41st Annual Business Meeting and Conference on Tire Science and Technology

New Horizons in Tire Evaluation

Program and Abstracts

September 12th – September 13th, 2022

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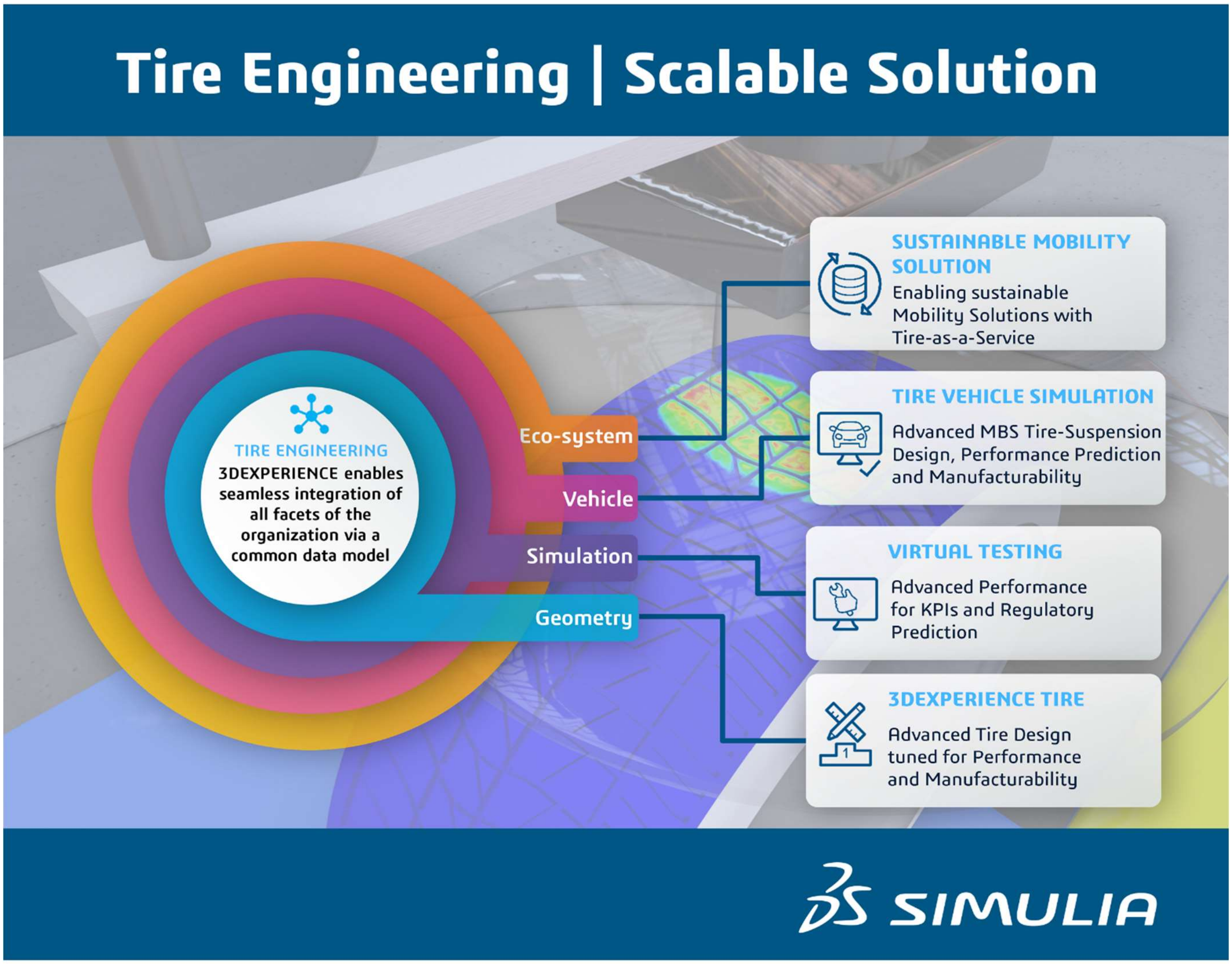

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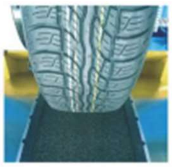

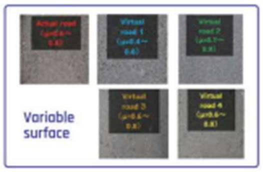

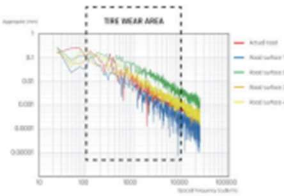

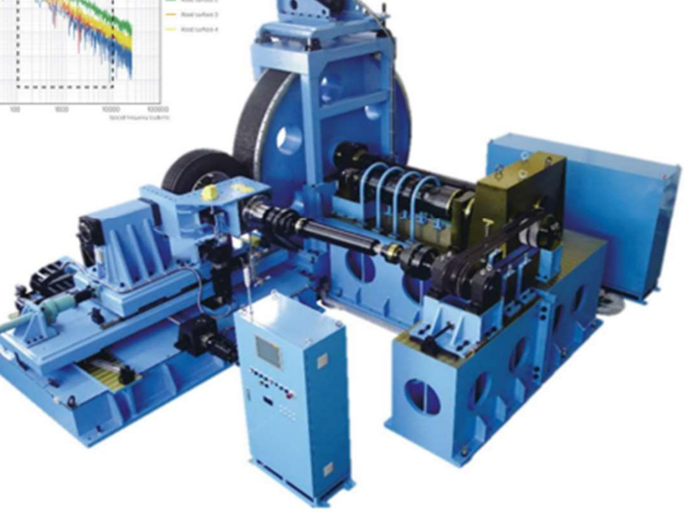

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ITEC 2022
TIRE MANUFACTURING
September 13-15, 2022 | J.S. Knight Center • Akron, OH
While you're in Akron, don't miss the International Tire Exhibition and Conference (ITEC) taking place September 13-15 at the John S. Knight Center!
It's the largest tire manufacturing show in North America.
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DANIEL HORRIGAN, MAYOR

Proclamation

To The People of Akron:

Whereas: **Tires are an indispensable component of our transportation system and are relied upon by 92% of American households in their daily lives; and**

Whereas: **Akron, the historically and aptly named *Rubber Capital of the World*, remains the hub for tire technology, with Technical Centers for nine of the top twenty-five tire companies located in greater Akron; and**

Whereas: **During a single week this September, approximately 1,500 experts and technologists from around the world are expected to attend several tire industry events in Akron including:**

> **The Tire Society's 41st Annual Science and Technology Conference to be held at The University of Akron;**
>
> **The 15th Biennial International Tire Exhibition & Conference, the largest tire manufacturing show in North America, to be held at the J.S. Knight Center;**
>
> **The 51st Tire Mechanics Short Course, hosted by The University of Akron's College of Engineering and Polymer Science.**

Now, Therefore: **I, Daniel Horrigan, Mayor of the City of Akron, Ohio, do hereby proclaim September 12-16, 2022, as:**

"Tire Week in Akron"

and welcome those who will travel to our city to attend a tire industry event.

In Witness Whereof: **I have hereunto set my hand and caused the Seal of the City of Akron to be affixed hereto this 20th day of July 2022.**

