DELIVERING DURABILITY ACROSS THE RUBBER SUPPLY CHAIN

ENDURICA COMMUNITY CONFERENCE

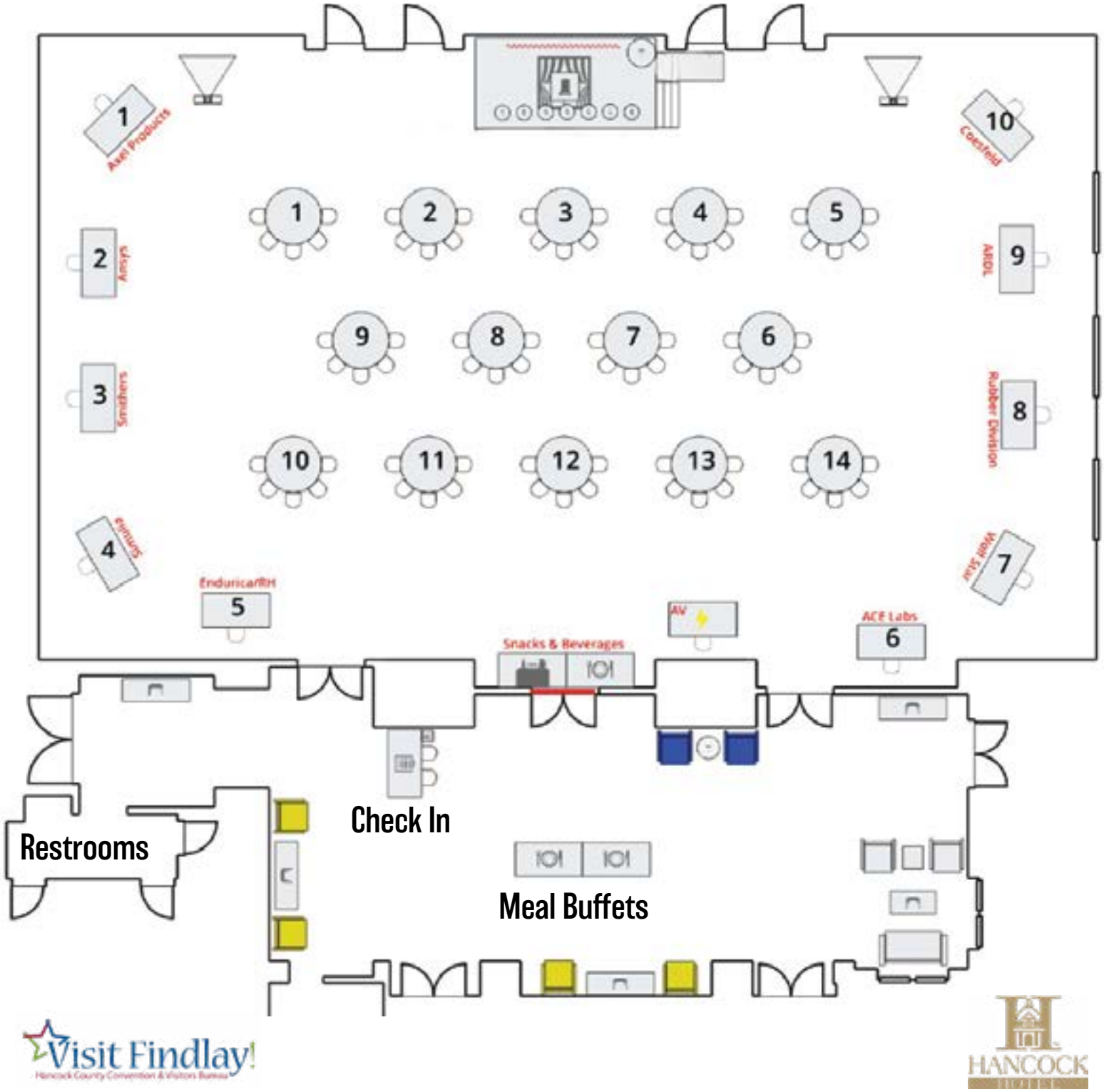
APRIL 8-9, 2024
FINDLAY, OHIO USA

#enduricaeclipse2024

#deliverdurability

WELCOME!

Endurica is excited and proud to present its first ever community conference. The Endurica community includes OEMs, rubber part suppliers and raw material suppliers. It includes engineers and management working across the supply chain to deliver durability: simulation engineers, test engineers, materials engineers, product engineers – anyone with a stake in delivering durability. Let's get durability right!



AGENDA

Monday April 8, 2024 – Day One

8:00 a.m. Continental Breakfast – Registration Opens

9:00 a.m. **Welcome**
William V. Mars, Ph.D., P.E.,
Founder and President, Endurica

OEM Perspective

9:15 a.m. **Owning Rubber Part Durability for Suspension Applications in the Virtual Age**
Matthew Wieczorek
Engineering Group Manager
General Motors Company

9:45 a.m. **Breaking New Ground: Delivering Elastomer Durability for Heavy Equipment**
Hui Deng, Ph.D.
Design Analysis & Simulation for NAFTA & APAC
CE Central Product Validation
CNH Industrial
Aniket Vishwarupe
Technical Specialist (FEA)
CNH Industrial

Materials and Testing

10:15 a.m. **Characterizing Tensile Strength Distribution to Evaluate Filler Dispersion Effects and Reliability of Rubber**
Lewis Tunnicliffe, Ph.D.
R&D Director – Rubber Carbon Blacks
Birla Carbon

10:45 a.m. Break

11:00 a.m. **Material Quality Effects on Failure Statistics of Rubber**
Christopher G. Robertson, Ph.D.
Principal Consultant
Polymer Technology Services, LLC

11:30 a.m. **Measuring Material Properties for the Durability Analysis of Rubber Products**
Kurt Miller
President
Axel Products

12:00 p.m. **Testing for Durability Simulation and Product Development**
Christian Kipscholl
President
Coesfeld Material Test GmbH

12:30 p.m. Lunch

1:30 p.m. Eclipse Viewing - to the roof!

Learning Stations / Refreshments / Networking

4:00 p.m. Browse, discuss, and get valuable information from Sponsor and Endurica stations.

6:00 p.m. Dinner featuring presentation by
David Cawthra and *Gail Reader*
Rubber Heart

Tuesday April 9, 2024 – Day Two

7:30 a.m. Full Breakfast

8:30 a.m. Accurate. Complete. Scalable: 3-year vision
William V. Mars, Ph.D., P.E.
Founder and President, Endurica

Supplier Perspective

9:00 a.m. **Rate Loss in Suspension Bushings**
Vladimir Pedraza Otero
Senior Design & Product Engineer, Rassini

9:30 a.m. **Predicting a Rubber Spring's Wohler Line with Endurica in the Presence of Self-Contact**
Nina Heinrich, Ph.D.
Structural Engineer, Trelleborg Antivibration Solutions

10:00 a.m. **Measuring Nonlinear Proving Ground Loads for a Rubber Component**
Tim Hunter, Ph.D.
President, Wolf Star Technologies

10:30 a.m. Break

11:00 a.m. **Delivering Durability Across the Rubber Supply Chain**
Panel discussion moderated by
Thomas G. Ebbott, Ph.D., Vice President, Endurica
Panelists

Kevin Barbash, VDDV Technical Specialist for Suspension and Driveline, General Motors

Scott Braddock, CAD / CAE Manager, Tenneco

Prasanna Kandapalli, Ph.D., Team Leader/Structural CAE Group, Performance Materials Division, BASF Corp.

