



Durability System Analysis Approach

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System Level Durability Simulation of 2005 Mustang

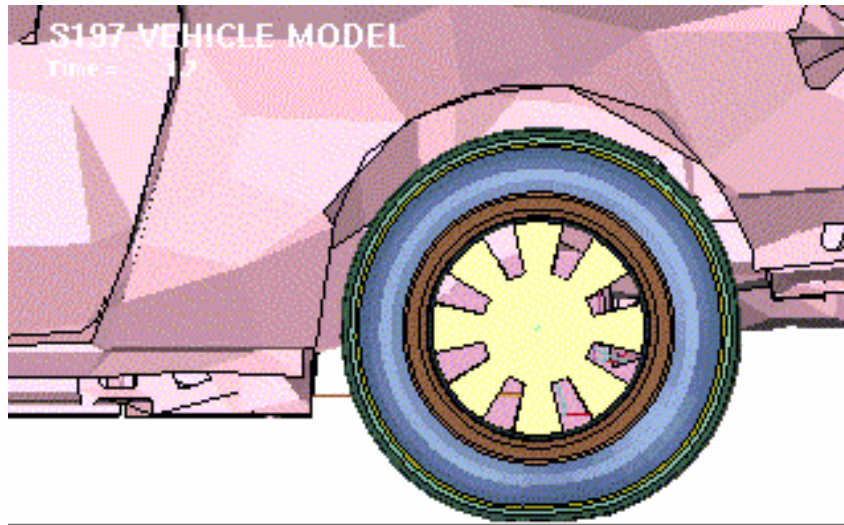


New Vehicles – New Simulation Technology

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Examples:

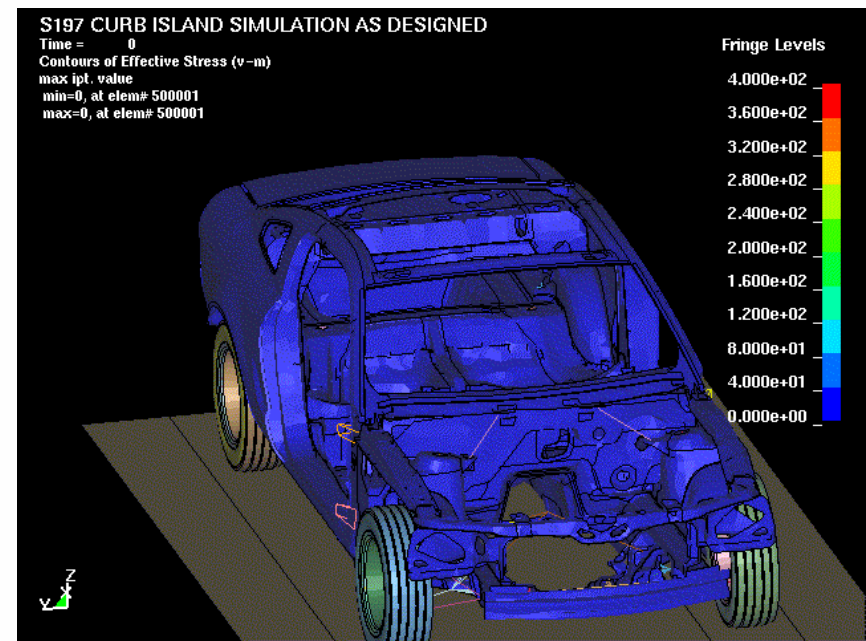
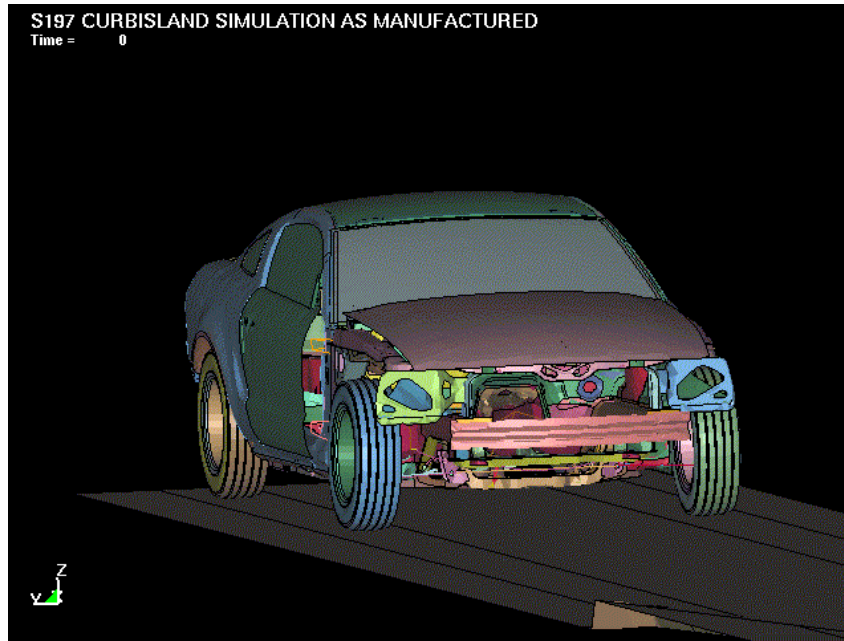


