Tire Society Conference

Reinventing the Tire

Digital Transformation, Data-Driven Advances, and Predictive Methods

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Abstracts

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1. The Next Frontier in Hydroplaning Detection: Bridging Vehicle-Level and Tire-Level Intelligence

Presenter: Masoud Ansari

Authors: Masoud Ansari[1], Alexandru Vilsan[1], Kanwar Bharat Singh[1]

[1] The Goodyear Tire & Rubber Company, Akron, Ohio, United States

ABSTRACT

Hydroplaning remains one of the most under-detected and consequential hazards in wet-road driving, contributing to thousands of safety-critical events annually. The phenomenon occurs when hydrodynamic forces at the tire-water-pavement interface progressively displace the contact patch, reducing the tire's effective grip for both longitudinal and lateral maneuvers. Accurate, real-time estimation of available grip at each tire is therefore critical for vehicle stability and control in limit-handling conditions.

Conventional detection methods rely on vehicle-level signals such as wheel speed differentials, yaw rate anomalies, and lateral acceleration deviations. These detection methods suffer from an inherent latency, and by the time the vehicle's dynamic response is measurable, the driver has already experienced a meaningful loss of control authority. The physics of hydroplaning, however, originates at the tire-road interface itself, and it is there that early, actionable detection must be pursued.

This work presents an intelligent tire system that leverages in-tire carcass acceleration measurements to estimate grip loss under partial hydroplaning conditions. A dedicated signal processing algorithm is developed and validated across a matrix of controlled experimental conditions, systematically varying vehicle speed, tire inflation pressure, and water film thickness. Results demonstrate the system's ability to detect the onset of hydroplaning with greater sensitivity and lead time than vehicle-level approaches, highlighting the potential of tire-centric sensing as a foundation for next-generation active safety systems.

PRESENTER BIOGRAPHY

Masoud Ansari is a Principal Software and Algorithm Engineer with the Global Tire Intelligence and Solutions (GTIS) department at The Goodyear Tire & Rubber Company, where he focuses on smart tire technologies. He joined Goodyear in 2025, bringing more than a decade of experience in signal processing, machine learning, tire dynamics, and sensor-based engineering. Before joining Goodyear, he worked at Bridgestone Americas, where he developed real-time algorithms and modeling approaches for tire-mounted sensing and tire intelligence systems. Earlier in his career, he held engineering and product development roles focused on NVH, elastomer systems, vehicle dynamics, and simulation. Dr. Ansari holds a Ph.D. in Mechanical Engineering from the University of Waterloo, complemented by graduate-level study in applied data science and machine learning.

2. Coupled Antioxidant Transport and Oxygen-Driven Oxidation in Rubber: A Computational Framework for Predicting Depletion Fronts, Degradation Patterns, and Service Lifetime

Presenter: Mahmoud Assaad
Authors: Mahmoud Assaad[1]
[1] Endurica LLC, Findlay, Ohio, United States

ABSTRACT

This study presents a comprehensive computational framework for modeling the coupled transport phenomena governing antioxidant migration and oxygen-driven oxidation in filled rubber compounds. The work addresses the critical need for predictive models that can accurately forecast rubber degradation and service lifetime under realistic operating conditions. The formulation includes a coupled system of partial differential equations describing antioxidant diffusion, oxygen diffusion, and oxidation reaction kinetics.

The model reveals several critical insights: antioxidant depletion initiates at exposed surfaces and propagates inward, creating characteristic depletion fronts; oxidation follows depletion fronts with a time lag, establishing moving oxidation fronts; and a degradation pattern emerges from the coupled transport processes. Service lifetime is determined by calculating the time required to reach a critical oxygen content, which depends on the compound composition and environmental conditions.

The model is demonstrated using rubber samples of NR, SBR, and EPDM. It predicts antioxidant depletion profiles, oxidation accumulation, mechanical property degradation from modulus softening or embrittlement, and the critical time for end of service. This work bridges fundamental polymer chemistry with practical engineering applications, providing a robust predictive tool for rubber degradation that accounts for the complex interplay between antioxidant migration, oxygen diffusion, and chemical reaction kinetics.

PRESENTER BIOGRAPHY

Mahmoud Assaad is Director of Technical Innovation at Endurica. He holds a Ph.D. in Engineering Science and Mechanics (major) and Applied Mathematics (minor) from Iowa State University (1983), an M.S. in Structural Engineering from Iowa State University (1979), an M.S. in Polymer Science from the University of Akron (1990), and a Diplome d'Ingenieur Civil-Section Travaux Public from Universite de Saint-Joseph, Ecole Superieure d'Ingenieur, Beirut, Lebanon (1976).

He is co-author of the Composite segment of The Pneumatic Tire book and has received numerous honors, including the Special Achievement Award from NASA, the 2008 Create the Future" design contest winner in the machinery/equipment category

3. Green-to-Cured Design Influence in Aircraft Tyre Manufacturing

Presenter: Abhishek Bhatnagar

Authors: Abhishek Bhatnagar[1], Hasher Maqbool[1]

[1] Dunlop Aircraft Tyres Limited, Birmingham, United Kingdom

ABSTRACT

This study examines the influence of green design parameters in aircraft tyre manufacturing and their effect on component positioning and tyre profile after vulcanization. Both first-stage and second-stage tyre building processes are evaluated. Radial aircraft tyres are particularly sensitive to minor variations in green profiles, dimensions, material distribution, and manufacturing tooling. Rubber flow and the filling of specific regions within the mould profile are often iterative in nature, making the accurate definition of green component placement and profiles essential to achieving the desired cured output.