Mayor
City of Akron

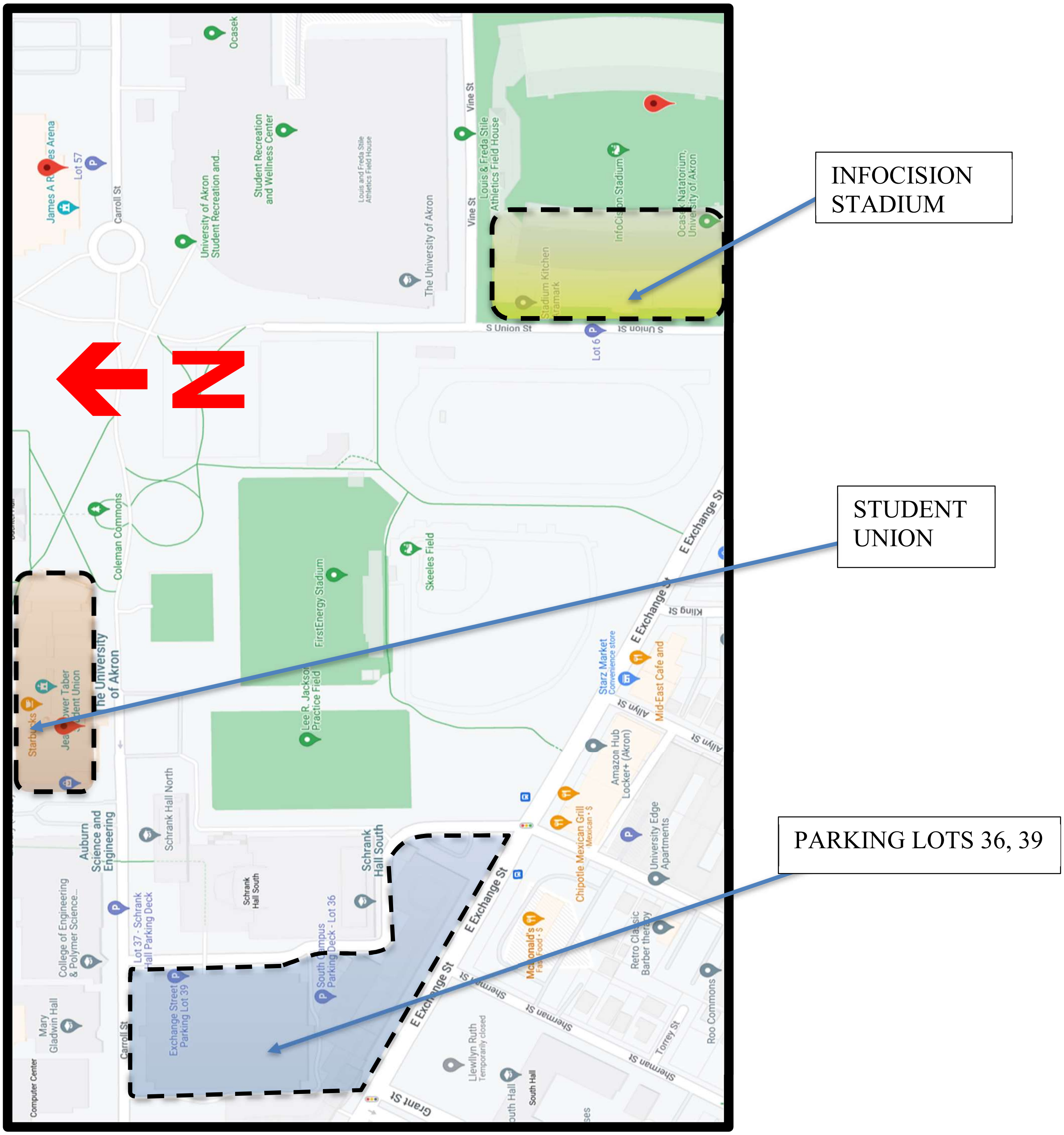
Day 1 – Mon, September 12, 2022

8:00 AM	**Conference Opening**		**Will Mars** *Tire Society President*
8:05 AM	**Welcome**		**Gary Miller** *President, University of Akron*
8:15 AM	**Keynote Address**	*A Future View of Mobility*	**Alexis Garcin** *Michelin North America, Inc., Chairman and President*
9:15 AM	**Announcements**		**Gobi Gobinath,** *Conference Chair*
9:20 AM	**Break**		
9:40AM	**Session 1: Durability**		**Xianwei Meng,** *Goodyear*
9:45 AM	1.1	Novel Method Using Symmetric Belt Arrangement to Minimize Belt Edge Separation in TBR Tire	**Ankush Yadav** *Ralston Tires*
10:10 AM	1.2	Understanding Cut Resistance and Strengthening Mechanisms: Reinforcement and Size Effect for Tire Rubbers	**Shing-Chung J. Wong** *University of Akron*
10:35 AM	1.3	Ozone and Fatigue Resistance of NR/EPDM Blends in Tire Sidewall Applications	**Will Mars** *Endurica*
11:00AM	**Session 2: Emerging Technologies**		**Matthew Van Gennip,** *Link Eng.*
11:05 AM	2.1	Development of a Prediction Model for Tire-Road Noise based on Convolution Neural Network	**Youngsam Yoon** *Hyundai Motor Company*
11:30 AM	2.2	Tires for Mars Rovers: Reinforcing BR and BR/VMQ Compounds with Carbon Black, Nano-$CaCO_3$ or Silica for Good Low-Temperature Dynamic-Mechanical Performance	**Rafal Anyszka** *University of Twente*
11:55AM	**Box Lunch (PROVIDED)**	Interactive Poster Presentations	
1:05 PM	**Session 3: Thermal Evaluation of Tires**		**Qian Li ,** Goodyear
1:10 PM	3.1	Thermally Sensitive Tire Model for High Performance Vehicle Applications	**Cedric Mousseau,** *General Motors*
1:35 PM	3.2	Thermo-mechanical Modeling of the Aircraft Tire-Runway Contact for Transient Maneuvers	**Dr. Matthias Wangenheim** *Leibniz University Hannover*
2:00PM	**Session 4: Tire Testing**		**Jerry Pospiech***, ACS, inc.*
2:05 PM	4.1	Contact Patch Pressure Behaviors in High-Speed Dynamic Conditions	**Marco Furlan & Henning Olsson** *Calspan Corporation*
2:30 PM	4.2	DIC, the Ultimate Non-contact Sensor for Dynamic Tire Testing	**Justin Bucienski,** *Trillon Quality Sys*
2:55 PM	4.3	Investigation on Tire Performance and Testing Under Longitudinal and Combined Slip States – Induced Versus Resultant Wheel Related Slip	**Ventseslav Yordanov** *IKA Aachen University*
3:20 PM	**Break**		
3:40 PM	**Session 5: Tire/Road Interaction**		**Eric Pierce,** *Smithers*
3:45 PM	5.1	Target Conflict for Force Transmission in Lateral and Longitudinal Direction of Rotated Tread Block Samples on Different Road Surfaces (Dry, Wet, Snow and Ice)	**Jonas Alexander Heidelberger** *Institute for Dynamic and Vibration Research*
4:10 AM	5.2	A Study on Self-Sustained Vibrations of a Tire Operating Above Peak Friction	**Carlo Lugaro** *Siemens Digital Industries*
4:35 PM	5.3	On the Influence of Tire Contact Patch Model Complexity on High Frequency Road Profile Simulation	**Girish R. Radhakrishnan** *OptimumG, LLC Technology*
5:15 PM	**Reception: Infocision Stadium 5th Floor**		
6:15 PM	**Banquet Welcome Address**		**Daniel Horrigan,** *Akron Mayor*
6:25 PM	**Awards Presentation**		**Barry Yavari,** *Awards Cmte. Chair*
7:55 PM	**Dinner Speech**	Round and Green: Engineering for Agriculture	**Dr. Nohoon Ki,** *John Deere Eng. Manager*
9:00 PM	**CLOSE OF DAY 1**		

Day 2 – Tuesday, September 13, 2022

8:00 AM	**Opening Remarks**	**Gobi Gobinath**, *Conference Chair*
8:05 AM	**Plenary Address** The Road Ahead - Technology and Policy in the Tire Industry	**Tracey Norberg** *US Tire Manufacturers Association* *Senior Vice President*
9:05 AM	**Annual Meeting** Business Update & State of the Society	**Will Mars** *Tire Society President*
9:55 AM	**Break**	
10:15 AM	**Session 6: Student Session**	**Matthew Schroeder**, *Goodyear*
10:20 AM	6.1 Simultaneous Determination of Additive Concentration in Rubber using ATR-FTIR Spectroscopy	**Stephen Merriman** *University of Akron*
10:45 AM	6.2 Automated Tire Mode Shape Classification using Zernike Annular Moments and Flattening	**Junhyeon Seo** *Virginia Polytechnic Institute*
11:10 AM	6.3 Identification of Characteristic Tire Parameters for the Virtual Steering System Design	**Dominic Neumann** *BMW Group*
11:35 AM	**Box Lunch (PROVIDED)**	
12:45 PM	**Panel Discussion** – The Future of Tire Testing	**Heather Bobbitt,** *General Motors*
1:45 PM	**Session 7: Virtual Tire**	**Mohammad Behroozi** *(TBD if Unavailable)* General Motors
1:50 PM	7.1 Generation of SWIFT Models Virtually Using FEA: Application to Cleat Simulations	**Yaswanth Siramdasu** *Hankook Tire - America*
2:15 PM	7.2 The Benefits of Virtual Tire Evaluation Using a Driver-in-the-Loop Simulator (DiL)	**Kelly Holshue** *VI-grade, Inc.*
2:40 PM	**Break**	
3:00 PM	**Session 8a: Tire Performance - Treadwear**	**Yusheng Chen,** *Flexsys*
3:05 PM	8.1 Tire Wear Investigation of EVs Using KOKUSAI's Tire Wear Tester	**Günter Leister, T***WMS Consulting*
3:30 PM	8.2 Factors Influencing Wear of Tyre Tread Rubber	**P. Ghosh,** *Hari Shankar Singhania Elastomer & Tyre Research Institute*
	Session 8b: Tire Performance - Noise	**Yusheng Chen,** *Flexsys*
3:55 PM	8.3 A study on the Mid-frequency Tire Sourced Cabin Noise in Electrical Vehicles (EV's)	**Pejman Razi,** *Hankook Tire - America*
4:20 PM	8.4 Pass-By Noise Prediction	**John Lewis,** *SIMULIA*
4:45 PM	**2022 Conference Closing Remarks & POD Availability Announcement**	**Gobi Gobinath,** *Goodyear* 2022 Conference Chair
4:50 PM	**2023 Conference Announcement**	**Cedric Mousseau,** *General Motors* 2023 Conference Chair
5:00 PM	**END OF CONFERENCE**	