Wheel Hop Analysis





Examples:



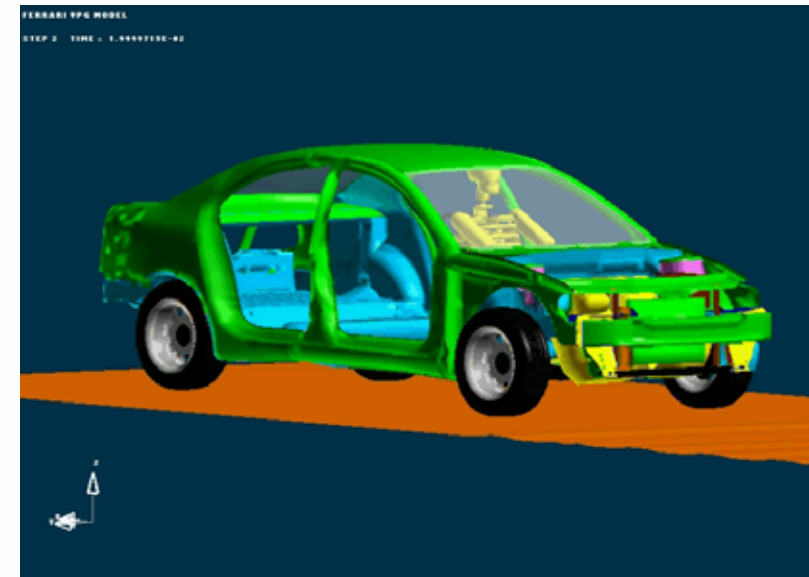
Curb Island Simulation

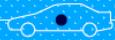


Why System Approach?



- Top Down design analysis approach will investigate what is required of the system.
- Takes into account the non-linear system interactions and material properties.
- Compatibility with vehicle test procedure.
- Facilitates enhanced loads management within the system.
- Helps eliminate over-engineered components.

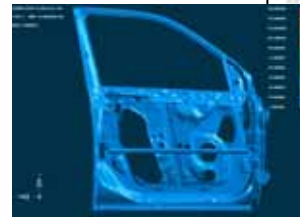
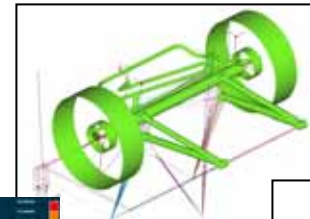
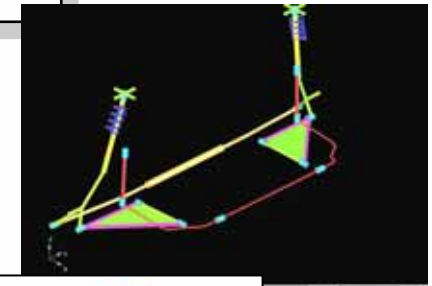
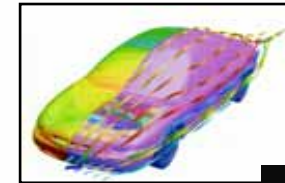
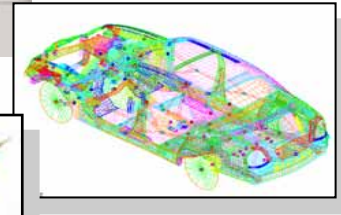
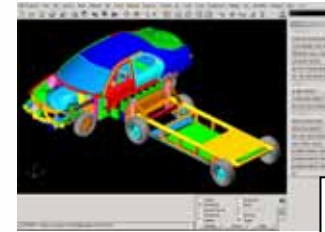