Small changes introduced at the green stage can result in measurable variations in cured tyre geometry, internal component positioning, and stress distribution. Variations in carcass material properties, ply endings, and gum or cushion coverage significantly influence stress plots, growth behaviour, and retreadability. These effects have direct implications for compliance with approved cured designs, certification requirements, and change management processes within the aerospace sector.

This study highlights the integrated role of tyre design expertise and finite element analysis (FEA) simulation in establishing robust green-to-cured design relationships. By defining optimal green design parameters, the work aims to support improved design control, predictable cured outcomes, and the continued maintenance of airworthiness approvals. This work aligns with the conference theme by exploring the sensitivity of green and cured designs in aircraft tyres.

PRESENTER BIOGRAPHY

Abhishek Bhatnagar is a visionary technology leader with over two decades of experience in engineering, product development, and strategic innovation across manufacturing, automotive, off-highway, and Aerospace industries. He is recognized for bridging business objectives with technical execution to deliver high-impact solutions that drive sustainable growth and long-term value.

Throughout his career, Abhishek has led cross-functional global teams, managed complex product lifecycles, and directed R&D initiatives from concept through commercialization. His strong business acumen supports a focus on value engineering, profitability, and niche product development to achieve competitive advantage in global markets.

With extensive global exposure across Asia, the Americas, and Europe, Abhishek has authored technical publications, delivered keynote presentations—including The Tire Society in 2015—and holds a patent in tyre tread design. He currently serves as Chief Designer at Dunlop Aircraft Tyres Limited and is a core member & producer of the SAE A-5 Aerospace Landing Gear Systems Committee.

4. Thermo-Mechanical Tire Modeling for Accurate Prediction of Temperature-Dependent Handling and Rolling Resistance

Presenter: Francesco Calabrese

Authors: Francesco Calabrese[1], Christoph Burkhart[2], Manfred Bäcker[2], Axel Gallrein[1], Tobias Ruhwedel[1]

[1] Fraunhofer ITWM, Kaiserslautern, Germany

[2] VTT – Virtual Tire Technologies GmbH, Kaiserslautern, Germany

ABSTRACT

Rolling resistance and tire handling performance are strongly governed by the tire's thermal state. Temperature changes rubber viscoelastic losses that drive rolling resistance, and modifies friction, adhesion, and stiffness that control handling. This work aims at accurate, physical prediction of tire characteristics and rolling resistance by improving temperature modeling and parameter identification in the physical thermo-mechanical tire model CDTire.

The CDTire thermodynamical framework is revisited to predict 3D temperature fields using a key advantage of CDTire: structural energy dissipation is computed directly from its multilayer shell model and is also responsible for rolling resistance. A finite-volume approach separates geometry and material effects: convective heat transfer to air and road, and conductive exchange, are modeled via Newton's law of cooling, while internal diffusion follows Fourier's law through specific heat and thermal conductivity. This separation allows tire geometry variation without re-identifying the full thermal model, focusing parameterization on thermo-mechanical quantities critical for handling and rolling losses, such as temperature-dependent tread shear modulus, sliding friction, and rate-dependent and rate-independent dissipations.

An indoor test-based methodology identifies these key dependencies for passenger car tires, characterizing temperature effects on rubber stiffness, sliding friction, inflation pressure, and inner friction. The model then predicts handling-relevant properties and rolling resistance under realistic operating conditions not only with CDTire/3D, but also in hard-realtime with CDTire/Realtime new implementation. Future work will extend the model to temperature-dependent tread abrasion, enabling "magic tire triangle virtual evaluation" of handling, rolling resistance, and wear.

PRESENTER BIOGRAPHY

Francesco Calabrese graduated at Naples University (Italy). He works in the field of applied mathematics with a focus on simulation and modeling for tire mechanics and vehicle dynamics.

His research centers on the development and application of advanced physical tire models—such as CDTire/3D—to support virtual vehicle development, digital twins, and simulation-based testing. His work contributes to improving vehicle performance, safety, and efficiency through computational methods, including hardware-in-the-loop simulation and multi-body system analysis.

He has authored and co-authored numerous conference papers on topics such as virtual tire design, tire modeling, and simulation in early vehicle development processes. His contributions are regularly presented at international industry conferences, reflecting his active role in bridging applied mathematics with real-world automotive engineering challenges.

His work exemplifies the mission of Fraunhofer ITWM: translating mathematical modeling and simulation into practical industrial applications.

5. Development and Experimental Validation of Transient Tire Temperature Digital Twin

[Student Presentation]

Presenter: Garrett DeBrock

Authors: Garrett DeBrock[1], Mason Greenland[1], Hunter Jones[1], Joseph St Germain[1], Anju Gupta[1], Will Mars[2]

[1] University of Toledo, Toledo, Ohio, United States
[2] Endurica LLC, Findlay, Ohio, United States

ABSTRACT

Accurate prediction of tire temperature is critical when evaluating durability, rolling resistance, and vehicle performance. Estimating the life of tires using experimental means can be an expensive process, which is why an increase in digital twin framing and automated approaches can be seen as a cost-effective solution to this problem.

