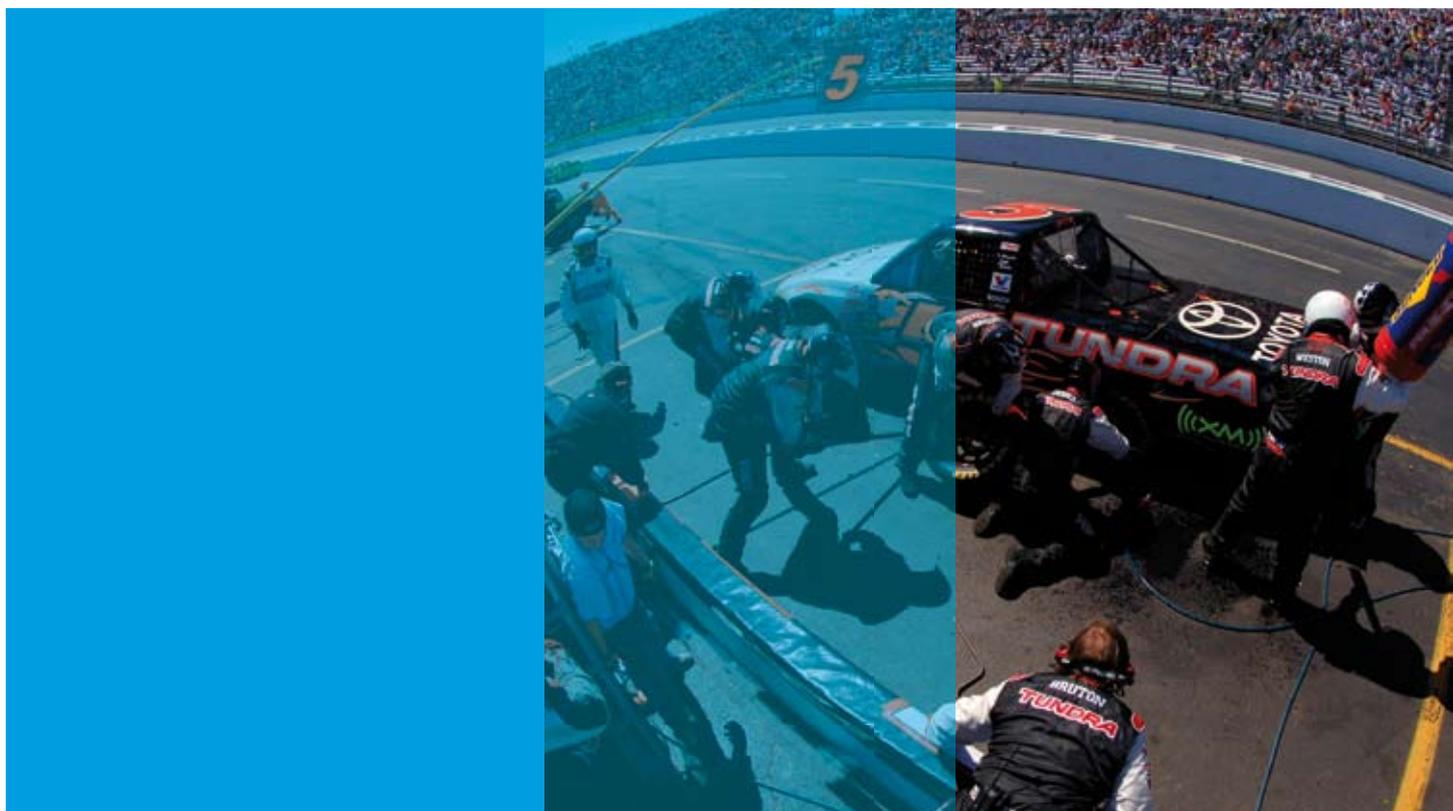


First to the finish line

Toyota Racing Development deploys LMS Virtual.Lab for designing faster and safer vehicles and making critical track-side setup decisions



A race may go on for hours and hundreds of miles. But inches and fractions of a second often decide on the winner. Strict racing regulations generally force engines and body styles to be very similar. So victory is often determined by subtle differences in chassis and suspension design, and specific set-ups tuned for the particular racetrack that day. Engineering simulation plays a critical role in this work at top-level race teams such as Toyota Racing Development. LMS Virtual.Lab Motion and Optimization are key to their winning strategy. Toyota Racing Development is partnering with LMS in developing a specialized motorsports simulation package that will help revolutionize auto racing with vehicles that are faster and safer than ever before.

