MD Nastran

The Multidiscipline Simulation Game Changer

The biggest issue facing today's manufacturers is cost reduction. Excessive defects in product development and variation in materials and manufacturing processes generate unexpectedly high costs. MD Nastran evaluates product performance with coupled system level simulations that consider the interaction between disciplines before the design decisions are made. Working from a common model, errors are drastically reduced and stochastic optimization minimizes the risk of variation and cataclysmic combinations that can't be determined by any other process. Ultimately, MD Nastran is changing the way the game is played to minimize changes after design decisions, time to manufacture, time to market and costs. Often these costs are the result of engineering change orders (ECO) after making design decisions and extraordinary warranty costs because defects were not identified and corrected earlier in the development process. By the time a design is approved or released for manufacture, when a defect is discovered with a process, part, subsystem or product, it can take weeks or months to respond. By the time the change reaches the shop floor many parts or products may be involved. Single-point simulation tools identify design defects after the design decisions have been made. MD Nastran identifies defects in the product, much earlier in the process and saves a lot of time and costs.

Multidiscipline Simulations

A good example of the need for multidiscipline simulations includes racing boats that begin to fly. This phenomenon is attributed to failure to simulate the interaction between airflow and structural deformation. Single point solutions allow multidiscipline analysis, but do not consider the interaction between disciplines. Only MD Nastran considers interaction (coupling) between disciplines, uses a common model, runs stochastics optimization and takes advantage of the speed of 64-bit HPC processors. Only an accurate representation of the complex interactions between key disciplines ensures simulation of the physical phenomena with real life results. Even with recent advances in modelers (pre and post processors), computing power and automated capabilities, discipline specialists still manually simulate the complex inter-discipline interactions as discrete analysis steps. Within a given discipline, analysis steps can be time consuming. However, assessing large volumes of analysis data to determine how to hand-off results from one discipline to another is inevitably orders of magnitude more tedious, subject to human error, compromises simulation accuracy and often is unrepeatable. Engineers sometimes carry information by hand or force the information from motion in a static manner to impact the FE representation of a system. MD Nastran connects them so the information is live, e.g. they are in an open loop environment. Whether it is linear, nonlinear, motion, CFD or explicit dynamics, MD Nastran allows disciplines to work together, rather than simply communicate with each other. Working together implies they provide correct engineering and mechanical feedback to each other at exactly the right time. Moving beyond traditional multi-physics systems, discipline chaining/integration between multi-body motion and FEA facilitates simulation capabilities that allow enterprise-wide multidiscipline simulation to drive design early in a product cycle, such as external system loads spectrum definition. The same is true with integrated FEA and CFD analysis.

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MD Nastran combines such best-in-class technology platforms as Nastran, Marc, Dytran and LS-Dyna into one fully integrated multidiscipline simulation solution for the enterprise. MD Nastran's multidiscipline coverage has increased since 2001, beginning with traditional best-of-class structural statics and dynamics; and then expanded with such core disciplines as state-of-the-art implicit/explicit nonlinear and multi-body motion. Such industry-specific disciplines as crash, NVH, acoustics, aeroelasticity and metal forming support all the disciplines necessary to meet the needs of all manufacturers, i.e. results that very closely represent real world behavior. By precisely addressing the physics, chaining/integrating key engineering disciplines and bridging traditional computational models MD Nastran represents the physical continuum with much higher accuracy. MD Nastran resulted from four years of intensive development, strategic acquisitions – particularly of ADAMS motion and Marc nonlinear analysis technologies, and important partnerships. The latter include LS-DYNA, which provides nonlinear dynamics for the embedded Nastran crash capability, and both Fluent and CD-adapco CFD for fluid-structure interaction (FSI) capabilities. FEA and CFD disciplines meet at the surfaces of solid structures and each may provide loads and boundaries for the other. However, manually inputting such data from one discipline to another prevents consideration of interactions and keeps engineers using each discipline separately. This ends up costing a lot of time. By using third party MpCCI, MD Nastran benefits from that program's inter-communication backbone to couple FEA and CFD capabilities.

MD Nastran offers a number of industry-specific capabilities made possible by its inter-related disciplines. These include noise, vibration and harshness (NVH) and acoustics for automotive design, crash and passenger safety, drop analysis, and thermal management from thermal conduction to 3D radiation problems.