This work develops an analytical model of the transient tire temperature using experimentation to make the process more streamlined. The digital twin system is developed based on a physics-based thermal model derived from work by Mars and Luchini, which describes the transient temperature response of a tire under straight-line rolling conditions. Additional heat generation mechanisms, including slip-induced heating during cornering, are incorporated to extend the model to dynamic driving scenarios. Experimental validation is conducted using an instrumented go-kart platform equipped with temperature, wheel speed, and inertial sensors. The analytical model is implemented in Python and compared against measured tire temperature data to evaluate predictive accuracy.

The developed digital twin captures transient tire temperature under both straight-line rolling and dynamic driving conditions. This approach helps provide a framework for real-time tire temperature prediction, with potential applications in tire design, performance optimization, and durability analysis.

PRESENTER BIOGRAPHY

Garrett DeBrock is a senior at the University of Toledo pursuing a bachelor’s degree in Mechanical Engineering. He grew up in Southeast Michigan and attended Milan High School. He has completed multiple engineering co-op rotations in the automotive industry and is currently the team lead for a senior design project focused on developing a digital twin for predicting tire temperature.

6. Non-Pneumatic Tire Design: Novel Structural Architecture and Material Selection for Next-Generation Performance

Presenter: Tom Feister

Authors: Tom Feister[1], Tim Baker[2]

[1] TriMech, Glen Allen, Virginia, United States

[2] A3T LLC, Akron, Ohio, United States

ABSTRACT

TriMech and A3T LLC, the US Research and Development arm of Triangle Tyre Group, present the mechanical design and material development of a next-generation non-pneumatic tire (NPT) featuring a series of novel structural and material innovations not previously implemented in NPT architectures. The design incorporates an innovative spoke geometry and load-bearing structure engineered to optimize stress distribution, deformation compliance, and durability under representative operating conditions.

Material selection was a central challenge in this work, requiring careful characterization of nonlinear, material behavior with additional durability testing. The interplay between structural geometry and material response was critical in evaluating target performance metrics.

Finite element analysis, conducted within Dassault Systèmes' 3DEXPERIENCE Platform, was used to validate design decisions and provide insight into structural response. Simulation served as an iterative design tool, enabling rapid evaluation of geometry and material combinations while maintaining solution fidelity for complex contact and nonlinear material conditions.

This work highlights key design considerations and trade-offs encountered in developing unconventional NPT architectures and offers broader implications for the advancement of non-pneumatic tire technology.

PRESENTER BIOGRAPHY

Tom Feister leads the structures simulation team at TriMech Enterprise Solutions. His background includes metal forming, materials testing, damage modeling, process optimization, structural integrity, and tire workflows. He honed his expertise in finite element analysis (FEA) in previous positions at EWI, KTH Parts, Scientific Forming Technologies Corporation (SFTC), and AutoForm Engineering. Tom specializes in helping engineers develop new skills in FEA that can be used to create a safer and more sustainable world. He is also an Ohio-certified Professional Engineer (PE) in the metallurgical and materials field.

7. TMC: A Real-Time Thermo-Mechanical Contact Model with Physically Interpretable Parameters

Presenter: Marco Furlan
Authors: Marco Furlan[1], Ethan Ackerman[1], Matthew Strang[1]
[1] Calspan, Buffalo, New York, United States

ABSTRACT

Accurate prediction of tire forces under varying operating conditions remains a critical challenge in vehicle dynamics simulation. Traditional empirical tire models provide robust performance within calibrated domains but lack the ability to extrapolate across changing thermal states, wear conditions, and contact mechanics. This limitation becomes increasingly significant in modern applications requiring predictive capability early in the development process.

This paper presents the Thermo-Mechanical Contact (TMC) model developed by Calspan, a physically-based tire model designed to capture the coupled interaction between thermal effects and contact mechanics at the tire–road interface. The model integrates a detailed representation of the contact patch coupled with structural, thermal and friction sub-models, enabling the prediction of frictional performance as a function of local operating conditions.

Unlike traditional approaches, TMC explicitly accounts for the evolution of the contact state through variables such as pressure distribution, sliding velocity, and temperature. This allows the model to naturally capture key phenomena including grip sensitivity to thermal state or the influence of tread depth and wear on performance.

The formulation achieves a balance between physical fidelity and computational efficiency, making it suitable for both offline analysis and real-time simulation environments. The model capabilities are demonstrated through comparisons across various tire maneuvers and operating conditions against a reference Magic Formula model.

The results show that incorporating physically-based thermal and contact mechanisms significantly improves the robustness and predictive capability of tire models, providing a valuable tool for vehicle development, optimization, and performance analysis.

PRESENTER BIOGRAPHY

Marco graduated with a degree in Mechanical Engineering from the Polytechnic University of Valencia in 2015. He received an MSc in Motorsport Engineering from Oxford Brookes University in 2016 and completed his PhD in Tire Friction at Loughborough University in 2024.

Marco’s experience includes working as a Tire Modelling Engineer at Jaguar Land Rover and, currently, as a Senior Modelling Engineer at Calspan, where he focuses on tribology, rubber friction estimation, and the development of Calspan’s thermo-mechanical tire model.

8. Impact of Tire Temperature on Rolling Resistance of Heavy-Duty Tires: Experimental Results from a Flat-Track Test Rig

Presenter: Mattias Hjort

Authors: Mattias Hjort[1], Sogol Kharrazi[1], Mikael Askerdal[2]

[1] VTI, Swedish National Road and Transport Research Institute, Linköping, Sweden

[2] Volvo Group Trucks Technology, Gothenburg, Sweden

ABSTRACT

Rolling resistance estimation is essential for predicting vehicle energy demand. This is particularly important for heavy trucks, whose large mass and long operating distances make rolling resistance a major contributor to overall energy consumption. For electric trucks, its effect on driving range makes accurate estimation even more critical. Improved rolling-resistance modeling therefore enables more reliable energy consumption prediction, better route planning, and reduced range anxiety.

