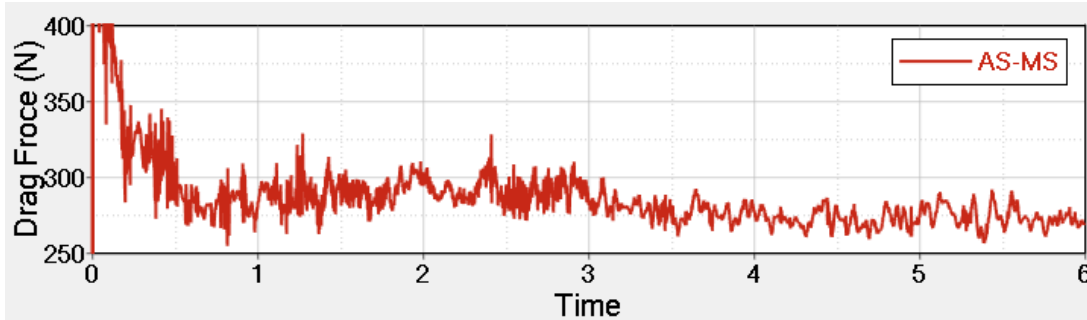
# SIMULATION RESULTS: MECHANICAL



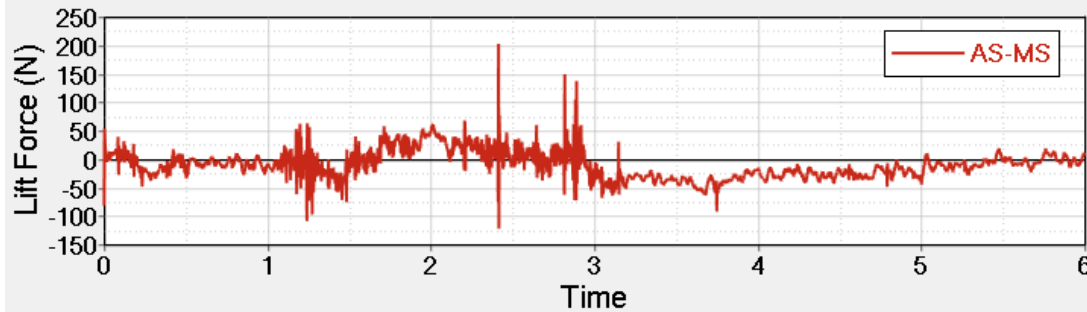
Aerodynamic forces decrease the velocity of the vehicle and tend to dampen mechanical motion of suspension components; Displacement of suspension is reduced by ~ 5mm



# SIMULATION RESULTS: AERODYNAMICS



Increased drag force as the vehicle yaws in and out of maneuver



Lift force is significantly impacted during lane change  
Downforce is negated, which leads to instability in the vehicle motion