UNIVERSITY OF AKRON CAMPUS MAP



About The Tire Society

The Tire Society was established to disseminate knowledge and to stimulate development in the science and technology of tires. This is pursued through technical meetings and publication of the journal, Tire Science and Technology. The Society is a not-for-profit Ohio corporation managed by a duly elected Executive Board of tire industry professionals who serve on a volunteer basis.

Many members volunteered their time to put together the 40th Annual Meeting and Conference.

CONFERENCE COMMITTEE:

2022 Program Chair:	Gobi Gobinath	*The Goodyear Tire & Rubber Company*
2023 Program Chair:	Cedric Mousseau	*General Motors*
2024 Program Chair:	Matthew Van Gennip	Link Engineering
Conference Committee Chair:	Jim McIntyre	*Bridgestone Americas*

PANEL CHAIRS:

Mohammad Behroozi	*General Motors*
Cedric Mousseau	*General Motors*

SESSION CHAIRS:

Mohammad Behroozi	*General Motors*
Yusheng Chen	*Flexsys*
Qian Li	*The Goodyear Tire & Rubber Company*
Xianwei Meng	*The Goodyear Tire & Rubber Company*
Eric Pierce	*Smithers*
Jerry Pospiech	*ACS, Inc.*
Matthew Schroeder	*The Goodyear Tire & Rubber Company*

AWARDS COMMITTEE:

Pooya Behroozinia(C,S)	*Maxxis Technology Center*
Anudeep Bhoopalam(C)	*Giti Tire R&D Center - North America*
Jason Bokar C,S)	*Michelin Americas R&D Corporation*
Yusheng Chen(C,S)	*Flexsys*
Osama Hamzeh(C)	*The Goodyear Tire & Rubber Company*
James Valerio (S)	*Hankook Tire & Technology*
Barry Yavari (Chair)	*The Goodyear Tire & Rubber Company*
Eric Hui Zhang(C,S)	*Bridgestone Americas*

* C – Conference Judge, S – Student Paper Judge

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Ric Mousseau	*General Motors*
Joerg Dehnert	*Continental*
Bin Chung	*Maxxis*
Ron Kennedy	*Virginia Tech (retired)*

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Michael Kaliske	*Technische Universität Dresden*
Yaswanth Siramdasu	*Hankook Tire & Technology*

The Tire Society also thanks Allen Press for their many contributions! In particular, we wish to thank Chris Lapine and Terry Leatherman for their tireless commitment to assisting the society in its goal of disseminating knowledge about the science and technology of tires.

In addition to the Journal Editor, the associate editors volunteer time to contribute to the peer review process associated with publishing manuscripts in the Tire Science & Technology Journal:

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Save the Date: **42nd Annual Meeting and Conference**

September 12th & 13th, 2023

Conference Theme: **The Intelligent Tire**

Program Chair:	Ric Mousseau	*General Motors*
Co-Chair:	Matthew Van Gennip	Link Engineering

The Conference Committee would appreciate your assistance and suggestions. A call for papers will be issued and will be available online.

Visit www.tiresociety.org for updates

Keynote Address

Alexis Garcin

Chairman and President,
Michelin North America, Inc.

Title of Talk: ***A Future View of Mobility***

Alexis Garcin is responsible for coordinating all activities of Michelin in North America, which encompasses more than $8 billion in sales and approximately 22,500 employees across Canada and the United States. Michelin, the leading mobility company, is working with tires, around tires and beyond tires to enable Motion for Life. Dedicated to enhancing its clients' mobility and sustainability, Michelin designs and distributes the most suitable tires, services and solutions for its customers' needs. Michelin provides digital services, maps and guides to help enrich trips and travels and make them unique experiences. Bringing its expertise to new markets, the company is investing in high-technology materials, 3D printing and hydrogen, to serve a wide a variety of industries—from aerospace to biotech.

Garcin joined Michelin in 2002 and has held numerous positions in France, Switzerland, Germany and now in the U.S. He began his Michelin career as Sales Director of the car dealer channel in France. He then worked in the passenger car division, where he held Sales Director positions for the European and German markets, prior to being named Managing Director of EUROMASTER, a wholly owned retail network subsidiary of the Michelin Group, in Germany. From 2011 to 2017, Garcin served as Michelin's Worldwide Strategic Marketing Director for the truck and bus division and most recently led the global long-distance transportation business line.

Before joining Michelin, Garcin held several positions for BOSCH Group, including Sales Director for Western Europe of the power tool division.

As a leader, Garcin is guided by purpose, humility, boldness, and authenticity. He prioritizes people, ensuring they always come first. He relentlessly pushes for progress by challenging the status quo, learning and applying best practices and meeting regularly with people—employees, customers, industry professionals and the community—who he finds to be a great source of inspiration.

He holds a degree in Economical Sciences from University Lumière in Lyon, France, , and a master's degree in Business and Management from Saint-Etienne Business School in France. Garcin serves on the board of the United States Tire Manufacturers Association (USTMA). Follow Alexis on LinkedIn to learn more about his thoughts on sustainable mobility, leadership and more.

Plenary Lecture

Tracey Norberg
Senior Vice President and General Counsel,
U.S. Tire Manufacturers Association

Title of Talk: ***The Road Ahead - Technology and Policy in the Tire Industry***

Tracey Norberg is Senior Vice President and General Counsel at the U.S. Tire Manufacturers Association in Washington DC.

USTMA members operate manufacturing facilities in 17 states, employ nearly 100,000 workers and generate annual sales of more than $27 billion.

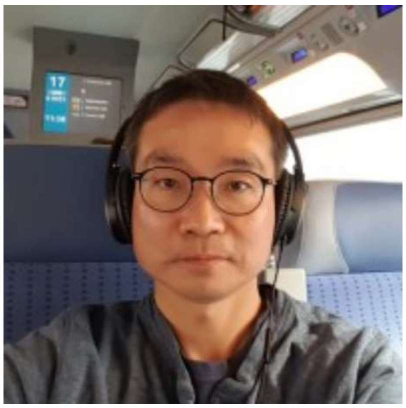
Ms. Norberg is responsible for management, legal and public policy in the areas of manufacturing, transportation, product safety, antitrust, industry litigation, innovation, sustainability, and trade. She spearheaded USTMA's policy, technical and scientific contributions to a National Academy of Sciences study on tire efficiency and defeated several congressional proposals and state bills that would have been onerous for tire industry.

Dinner Speaker

Nohoon Ki

Engineering Manager,
John Deere Company

Title of Talk: ***Round and Green: Engineering for Agriculture***



Dr. Nohoon Ki is Engineering Manager at John Deere in Cedar Falls, Iowa.

His team is responsible for the engineering and implementation of wheel, track, and suspension systems on John Deere agricultural equipment. He has particular expertise in Multibody Dynamics and is the holder of 2 patents. He has 22 years of industry experience, all with Deere, since earning his Ph.D. from Purdue University.