Tire temperature is a key factor influencing rolling resistance and should be included in rolling-resistance models. Because tire temperature can change rapidly during real driving, capturing non-steady-state behavior is necessary. Developing such models requires measurements of how rolling resistance varies with temperature. Since controlled on-road testing is challenging, a test rig offers a more practical and controlled environment for regulation of tire temperature.

This paper presents non-steady-state rolling-resistance measurements of a trailer tire on a flat-track test rig with a moving steel belt, at tire temperatures from 0 °C to 80 °C in 20 °C increments. Cold-tire conditions were achieved by stabilizing the tire in a cooled room, while warm-tire conditions were produced by rolling the tire under load on small cylinders. Inner and outer tire tread temperatures were recorded using infrared sensors.

For each test condition, five measurements were conducted, with additional variations in tire pressure (6-10 bar) and speed (10-30 km/h). The final paper will present the full measurement dataset together with fitted curves describing the temperature dependence of rolling resistance.

PRESENTER BIOGRAPHY

Mattias Hjort has a background in physics and received his Ph.D. in 2001 at Linköping University. He has been at the Swedish National Road and Transport Research Institute (VTI) since 2003, where he currently acts as research leader with particular focus on tyre-road interaction. Other research interests are vehicle dynamics and the relation to traffic safety, with vehicle type ranging from bicycles to HGV’s. He is in charge of VTI´s advanced measurement equipment for tyre measurements, with special attention on developing their stationary tyre test facility, which recently also has been used for rolling resistance measurements.

9. EURO 7 Tire Abrasion: Regulatory Timeline, Equivalence Procedures, and Circuit Development

Presenter: Alejandro Hortet

Authors: Alejandro Hortet[1], Marcel Mathissen[2], Carlos Agudelo[1], Barry Purtymun[3]

[1] Link Engineering, Plymouth, Michigan, United States

[2] Link Engineering, Limburg an der Lahn, Germany

[3] Link Engineering, Wittmann, Arizona, United States

ABSTRACT

This presentation will provide an overview of the EURO 7 regulatory timeline for tire-abrasion measurement and examine its implications for testing protocols, validation strategies, and industry readiness. It will also outline the role of the equivalence procedure and the establishment of designated equivalent circuits, with particular focus on the driving circuit and its function within a standardized abrasion-assessment framework.

The session will then introduce one of the three designated circuits and describe its development through an integrated process that combines simulation-driven design with comprehensive on-road vehicle testing. This end-to-end approach demonstrates how advanced modeling and empirical validation can be aligned to create representative, repeatable, and regulation-compliant test environments that support future abrasion-compliance requirements under EURO 7.

PRESENTER BIOGRAPHY

Alejandro Hortet is a Technical Product Manager at Link Engineering, specializing in brake-emissions measurement technologies. Since 2016, he has worked extensively on the development, installation, and validation of particulate-measurement systems across Link's U.S. and German facilities, as well as with customers worldwide. He plays a key role in guiding customers through technical implementation and regulatory interpretation. As industry focus expanded with EURO 7, Alejandro transitioned naturally into tire-abrasion measurement and the broader LINK Tire portfolio. His recent work centers on understanding emerging regulatory requirements and supporting the industry's readiness for upcoming abrasion-compliance standards. Alejandro holds a Bachelor's degree in Mechanical Engineering from Boise State University.

10. Tire Model Adaptation by Off-line Methodology using Full Vehicle Simulations and Experimental Tests

Presenter: Jungsik Kim

Authors: Jungsik Kim[1], Eunjae Lee[1], Jonghyup Lee[2]

[1] Hankook Tire Co. Ltd., Daejeon, South Korea

[2] Sookmyung University, Seoul, South Korea

ABSTRACT

At the early stage of vehicle and tire design, an accurate vehicle model that can represent vehicle handling behaviors well is important. Among the many components of a vehicle model, tire model is one of key factors that decide the dynamic responses of vehicle, since tires are the components that connect the vehicle to the road and, except gravitational and aerodynamics forces, all forces acting on the vehicle are generated by them.

The proposed methodology is made in three subsequent steps. During the first phase, the Magic Formula-Tyre (MF-Tyre) model coefficients of individual tire for pure cornering conditions are identified through an indoor laboratory test. Then vehicle dynamic measurements (vehicle sideslip angle, yaw rate, lateral acceleration, speed and steer angle) are carried out during standard handling maneuvers (ramp steer, frequency response). The results of these two steps are used as inputs to the last phase, where dynamic simulations of a virtual model are performed with constrained minimization algorithm that identifies the MF-Tyre model coefficients for each individual tire of axle in order to adjust the response obtained in simulation to real measurement data.

The finally identified tire models have been transferred to vehicle models to simulate the vehicle handling behavior. Then a direct matching between the measured and the simulated dynamic response of vehicle could be performed, showing a good agreement. As a further verification of the proposed methodology, tire model coefficients are successfully identified for vehicle measurements on wet road conditions.