Mohammed Rezaul Karim, Ph.D., Technical Consultant, Celanese

Anoop Varghese, Ph.D., Technical Specialist, Durability & Simulation Bridgestone Americas

Touhid Zarrin-Ghalami, Ph.D., CAE Front Chassis Engineer, Durability Technical Specialist, Stellantis, NA

12:00 p.m. Lunch — featuring presentation by
Bruce Meyer, Editor of *Rubber News*

12:45 p.m. **Code Feature Update and 1 Year Development Plan**
Jesse Suter, Development Manager, Endurica

1:15 p.m. **Optimal Design of a Support Ring Type Run-Flat Tire System for High Fatigue Life in Zero Pressure Driving Conditions**
Abhishek Saraswat, Graduate Student, Virginia Tech working at Centre for Tire Research (CenTiRe)

1:45 p.m. **Workflows for Tire Analysis**
Mark Bauman, Engineering Analyst, Endurica

2:15 p.m. **Computing Tire Durability from Road Loads from the Nurburgring Circuit**
Jason Barr, Simulia Industry Process Consultant, Dassault Systemes

2:45 p.m. **Break** – last chance to visit with sponsors

3:00 p.m. **Companion Material Property Comparator**
Ethan Steiner, Sales Engineer, Endurica

3:15 p.m. **Durability Workflows with Ansys**
Salim Yagoub, Structural Analysis Engineer, FE-Tech

3:45 p.m. Concluding Remarks / Giveaways from Sponsors

4:00 p.m. Adjourn

OWNING RUBBER PART DURABILITY
FOR SUSPENSION APPLICATIONS IN THE VIRTUAL AGE

OEM

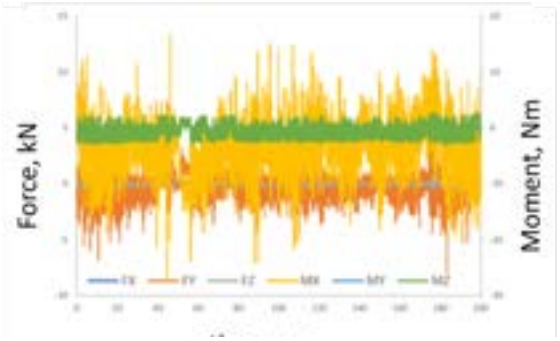
ABSTRACT

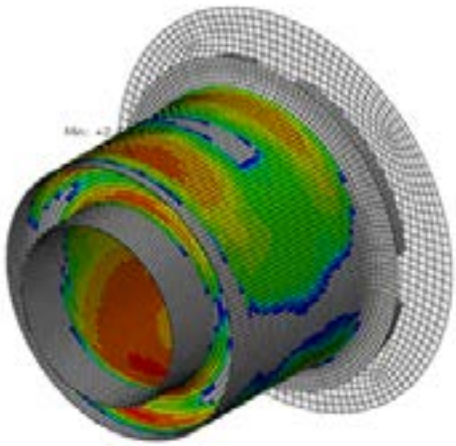
The qualification requirements of automakers derive from track testing in which road load and moment inputs to a part in x, y, and z directions are recorded over a set of driving conditions selected to represent typical operation. Because recorded histories are lengthy, often comprising many millions of time steps, past industry practice has been to specify simplified block cycle schedules for purposes of durability testing or analysis. Simplification, however, depends on imprecise human judgment, and risks fidelity of the inferred life and failure mode relative to actual. Fortunately, virtual methods for fatigue life prediction are available that are capable of processing full, real-time, multiaxial road load histories. Two examples of filled natural rubber ride bushings are considered here to demonstrate. Each bushing is subject to a schedule of 11 distinct recorded track events. Endurica EIE™ map building procedures are first used together with a finite element solution to map the loading space (x, y, and z) and to obtain stress/strain solutions at each gridpoint in the load space. EIE is then used with the recorded histories to interpolate from the recorded road load inputs on the bushing to stress-strain history at each element centroid in the finite element model. The interpolated stress-strain histories are then used to compute damage accrual and fatigue life across all 11 events. The computational requirements of this workflow are benchmarked with the outcome that the entire schedule in full detail can be analyzed on a timescale well suited for use at the earliest stages of business development and engineering.

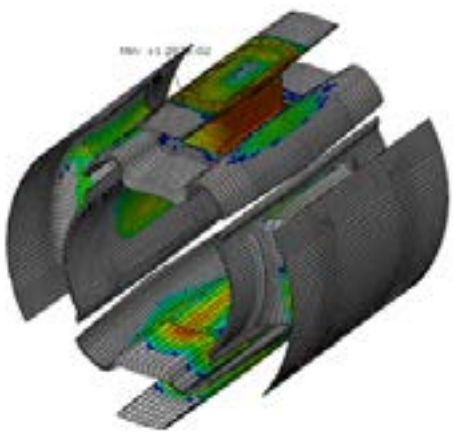
Matthew Wieczorek

Engineering Group Manager, General Motors Company

Matt is the Engineering Group Manager for the fuel delivery systems team at General Motors, leading a team of technical specialists and engineers who design and release fuel injection and evaporative emissions control components for gasoline and diesel engines. He was promoted into his current position from his role of Technical Expert (BOM Family Owner) for Suspension Bushings, Mounts, and Jounce Bumpers which he held for nearly six years. During this time, Matt was GM's corporate technical expert for suspension rubber, managing technical requirements for suspension bushings, body mounts, cradle mounts, strut/shock mounts, and suspension bumpers. He provided technical leadership and trouble-shooting expertise to the suspension and structure DREs. Prior to this, Matt was the Lead Design and Release Engineer, Heavy Duty Truck Frames and Suspensions. During this time Matt was the technical lead for a team of engineers responsible for the vehicle frame and suspension syste, interfaces between components, and interactions with other vehicle systems. Matt earned his Bachelor's Degree in Electrical Engineering from The University of Toledo.







General Motors' vision is to create a world with Zero Crashes, Zero Emissions, and Zero Congestion, and is committed to leading the way toward this future. In the midst of today's transportation revolution GM has the ambition, the talent and the technology to realize the safer, better and more sustainable world we all want. As an open, inclusive company, General Motors is creating an environment where everyone feels welcomed and valued for who they are — one team, where all ideas are considered and heard, where everyone can contribute to their fullest potential, with a culture based in respect, integrity, accountability, and equality. The team at GM brings wide-ranging perspectives and experiences to solving the complex transportation challenges of today and tomorrow. General Motors pioneers the innovations that move and connect people to what matters.

BREAKING NEW GROUND
DELIVERING ELASTOMER DURABILITY FOR HEAVY EQUIPMENT

OEM

ABSTRACT

Fatigue life of the isomount has always been a big issue for the heavy equipment industry. A lot of money has been spent in physical testing. The procedure is very time consuming and usually has a hard time meeting development milestones. Therefore, in CNH we are using Endurica to predict the fatigue life of the rubber isomounts. The example shown in this presentation shows good correlation with our testing.

Hui Deng, Ph.D.
Design Analysis & Simulation for NAFTA & APAC CE Central Product Validation

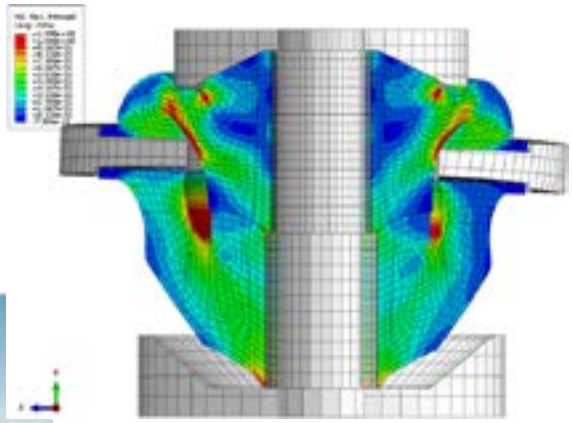
In 1997, Hui joined CASE which later became CNH and CHNI, and has held numerous positions including analyst, technical specialist, manager, and technical leader. He is currently responsible for virtual simulation for CNHI construction equipment in both the NAFTA (Mexico, Canada and the United States) and the LATAM (South America, Central America, Mexico, and the islands of the Caribbean) regions. His work spans CNH Industrial's key products including the Tractor Loader Backhoe, Skid Steer Loader, Dozer, Compact Track Loader and Wheel Loader.

Deng earned his Ph.D. from the Department of Mechanical & Aerospace Engineering at the University of Florida; his Master's and Bachelor's degrees were conferred by the Department of Mechanics and Engineering Science at Beijing University in China.

Aniket Vishwarupe
Technical Specialist (FEA)

Aniket has worked with CNHI for last 11 years and currently serves in a Technical Specialist (FEA) role. He has helped to engineer various construction equipment including CNHI's Wheel Loader, Vibratory Compactor, Tractor Loader Backhoe and Skid Steer Loader, as well as other large tractors and attachments. Aniket works mainly on frames, attachments, driveline components, and supporting structures.

He holds a Bachelor's of Mechanical Engineering from Government College of Engineering Aurangabad MH, India and a Master's of Mechanical Engineering (focus on Solid Mechanics, design and manufacturing) from University of Florida.



CNH is a world-class capital goods company specializing in equipment and services for agriculture and construction. The company operates commercially through its brand portfolio which includes Case IH, New Holland Agriculture, New Holland Construction, and CASE Construction Equipment. Building on more than two centuries of history, CNH Industrial continues to pioneer, innovate and drive customer efficiency toward greater success. CNH's 40,000+ employees focus on empowering customers to grow, and build, a better world.