Toyota's racing heritage

Toyota has a long history in motorsports and has been active in North American racing circuits since the 1970s. Fans have witnessed Toyota victories in races including the Indianapolis 500, the Daytona 24 Hours, the 12 Hours of Sebring, the Baja 1000, the Grand Am Road Racing Series, National Hot Rod Association races, the Championship Auto Racing Team (CART) series and the Pikes Peak Hill Climb where the Toyota Celica still holds the world record. In 2004, Toyota entered the NASCAR Craftsman Truck Series, becoming the first manufacturer to be invited into the NASCAR professional racing ranks outside of the original domestic U.S.-based manufacturers. During this inaugural season in the series, Toyota Tundras visited victory lane four times and recorded five pole positions as well as 25 top-five finishes.

Engineers behind the scenes

Much of the thrill and excitement of professional racing comes from hearing the vehicle engines scream as they go past the stands and seeing the skill and daring of drivers as they maneuver just inches from one another at speeds over 220 mph. Behind all this glamour and glory, however, success is built on the quiet work of race vehicle engineers like Skip Essma. He's with Toyota Racing Development (TRD), which powers all of Toyota's North American racing programs. A subsidiary of Toyota Motor Sales, U.S.A., TRD designs and builds engines and race cars in addition to manufacturing and marketing performance aftermarket parts for many Toyota street vehicles. "In the past, most vehicle development was based solely on seat-of-the-pants intuition and extensive physical testing. But to put a cap on vehicle development expenditures, governing bodies at racing organizations

have instituted stringent restrictions on testing," Essma says. "As a result, much more simulation is now being performed by professional racing teams to leverage their technical expertise and background in developing winning racecars."

A contest of subtleties

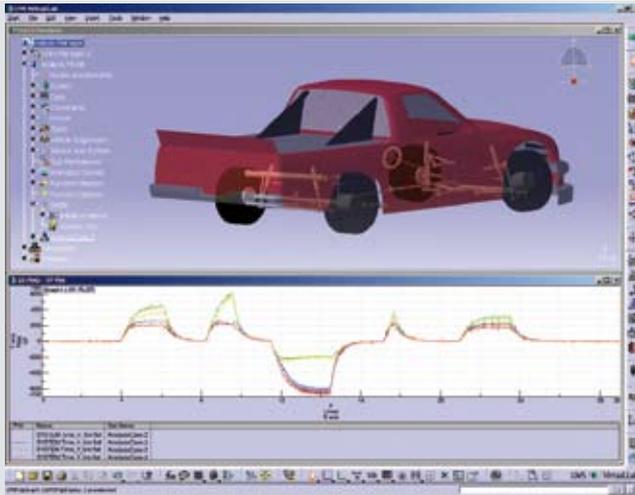
"Because of strict rules to even out the competition on the track, all vehicles within a class are powered by the same size engine and have nearly the same body configuration," he says. "Working within these guidelines, racing teams get a competitive edge in two ways: superior design of the chassis structure, and the best set-ups of vehicle suspension and other systems for each race to account for variabilities in the track, weather conditions, tires and drivers."

According to Essma, TRD focuses on both these critical areas with LMS

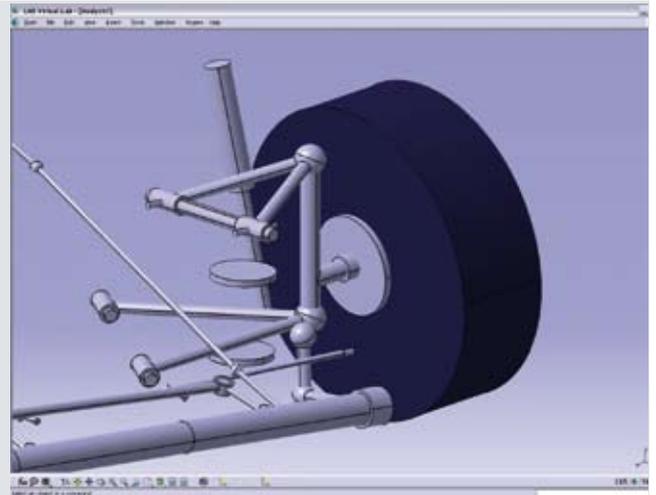


"LMS Virtual.Lab gives us a definite competitive advantage that will undoubtedly help us strengthen our standings in the racing industry in the years to come"

Skip Essma - Toyota Racing Development



The Toyota Tundra is modeled with LMS Virtual.Lab Motion to analyze the dynamic behavior of the vehicle, with plots indicating the loads on the four tires. Racing engineers use this data to study suspension design and set-up parameters and their effect on vehicle handling and performance.