<u>Panel Discussion</u>: **The Future of Tire Testing**

Building effective predictive methods in our emerging “digital twin” era requires evolving test methods to provide better representation of tire mechanical behavior under circumstances that currently challenge the validity of virtual assessment. Phenomena including temperature effects, worn behavior, wet surfaces, soil interaction and snow mobility may not be fully understood but must be addressed to create useful vehicle-level assessments. The testing required to develop specialty tires for racing, agricultural or heavy industrial applications remains difficult. As OEMs continue to compress development cycles, big data, machine learning algorithms and databasing methods are becoming important tools in tire development . Testing specialists from a variety of backgrounds will address the challenges ahead of industry and provide insights into next steps.

Moderator: Heather Bobbitt, Tire Modeling Group Manager,
General Motors, USA

Heather Bobbitt is responsible for the development of tire modeling talent to support model creation for all tire applications and new tool advancement to facilitate growth and reliance in the virtual space. Her team supports everything from OE to Motorsports to Lunar. Bobbitt incorporates industry expertise from tire suppliers, universities, and industry partners, along with the collective GM knowledge on tire dynamics. Bobbitt has 11 years with General Motors in a variety of positions from Vehicle Dynamics, Driveline, Tire Development and Tire Modeling. She has a B.S. in Mechanical Engineering and a Ph.D. in Mechanical Engineering from Virginia Tech.

Panelist: Henning Olsson, Senior Director, Technology,
Calspan Corporation, USA

Since joining Calspan in 2015, Henning has been developing and implementing testing technologies to help Calspan’s customers bring new and innovative tires and vehicles to market faster than before. With extensive experience in the use of CAE and simulations to understand and predict tire performance, Henning works side-by-side with global customers to make tire testing and modelling more accurate, repeatable and cost-effective. Prior to joining Calspan, Henning spent several years as vehicle dynamics engineer in high-level motorsports. Henning received his B.S in Engineering from Dartmouth College and his M.S in Automotive Engineering from the Royal Institute of Technology in Sweden.

Panelist: Jonathan Darab, Operations Director,
Global Center for Automotive Performance Simulation (GCAPS), USA

Jonathan Darab has a B.S in Mechanical Engineering and a M.S in Global Vehicle Integration. He spent 12 years at General Motors in a variety of jobs from design to test to manufacturing quality with the majority of the positions in Vehicle Dynamics. In these positions, Mr. Darab operated servo-hydraulic equipment for Vehicle Dynamics characterization, conducted advanced development of suspensions, and developed equipment and test procedures for advanced vehicle and tire testing. As Operations Director at GCAPS his responsibilities include new business development, technical sales, customer relations, and new technology development. Mr. Darab holds 4 patents in tire and suspensions

Panelist: Christian Bachmann, Senior Manager Tyre Technology, FKA, Germany

Christian is responsible for all tire testing, simulation and research activities in the chassis and NVH department at FKA. He graduated as mechanical engineer at RWTH Aachen University and focused on tires since 2005 as scientific researcher at the Institute for Automotive Engineering, RWTH Aachen University. In his PhD thesis he compared rolling resistance results from laboratory measurements with real-road test data employing a mobile tire test rig, that he developed together with some colleagues. In the past he was mainly concerned with tire test rig design and development, as well as test procedure developments to improve tire model fidelity in the simulation. Since 2011 his responsibilities include in addition strategic business development, establishing new research partnerships with tire industry and OEM, customer relations, staff management and sales.

Panelist: Matt Kent, Technical Director of Tire & Wheel Test Lab, Smithers, USA

Matt joined Smithers in 2017. He is focused on Smithers' force and moment testing operations, staff management, and technical decision-making. He also manages a partnership between Smithers and six global tire manufacturers that introduced a new MTS Flat Trac CT+ system and facility expansion in 2018. Matt has over 17 years of experience in the tire industry, including management experience on the manufacturing side of the business. He has been responsible for numerous test machines, including MTS Flat Tracs, spring rate, laser measurement, acoustic, uniformity, and high- and low-speed durability. Matt has a Bachelor of Science in Mechanical Engineering from the University of Toledo. He is a certified Six Sigma Black Belt, is certified in FARO Measurement Systems, and has had training in Lean and pneumatic systems design. He spent the first part of his career designing automated tire building systems before moving into his multiple roles in tire testing.

Panelist: Mike Stackpole, President and Founder, Stackpole Engineering Services, Inc., USA

Michael obtained his Bachelor of Engineering from Stevens Institute of Technology and his Master of Engineering Degree from the University of Akron. Early in his career, Michael worked in various vehicle dynamics and tire modeling technical roles at both The Goodyear Tire & Rubber Company and Bridgestone/Firestone. There he developed expertise in the areas of tire/vehicle simulation development, tire testing and custom tire model development. He and his wife Tracy established Stackpole Engineering Services in 1999 to further this expertise, providing engineering software solutions, tire testing, tire modeling and engineering services to OEM Vehicle and Tire Manufacturers and Professional Race Programs across the globe.

Paper 1.1

Novel Method Using Symmetric Belt Arrangement to Minimize Belt Edge Separation in TBR Tire

Ankush Yadav[1,2], Ashish Sharma[2] and Jitendra Mahajan[2]

One of the common causes of tire failure is belt edge separation. There are various reasons of belt edge separation like adhesion loss, high heat generation, interlaminar shear etc. Since interlaminar shear is one of the most prominent reasons for belt edge separation and can be controlled by varying design parameter like belt angle, belt width, rubber gauge etc.

This paper focuses on studying the phenomenon of belt edge separation using belt lay arrangement. We have studied two different belt lay arrangements namely symmetric and asymmetric, their effect on belt edge separation parameters using FEM technique. MSC MARC commercial Finite Element software was used to conduct FE analysis on a 11R22.5 tire model under static conditions.

From numerical simulations, it is evident that the symmetric belt arrangement minimizes strain energy density, principal stresses and principal strains in belt edge region compared to the asymmetric arrangement. In practicality asymmetric arrangement is the one that is commonly used by tire companies for Truck bus radial (TBR) tire. Through this paper we have proposed a new belt package to practically use the symmetric belt lay arrangement.

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2 Ralson Tyres, India

Paper 1.2

Understanding Cut Resistance and Strengthening Mechanisms: Reinforcement and Size Effect for Tire Rubbers

Shing-Chung J. Wong[1,2], Xin Wang[2], Soon W. Moon[3]

Sidewall and tread cuts account for 50% of damage to OTR tires in mines of the oil sands industry. The mix of sharp stone edges, ice and water create severe and tortuous conditions under which OTR rubber compounds need to operate. The wet conditions and high loads of haul trucks increase the degradation and thus embrittlement effects of rubbers. Extreme temperatures and thermal fatigue also exacerbate crack propagations and catastrophic failures. The cut and crack resistance of compounds for the mining industry have not been well understood. Most attributed to heat and little was done on the pressing need of a reinforcement strategy due to size and high payload. Properties obtained in laboratories during tire development could only be made meaningful when appropriate size effects and scaling laws were taken into consideration. Larger trucks and tires are desired for increased payloads because of mining operations.

In this study, we evaluated a few reinforcements for tire rubbers. We focused on the strengthening effects of nylon, Kevlar and carbon fabrics on natural rubbers (NR) and styrene-butylene rubbers (SBR). Studies were performed to evaluate impact performance, scratch resistance of compounds, temperature effects and interlaminate delamination forces. Multiple reinforcements with carbon delivered the best performance in comparison to other reinforcement schemes. The thickness of reinforced specimens was increased fourfold to understand the thickness effect on fracture toughness and elastic energy release rates. Toughness decreased as thickness increased. Weibull analysis was employed to characterize large rubber compounds. The objective was to provide a viable strategy for OTR tires suppliers with potential reinforcement options and upsizing conditions to meet the ever-increasing payloads (400+ US ton) of hauling and synthetic crude extraction.

1 Corresponding author: swong@uakron.edu
2 Department of Mechanical Engineering, University of Akron
3 Syncrude Canada Ltd.

Paper 1.3

Ozone and Fatigue Resistance of NR/EPDM *B*lends in Tire Sidewall Applications

William V Mars[1,2], Erick Sharp[3], Jaden Slovensky[3], Yang Chen[4], Ethan Steiner[2]

Tire sidewall durability depends on specifying compounds with sufficient resistance to fatigue crack growth and to ozone attack. Here the suitability of a series of NR/EPDM blends was evaluated via characterization and simulation. Fatigue crack growth properties were estimated from measurements of intrinsic strength and tear strength made with the Coesfeld Intrinsic Strength Analyzer. Ozone attack threshold and rate were obtained via observations of crack development following exposure in an ozone chamber. The ozone attack measurements also provide information about the distribution of crack precursors in each compound. Finally, using FEA-computed sidewall strain history for steady rolling, estimates were made of sidewall life and likely distribution of cracking.

