Daimler Trucks Accelerates Product Development Cycle with 10X Faster MSC Nastran Performance

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Daimler Trucks manufactures and sells commercial trucks and buses as well as performs services and maintenance of their products. Daimler strives for efficiency and innovation, and the Daimler Trucks North America development team is applying computer-aided engineering (CAE) techniques to the truck development process to help the company achieve these goals.

Truck manufacturers must ensure the safe carriage of payloads while simultaneously light-weighting their vehicles to improve fuel efficiency and associated emissions, and the ability to predict the fatigue life of the vehicle components is extremely important. Predicting fatigue life accurately in the early stages of the design and development cycle enhances product life, reduces testing and prototype costs and accelerates time to market.

MSC Nastran is the crucial link in our durability analysis workflow to perform finite element analysis. Our team has selected MSC Nastran because we conducted a market evaluation and found its performance was consistently 10X faster compared to competing finite element software products.

Workflow:

Figure 1: **Durability Analysis Workflow at Daimler Trucks NA**

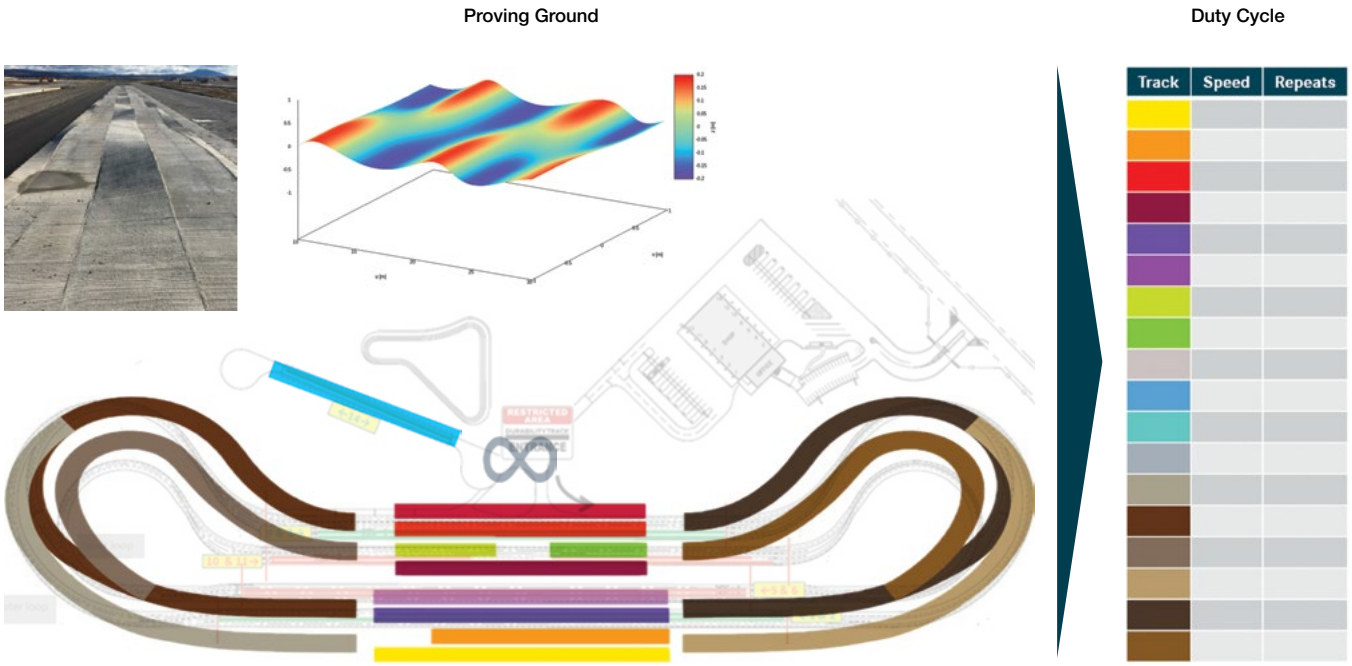

Figure 2: **Simulation of all durability events of physical test according to duty cycle**

We perform multibody simulation in order to accurately replicate the dynamic and non-linear bushing behavior and to capture the road input by using sophisticated, elastic tire models together with 3D road profiles. All durability events of the physical test program are simulated in full length according to the duty cycle. Different duty cycles are used dependent on the vehicle type and the targeted customer profile (e.g. highway vs. extreme duty application).