PRESENTER BIOGRAPHY

Jungsik Kim is a vehicle dynamics expert at the Research Center of Hankook Tire. His main areas of focus include vehicle and tire modeling, vehicle dynamic measurements and simulations for handling performance, target-based tire development processes (V-Model), and driving simulator applications for tire development

11. Coupled Thermo–Kinetics Simulation for Prediction of Tire Curing Behaviour

Presenter: Kaustubh Morankar

Authors: Kaustubh Morankar[1], Unnikrishnan Govindan[1], Suhas Patil[1], Dilip Vaidya[1]

[1] BKT Tires, Mumbai, India

ABSTRACT

In this study, a numerical framework is proposed for prediction of curing behaviour relevant to tire manufacturing process, using transient thermal simulation coupled with cure kinetics modelling. Workflow of transient heat transfer analysis is defined to capture temperature progression evolution within a rubber block, under vulcanization conditions representative of tire curing.

The degree of cure is evaluated using the Kamal–Sourour model, with material parameters identified through isothermal rheometer data. Furthermore, non-isothermal and spatial cure gradients are quantified using local temperature histories. The cure-dependent torque predicted by the simulation is then compared with experimental torque obtained under non-isothermal temperature profiles, demonstrating the model's capability to capture realistic curing behaviour.

PRESENTER BIOGRAPHY

Kaustubh Morankar is an alumnus of the Indian Institute of Technology Kharagpur, specializing in tire mechanics, rubber material modeling and finite element analysis. His work focuses on hyperelastic-viscoelastic characterization, fatigue life prediction and simulation driven optimization of rubber components. He has contributed to research and industrial projects involving DMA-based material modeling, stress strain calibration, and advanced durability studies.

12. Formulation Optimization and Dynamic Characterization of a Flexoelectric Polyelectrolyte Elastomer for Tire Sensor Applications Using Extreme Vertices Mixture Design

[Student Presentation]

Presenter: Shahba Tasmiya Mouna

Authors: Shahba Tasmiya Mouna[1], Mehdi Sahami[1], Jae Won Choi[1]

[1] University of Akron, Akron, Ohio, United States

ABSTRACT

Flexoelectric polyelectrolyte elastomers (FPEs) present a promising route toward self-powered tire sensing by converting mechanical bending deformation into electrical signals without external power sources. However, simultaneously satisfying the mechanical and electrical performance demands of tire environments through a single material formulation remains a significant challenge.

This study employs a statistical mixture design-of-experiments (DOE) approach to systematically optimize a ternary FPE system consisting of a functionalized polyether amine–acrylate polymer backbone, an imidazolium-based ionic liquid, and a photo initiator. An extreme vertices mixture design was adopted to explore the constrained composition space, with elongation at break and ionic conductivity serving as dual response variables. Predictive regression models were developed from the experimental dataset and demonstrated strong predictive capability for both responses. Contour plot analysis revealed an inherent trade-off between the two properties, with their optimal regions occupying opposing areas of the design space. Multi-response optimization was used to identify a balanced formulation that meets the minimum elongation threshold required for tire applications while maintaining adequate ionic conductivity. Validation experiments on the optimized blend confirmed agreement between predicted and measured values for both responses.

The optimized FPE formulation is further subjected to dynamic characterization to evaluate its electromechanical response under cyclic loading conditions representative of tire operation. This work demonstrates the effectiveness of mixture DOE methodology in navigating competing property requirements in functional elastomer systems and establishes a material foundation for subsequent FPE tire sensor characterization and dynamic rolling-tire testing.

PRESENTER BIOGRAPHY

Shahba Tasmiya Mouna is a Ph.D. candidate in Mechanical Engineering at The University of Akron. Her research centers on developing stretchable iontronic sensors for multi-axis force sensing in deformable systems. She has established a unified soft sensing platform with applications in biomedical wearables, automotive systems, and robotic manipulation.

13. Tire NVH and Ride Comfort: Critical Review of Testing Methods through the Lens of Tire-Road Interaction – Strategies, Surfaces, Pros, Cons, and Pathways Forward

Presenter: Johann Pankau

Authors: Johann Pankau[1]

[1] NVH Consulting LLC, Shelby Township, Michigan, United States

ABSTRACT

Noise, Vibration, and Harshness (NVH) performance and ride comfort are key differentiators in modern tire and vehicle development. Global OEMs and tire manufacturers apply markedly different testing methodologies for interior and exterior tire noise evaluation, often resulting in inconsistent tire rankings despite shared objectives.

This presentation critically reviews established testing strategies, focusing on the central role of tire-road interaction in excitation mechanisms, vibration transfer, and subjective/objective assessments.

Key interior tire NVH approaches are examined, including drum dynamometer fixed-spindle vibration measurements, which isolate structure-borne paths but underrepresent airborne contributions and real-road variability; drum dynamometer microphone-based measurements, which provide repeatable airborne noise data yet suffer from curvature artifacts and enclosure effects; full-vehicle drum testing, which offers better system-level insight but is limited by idealized boundary conditions; and full-vehicle road testing, which delivers realistic excitation but lacks repeatability due to environmental and surface variations.

Road surface micro- and macro-texture differentially excite frequency ranges (low-frequency structure-borne on coarse proving grounds versus high-frequency airborne from tread patterns). Tread pattern mechanics, damping, and coupling with road structure are discussed, together with the integrated tire-suspension system (vertical stiffness, sidewall/crown design, compound, springs, and shock absorbers).