1 Corresponding author: wvmars@endurica.com
2 Endurica LLC
3 ACE Products and Consulting
4 Michigan State University

Paper 2.1

"Development of a Prediction Model for Tire-Road Noise based on Convolution Neural Network"

Yoon, Youngsam[1,2] Lee, Jaehun[2] Yum, Kiho[2] Lee, Sang-Kwon[3] Hwang , SungWook[4]

In new car development projects, there are a lot of issues for dissatisfaction with NVH, R&H, and basic performance of tire patterns. There have been cases in which specifications are not fixed in a timely manner in the master car quality assurance stage and are fixed in the pilot stage. The reason for this problem is that there is no tool for conducting design reviews such as a tire performance prediction model and a design review system, although a tire design review should be conducted with a supplier from a system perspective of the vehicle at the tire design review stage. In addition, since it is impossible to accurately identify the contents of the supplier and to analyze the tire design principle based on the progress of the supplier-based review, there is a limit to the engineering perspective review.

In this study, a convolutional neural network (CNN) was developed based on the non-supervised training method to predict tire performance for PRAT, Torque steer under acceleration, Snow, Hydroplaning, Wet Braking, Dry Mu, Cornering Stiffness, Pattern noise. Two learning algorithms, i.e., stochastic gradient descent (SGD) and RMSProp, were applied to the CNN model for comparison of their learning performance. The RMSProp algorithm was selected for the CNN model. In this case, an image of the pattern of the tire to be designed was used as the input of the CNN. The CNN was developed and its utility in the early design stage was discussed. Therefore, a technology for predicting tire performance was developed by developing an artificial intelligence review system based on input of a database of design elements for tire performance and output of tire performance evaluation results, and by developing a GUI-based review system, design review accuracy was improved, and duration was shortened to ensure timely development and quality mass production of specifications before the master car.

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Paper 2.2

Tires for Mars Rovers: Reinforcing BR and BR/VMQ Compounds with Carbon Black, Nano-$CaCO_3$ or Silica for Good Low-Temperature Dynamic-Mechanical Performance

Rafal Anyszka[1-4], Li Jia[3], and Anke Blume[2]

Recently Mars exploration is drawing more and more attention. Not only wealthy countries but also private companies are interested in reaching Mars as a potential human colony and future market. However, Martian weather conditions differ significantly from Earth. The daily temperature range is much higher and minimum temperatures much lower (-120 – 20°C). Mars's surface is exposed to particulate and UV radiation due to a lack of a magnetosphere and ozone layer. Also, the atmospheric pressure is much lower in comparison to Earth. All these factors determine a new, challenging environment requiring tailor-made materials for satisfactory performance. One of the most important engineering materials is rubber that provides high elastic and damping properties. It is an irreplaceable material for manufacturing tires, gaskets, seals, dampers, and many other functional elements.

The aim of this project is to design tailor-made rubber compounds that withstand Martian conditions by using low glass-temperature rubbers – butadiene rubber (BR) or a unique butadiene/silicone rubber blend (BR/VMQ) to provide still good elasticity at the given low temperatures on Mars. The rubbers are reinforced with different grade carbon blacks (CB), silica, or nano-calcium carbonate (CaCO3), to improve their dynamic-mechanical properties. The effects will be discussed based on dynamic-mechanical analysis, differential scanning calorimetry, Payne effect, and mechanical properties measurements. The results show that the application of BR and BR/VMQ blends is a promising route to designing a high-performance rubber for Martian utilization.

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Paper 3.1

Thermally Sensitive Tire Model for High Performance Vehicle Applications

Cedric Mousseau[1,2], John Collier[2], Rich Reichenbach[2], Edward Mc Lennon[2], Heather Bobbitt[2], Raghuram Thiagarajan[3]

Tires in high performance vehicle applications experience large slip angle and load solicitations to the tire during racetrack competition events. These tire solicitations, which cause a significant tire sliding during high-load events, will induce large amounts of thermal energy that will cause significant evolution tire performance. This evolution manifests itself as changes in tire-road adherence and tire stiffness behavior. Common practice has been to design the tire force and moment testing procedure to reproduce the thermal state tire during the vehicle handling events of interest.

It is very difficult to design a procedure that can robustly reproduce the full thermal state that a tire experiences during this kind of vehicle operation. These shortcomings have spurred the development of "thermal tire models" which use, experimentally and/or analytically derived relationships between tire force and moment performance and temperature-estimated states. The thermal tire test procedure is optimized to fit models that can broadly estimate tire force and moment performance over a wide range of thermal states.

This paper describes a tire model that consists of two sub-models:

1) A thermal compensation model that accounts for changes in tire force and moment performance as a function of tire temperature;
2) A thermal generation model that estimates the tire temperature state from the tire solicitation time history.

The model runs in real-time and was optimized for driver-in-the-loop and lap time simulation applications. The paper briefly describes relevant prior work in thermal tire modeling, the major assumptions incorporated into the thermal compensation and generation models, shows results from a driver-in-loop application, and concludes with a summary and a brief description of possible future work.

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Paper 3.2

Thermo-mechanical Modeling of the Aircraft Tire-Runway Contact for Transient Maneuvers

Stephanie Kahms[1,2], Michael Hindemith[2], Matthias Wangenheim[2]

The aircraft tire is the link between the aircraft and the runway and transmits forces and moments within the contact area. During ground maneuvers, the tire is exposed to a wide range of operating conditions. The tires support the weight of the aircraft, they ensure safe rolling during taxiing and they transfer the required forces to the runway during take-off and landing.

Temperature development during these maneuvers is of great importance because temperature can affect both material stiffness and friction behavior. Heat is generated inside the tire due to energy dissipation caused by the cyclic loading of the tire during rolling. In addition, heat is generated due to friction in the tire-runway contact. Experimental measurements of the temperature distribution in the entire tire are not yet possible. The tire temperatures can only be determined at selected critical spots. Simulation models can help to obtain a better understanding of the overall tire temperature distribution during transient maneuver.

In this work, the transient thermo-mechanical processes of an aircraft tire are modeled based on a simple physical tire model. An extended brush model is used to simulate the contact forces. The tire temperature is determined via the transient heat conduction equation in radial and circumferential directions. The mechanical and thermal models are coupled via the coefficient of friction and the sliding velocities in contact. The free model parameters are parameterized using experimental data and the overall model is validated by measurements on the whole tire. The validated thermo-mechanical tire model is used for simulations or the analysis of different driving maneuvers to get a better understanding of the temperature development in the aircraft tire.

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Paper 4.1

Contact Patch Pressure Behaviors in High-Speed Dynamic Conditions

Marco Furlan[2], Mateo Gladstone[2], Matthew Strang[2], and **Henning Olsson**[1,2]

Many of the challenging problems in tire dynamics are related to what happens inside the contact patch. Important tire performance attributes such as grip/friction, wear and noise are all directly related to the contact patch.

Calspan and its technology partner, Tekscan, have developed a novel sensor system that measures the contact patch pressure of the tire as it is rolling at high speed on a flat-belt tire test machine. The measurement results provide detailed insights into the contact patch pressure distribution in both pure and combined slip conditions on a flat roadway surface.

Two applications of this type of measurement data have been explored. First, the contact patch behaviors of three tires of the same size and type, but from different manufacturers were compared. The results highlight how differences in tire design decisions influence the contact patch behavior and in turn the overall tire performance. Secondly, the measurement data was used to improve the contact patch model within a thermo-mechanical brush tire model, resulting in improved model fidelity.

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Paper 4.2

DIC, the ultimate non-contact sensor for dynamic tire testing

Justin Bucienski[1,2]

Testing remains one of the primary challenges facing the tire industry. Due to the dynamic nature of most tire testing, wired single-point sensors are often unable to reliably measure deformation. For sidewall deformation, slip, shape analysis, and harsh environment testing, non-contact measurement methodologies are preferred.