NVH studies make the benefits of MD Nastran obvious. An ADAMS model simulates the car on a bumpy road, indicating how the irregular surface impacts the noise and vibration of a particular vehicle. MD Nastran makes it possible to turn the ADAMS model into a mathematical representation integrated with a full Nastran NVH model. Engineers use the same model for simultaneous simulation of the acoustics for the passenger cavity – resulting in an integrated study of true NVH characteristics on a real road, complete with defects and bumps. The loads generated by the NVH simulation can also be used later for crash simulation.

In another example of the coupled disciplines in MD Nastran, automotive engineers who have run an ADAMS simulation of a suspension system can go into Nastran to assess the life of the A-arm with the suspension data forming an essential part of the analysis.

Common Model

MD Nastran can reduce the time-to-solution up to 50% when compared with bundled single-point simulation tools because customers can now work with a single common data model in place of multiple models for uncoupled discipline analysis using multiple single point tools. Based on a system level model – single data model with multi-physics representations – MD Nastran allows everybody working on a design access to the same data. This does not mean use of a single model across every discipline, but that extractions from a common model are used to create representations of systems for simulation with common loads and constraints. The system level models created with rigid body elements can be imported into MD Nastran. However, not every simulation problem is solved with a single equation. It requires a number of equations working with common data to provide the most realistic simulation possible. A finite element (FE) model is an abstraction of a physical system that can be loaded and conditioned to study various disciplines. The type of disciplines that must interact with each other guide and determine whether analysis is simultaneous, integrated, staggered or loosely coupled. A system level model that combines motion studies with FEA and CFD offers many applications for multiphysics. For example, MD Nastran removes the barriers between linear and nonlinear analysis for the aerospace industry, which is focused on the use of highly specialized materials. MD Nastran recognizes loads that impose strain values over 3-4% and automatically performs nonlinear analysis.

Optimization

Users can run optimization loops at various levels of simulation. Shape and topological optimization operate within each discipline, and variability (stochastic or probabilistic) optimization determines the robustness of the design. Engineers can look at system equations and determine variability at all levels – especially where material properties and manufacturing processes have a great deal of variability. MD Nastran's unique optimization sequence allows the combination of such varied engineering events as static analysis and NVH, etc.

64-Bit High Performance Computing

Ten-years ago, modeling rivets in an aircraft FE wing model was not even a consideration; today it is commonplace. More sophisticated and complex simulation models with unbounded model and analysis data set size increasingly have become a necessity. At the other end of the lifecycle, engineers simulate entire vehicle systems prior to manufacturing. Even before considering discipline integration, it is clear that model size and complexity remains unbounded. Taking into account inter-discipline simulations places an even greater burden on computational resources and demands, fueling the continuing demand for computational optimization. To this end, MD Nastran continues the leadership in high-performance computing established by its predecessor products with its first mover port to true 64-bit (ILP), continued investment in solver optimization, SMP/DMP (shared memory parallel / distributed memory parallel) support and enhancements to our superelement technique for large/complex model management and optimization capabilities. The ambitious scope of MD Nastran means that it must handle very large problems – and to make very large simulations fit within today's time constraints, the program runs on both 32-bit and 64-bit computer cluster environments. MD Nastran is especially optimized to run on the 64-bit supercomputing environment. With the 64-bit enabled MD Nastran, MSC.Software offers the best scalable simulation platform and leads the industry in the migration from 32-bit to 64-bit architecture. Actual speed will depend on the kind of parallelization used for computing, and for really huge problems, may require hundreds of 64-bit processors.

For example, with MD Nastran aircraft engineers can conduct the analysis of an aircraft wing load that includes hundreds or thousands or individual rivets. Studying a single rivet in such an application requires complex nonlinear elastoplastic analysis. In the past, such an analysis required more computer power than most engineers could access. Today's computers enable full wing simulation, with all the rivets – resulting in savings to companies, compared to physical tests, in the order of half a billion dollars for a new generation aircraft.

Conclusion

It is a given that manufacturers need to perform interoperable multi-disciplinary analyses on growing models (parts and assemblies) to continue to satisfy the high demands of their consumers. MD Nastran's complete multidiscipline coverage allows manufacturing customers to address a broad set of true multi-discipline problems with higher accuracy and reliable performance predictions. Additionally, MD Nastran utilizes multi-disciplinary interactions to solve the large and continuously growing models of assemblies with millions of degrees of freedom efficiently and quickly via HPC 64-bit processing. The power of MD Nastran puts customers one step closer to an enterprise simulation environment of the future.

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