With LMS Virtual.Lab, racing engineers can study vehicle alignment in detail to determine set-up adjustments such as camber, caster, toe, wheelbase and ride height.

simulation solutions. LMS Virtual.Lab Motion multi-body simulation software is used to model suspension systems as well as the full vehicle to predict their dynamic mechanical performance. LMS Virtual.Lab Optimization automatically runs through numerous design of experiments (DOE) in comparing the impact of multiple (and often conflicting) attributes so engineers can make intelligent trade-off decisions to balance these variables and zero in on a refined design. The tight integration between both applications results in a coupled approach in which the optimization routine drives a series of multi-body simulations and then displays the DOE results as a response surface model (RSM) that shows engineers how key parameters interact and what combination of these variables constitutes the optimal design.

Driving virtual vehicles

Essma explains that to arrive at the best chassis design, TRD models the entire vehicle with LMS Virtual.Lab Motion, including the frame, suspension, steering, braking system and body. The software

enables engineers to use multibody simulation to accurately predict handling, grip, cornering, balance and laptime. According to Essma, TRD particularly values the powerful capabilities of LMS Virtual.Lab Motion for efficiently designing, analyzing and optimizing suspension models. Full integration with CAD allows engineers to quickly model design changes, and analyze kinematic and dynamic performance. Post-processing and visualization features are used to effectively identify and correct weaknesses in suspension designs. Optimization capabilities manage all the many racing vehicle variables that come into play in the multi-body simulations, and allow engineers to come up with a refined overall vehicle design. They also provide a tool for crew chiefs to best decide track-side setups on race day: what gears to run, springs, cambers, toes, anti-roll bars, roll centers, shocks, anti-dive geometry, tire pressures, aerodynamics, cooling, and more.

“Each optimization study typically investigates perhaps a dozen variables. But sometimes we solve problems

considering 40 or 50 parameters,” says Essma. “Without multi-body simulation and optimization technology working together automatically, problems of this magnitude would not be practical to solve manually. The integrated modeling, simulation and optimization capabilities enable us to efficiently investigate design variants, gain valuable insight into vehicle behavior and fully exploit every possible performance improvement.” Like everyone on the racing team, crew chiefs have racing in their blood, years of experience under their belts and tremendous insight into the behavior of the vehicle. “Simulation-based optimization results are a new important tool that leverages this expertise and knowledge,” says Essma. “Simulation takes out the guesswork and installs consistency and objectivity into the decision-making process.” The goal is faster vehicle speed, of course. But Essma emphasizes that the overriding concern in race engineering is safety and that simulation is an extremely valuable tool in assessing crashworthiness, handling and stability. “Engineering simulation will enable us to develop the fastest safest racing



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vehicles the industry has ever seen.”

Motorsports simulation package

TRD is currently using LMS Virtual.Lab Motion and Optimization on their Toyota Tundras that run in the NASCAR Craftsman Truck Series. Simulation work on this series is ramping up quickly and plans are to expand use of the multibody and optimization tools in the racing program. “The key is that we can use virtual prototyping to cover the entire process from initial vehicle concept right on through to duplicating what crew chiefs do to set up the vehicle at the track to optimize vehicle performance,”

explains Essma. “Beyond the truck series, the insight and background we obtain with virtual prototyping will undoubtedly transfer to the Indy cars and other Toyota racing vehicles.”

Throughout the implementation process, a team of application engineers from LMS International has worked closely with Essma and his TRD racing vehicle team. As a part of this work and in a partnership with TRD, LMS is developing a vertical application Motorsports Simulation Package aimed specifically at race vehicle engineers. With LMS Virtual.Lab Motion and Optimization tightly integrated within the same package, the software is customized for the racing

industry with a user interface and powerful capabilities used by teams. Capabilities focus on overall suspension design and tuning, lap simulation including optimal paths and track speed, aerodynamic forces, traction, tire models, cornering, steering, ride and handling. “Combining our years of broad race vehicle experience with the unmatched capabilities of LMS Virtual.Lab Motion results in an integrated simulation solution that leverages the skill and passion of our racing teams in putting winning vehicles on the track,” says Essma. “LMS Virtual.Lab gives us a definite competitive advantage that will undoubtedly help us strengthen our standings in the racing industry in the years to come.” ■

“The integrated modeling simulation and optimization capabilities of LMS Virtual.Lab enable us to exploit every possible performance improvement”

Skip Essma - Toyota Racing Development



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LMS is focused on the mission critical performance attributes in key manufacturing industries, including structural integrity, system dynamics, handling, safety, reliability, comfort and sound quality. Through our technology, people and over 25 years of experience, LMS has become the partner of choice for most of the leading discrete manufacturing companies worldwide.

LMS is certified to ISO9001:2000 quality standards and operates through a network of subsidiaries and representatives in key locations around the world.