One such technology is digital image correlation (DIC). With DIC, the entirety of a visible surface can be measured in 3D and processed via pattern recognition algorithms. Quantities such as strain, displacement, velocity, and acceleration can be measured in full field instead of solely at single points. Since DIC is non-contact, the apparatus has no influence on the measured response.

This paper will explore the utility of DIC for the applications mentioned above and for other uses such as FEA validation, material characterization, and modal analysis.

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Paper 4.3

Investigation on Tire Performance and Testing under Longitudinal and Combined Slip States – Induced versus Resultant Wheel Related Slip

Ventseslav Yordanov[1,2], Mark Harris[3], Christian Bachmann[3],Konstantin Sedlan[4]

Tires influence many overall vehicle characteristics including safety, performance, comfort and handling feel. Testing is needed to characterize tires for the selection of OEM submissions as well as for the development of other suspension and chassis components. The reality that tire responses are highly non-linear and change significantly with temperature, wear and surface paring makes testing to adequately characterize tires for vehicle development difficult.

It can be further stated that achieving robust, repeatable braking and driving measurements is particularly challenging. Unlike cornering tests, the test rig input is directly opposed to the tire response vector. Moreover, utilizing an estimated parameter (e.g. slip ratio) as a control value prohibits a clear distinction between the linear test rig input and the non-linear tire response.

In this paper, the influence of the wheel-related slip control on the tire performance under longitudinal and combined slip conditions is investigated. Two different tire types are measured in a laboratory environment on an MTS Flat-Trac CT+ tire test rig. A variety of test procedures are used to consider the influence of slip and torque rates under different operating conditions (e.g. wheel loads and velocities). In conclusion, a recommendation is given for a low-wear and cost-efficient testing methodology for an improved assessment of tire longitudinal and combined slip characteristics by utilizing a linear test rig input.

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Paper 5.1

Target Conflict for Force Transmission in Lateral and Longitudinal Direction of Rotated Tread Block Samples on Different Road Surfaces (Dry, Wet, Snow and Ice)

Jonas Alexander Heidelberger[1,2], Matthias Wangenheim[2], Klaus Wiese[3], Burkhard Wies[3], Christoph Bederna[3]

It is known that different weather conditions require specific designs to take into account the main mechanisms acting between the tire tread block and the road surface. When developing all-season tires, additional research is necessary to find the best solution considering various road conditions.

This paper analyzes the influence of the inclination angle of tire tread blocks and its siping philosophy on different surfaces on the friction forces in lateral and longitudinal direction. The tests were conducted on the hybrid test rig RePTiL (Realistic Pattern Testing in Lab) at the Institute for Dynamics and Vibration Research of the Leibniz University of Hannover with different single tread blocks. Tire tread blocks with different numbers of sipes were rotated with an angle between 0° to 90° in 15° increments. In order to simulate different road conditions, artificially produced ice and snow tracks and real road wet and dry asphalt, were used. For a better understanding of the mechanisms, high-speed images of the same samples sliding over a wet glass track were taken from below.

On one hand, the measurement results and videos help to understand the influence of an inclination angle of a tread block sample on the friction process and show the different friction mechanisms on different surfaces and resulting forces in the two directions. On the other hand, the results show clear favorites for optimizing performance on individual surfaces as well as on all surfaces.

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Paper 5.2

A Study on Self-Sustained Vibrations of a Tire Operating Above Peak Friction

Carlo Lugaro[1,2], Mohsen Alirezaei[2,3], and Yi Li[4]

When a tire operates at a side slip level above peak friction, large vibrations in the produced forces and moments are observed. In the lateral direction, these vibrations are typically centered at frequencies close to 50 Hz and significantly affect the force that is produced by the tire. As an example, high dynamics vehicle maneuvers with an ESP control system in the loop can be affected by this behavior. To accurately reproduce the tire response in these operating conditions, it is important to employ a model that can capture this phenomenon.

Based on analysis of non-linear unstable systems and limit cycle phenomenon, a theory is presented that provides a physical background for the source of vibrations. The theory also gives insight in how the frequency and amplitude of the vibrations are influenced by the tire physical characteristics and the operating conditions. It is found that the most dominant characteristics are the shape of the steady-state force response of the tire around peak friction, the contact patch mass, the carcass damping and stiffness.

Simulations with physical models of different complexity levels, as well as with the commercial MF-Tyre/MF-Swift tire software model, validate the theory and demonstrate how the vibrations can be reproduced in a simulation environment. The simulation results are compared with tire measurements in different operating conditions, validating the exposed theory and employed models.

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Paper 5.3

On the Influence of Tire Contact Patch Model Complexity on High Frequency Road Profile Simulation

Girish R. Radhakrishnan[1,2], Zakariás Erősdi[2], Pedro Calorio[2], Bruno Finco[2], Claude J. Rouelle[2]

Race tires are subject to high speeds and high vertical loads during cornering. They are also subject to extreme stress when they are driven over high frequency and low amplitude curbs often leading to tire failures.

Research and development by Davis D.C., Zegelaar P.W.A., has shown that when the tire moves over high frequency, low amplitude, and short wavelength obstacles, it exhibits obstacle-enveloping properties. Tire response over such obstacles includes vertical force variation, longitudinal force variation, and rotational speed variation. Additionally, such road inputs excite tire belt dynamics which include high frequency modes. Therefore, a single contact point model is no longer sufficient to predict tire response over such obstacles.

To better capture the tire obstacle-enveloping behaviour, advanced contact patch models such as the tandem-cam model by Zegelaar P.W.A., the radial-interradial spring model by Badalmenti J.M., Davis jr G.R., and the flexible ring model by Gong S., have been developed. To capture high frequency tire belt dynamics, the rigid-ring model has been developed by Zegelaar P.W.A. Previous work combines the rigid-ring model with the tandem-cam model to capture obstacle-enveloping behaviour and tire belt dynamics upto 60-100Hz.

This paper presents a comparative study of different advanced contact patch models in combination with the rigid-ring model to simulate high frequency curbs typically found at racetracks. The curb profile of the Signes corner at the Paul Ricard racetrack is chosen for simulations as they are known to be extremely demanding on the tires often causing failures. An advanced four-wheel model is used to simulate an LMP2 racecar at high speeds. Metrics to quantify the tire response over these high frequency curbs are created and an investigation is conducted to quantify the influence of tire contact patch model complexity on the metrics.

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Paper 6.1

Simultaneous Determination of Additive Concentration in Rubber using ATR-FTIR Spectroscopy

Stephen Merriman[1,2], Dinesh Chandra[3], Marc Borowczak[4], Ali Dhinojwala[2], David Benko[3]

Using attenuated total reflection (ATR) Fourier transform infrared (FTIR) spectroscopy for direct quantitative analysis is highly desirable for many sample systems due to advantages such as rapid spectra collection and being completely non-destructive. However, for many complex sample matrices the feasibility of direct quantitative analysis using ATR-FTIR is uncertain. The commonly used Beer-Lambert law may not be applicable for many systems in general, besides sample related complexities such as inhomogeneity, variable optical properties, or heavily overlapping absorption bands.

In this study, we consider fully formulated vulcanized rubber with carbon black or silica as the primary filler as our system of interest. We developed a method to simultaneously quantify the concentration of three different antidegradents of similar chemical structure directly on rubber samples using ATR-FTIR spectra. Results show that absorbance follows the Beer-Lambert law well for the range of antidegradent concentrations considered. Despite this, a direct application of the Beer-Lambert law to deconvolute overlapping peaks between antidegradents proved insufficient. Through the application of partial least squares (PLS) multivariate analysis, remarkable prediction accuracy of within about 0.15 wt% error for all three antidegradents was achieved for both types of rubber formulations, even with high levels of carbon black. These results show the value this method has for quantitative analysis of additives in rubber. Our investigation highlights the potential usefulness of FTIR spectroscopy in general for rapid quantitative analysis directly on samples of interest without any prior chemical separation.

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Paper 6.2

Automated Tire Mode Shape Classification using Zernike Annular Moments and Flattening

Junhyeon Seo[1], Sudharsan Parthasarathy[1], Siddharth Jain[1], **Rakesh K. Kapania**[1,2]

Tire vibration analysis is a critical step toward understanding tire performance and the automobile in terms of structural-borne noise, vibration, and harshnesses (NVH). In particular, the specific tire mode shapes at certain frequency ranges cause various issues concerning driving controllability, ride, and braking performances. Therefore, it is required to classify mode shapes representing the vibrational features, including modal displacements, wave numbers, and symmetricity for each frequency range.