Laboratory methods excel in repeatability and isolation but often diverge from on-road reality, while road testing mirrors customer experience yet hinders comparability. Ride comfort evaluation addresses subjective vs. objective metrics, correlation challenges, indoor testing limitations, and key tire parameters.

Drawing on over 36 years of hands-on automotive NVH experience at Continental and beyond, the author offers recommendations and forward-looking ideas.

PRESENTER BIOGRAPHY

Johann Pankau is the Founder and CTO of NVH Consulting LLC, established in 2025. He brings over 35 years of international automotive R&D expertise, specializing in vehicle chassis, tires, brakes, NVH, ride comfort, and CAE methods.

Until the end of 2024, he led Tire NVH and Ride & Comfort activities at Continental Tire North America, responsible for simulation, vehicle interaction, benchmarking, and optimization. Previously, at ITT Teves and Continental Teves, he developed brake systems, built and managed a state-of-the-art NVH laboratory, and successfully transformed the department into a profit center serving internal and external customers.

Johann holds a Master's degree in Applied Mechanics from Darmstadt University of Technology (1990). For the past 16 years, he has taught Vehicle Dynamics at Oakland University in Michigan.

His consulting practice supports the automotive industry as well as aerospace and consumer electronics sectors.

14. Range at Risk: Reliable Low-Temperature Rolling Resistance Prediction Using Advanced Rubber and Cord Material Models within an Enhanced Parallel Rheological Framework

Presenter: Gautam Sagar

Authors: Gautam Sagar[1], Anuwat Suwannachit[1], Maik Brinkmeier[1]

[1] Continental Reifen Deutschland GmbH, Hannover, Germany

ABSTRACT

Rolling resistance (RR) is pivotal for electric-vehicle (BEV) range and regulatory labeling. Yet ISO test conditions (20–30 °C, 25 °C target) do not represent real winter usage, where the strong temperature dependence of viscoelastic losses increases RR and significantly reduces BEV range. This work introduces an industrialized simulation chain capable of predicting RR across both ambient and sub-zero temperatures.

The method integrates a non-linear viscoelastic rubber model with Mullins effects, advanced non-linear cord models with viscoelastic effects, and a relative-kinematic tire formulation, supported by robust Parallel Rheological Framework (PRF) parameter identification from targeted rubber and cord testing. Applied to full-tire simulations, the framework reproduces known RR - temperature trends in the ISO range and reliably extends to real-world low-temperature conditions. The results identify cap compound viscoelasticity as the dominant contributor to RR temperature sensitivity, while also quantifying non-negligible structural effects. This contribution further presents a comparative evaluation of tire test results obtained using linear and nonlinear viscoelastic rubber material models.

The methodology further reveals key target conflicts, such as the interplay between low-temperature RR and wet-grip performance and supports compound-structure co-optimization early in the development process. This reduces reliance on physical builds and accelerates the design cycle. The outcome is a predictive, temperature-resolved RR capability that enhances label compliance and ensures robust winter driving range for BEVs.

PRESENTER BIOGRAPHY

Dr.-Ing. Gautam Sagar received his Bachelor in Mechanical Engineering from India (2002), Masters in Virtual Engineering from France (2004) and his Ph.D. in Computational Mechanics from Germany (2009). During his PhD he worked on constitutive material models of Shape Memory Alloys. During 2004 - 2005 he worked at Bajaj Auto (R&D), India. From 2009 through 2011 he worked for Airbus (R&D) where he contributed to the development of different part of A350. He joined the Continental Tires R&D Center, Hannover, Germany in 2011, where he has been involved in developing different simulation methods for tire performances and constitutive material models. He is currently working as Principal Engineer and leading Next-Gen Material Modelling for Virtual Development & automation activities.

15. Carbon Footprint Mitigation in SBR Compounds through the Synergistic Use of Active Zinc Oxide and Devulcanized Ground Tire Rubber

Presenter: Marziyeh Shabani

Authors: Marziyeh Shabani[1]

[1] University of Akron, Akron, Ohio, United States

ABSTRACT

End-of-life tires (ELTs), a major source of vulcanized rubber waste, present significant recycling challenges due to their permanent covalent crosslinked structure, which limits reprocessability. Environmental concerns are further intensified by the leaching of zinc oxide (ZnO), a widely used curing activator, into aquatic environments, where it poses toxicity risks. To address both sustainability and performance, this study proposes a dual strategy combining selective devulcanization with reduced loading of high-efficiency, eco-friendly ZnO alternatives (Acti ECO+C) engineered to minimize migration and leaching.

A systematic investigation was conducted on the effects of ZnO type and devulcanized ground tire rubber (dGTR) content in styrene–butadiene rubber (SBR) compounds. In virgin SBR systems, Active ZnO and ECO+C ZnO, used at approximately half the loading of conventional French-process ZnO, enhanced tensile strength by 52% and 57%, respectively. Devulcanization of ground tire rubber via ultrasonic treatment at room temperature and 140 °C showed, through Horikx analysis, that room-temperature processing enabled more selective sulfur crosslink cleavage with minimal main-chain degradation, and was therefore selected.

SBR compounds containing 50 wt% dGTR and active ZnO grades exhibited tensile strength improvements of up to 50% despite reduced ZnO loading. Further comparison of 50 wt% and 15 wt% dGTR systems, both with ECO+C ZnO, demonstrated the importance of optimized composition. Adhesion testing and DSC analysis confirmed improved interfacial interactions and compatibility within the rubber matrix.