Finite element methods are used in MSC Nastran to compute the stress distribution in the vehicle substructures, like chassis, cab or hood. In the FE simulation, the substructure is excited in all interface locations with the loads retrieved from the Multi-Body simulation.

The stress results of the FE analysis are used to calculate damage for almost every metal component and selected plastic parts. Finally, we receive a distribution of the combined damage for a complete duty cycle as well as the damage contribution of every durability event.

The FE analysis of a particular substructure is approached in two steps. At first, we perform a normal mode analysis in order to compute real modes, residual vectors and modal stresses. In addition to the usual result data we keep the MASTER/DBALL and IFPDAT files. This analysis has to be executed once for a specific model.

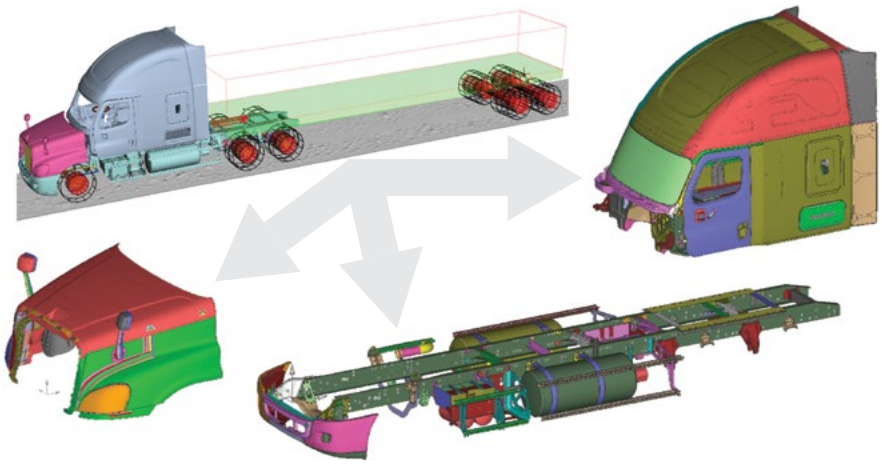

Figure 3: **Substructure of a truck - with input loads from MBS simulation**

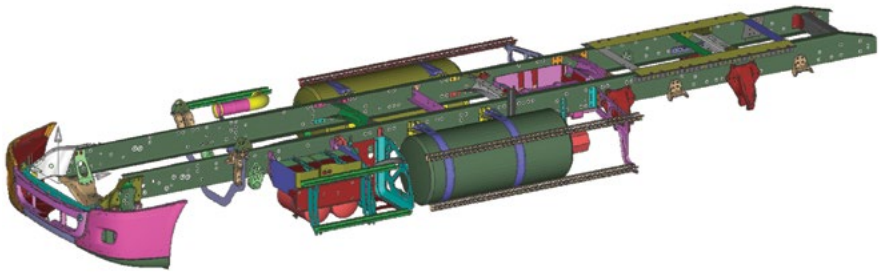

Figure 3: **Simulation of sub-structures with input loads from MBS simulations**

In the second step we run a transient modal analysis for every durability event, which is set up as a restart run based on the normal mode analysis. A ‘restart’ is a logical way of continuing from a previous run without having to start from the beginning. In dynamic analysis, the calculation of normal modes is, in general, the most expensive operation in terms of computation time and cost. Using the restart option, the normal modes do not have to be re-calculated for every durability event. This does not only save computation

time but also ensures consistency regarding the modes of the eigenmode analysis and the participation factors of the several durability events.

The main result of the second step is the computation of the participation factors for every durability event. Additionally, we also export the interface loads which are applied to the FE model as well as the displacements of selected nodes. The interface loads and the nodal displacements are used to animate the time-dependent deformation in response to the applied interface loads.