CHARACTERIZING TENSILE STRENGTH DISTRIBUTION TO EVALUATE FILLER DISPERSION EFFECTS AND RELIABILITY OF RUBBER

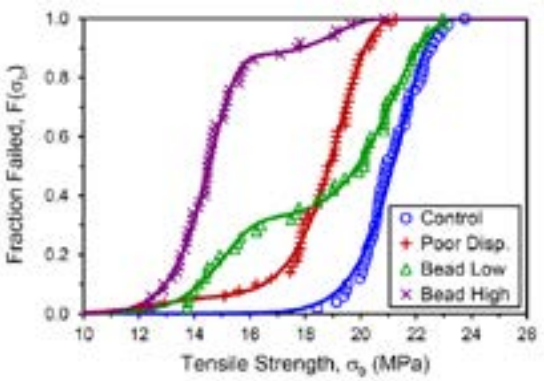
ABSTRACT

Undispersed filler agglomerates or other substantial inclusions/contaminants in rubber can act as large crack precursors that reduce the strength and fatigue lifetime of the material. To demonstrate this, we use tensile strength (stress at break, σb) data from 50 specimens to characterize the failure distribution behavior of carbon black (CB) reinforced styrene-butadiene rubber (SBR) compounds. Poor mixing was simulated by adding a portion of the CB late in the mixing process, and glass beads (microspheres) with 517 μm average diameter were introduced during milling to reproduce the effects of large inclusions. The σb distribution was well described with a simple unimodal Weibull distribution for the control compound, but the tensile strengths of the poor CB dispersion material and the compounds with the glass beads required bimodal Weibull distributions. For the material with the lowest level of glass beads–corresponding to less than one microsphere per test specimen–the bimodal failure distribution spanned a very large range of σb from 13.7 to 22.7 MPa in contrast to the relatively narrow σb distribution for the control from 18.4 to 23.8 MPa. Crack precursor size (c0) distributions were also inferred from the data, and the glass beads introduced c0 values in the 400 μm range compared to about 180 μm for the control. In contrast to σb, critical tearing energy (tear strength) was unaffected by the presence of the CB agglomerates and glass beads, because the strain energy focuses on the pre-cut macroscopic crack in the sample during tear testing rather than on the microscopic crack precursors within the rubber. The glass beads were not detected by conventional filler dispersion measurements using interferometric microscopy, indicating that tensile strength distribution characterization is an important complementary approach for identifying the presence of minor amounts of large inclusions in rubber.

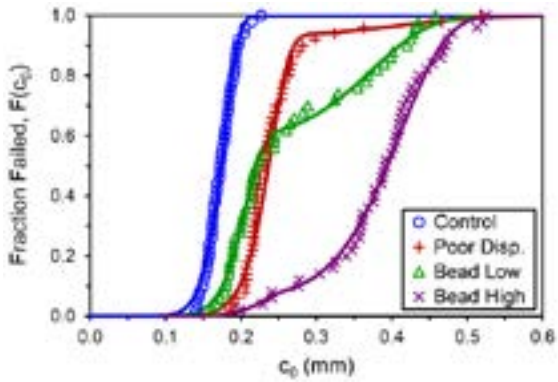
Lewis Tunnicliffe, Ph.D.

R&D Director - Rubber Carbon Blacks

Lewis holds a master's and PhD degree in Materials Science with a focus on rubber materials from Queen Mary University of London. He has expertise in carbon black as well as fracture, viscoelasticity, particle reinforcement and structure-property relationships of rubbers. Lewis received the 2022 Sparks-Thomas Award from the Rubber Division, ACS and has published over 20 peer reviewed articles and two book chapters on rubber science and technology. He is currently based in Atlanta, GA.



$$c_0 = \frac{T_c(1+\varepsilon_b)^{1/2}}{\pi W_b}$$



Birla Carbon is one of the world's largest manufacturers and suppliers of high-quality carbon black and is one of the flagship businesses of the $60 billion global conglomerate Aditya Birla Group, whose footprint extends across 12 countries with 16 manufacturing facilities with a combined annual capacity of 2 million tonnes.

Birla Carbon provides a complete portfolio of products across ASTM grades and specialty blacks to meet the specific end requirements across tires, rubbers, plastics, inks, and paints sectors worldwide. With two state-of-the-art technology centers at Marietta (USA) and Taloja (India), Birla Carbon is an ardent practitioner of sustainable development. Sustainability aspects include employee safety, environmental stewardship, efficient use of carbon black, and a key focus on conducting operations in a socially and ethically responsible manner.

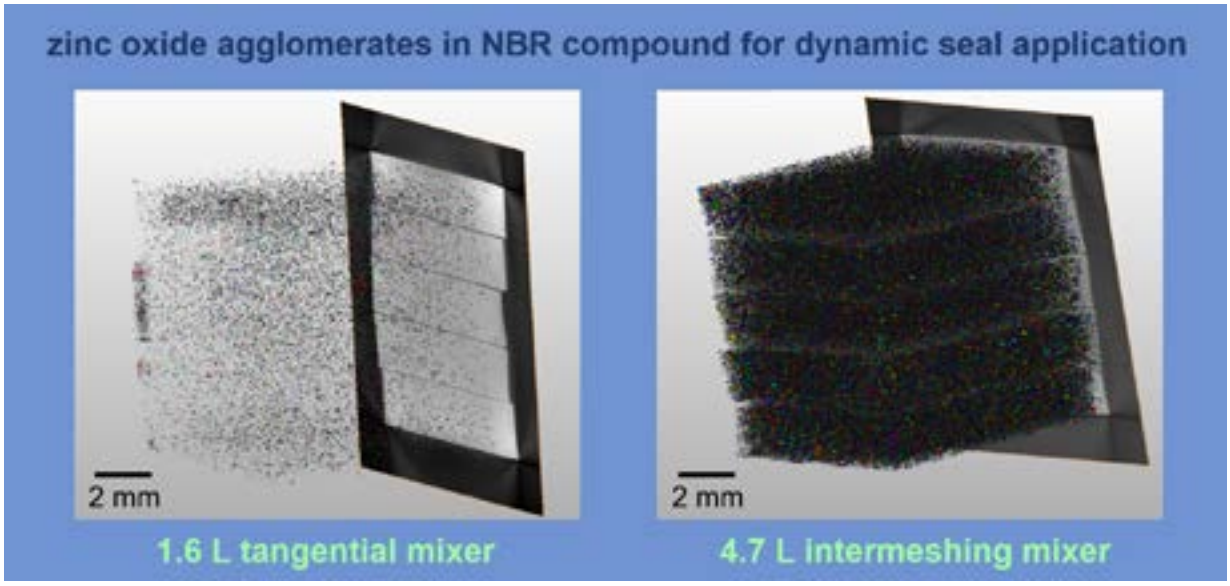
MATERIAL QUALITY EFFECTS
ON FAILURE STATISTICS OF RUBBER

ABSTRACT

Fracture in rubber starts from microscopic crack precursors that are also called flaws, defects, or inclusions. Crack precursors can come from formulation ingredients that are not fully dispersed during the rubber mixing process, such as filler agglomerates. Contaminants in raw materials, like dirt in natural rubber or sieve residue from ball coke, grit, and the like in carbon black, can also be the critical flaws that initiate cracks in rubber. It will be shown how characterizing failure statistics for tensile strength (tensile strength distribution) is a simple and effective way to quantify filler dispersion effects and diagnose the presence of defects/inclusions in rubber. The approach is applied to compare mixing quality for three internal mixers of varied size and type used for mixing a carbon black filled nitrile-butadiene rubber (NBR) formulation. A study of model defects in a carbon black filled styrene-butadiene rubber (SBR) compound gives insights into the number of replicate test specimens that are needed to “find” large inclusions present at low concentration. The implications of material quality effects on product durability and its prediction will also be discussed.

Christopher C. Robertson, Ph.D.
Principal Consultant

Chris is principal consultant at Polymer Technology Services LLC in Akron, Ohio (USA), a company that he founded in 2021 to provide technical consulting and training for the rubber industry and the polymer technology field in general. The consulting that Chris is involved with includes working as an expert witness for legal cases in the intellectual property and product liability areas. Chris has more than 20 years of experience as a materials scientist and engineer in the tire, synthetic rubber, rubber additives, and plastics industries, including four years in a combined commercial and technical role at Endurica LLC. Since 2020, Chris is serving as the editor-in-chief of the scientific journal *Rubber Chemistry and Technology* and was an associate editor for 10 years prior. Chris also teaches online graduate courses on elastomer science and technology as an adjunct professor in the Department of Plastics Engineering at the University of Massachusetts Lowell. Chris has expertise and research interest in polymer viscoelasticity and rheology, rubber compound development, and elastomer fracture behavior.