Overall, the combined approach significantly enhances mechanical performance while reducing ZnO usage, offering a sustainable pathway for ELT recycling.

PRESENTER BIOGRAPHY

Marziyeh Shabani is a Ph.D. candidate in Polymer Science and Engineering at the University of Akron, specializing in sustainable polymer materials and recycling technologies. Her research focuses on sustainable polymer recycling, particularly devulcanization of end-of-life tires and the conversion of polypropylene into value-added products. Marziyeh has authored multiple peer-reviewed publications and presented her work at leading conferences, including the ACS Rubber Division, GPS, International Elastomer Conference and Ohio Rubber Group Technical Meetings, where she received recognition for best poster presentation. Her research has been supported by competitive funding, including a CenTiRe grant awarded to a select group of proposals. She is the recipient of several prestigious awards, including the Darrell H. Reneker Scholarship, SPE TPO, ACS Rubber Division Scholarship, and Ohio Rubber Group Scholarship. Marziyeh aims to translate her research into industrial impact by developing sustainable recycling solutions.

16. Rapid Virtual Generation of CDTire Models for Tire Rolling NVH Prediction

Presenter: Yaswanth Siramdasu

Authors: Yaswanth Siramdasu[1], Alan Kedari[2], Gibin Gil[3], Robert Wheeler[1]

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ABSTRACT

In the era of virtual chassis development, OEMs and tire suppliers collaborate closely to tune Ride, Handling, and NVH performance, primarily through the exchange of virtual tire models. This shift is pushing tire suppliers to prioritize and accelerate the delivery of virtual models. OEMs are streamlining workflow through the targeted use of Magic Formula (handling), SWIFT (ride), FTire (durability) and CDTire (NVH). Having integrated Magic Formula for virtual handling via Driver-in-the-Loop, OEMs are now shifting focus to the next frontiers: Ride and NVH.

In this work, virtual based CDTire models are generated to support virtual NVH simulations. Because CDTire's composite shell elements share an FE framework, fully functional models can be created in just hours using simple FE techniques, standard material data, and earlier virtual methods [1].

This paper outlines the practical application of CDTire models and the essential credibility checks required before OEM delivery. It also evaluates CDTire's ability to capture the impact of design variations on rolling NVH metrics. Finally, vehicle-level simulations are conducted to explore reducing interior sound pressure levels and axle point acceleration.

PRESENTER BIOGRAPHY

Yaswanth is a research mechanical engineer at Hankook Tire since 2015, specializing in OE customer support and product development virtualization. He is mainly interested in using tire simulation tools to parameterize CDTire, FTire, and SWIFT tire models easily. His other interests are virtual chassis development and tire mechanics.

17. An Extended Phenomenological Friction Model for Tire–Road Interaction in FE Simulation

[Student Presentation]

Presenter: Sumit Tarachandani

Authors: Sumit Tarachandani[1], Lorenzo Massimi[2], Pasquale Agoretti[2], Michael Kaliske[1]

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ABSTRACT

The interaction between tire and road surface plays a key role in vehicle safety, performance, and energy efficiency, and, therefore, remains a long-standing field of interest within the tire industry. Reliable numerical prediction of this interaction critically depends on an accurate description of frictional behavior at the contact interface. Despite extensive research, friction formulations commonly used in finite element (FE) analysis either focus solely on the difference between the static and kinetic friction coefficients or are based solely on the pressure–velocity dependence. Consequently, these approaches do not explicitly incorporate contact history, which limits their ability to reproduce the transient and history-dependent frictional response observed in rubber–road interaction. This work introduces a phenomenological friction model developed to capture pressure–velocity effects and continuous transitions between static and kinetic friction regimes, while also reflecting the evolving frictional response that arises during sustained contact. By allowing the friction behavior to dynamically adjust to both the instantaneous and accumulated contact variables at the interface, the formulation can reproduce memory effects, pre-sliding behavior, and transient friction evolution in a physically consistent manner. The parameters of the proposed model are calibrated using experimental data obtained from proper friction tests on rubber blocks. Following calibration, the friction formulation is implemented into a tire rolling simulation under representative loading and rolling conditions. The resulting friction forces and contact pressure distribution are examined and compared to conventional friction models.

PRESENTER BIOGRAPHY

Sumit Tarachandani is a Research Assistant at the Institute for Structural Analysis of Prof. Kaliske at Technische Universität Dresden, Germany. He received his M.Sc. degree in 2022 in Advanced Computational and Civil Engineering Structural Studies (ACCESS). His research focuses on computational contact mechanics and friction modeling in finite element simulations. He works on the development and implementation of advanced contact formulations for large deformation problems and collaborates with tire manufacturers on the numerical simulation of rolling tires.

18. Early Determination of Tire Development Direction Using Driving Simulators and Vehicle Simulation

Presenter: Akio Uesaka

Authors: Akio Uesaka[1], Naohiro Ishigami[1], Yoshinao Shirakashi[1], Ibuki Yamazaki[1], Hiroshi Nashio[1]

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ABSTRACT

Recently, Model Based Development (MBD) has gained attention for improving development efficiency, reducing costs, and enhancing product performance. In tire development, the use of driving simulators and vehicle simulations has also expanded. This study reports on the applicability and effectiveness of a driving simulator (VI-grade, COMPACT FSS) aimed at improving the tire development process.