Once the transient response analysis is performed, we use MSC Nastran results to derive stress time-history by superposition of modal stress and participation factors in nCode. E-N analysis for metal parts and S-N analysis for plastic parts is performed for every durability event. Through these analyses we achieve an accurate prediction of the combined fatigue damage according to the duty cycle. This completes our workflow.

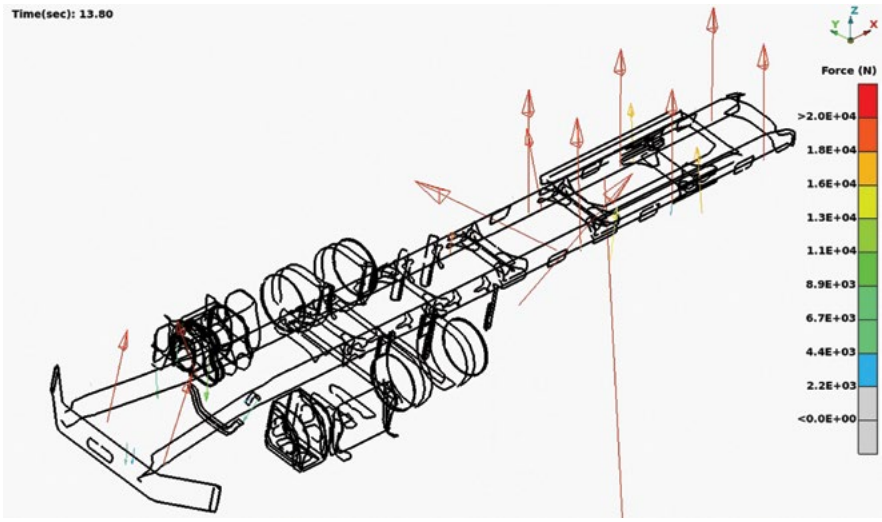

Figure 4: **Transient Response Analysis on Substructure of a Truck with Restart**

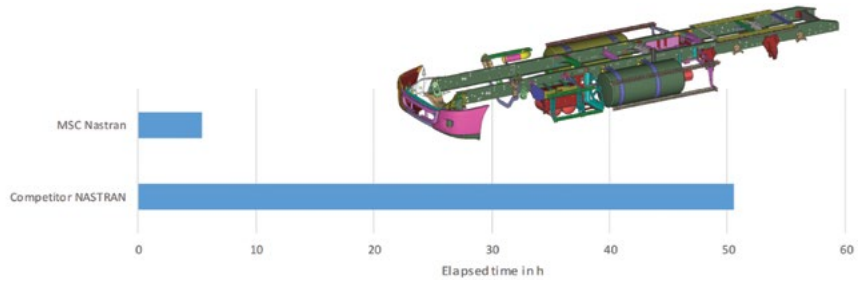

Figure 5: **Time reduced using MSC Nastran**

Solution Time Using MSC Nastran and Competitor Finite Element Solvers

When we compared the solution time for normal modes analysis using MSC Nastran and the competing finite element solver we had been using, we observed that MSC Nastran can solve this model in 5 hours whereas our previous finite element analysis product took over 50 hours to perform the same analysis using the same machine environment. Normal Modes Analysis (SOL 103) is 10 times faster using MSC Nastran.

The performance issues using the former finite element solver were mainly related to the modal stress computation of second order solid elements.

The validation of a full vehicle incorporates the analysis of the chassis, cab and hood structure. By performing these analyses with MSC Nastran we reduce the overall turnaround time by a couple of days. With that, the use of the MSC Nastran solver is crucial to perform our durability analyses.

Summary

The Durability process at the Daimler Trucks North America has been outlined above. The durability process has enabled identification of high stress locations more effectively. We found the overall process to be nearly ten times faster than the previous method. With fewer and smaller intermediate files, the bookkeeping is also much simpler. We have successfully validated this methodology based on several parameters and it has exhibited a good level of correlation with our physical test data. The Daimler Trucks North America team see several opportunities in running similar simulations in the near future. MSC's robust offering of MSC Nastran solver, continuous support from field team as well as continuous investments in the development has made a significant difference in simplifying and speeding up our durability analysis.