Polymer Technology Services LLC provides technical consulting services in the areas of

- Materials development for tires, anti-vibration systems, seals, and other rubber applications
- Raw materials selection and compound formulation to improve viscoelastic behavior, durability, and other properties of rubber/elastomers
- Developing lab test methods to predict product performance
- Rubber, thermoplastic elastomers, plastics, and related raw materials
- Technical marketing of raw materials and lab instruments
- Expert witness in patent litigation and other legal matters
- Customized rubber technology short courses for industrial scientists, engineers, and technologists

MEASURING MATERIAL PROPERTIES
FOR THE DURABILITY ANALYSIS OF RUBBER PRODUCTS

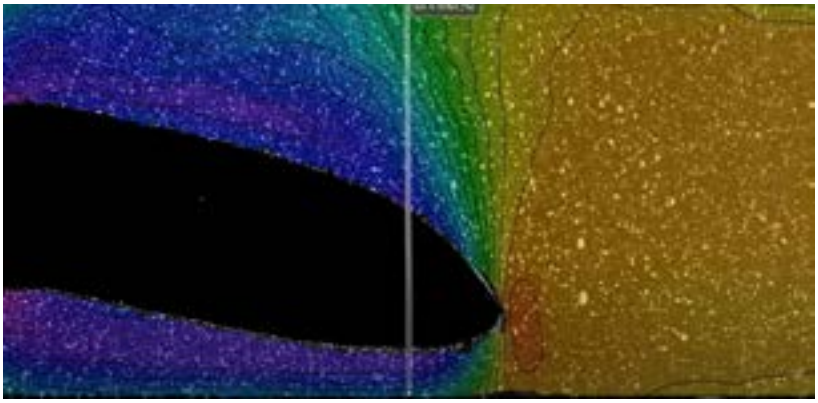
PRESENTING SPONSOR

ABSTRACT

Successful fatigue and failure analysis begins with accurate material properties. Rubber parts experience complex strain distributions and unique failure mechanisms. Traditional and advanced laboratory experiments used to capture these properties are presented.

Kurt Miller
President

Kurt is the Founder and President of Axel Products, Inc., an engineering lab specializing in the structural testing of nonlinear materials for engineers and analysts since 1994. Prior to founding the firm he worked at Instron Corporation in engineering, applications and sales. Kurt is a 1983 graduate of Cornell University with a degree in Mechanical & Aerospace Engineering and has completed graduate-level coursework in Robotics and Artificial Intelligence at Harvard University and in Business Administration at University of Michigan.



Axel Products provides testing services for engineers and analysts. The focus is on the characterization of nonlinear materials such as elastomers and plastics. Data from the Axel laboratory is often used to develop material models in finite element analysis codes such as ABAQUS, Endurica, MSC.Marc, ANSYS, and LS-Dyna. Testing services are also provided to examine sealing and fatigue problems, long term thermal mechanical testing and high strain rate testing. The company was founded in 1994.

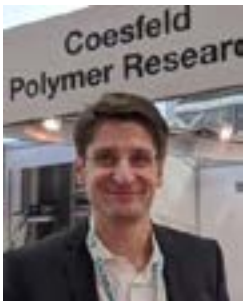
TESTING FOR DURABILITY SIMULATION
AND PRODUCT DEVELOPMENT

PRESENTING SPONSOR

ABSTRACT

Meet the demands of durability simulation and materials development on a production scale with Coesfeld testing instruments. Coesfeld builds instruments that are demanded by modern engineering workflows. For more than 50 years, Coesfeld has been a leader in developing measurement instrumentation for research and development in the rubber and plastics industry. Our Tear and Fatigue Analyser was the first fully automated, commercial system for measuring fatigue crack growth. We have continued to improve and develop the system, which today provides the most reliable and efficient crack growth measurements available on the market. We have partnered with Endurica to launch the Intrinsic Strength Analyser, which provides a method for measuring rubber's fatigue limit. We also offer a number of other instruments for measuring heat build up, friction, cut and chip, and ozone attack.

Christian Kipscholl, Ph.D.
President



Christian Kipscholl is the President of Coesfeld MaterialTest GmbH. For more than 50 years, Coesfeld has been a leader in the development of materials testing instruments for the rubber industry. Dr. Kipscholl studied Industrial Engineering at the Technical University of Darmstadt. He holds a Dr.-Ing. degree from the Faculty of Electrical Engineering and Information Technology at the Technical University of Darmstadt.

Coesfeld Materialtest develops, produces, and sells material testing machines for plastics, composites, elastomers, and other mineral oil products worldwide. Tailor-made, high-quality test devices are crafted through individual or small series production, responding to specific requirements. Standardized instruments for relevant test standards including DIN, ISO, EN, ASTM and others, are also available. Coesfeld was founded in 1968 by Adolf Coesfeld, and is now in its third generation of family leadership with headquarters and production in Dortmunc, Germany. The business has a three-prong approach, divided into the production of standard products, work on custom-made instruments, and the 2013 addition of PRL - Polymer Research Lab - to independently provide contract measurements and services for material development.

ACCURATE. COMPLETE. SCALEABLE.
ENDURICA 3-YEAR VISION

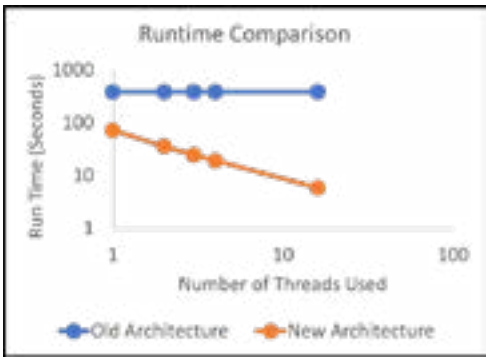
CONFERENCE HOST

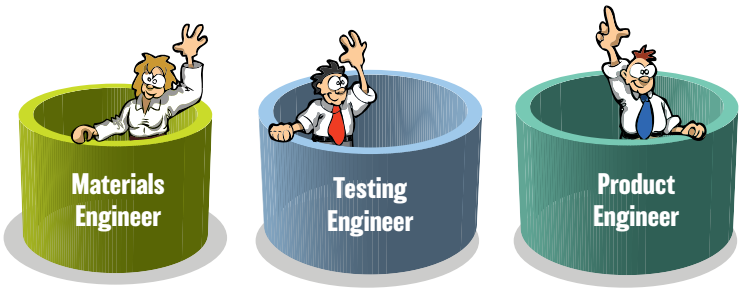
ABSTRACT

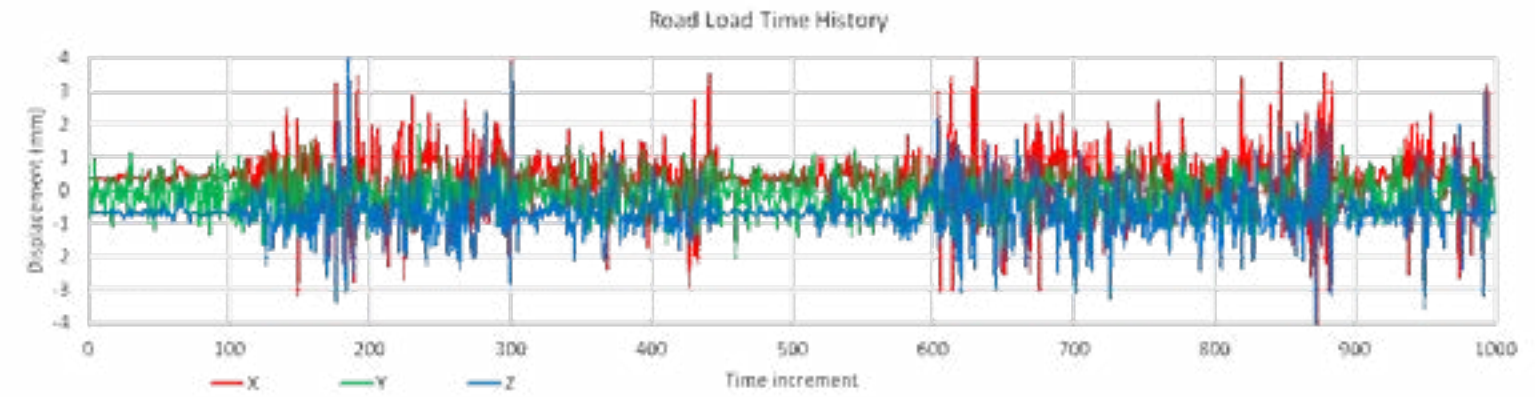
Durability is a core part of the value proposition for most engineered rubber products. Achieving it requires correct decisions along a quite lengthy chain of events that occur along the supply chain. Raw materials must be correctly selected, sourced, and controlled. Rubber parts must be correctly specified, designed, tested, and manufactured. Systems containing rubber must operate under incredibly complex service conditions, which must be properly quantified, incorporated to procurement and purchasing requirements, and evaluated. Conflicts and gaps between how requirements are understood and fulfilled between parties in the chain can create problems that result in under-optimized durability. Simulation offers a powerful tool for addressing such problems, and is more and more becoming a requirement across the supply chain. This presentation discusses Endurica's vision for durability workflows for the rubber industry, and what it means to achieve solutions that are accurate, complete and scalable.