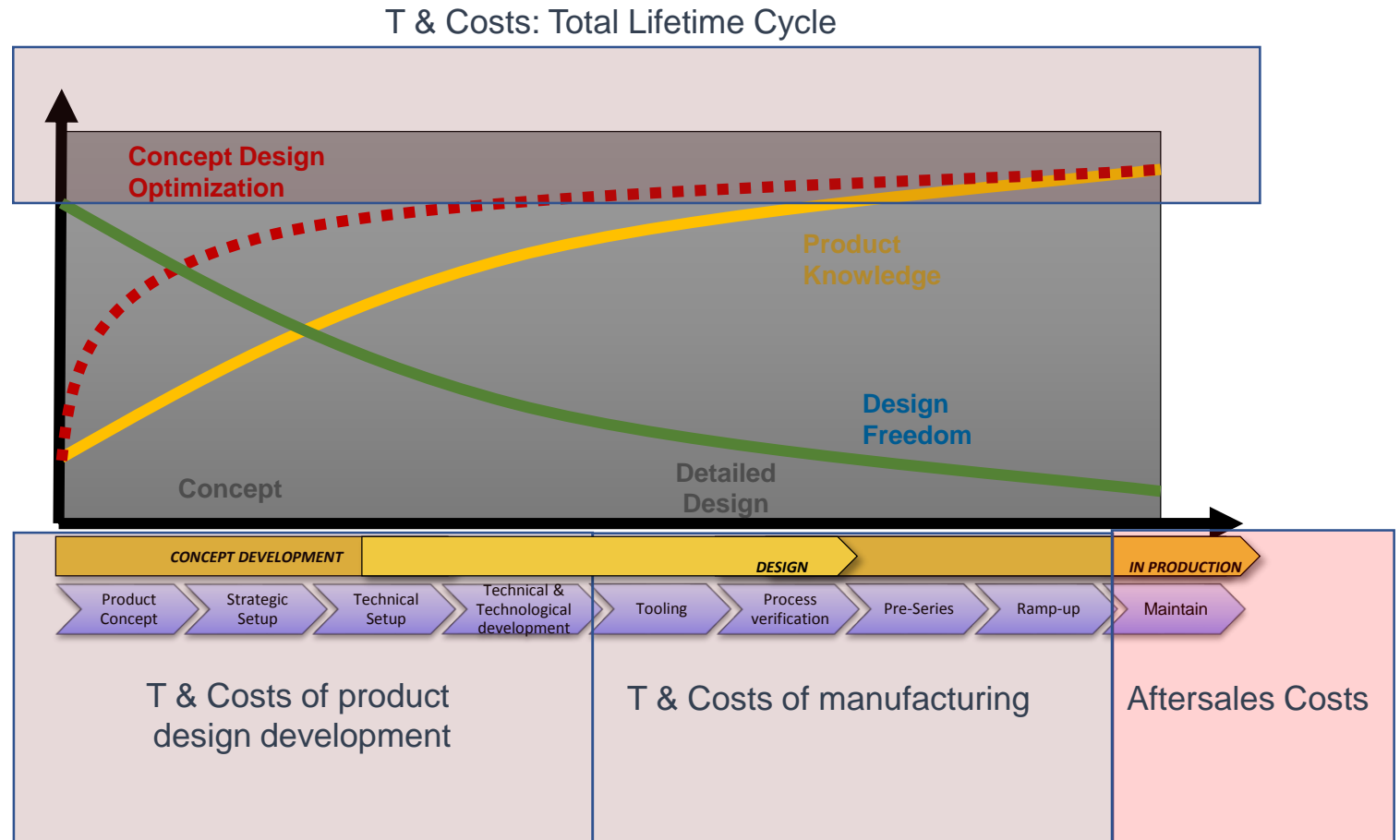


# SUMMARY

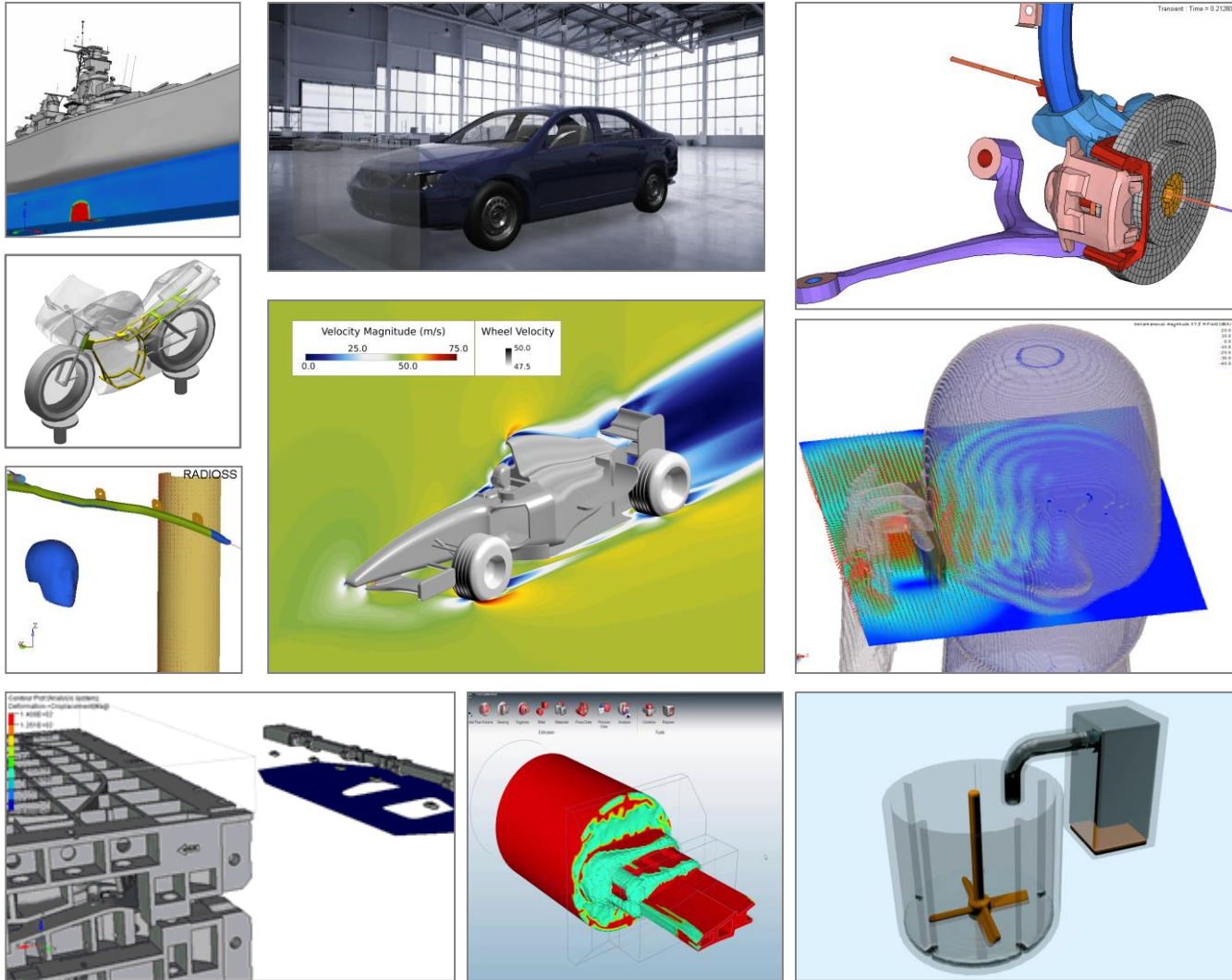
- ✓ Co-simulation empowers you to do multi-physics simulation WITHOUT any model simplification
- ✓ Multi-body Simulation (MBS)-Computational Fluid Dynamics (CFD) co-simulation enables you to better model reality
- ✓ This paper describes the importance of pushing the envelope in terms of added physics in simulating the mechanical system using MotionSolve (Multi-body simulation) tightly coupled with AcuSolve (Computational Fluid Dynamics) numerical solver to better model reality and thereby accurately simulate the drivability of the vehicle



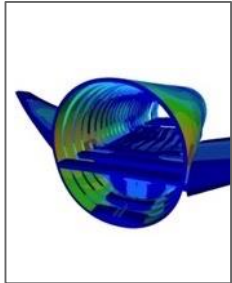