Other CAE Groups using System Approach



- Safety
- NVH
- Thermal / Aero
- Vehicle Dynamics/Road Loads
- Door / Hood Systems





Trends for Vehicle System Durability



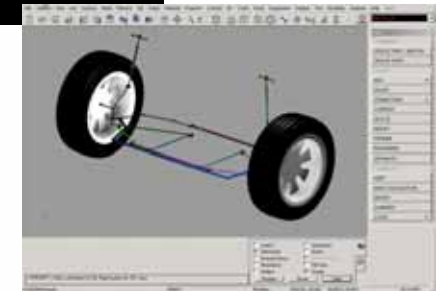
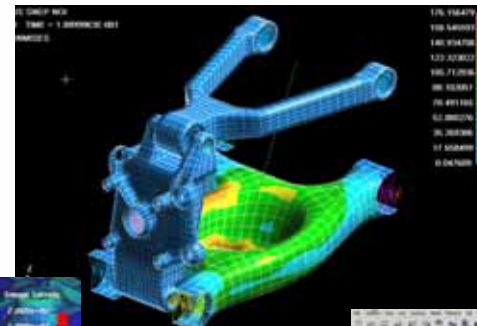
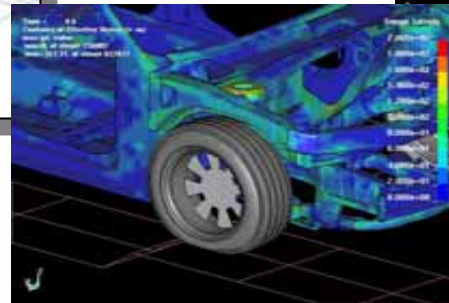
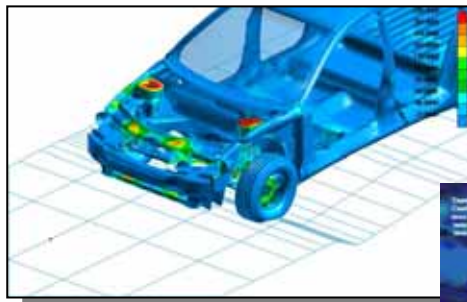
- Many automotive manufacturers are integrating system-based analysis into their development programs.
- Transient, non-linear codes are used increasingly as affordable, more powerful computers are released.
- System-based analysis is often used to troubleshoot durability issues related to late-in-development tuning or design changes.
- Some auto manufacturers are using this method to predict road loads in early design phase.



Definition of a System



- Two or more components connected by bushings, springs, joints, mounts and welds.
- Represents test configurations – Event Based.