William V. Mars, Ph.D.
Founder & President

Dr. Will Mars is an international leader in the failure mechanics of rubber. He is the founder and president of Endurica LLC, and the firm's products and services are used by leading firms around the world to manage durability. He is the author of the Endurica fatigue life solver, the world's best-validated fatigue life simulation system for elastomers. Dr. Mars' career focuses on applying experimental and computational mechanics in pursuit of better-performing rubber products and he has three decades of experience developing testing and simulation methods in the rubber industry. Dr. Mars earned his Honors BSME with Polymer Specialization at the University of Akron, and his Master's and Ph.D. degrees at the University of Toledo. He has received several awards for his scientific contributions and innovations including the 2022 Herzlich Medal for outstanding impact and innovation in the tire industry, the 2020 Tibbett's Award from the Small Business Administration of the United States for excellence in creating cutting-edge technologies, the 2017 Rubber Division ACS Arnold Smith Special Service Award, the 2007 Sparks Thomas Award of ACS Rubber Division, and the 1999 Henry Fuchs Award of the SAE Fatigue Design & Evaluation committee. Dr. Mars served as the chief editor of *Rubber Chemistry and Technology* for 10 years and is a former editor of *Tire Science and Technology* as well. He has over 60 peer-reviewed scientific publications and four patents in the area of elastomer durability.







Endurica helps you answer your key question: "How Long Will It Last?" through the world's most comprehensive CAE workflows for fatigue analysis of elastomers. Endurica solutions include simulation software, characterization services, testing instruments, and training. We help you test fatigue performance on new or existing design ideas with a variety of rubber compounds/materials, enabling you to know your solutions will work before you mix and mold. Endurica assists you with experimentation, exploration, and reduces the total number of iterations needed to maximize your design's potential. Founded in 2008 to bring fatigue life prediction capabilities to the rubber industry, Endurica is the best-validated and most versatile fatigue life simulation system for elastomers. Address durability issues earlier in the product development process than ever before and get to market faster with Endurica.

RATE LOSS IN SUSPENSION BUSHINGS

SUPPLIER PERSPECTIVE

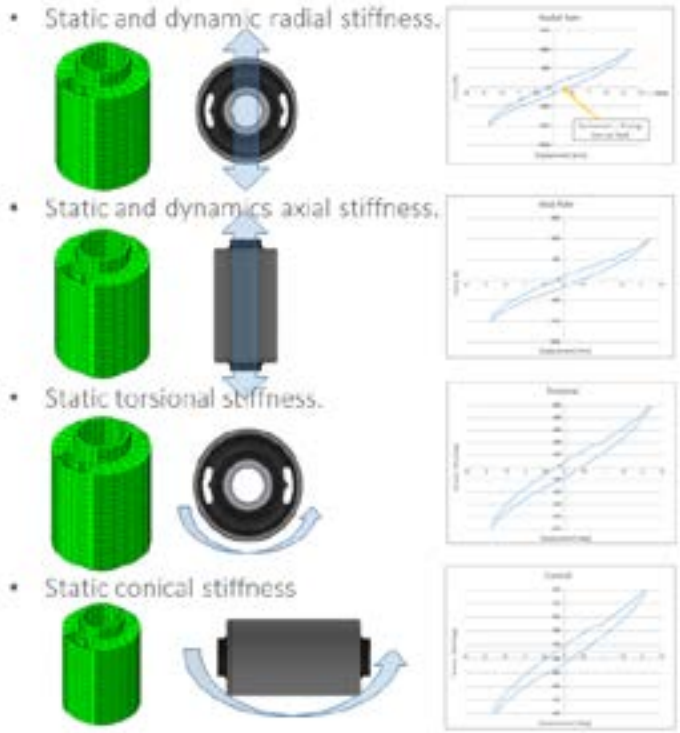
ABSTRACT

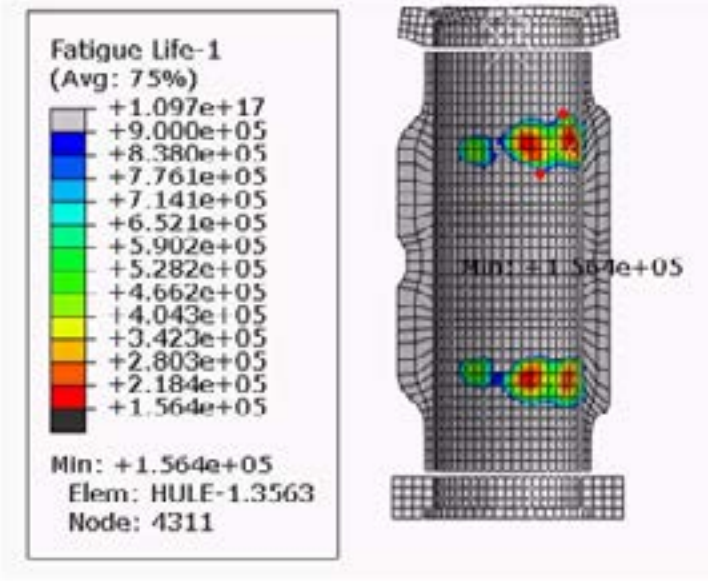
The failure criterion for suspension bushing is often based on stiffness rate loss rather than crack growth. In this work, we discuss Rassini's testing requirements and simulation workflow for managing this failure mode.

Vladimir Pedraza Otero

Senior Design & Product Engineer

Vladimir has 15 years of experience in mechanical design with seven years of experience in bushing design, test development and FEA. He has been with Rassini Bypasa since 2017 monitoring projects from development, design, prototypes, testing, control plan to production part approval process release, and verification. Prior to this he worked with Voltran Transformers progressing from Mechanical Designer to Technical Manager to Mechanical Designer Approval roles. Vladimir has also worked as a Process Engineer iimplementing a continuous improvement project/lean manufacturing proces in a welding plant.He attended Pachuca Technological Institute.





Rassini is the world's largest producer of suspension components for light commercial vehicles and the only fully integrated brake rotor producer in America. The firm develops mobility solutions through big data, artificial intelligence, widespread digitalization and innovation in both processes and materials. Rassini offers solutions to car manufacturers in 10 countries, supplying components to more than eight million cars each year.

PREDICTING A RUBBER SPRING'S WOHLER LINE
WITH ENDURICA IN THE PRESENCE OF SELF-CONTACT

SUPPLIER PERSPECTIVE

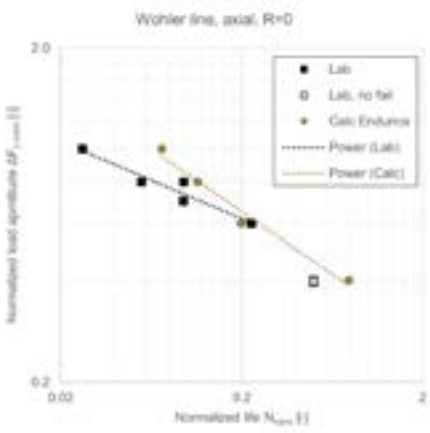
ABSTRACT

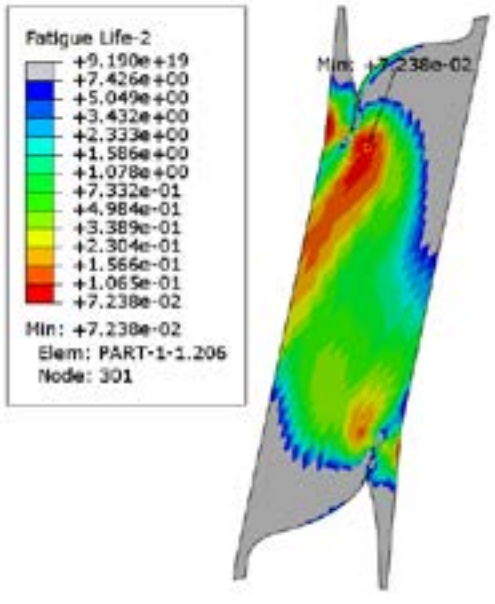
Fatigue tests with different load amplitudes under fully relaxing conditions were carried out to obtain the Wohler line of a conical rubber-to-metal spring, which is representative for railway applications. Using Abaqus FEA, the same load cases were simulated to calculate the strain histories and, subsequently, a fatigue life prediction from Endurica. A close agreement between measured and calculated life was found, in particular for low load amplitude. At high amplitude, the calculation overestimates the life about a factor of three. For this type of deviation self-contact, which intensifies with increasing load, is discussed as a likely reason. Further challenges, i.e. extrapolation of measured material properties and varying failure criterions, will be highlighted.