We first build a database employing common features in tire modes obtained from finite element analysis (FEA). The effect of design changes or environmental changes on the key features of the vibration modes can be rapidly predicted using this database.

This study aims to identify and classify features as a preliminary step in developing the tire modal classification tools. Specifically, one of the feature recognition methods, the Zernike annular moment (ZAM), was used to derive the characteristics of each tire mode shape. The variable values of each ZAM's polynomial can be organized as a vector representing the feature map of individual mode shapes. The series of vector values from each mode shape were compared using the modal assurance criteria (MAC).

This paper also proposes a flattening approach to mapping the modal displacements on the undeformed neutral surface. This approach is used to determine the wave number and symmetricity along with both meridional and circumferential directions of a tire. Using both the proposed methods, namely ZAM-MAC and the flattening approach, we successfully counted wave numbers and determined the symmetricity of the applied baseline tire finite element model in a frequency range under 200 Hz. Also, the tire mode shapes are categorized in diverse representative groups such as axial, radial, torsional, pitch, and other bending modes. The frequency range will be increased in future studies.

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Paper 6.3

Identification of characteristic tire parameters for the virtual steering system design

Dominic Neumann[1,2], Mustaba Ahmadi[3], Mario Weinberger[2], Dieter Schramm[4]

The virtual design of steering systems requires suitable premises for predicting realistic steering rack forces. This includes the proper tire used for the parking maneuver. It is important to select the tire from a portfolio that generates the highest rack forces at the vehicle, so that the mechanical dimensioning of the steering system can be safeguarded for all tires of a vehicle type.

To avoid time-consuming and expensive full vehicle measurements, drilling torques of tires are measured on a Flat-Trac to determine the so-called worst-case tire. However, the determined drilling torques do not always correlate with the measured rack forces.

This work therefore investigates the suitability of a K&C test rig converted to a tire test rig. First, it is investigated whether the wheel movements from the parking maneuver can be decomposed into their individual elements on the test bench. In addition, reproducibility studies are carried out and three different methods for determining the aligning torque under camber are presented. Furthermore, measurements for static and dynamic friction values, as well as stiffnesses and the contact patch, are integrated into the new measurement procedure.

It becomes apparent that the temperature and the wear level of the tire play a major role in the reproducibility of the measurements. If the measurement procedure described in this paper is followed exactly, the scatter of the drilling torque can be reduced by up to 24 %. For the dynamic and the static friction values, the scatter is reduced by about 17 % and 22 %, respectively. Stiffness scatter can be reduced by up to 16 %.

With the new measurement procedure, the worst-case tire can be reliably determined. The measured drilling torques correlate with the rack forces and the additional tire characteristics permit finer resolution.

After evaluation and interpretation, recommendations for future developments are discussed.

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Paper 7.1

Generation of SWIFT Models Virtually Using FEA: Application to Cleat Simulations

Yaswanth Siramdasu[1,2], Gibin Gil[3]

Parameterization methods for commercial tire models (SWIFT and FTire) are developed around existing testing protocols. As an example, cleat tests are used for estimating belt mass and stiffness, and enveloping tests for estimating belt bending and contact stiffness parameters in respective tire models. Currently, this is the only way commercial tire models are parameterized for use mainly by vehicle OEM companies. At present, tire suppliers are stepping up to supply commercial tire models as a part of virtual tire submissions and are virtually simulating standard testing protocols. It is envisioned that with a proper fundamental understanding of commercial tire model parameters and its modeling approach to capture the respective tire dynamics, we can develop simple FE techniques to estimate respective tire model parameters, thus avoiding the simulation of cleat and other dynamic tests using FE.

With that motivation, previous work already showed the estimation of belt mass and bending properties from FE part separation technique. In this work, with a fundamental understanding that the front cam and rear cam models in SWIFT are mathematically modeling the curvature of the loaded tire just outside of footprint, it is shown that by fitting the tandem model to loaded FE model deformed co-ordinates, length (ae), height (be), order of cam (ce), and distance between the cams (ls) can be estimated easily. This simple loaded FE model fitting technique is combined with other computationally simple FE static stiffness, footprint and modal analysis to estimate other SWIFT parameters. Finally, SWIFT models from the above FE techniques are developed for several tire designs and validated against enveloping and dynamic in-plane cleat test data. The simulation response predicted the variation in enveloping and other ride metrics in-line with testing data.

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Paper 7.2

The Benefits of Virtual Tire Evaluation using a Driver-in-the-Loop Simulator (DiL)

Kelly Holshue[1,2], Gary Newton, Jr.[2]

Automotive manufacturers and their tire suppliers are pushing towards more simulation/modeling in efforts to eliminate cost, time, and physical porotypes. These tools also help to achieve a more sustainable environmental footprint and reduce carbon emissions. By utilizing real time simulation software, companies can virtually evaluate products before ever having to build expensive prototypes. This allows timing to be reduced and costs to be cut. The addition of driver-in-the-loop simulators adds to the real time software allowing this concept of virtual evaluations to become reality. These simulators reduce the need for large amounts of submission tires and the post-evaluation waste of scrapping of them. They also eliminate delays caused by weather and other human factors. Snow testing can be done in the middle of summer; dry and wet testing can be done back-to-back the same day with no down time.

Driver-in-the-loop [DiL] simulators are machines that are capable of multiple degrees of freedom allowing the driver/occupant to feel multiple degrees of motion during simulated driving. Drivers can feel things like pitch, yaw, acceleration/deceleration, turning, vertical motion, just like you would feel while driving a real motor vehicle. DiL simulators range from simple to complex and include graphical immersion that links the driver to the vehicle performances allowing evaluations of component, (sub)system and full vehicle testing. The immersion and degrees of freedom coupled with the motion programming allow the driver to use the DiL to perform both objective and subjective measurements.

Successful use of a DiL simulator to evaluate tires offers significant cost and time to market reductions as well as improve a company's green initiatives. The most notable change with the largest immediate return is the reduction of physical tires that are created. This paper will share an example of how a DiL simulator can be used to impact a tire program and the financial ROI from the effort.

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Paper 8.1

Tire Wear Investigation of EVs using Kokusai's Tire Wear Tester

Günter Leister[1], Markus Winter[2]

The mobility of the future will be shaped by the electrification of the vehicle drive. Electromobility can make a very large contribution to environmental and climate protection and helps to reduce exhaust and noise emissions.

These vehicles have a very high torque paired with a response without significant delay, although due to the current battery technology, the battery-electric vehicles have a significantly higher total weight compared to a vehicle with a combustion engine.

The longitudinal and transverse dynamic forces that occur must be transmitted through the tire, which makes the only contact with the road. This study deals with the optimization of tire wear in battery-electric vehicles through appropriate measures.

Tires are examined with respect to operational performance (mileage) and operational stability before the series release. Tire wear and tear endurance tests are carried out on test tracks and on public roads. The wear patterns of the tires should be captured and evaluated. These help the tire developer get a specific potential statement on the respective tires or tread profiles.

The wear characteristics can be reproduced on the test rig as well. There are methods developed for reproducing measured load collectives or for re-creating the results of simulation without season, road, vehicle, course and driver influence. One focus of this procedure is reducing the measurement time compared with ab outdoor test, the other is the energy efficiency of the procedure. KOKUSAI uses a special drum surface which avoids drum wear for many years and additionally consumes a very small amount of energy during a measurement.

If you look at electric vehicles now, there are two fundamental changes: the vehicle weight and the characteristics of the drive torque. In this investigation this influence is quantified.

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Paper 8.2

Factors Influencing Wear of Tyre Tread Rubber

P. Ghosh[1,2], C. Ajay[2] and R. Mukhopadhyay[2]

Tyre wear always remains an important research topic due to its implication on tyre life and environment. With the advent of Electric Vehicle (EV), tyres wear is gaining more importance as tyres will experience higher torque coupled with higher loads due to the increased vehicle weight of EVs. Further, to meet lower rolling resistance requirements of EV tyres, balancing other properties, such as, traction and wear have become a major challenge to tyre designers.