System Approach Method



- **Build model**

- Assemble from various sources
- Re-use of data

- **Analyze**

- Study the behavior as the testing would be performed

- **Correlate with test**

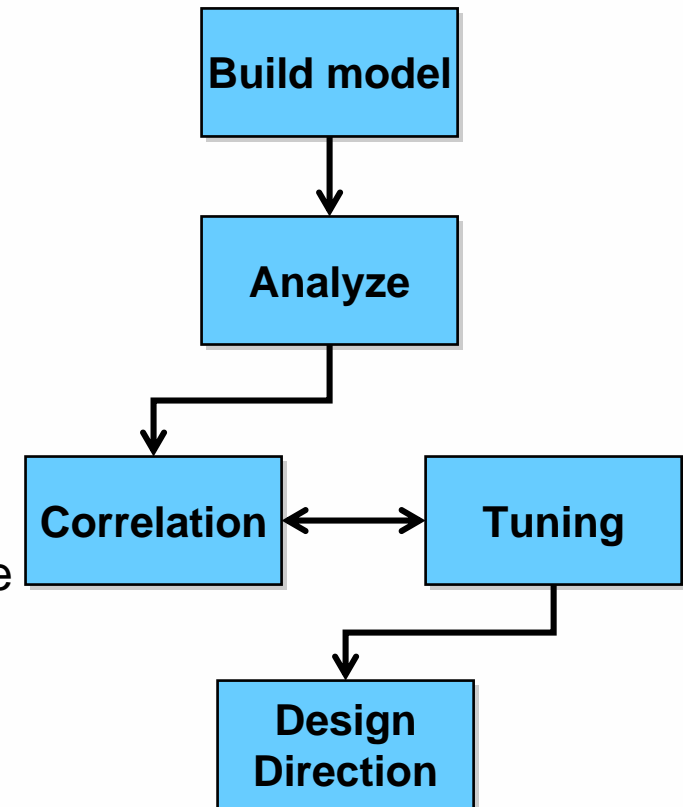
- Compare the simulation/test results

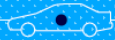
- **Tuning**

- Improve the simulation as necessary to provide the appropriate level of correlation

- **Give design direction**

- Improve the design through the simulation results

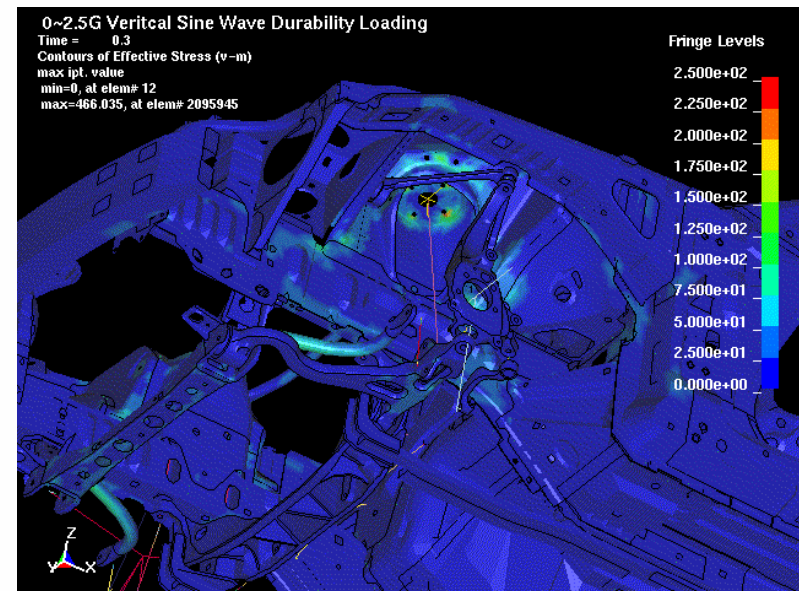




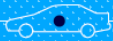
No need for tuning if we have accurate:



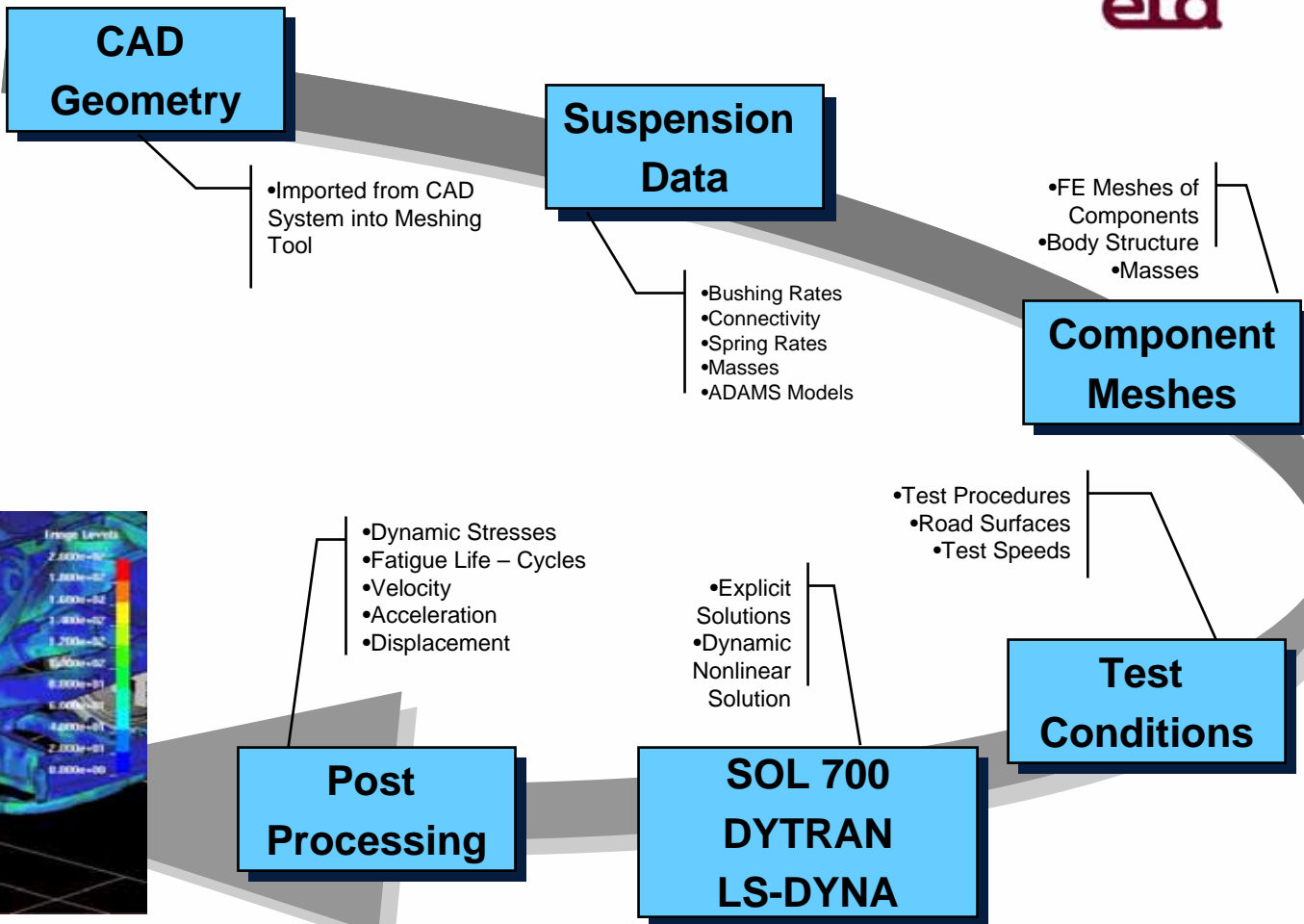
- Material information
- Shock, spring and bushing data
- Geometry/Welds
- Tire stiffness
- Less test variability (load, ...)
 - Body fixed (ground), rigid, or flex
 - Assumed boundary conditions



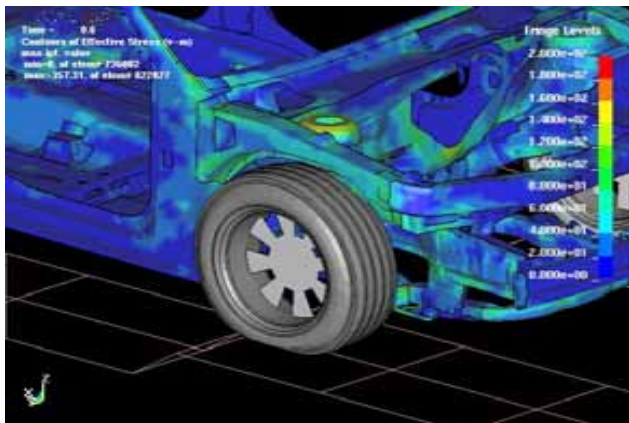
- We can achieve higher accuracy earlier in the development process, with less reliance on testing