Nina Heinrich, Ph.D.
Structural Engineer

A detail-oriented expert engineer, Nina found her passion in the rail vehicle industry. Her FEA skills include mastery of Abaqus simulation models and related Python programming scripting. Nina's outstanding presentation and educational skills are supported by an ever-present eagerness to master new topics and take on challenging tasks. She joined Trelleborg Antivibration Solutions in 2021 as a Structural Engineer, conducting FEA calculations of rubber-to-metal parts and air spring systems for railway applications. Nina also runs proof of strength (FKM) and rubber fatigue analyses. She enjoys contributing to innovation activities while managing internal and external research projects and advising colleagues on the latest in FEA developments.

During her college years, Nina interned at Schaeffler, validating simulations with measurement data and performing FEA calculations of timing chain tensioners as well as at Sachs Engineering GmbH developming kinematic models for pitch angle control of vertical axis wind turbines. She earned her Doctor of Engineering - Ph.D., from Technische Universität Chemnitz, Germany, with extensive work on the FE modeling of elastomer components with reinforcing textile cords at the example of air springs. She also holds Master of Science and Bachelor of Science degrees in Mechanical Engineering from Technische Universität Chemnitz.





Machinery drives industry around the world, from trains carrying cargo along the rails through to off-highways vehicles laying the foundations of the future. But wherever there's machinery, there's vibration, and where there's vibration there's a need to protect productivity and the people who work in these environments.

Trelleborg Antivibration Solutions creates shock, noise and suspension solutions that are tailored to their specific environments. Taking your project from concept, through manufacturing, to testing and installation, our expert polymer engineers are on hand to keep your operations running smoothly, safely and efficiently. Trelleborg specializes in Antivibration Solutions for: Rail and Mass Transit, Marine, Industrial Applications, and Off-Highway Vehicles.

MEASURING NON-LINEAR PROVING GROUND LOADS
FOR A RUBBER COMPONENT

PRESENTING SPONSOR

ABSTRACT

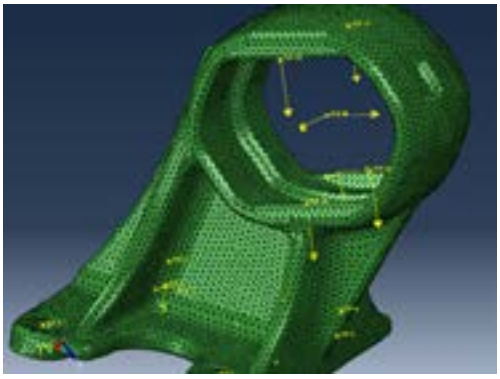
Engine mounts typically have snubbing features and thus undergo much non-linear loading during proving ground testing and normal operation. It is important to understand the non-linear loading of engine mounting systems for the durability of the engine mounts and the associated systems. Shown in this paper will be an application of the True-Load load reconstruction software and advanced application of Hybrid loading methodology to approximate the non-linear snubbing loads from the engine mounts.

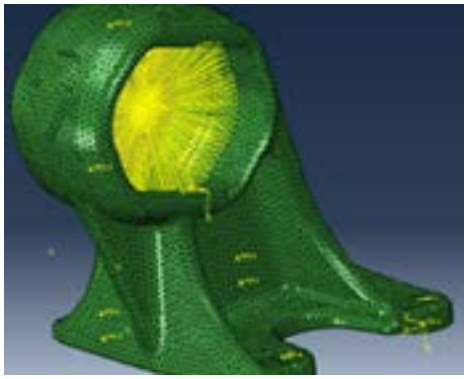
Tim Hunter, Ph.D.
President

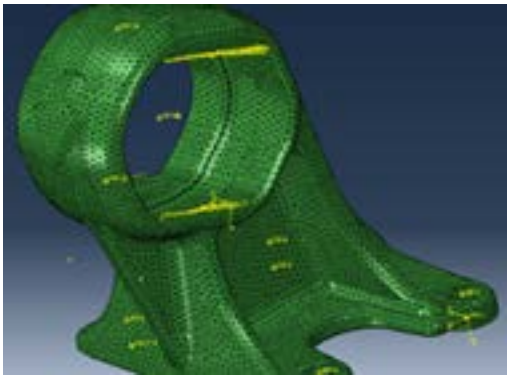
Tim is considered a world authority on Structural Analysis and the author of True-Load software which provides a critical understanding of loading on complex structures. His mission is to bridge the gap from the current state of engineering tools to the solutions needed for future success. True-Load extends the capabilities of FEA software, equipping product engineers to answer key questions from “what are my loads?” to “where is the best place to lay strain gauges?” and “what is the best shape?”.

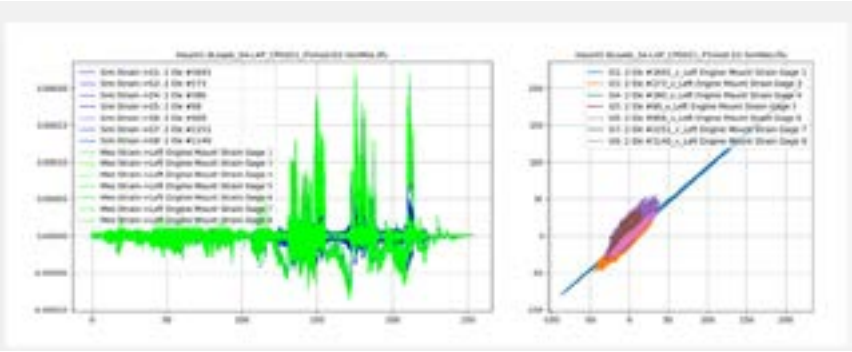
Prior to founding True-Load, Tim was with Harley-Davidson for 22 years and led a group of 70 engineers, designers and managers. During his tenure there, Tim had exposure and responsibility for every aspect of the product development process – every model of motorcycle in Harley-Davidson’s production benefitted from his direct influence, from the frame and swingarm to nearly every gas tank and fender.

He holds both a Ph.D. in Engineering Mechanics and an MSME in Mechanical Engineering from the University of Wisconsin-Milwaukee. Tim met his wife, Ceal, while attending Marquette University as an undergrad. He was the crazy engineer who loved his studies and also took a full load of dance classes through the theater department. He has been married for over 30 years and has two grown daughters who are well on their way in technical careers.









Wolf Star Technologies understands the challenges of product development, including the structural and dynamic issues that plague every project. Wolf Star Technologies has unique, first-to-market solutions that meet the fundamental needs of engineers / analysts working with FEA tools. The firm's software packages, True-Load, True-QSE and True-LDE, bring understanding to dynamic loading of structures and extract decision ready data from FEA models.

DELIVERING DURABILITY ACROSS THE RUBBER SUPPLY CHAIN
PANEL DISCUSSION

OVERVIEW

This panel discussion will be a unique opportunity to hear from representatives across the supply chain providing unique insights into the contemporary and future challenges for ensuring the best durability for our products. The discussion will include: How durability requirements will change in the near future; challenges to meet durability requirements together with sustainability goals; the move toward more modeling and simulation and zero prototypes; and the role of machine learning and AI in future materials, component and vehicle development.

Thomas G. Ebbott, Ph.D. - Moderator

Vice President

Tom is a tire industry veteran known for his leadership in driving advances in modeling, simulation and workflows across a global organization. He joined Endurica in 2022 after a 35-year career at Goodyear. While at Goodyear, he held various technical and leadership positions with experience in product development, modeling and simulation, and materials characterization. He was a major contributor to multiple technical partnerships. He also enjoyed a two-year assignment at Goodyear's technical center in Luxembourg as the Manager of Computational Mechanics. He has published many papers and received numerous awards including four Superior Paper Awards from the Tire Society. Tom received his Ph.D. from the University of Wisconsin with a research topic of fracture and crack growth in polymers.

Kevin Barbash

VDDV Technical Specialist for Suspension and Driveline, General Motors

Kevin Barbash is the VDDV Technical Specialist for Suspension and Driveline at General Motors. He has over 15 years of CAE experience at GM focused on chassis analysis and loads prediction. Kevin is the co-author of "Critical Plane Analysis of Rubber Bushing Durability under Road Loads," Society of Automotive Engineering (SAE) Technical Paper No. 2016-01-0393. He is also providing technical input on a second publication, "Durability of Elastomeric Bushings Computed from Track-Recorded Multi-Channel Road Load Input," scheduled to be presented later this month at the SAE World Congress Event. Kevin earned his Master's of Science in Engineering from Purdue University and his Bachelor's of Science in Mechanical Engineering from Penn State.