# KNOWLEDGE OF THE PRODUCT DURING ITS DEVELOPMENT PROCESS AND PROJECTION OF COST/RISKS



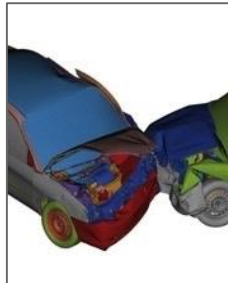
# “Assioma”: MULTIPHYSICS to avoid unforeseen behaviours



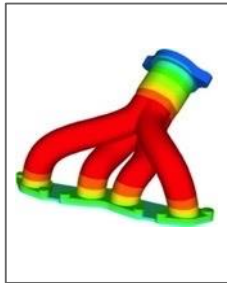
# ALTAIR SOLVER TECHNOLOGY



Structural  
Analysis



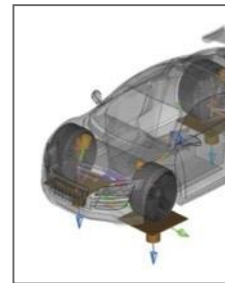
Crash, Safety,  
Impact & Blast



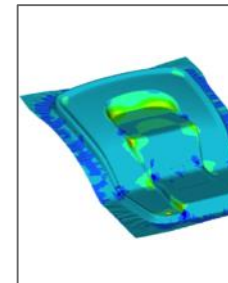
Thermal  
Analysis



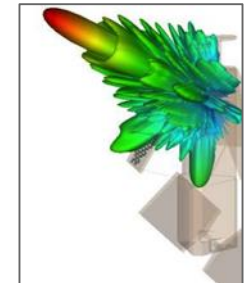
Fluid  
Dynamics



Systems  
Simulation



Manufacturing  
Simulation



Electro-  
Magnetics

Multiphysics Analysis and Optimization

Digital Materials





We ask you to not just design something.  
We ask you to DESIGN THE DIFFERENCE™