Considering these challenges, the present work aims to understand the influence of important parameters, such as, load, surface roughness, surface temperature and material aging effects on the wear of rubber compounds. Wear measurements of tread compounds based on Natural Rubber (NR) and its blend with Polybutadiene Rubber (BR) were carried out using a Laboratory Abrasion Tester (LAT 100). It has been observed that NR based compounds show higher sensitivity with respect to wear loss towards all these variables in comparison with NR/BR blend compound. Material degradation due to prolonged aging was also captured through an infrared spectroscopic technique. The surface topography of the worn surface of the abraded sample was measured using a high-resolution Optical Microscope.

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Paper 8.3

A study on the Mid-frequency Tire-sourced Cabin Noise in Electrical Vehicles (EV's)

Pejman Razi[1,2]

This study investigates and provides a framework for addressing a reported tire-sourced cabin noise in the mid-frequency range of 300-500 Hz for an EV. Noise, Vibration, and Harshness (NVH) of EV's present new challenges compared to internal combustion engine (ICE) vehicles due to significant design changes between the two vehicle types. In turn, the tire-road interaction noise becomes more significant source of cabin noise in EV's.

In this regard, some prominent EV manufacturers recently reported relatively high measured cabin noise particularly in the mid-frequency range of 300-500 Hz. Identifying root cause(s) of noise in that range is a challenging task as both tire structure-borne and air-borne sources are contributors in that frequency range of elevated noise.

The current work presents the results of an experimental modal analysis to provide insight in some of potential sources of the reported noise for an All Season tire/wheel assembly designed for an EV vehicle. The subsequent parametric simulations, conducted via the tire-vehicle finite element model, evaluates some of the mitigation solutions for the reported noise.

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Paper 8.4

Pass-By Noise Prediction

Phil Shorter[2], **John Lewis**[1,2]

Industry analysts are predicting that vehicle miles traveled globally will double to 20 trillion miles by 2030. Along with mobility changes towards CASE (Connected Autonomous Shared Electric), tire demand and performance is very likely to increase. To help Tire OEMs satisfy these new demands and requirements, DASSAULT SYSTEMES has developed new methods for modeling “tread” noise (includes tread pattern as both a source and amplification in path). These methods combine time domain explicit model (Abaqus) for tread motion with frequency domain vibro-acoustic model (wave6) for noise and vibration prediction.

The Abaqus methodology employs state of the art techniques, such as:

- Advanced simulation methods to rapidly achieve a stabilized rolling condition.
- Advanced non-linear viscoelastic (PRF) material models to ensure a realistic tread response as the lugs impact and release from the footprint region. For example, TanD → PRF as a starting point for material calibration.
- Advanced meshing methods to capture important Sipe and sub-surface feature effects

The Wave6 methodology employs state-of-the-art techniques that can be used to:

- Diagnose high frequency tread motion (using high pass filters)
- Diagnose source contributions (pumping and vibration on source surface)
- Diagnose path contributions (acoustic amplification from tread and contact patch)
- Diagnose response (including spatial source contributions using source windowing)

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Conference Schedule

Monday- Sept 12	Tuesday- Sept 13
8:00 AM- 8:05 AM Conference Opening **Will Mars** *Tire Society President* **8:05 AM-8:15AM - Welcome** **Gary Miller** *President, University of Akron*	**8:00 AM-8:05 AM Opening Remarks** **Gobi Gobinath** *Conference Chair*
8:15 AM- 9:15 AM Keynote Address **Alexis Garcin** **Michelin North America, Inc.,** **Chairman and President** "A Future View of Mobility"	**8:05 AM- 9:05 AM - Plenary Address** **Tracey Norberg** Senior Vice president, USTMA "The Road Ahead - Technology and Policy in the Tire Industry"
9:15 AM-9:20 AM Announcements **Gobi Gobinath** Conference Chair	**9:05 AM-9:55 AM Annual Meeting** **Will Mars** **Tire Society President** **"Business update & State of the Society"**
9:20 AM-9:40 AM - Break	**9:55 AM-10:15 AM - Break**
9:40 AM-11:00 AM Durability (3 Presentations) **Session Chair: Xianwei Meng,The Goodyear Tire and Rubber Company**	**10:15 AM-11:35 AM- Student Session (3 presentations)** **Session Chair: Matt Schroeder , The Goodyear Tire and Rubber Company**
11:00 AM-11:55 AM--Emerging Technologies (2 presentations) **Session Chair:Matthew Van Gennip, Link Engg**	**11:35 AM -12:45 PM Box Lunch(PROVIDED)**
11:55 AM-1:05 PM Box Lunch (PROVIDED) Interactive Poster Presentations	**12:45 PM-1:45 PM Panel Discussion:-Future of Tire Testing** **Moderator: Heather Bobbit,General Motors**
1:05 PM- 2:00 PM -Thermal Evaluation of Tires (2 Presentations) **Session Chair: Qian Li ,The Goodyear Tire and Rubber Company**	**1:45 PM-2:40 PM -Virtual Tire (2 Presentations)** **Session Chair: Mohammad Behroozi, General Motors**
2:00 PM-3:20 PM Tire Testing (3 presentations) **Session Chair: Jerry Pospiech, ACS inc.**	**2:40 PM-3:00 PM- Break**
3:20 PM-3:40 PM- Break	**3:00 PM- 3:55 PM--Tire Performance -Treadwear (2 Presentations)** **Session Chair :Yusheng Chen, Flexsys**
3:40 PM-5:00 PM- Tire/Road Interaction (3 Presentatiions) **Session Chair: Eric Pierce, Smithers**	**3:55 PM-4:45 PM - Tire Performance - Noise(2 Presentations)** **Session Chair -Yusheng Chen, Flexsys**
5:15 PM-6:15 PM Reception: Infoision stadium 5th Floor	**4:45 PM-4:50 PM 2022 Conf. Closing Remarks & POD Availability Announcement** **Gobi Gobinath** *, Goodyear* *Conference Chair* **4:50 PM-5:00 PM 2023 Conference Announcement** **Cedric Mousseau,** *General Motors* 2023 Conference Chair
6:15 PM-6:25 PM -Banquet Welcome Adddress **Daniel Horrigan** **Akron Mayor** **6:25 PM-7:55 PM Awards Presentation** **Barry Yavari** **Chairman, Tire Society Awards Committee** **7:55 PM-9:00 PM Dinner Speech** **Dr. Nohoon Ki,** **Engineering Manager** **John Deere** **"Round and Green: Engineering for Agriculture"**	**5:00PM - END OF CONFERENCE**
9:00 PM- CLOSE OF DAY 1	

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Tire Society 2022 Meeting and Conference
Poster Session Summary

3D Printed Curvilinear Sensor and Tread for Smart Tires Applications

Mazen Kiki[1], Bipendra Basnet[1], Sarath Kamath[1], Jae-Won Choi[1,2]

Molecular Engineering and Additive Manufacturing of Polyisobutylene-Based Functional Elastomers

Naifu Shen[3], Linrui Duan[3], Muxuan Yang[3], Weinan Xu[2,3]

A Computational Model for Non-destructive Measurements of Snow Properties Using Seismic Wave Propagation for Winter Tire Design Purposes

SeyedArmin MotahariTabari[4], Nariman Mahabadi[2,4]

Aerodynamic Drag Performance of Spherical Tire

Akshay K. Pakala[1], and Alex Povitsky[1,2]

Feasibility Study on Temperature Stable Piezoelectric Energy Harvester for Smart Tire Sensors

Niccolo Lemonis[5], Ryan C. Toonen[6], Kye-Shin Lee[2,5]

Comparative Testing of Compression Testing Devices in Snow

Mohit Nitin Shenvi[7,8], Corina Sandu[2,7], Costin Untaroiu[2,8]

Modelling and Prediction of Snow Compression and Shear Behavior Using Finite Element Analysis – Arbitrary Lagrangian-Eulerian and Smoothed Particle Hydrodynamics Techniques

Yogesh Surkutwar[8], Costin Untaroiu[2,8], Corina Sandu[2,7]

Enhanced Crystallinity of Recycled PET Materials

Gavan Lienhart[3], Sayan Basak[3], Leyao Wu[3], James Eagan[2,3], Kevin Cavicchi[2,3], Sadhan Jana[2,3]

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[2] Faculty Advisor
[3] University of Akron, School of Polymer Science and Polymer Engineering
[4] University of Akron, Department of Civil Engineering
[5] University of Akron, Department of Electrical and Computer Engineering
[6] NASA – Glenn Research Center
[7] Virginia Tech, Terramechanics, Multibody, and Vehicle Systems Laboratory
[8] Virginia Tech, Center for Injury Biomechanics