Scott Braddock

CAD/CAE Manager, NVH Performance Materials, Clevite / Tenneco

Scott Braddock is the CAD and CAE manager for Clevite / Tenneco in Milan, OH. He has been with Tenneco since 2005, and has experience as a light vehicle product engineer, finite element analyst, and manager. Scott earned his Bachelor's of Science in mechanical engineering and a Master's of Science in engineering from the University of Toledo.

Prasanna Kandapalli, Ph.D.

Team Leader/Structural CAE Group, Performance Materials Division, BASF Corp.

Prasanna has almost 30 years of experience in CAE simulation, primarily in structural applications including seating, mounts, brackets, powertrain components, etc. in the automotive industry. His work spans linear and non-linear static and dynamic analyses, plus creep and fatigue analyses, and vibration and acoustical analyses. Most recently, Prasanna has focused on modeling anisotropic behavior of fiber filled composites (glass filled polyamides 6/66) with emphasis on static loading, durability and crash worthiness. He also, recently completed a research study on modeling fatigue behavior of TPU (Thermo-Plastic Urethanes). Prasanna earned his Ph.D. and Master's of Science in Engineering Mechanics from the University of Kentucky and his Bachelor's of Science degree in Mechanical Engineering from VNIT in Nagpur, India.

Mohammed Rezaul Karim, Ph.D.

Technical Consultant, Celanese

Mohammed currently serves as a Technical Consultant at Celanese in Wilmington, Delaware. Prior to Celanese aquiring DuPont's Mobility & Materials business, Mohammed worked as a Technical Consultant, Mobility & Materials completing structural analysis with ABAQUS analyzing different loading scenario including Static, Impact, Creep, Fluid Structure Interaction (FSI), and more. He also completed material modeling and optimization of elastomers, unreinforced and reinforced composites (short and continuous fibers) with DIGIMAT, Polyumod Mcalibration and Isight, as well as injection molding simulation with MOLDFLOW. Another key part of Mohammed's work involved Metal to Plastic conversion to reduce weight and cost.

He has also held the positions of Senior Mechanical Analyst with Gentex, working with composite materials to design military helmets, and he worked as a Senior Engineer with Holtec. Mohammed earned his Ph.D. in Mechanical Engineering from The University of Akron, his Master's of Science in Mechanical Engineering from Tuskegee University and his Bachelor's of Science degree in Mechanical Engineering from Bangladesh University of Engineering & Technology.

Anoop Varghese, Ph.D.

Technical Specialist, Durability & Simulation, Attribute Engineering, Core Product Engineering, Bridgestone Americas

Anoop is a Technical Specialist in the Attribute Engineering department within Research & Development at Bridgestone Americas. His expertise in durability and simulations is used in product development, ensuring that Bridgestone's internal tests reflect market conditions, as well as improving test methods and simulations used in the design process of tires.

During his 14 years with Bridgestone, Anoop has developed new simulations, prediction tools, and material tests, led cross-function teams focused on complex problems, and directed internal software development. He was the program chair for 2015 Tire Society Conference and Associate Editor of *Tire Science and Technology* in 2016.

Anoop earned his Ph.D. in Engineering Mechanics from Virginia Tech after graduating from Indian Institute of Technology – Madras. In his spare time, Anoop is a passionate squash player and skilled cook.

Touhid Zarrin-Ghalami, Ph.D.

CAE Front Chassis Engineer, Durability Technical Specialist, Stellantis NA

Touhid is a CAE Front Chassis Engineer and Durability Technical Specialist at Stellantis. He recently received recognition from Stellantis for excellence as an internal instructor on the topic of rubber fatigue. He has more than 10 years with Stellantis. Touhid earned his Ph.D. at the University of Toledo under Prof. Ali Fatemi, with his dissertation on the topic of multiaxial fatigue life prediction for elastomers.

DELIVERING DURABILITY ACROSS THE RUBBER SUPPLY CHAIN
PANEL DISCUSSION

CODE FEATURE UPDATE
AND ONE YEAR DEVELOPMENT PLAN

CONFERENCE HOST

ABSTRACT

This talk presents an overview of the recent updates implemented in our software's codebase, alongside a development plan for the upcoming year.

The updates section details the enhancements made to the existing features, the introduction of new functionalities, and the resolution of previously identified bugs, aiming to improve the overall user experience, available features, and system performance. These changes are contextualized within the broader goals of Endurica, demonstrating their alignment with our long-term vision for the software.

The one-year development plan is focused on continuing to refine the current features based on user feedback and on introducing new functionalities designed to progressively build upon the software's capabilities.

Jesse Suter
Development Manager

Jesse is responsible for all software development at Endurica. During his tenure he has rearchitected Endurica's software to take advantage of multi-threading and parallel execution. Jesse has written the code for numerous technological advancements enabling Endurica's solutions for road load signals, incremental analyses, tire cyclic symmetry, and more. He is also in charge of worldwide customer support. Jesse has been with Endurica since 2014 and holds a Bachelor's of Mechanical Engineering degree from the University of Notre Dame. Jesse is an accomplished wood worker who also makes an amazing cup of coffee. He and his wife, Liz, have a daughter, Millie, who was born in February.

Endurica CL™

Fatigue Analysis Software

Endurica

Get Durability Right®

Endurica DT™

Incremental Fatigue Analysis

Endurica EIE™

Fast Loads Processing

OPTIMAL TIRE DESIGN OF A SUPPORT RING TYPE RUN FLAT TIRE SYSTEM
FOR HIGH FATIGUE LIFE IN ZERO PRESSURE DRIVING CONDITIONS

ABSTRACT

Rim mounted run-flat systems support the tire structure in case of flats and allow the vehicle to continue running for a specified distance with reduced driving speeds. We are presenting a potential methodology for designing rim mounted run flat inserts for tires using structural and durability simulations. For designing such systems, durability of both the tire structure and insert structure becomes important specifically when the system is operating in deflated conditions. We have used ABAQUS for structural simulations with the results being transferred to Endurica CL for durability simulations. Since the durability parameters for rubbers are highly dependent on temperature, the steady state temperature profile of the tire and insert is required to get better estimates for system life. An iterative process was used for this as the rubber hysteresis properties are also temperature dependent. Endurica computes heat generation by using structural results which is then transferred to ABAQUS for thermal simulation. After steady temperature distribution is achieved, the final life predictions are done by Endurica.

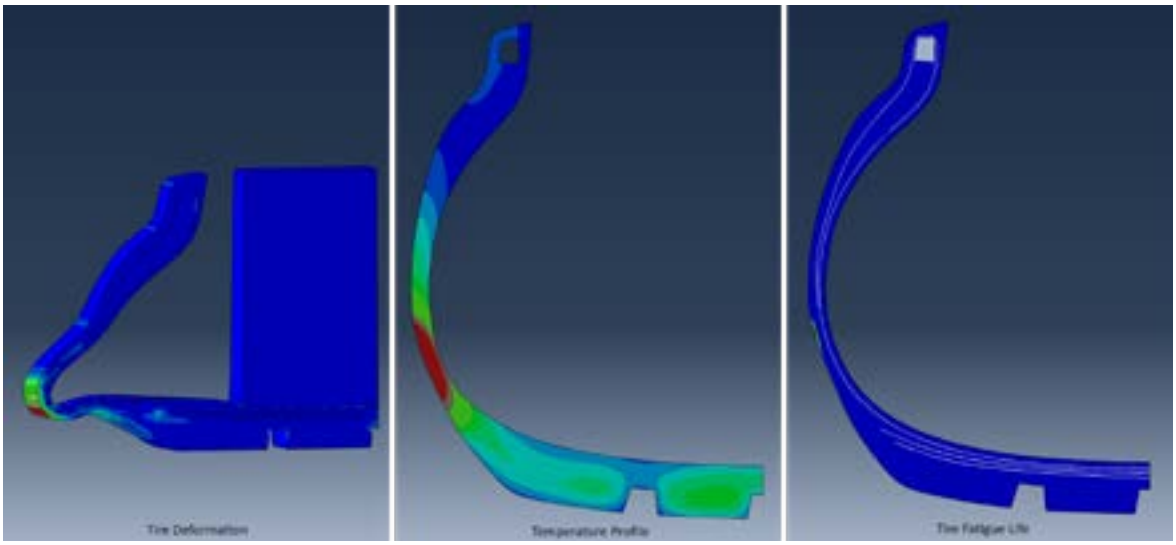
The design process starts with fixing target values for maximum load, maximum speed, and the desired mileage when driving under such conditions with a completely deflated tire. The initial part of the design process involves using a rigid cylindrical structure of varying height and thickness as the insert to get estimate of life of tire structure for different levels of deformation. Dimensions so obtained are then used as a starting point for further optimizing design of the insert structure considering durability of the whole system. This methodology was found to be effective for designing run flat systems that meet our design targets.