Conventional tire development often suffers from discrepancies among performance predictions in the design phase, prototype tire evaluations, bench test results, and full-scale vehicle matching. These inconsistencies frequently lead to rework and reduced development efficiency. To address this issue, pre-verification using a driving simulator and vehicle simulation was introduced to improve early-stage decision accuracy.

First, using an MF-Tyre model derived from measurement data of an actual tire, the correlation between sensory evaluations by driving simulator and vehicle tests was examined. The results showed clear agreement in evaluation trends, demonstrating the applicability of the driving simulator to tire development. Second, vehicle simulations were conducted to evaluate differences in vehicle behavior, revealing clear relationships with differences in tire characteristics.

Next, a parametric study using the MF-Tyre model investigated the effects of handling-related lateral response on vehicle behavior in the driving simulator. This approach enabled identification of the desired performance direction prior to prototyping, significantly improving development efficiency. Subsequent sensory evaluations of prototype tires confirmed performance improvements, validating the effectiveness of the simulation-based development approach.

Overall, the MBD framework using a driving simulator and vehicle simulations proved to be effective technology for improving efficiency and reducing costs in tire development.

PRESENTER BIOGRAPHY

Akio Uesaka joined TOYO TIRE Corporation in 2023. As an engineer in the Advanced Technology Development Department, he is engaged in research related to Model Based Development (MBD). His work focuses on applying MBD methodologies to tire development through a combination of experimental testing and simulation, with the aim of enhancing development efficiency and accuracy.

19. Numerical Framework for Tire Wear Simulation Based on a Novel Mesh Updating Algorithm

[Student Presentation]

Presenter: Sergio Andres Antuna Uzeda

Authors: Sergio Andres Antuna Uzeda[1], Felix Hartung[1], Mahendra Pal[2], Vidit Bansal[2], Sharad Goyal[2], Sujith Nair[2], Renji Issac[2], Michael Kaliske[1]

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ABSTRACT

Tire tread wear affects the tire's service life, safety, and environmental impact. Therefore, analyzing this phenomenon is fundamental for tire design development and assessment. Current approaches rely on a combination of experimental testing and computational techniques. Although experiments provide valuable data, they are time-consuming and costly, which leads to an increasing reliance on computational tools to support design decisions, and product development.

In this work, a numerical framework based on the finite element method is presented to simulate rubber wear in periodically treaded tires. The wear rate is described using a non-linear evolution approach, that relates material loss to the frictional energy rate. Rubber loss is considered in the model through modification of the geometry of the elements in contact. These modifications are applied such that the removed volume is consistent with the computed wear volume.

Under severe wear, the contact element geometries become highly distorted. Therefore, the mesh must be updated. The re-definition of an adequate mesh is a time-consuming task for engineers. To address this challenge, a novel automatic mesh update strategy is proposed, in which contact elements are topologically modified or removed entirely from the analysis. This allows to completely wear-off the tire tread, without the need for manual re-meshing. Additionally, a mesh smoothing module is included to reduce element distortions. The numerical and physical performance of the framework is analyzed through numerical studies on different models, including rubber blocks and simplified tires.

PRESENTER BIOGRAPHY

Sergio Andres Antuna Uzeda, M.Sc., is a doctoral researcher at the Institute for Structural Analysis at Technische Universität Dresden and holds a Master’s degree in Advanced Computational and Civil Engineering Structural Studies. His research focuses on numerical simulation of tire wear applying the finite element method, with particular emphasis on methods for handling geometry evolution and mesh distortion caused by wear. His broader research interests include advanced material modeling, tire mechanics, and frictional contact mechanics.

20. Fatigue Life Prediction of OTR Tires Accounting for Vulcanization-Induced Property Gradients

Presenter: Hao Wang

Authors: Hao Wang[1], William Mars[2], Dandan Hou[3], Longhai Mu[1]

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[2] Endurica LLC, Findlay, Ohio, United States

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ABSTRACT

Current tire durability simulations, including those incorporating viscoelastic self-heating, typically assume homogeneous material properties for each rubber component. However, in thick OTR tire sections (e.g., tread, shoulder, belt package), non-uniform thermal histories during vulcanization cause spatially varying cure states, leading to significant gradients in mechanical and fatigue properties that compromise the accuracy of conventional homogeneous models.

This study develops a cure-state-dependent material characterization and simulation framework for OTR tires. Experimental characterization using a cure rheometer and tear tests will quantify the dependence of stiffness and tearing energy on vulcanization degree for tread and belt compounds. These data will inform spatially varying constitutive and fatigue models implemented within Abaqus and Endurica MP (Multiphysics), leveraging its time-dependent material property evolution capabilities traditionally used for oxidative aging.

The framework will simulate OTR tire fatigue life under rolling conditions, explicitly accounting for cure-induced property non-uniformity. Results will be compared against baseline homogeneous models to isolate the impact of vulcanization gradients on durability, with pathways for integration into coupled thermo-oxidative aging analyses. This approach addresses a critical gap between manufacturing process physics and field durability prediction.

PRESENTER BIOGRAPHY

Hao Wang holds a Master's degree in Automotive Engineering from the School of Vehicle and Mobility at Tsinghua University, where his research focused on finite element simulation and fatigue analysis of rubber components and tires. His academic contributions were recognized with the 2015 Honorable Mention Award from The Tire Society. Currently serving as the General Manager of E-rubber Technology (Tianjin) Co., Ltd., he leads initiatives to integrate intelligent measurement technologies and multiphysics simulation methods into tire product development and performance optimization.