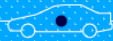


System Modeling Process

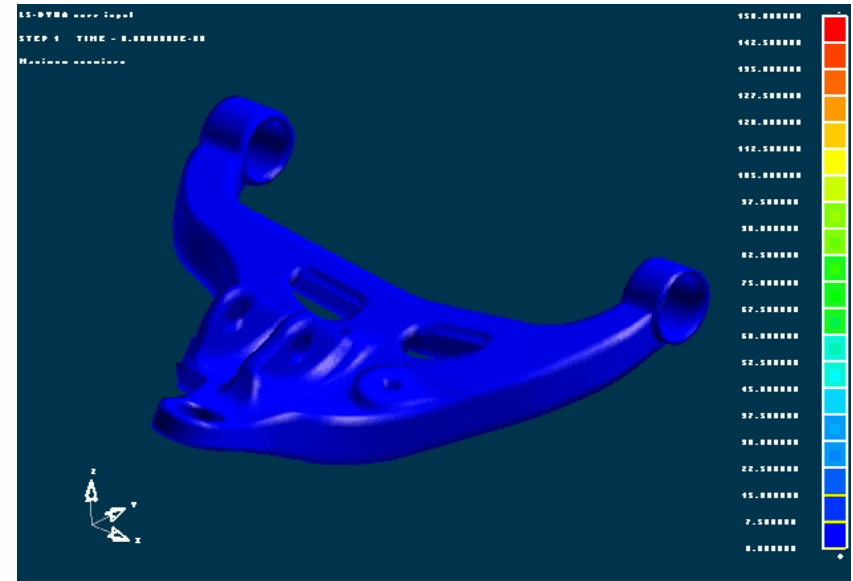


System-Level Results





Examples:



LCA Stress Analysis

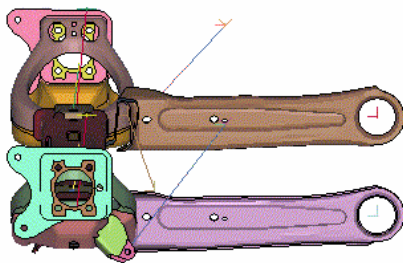
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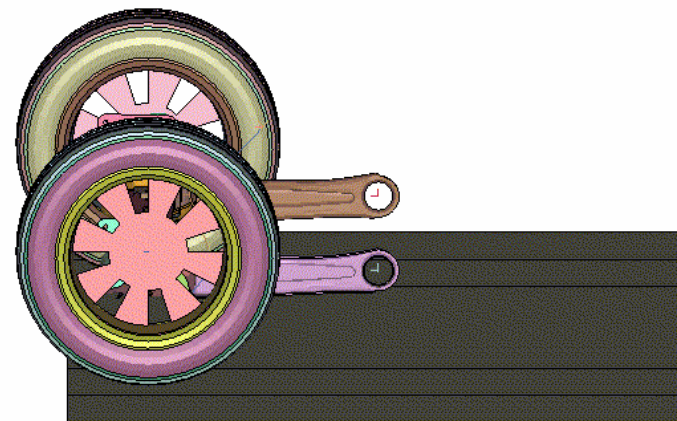
Examples:



V229 Rear Axle Study- No Tires
Time = 0



V229 Rear Axle Study- With Tires
Time = 0

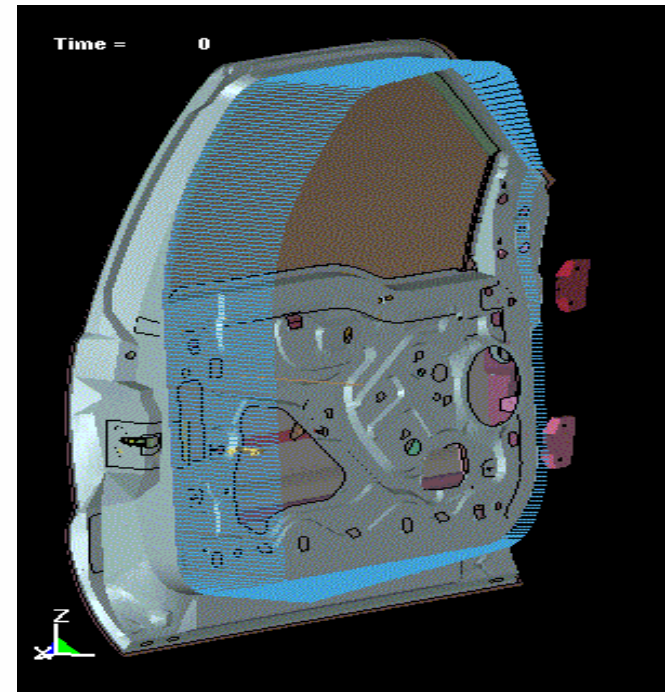
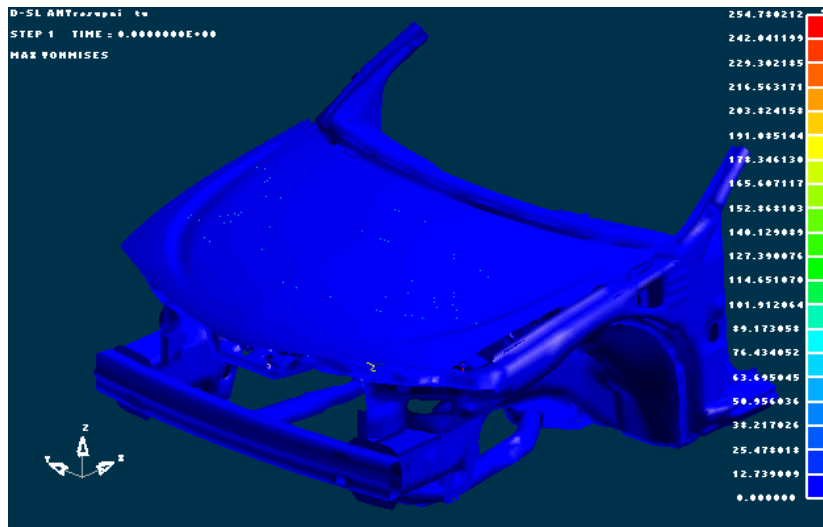


30 MPH Chuckhole Analysis

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Examples:



Hood and Door Slam Analyses



Benefits of a System Approach



Using a dynamic nonlinear FE approach for System Level analysis provides data not available from other simulations:

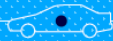
- Displacements (dynamic, nonlinear)
 - Stresses / Strains (dynamic, nonlinear)
 - Velocities (time varying)
 - Accelerations (time varying)
-
- A substantially greater amount of data now available to understand the problem and develop a recommended design change



Issues and Requirements



- Currently not enough experience or CAE knowledge- base
 - Experience is built on using implicit software for durability analysis
- Time penalty
 - Trends in computing continue to ease this penalty
- Requires resource utilization study
 - How should best use your simulation resources
- Software Requirements
 - Non-linear material properties
 - 3-D Tire-Road interaction
 - Contact Algorithm



Conclusions



System approach can be a benefit for:

- Evaluating design changes that affect loads (path, magnitude)
- Inclusion of more realistic boundary conditions and loads
 - Simulates what is tested, not a guess at the boundary conditions
- Help to understand root cause phenomena by:
 - Looking at interaction of parts
 - Dynamics phenomena of the structure



Recommendations



- Leverage traditional approaches available in ADAMS and NASTRAN environment
- Develop system level expertise using Explicit Solutions
- Build system model for vehicle programs in early vehicle development phase
- Analyze and verify systems for all major milestones
- Implement **SOL700 & DYTRAN** for these types of simulations
 - LS-DYNA capability is key for the success of these simulations
- Implement tools that enable system level simulations