Abhishek Saraswat
Graduate Student

Abhishek Saraswat is a graduate student at Virginia Tech working in the Centre for Tire Research (CenTiRe). He is currently serving as a Graduate Research Assistant, working on the design of run flat tire systems for optimal durability and performance.

Before pursuing his advanced degree, Abhishek worked as the Assistant Manager (CAE), Advance Engineering (R&D) at CEAT Tyres in Halol, Gujarat, India. His work there centered on developing and implementing noise and vibration simulation methodologies for tires. He was also involved in structural simulations for tires and tire testing data processing and analysis for performance prediction and model validation.

Abhishek received his Bachelor's and Master's of Technology Degrees in Mechanical Engineering from the Indian Institute of Technology, Kanpur and worked for an additional year there as a Project Engineer in their Acoustics Lab.



CenTiRe is a consortium of tire and tire-related industry members with two world-class universities, Virginia Tech and The University of Akron. CenTiRe conducts leading-edge, pre-competitive research in materials, tire physics (including modeling), testing, manufacturing, and sustainability that is of interest and directed by the industry members. Members include global tire manufacturers, material suppliers, vehicle manufacturers, and test equipment and service suppliers who collectively provide direction and decisions on research and operation of the Center to produce results that are meaningful and transferable to the member companies. Virgina Tech is well known for its expertise in tire and vehicle mechanics and dynamics, road pavement characterization, simulation, and testing. The University of Akron is world-class in polymer science and polymer engineering. Faculty at the universities provide their technical expertise and guidance to the graduate students performing the research, and interact with the industry members.

WORKFLOWS FOR TIRE ANALYSIS
ABAQUS STEADY STATE SELF-HEATING TIRE MODEL

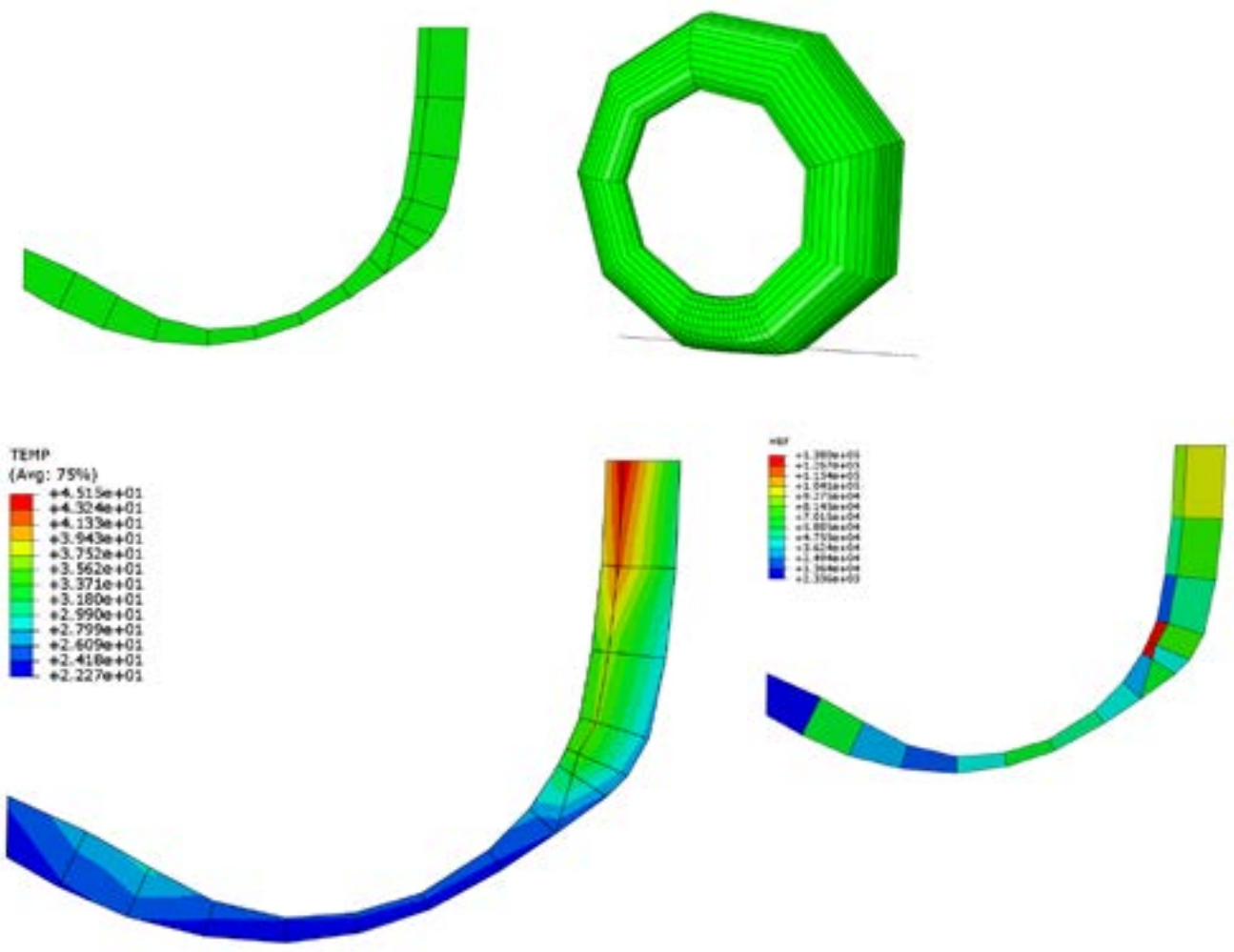
CONFERENCE HOST

ABSTRACT

Last year, Endurica changed our fatigue solvers to a new architecture. This demo of a tire modeling workflow will show how strain and temperature fields from a steady state rolling tire can be analyzed with the latest toolset.

Mark Bauman
Engineering Analyst

Mark works as an engineering analyst for Endurica in the areas of Fatigue Property Mapping testing services and CAE services. He has been with Endurica for 10 years and has additional experience in product design and simulation. Prior to joining Endurica, Mark's experience included employment at NASA's Wallops Flight Facility where he performed strength tests on rubber sensor mounts for the Orion Spacecraft. His skills include MATLAB, Abaqus, Ansys, Marc, and SOLIDWORKS. He earned his bachelor's degree in Mechanical Engineering from Purdue University Northwest. Mark is a three-time Indiana State Chess Champion. He and his wife, Margaret, have two children, Moriah and Mason.



Endurica
Get Durability Right®

COMPUTING TIRE DURABILITY
FROM ROAD LOADS FROM THE NURBURGRING CIRCUIT

PRESENTING SPONSOR

ABSTRACT

A future intelligent tire application may require tracking damage accrual based on tires' real-world operating conditions. This work demonstrates such an application utilizing commercial, off-the-shelf tools: the Simpack multibody dynamics code, the Abaqus finite element solver, and the Endurica EIE and DT fatigue solvers.

Nurburgring circuit vehicle events for laps on four P225/35R20 tires were simulated via multibody dynamics. For each of the four tires, the history of three channels (speed, slip angle, vertical tire load) were computed and recorded for 13 miles over 8 minutes at a data acquisition rate of ~100 Hz. Damage in the tire was accrued on a finite element mesh via Endurica DT, using strain history that was interpolated via Endurica EIE for each time step of event history. The interpolation grid, or map, was pre-computed in Abaqus using steady-state rolling simulation results covering the ranges of 25 to 165 kph for speed, -10° to +10° for slip angle, and 0.1x to 1.5x of TRA load.

The simulation results show how real-world driving events and tire operating conditions contribute to tire damage. It also demonstrates the feasibility and requirements for live tracking of tire damage accrual.

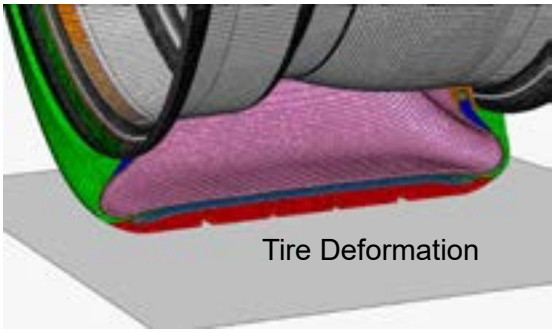
Jason Barr[1*], William Mars[2], Tom Ebbott[2] John Lewis[1], Jesse Suter[2]

1 Dassault Americas Corp., 175 Wyman St., Waltham, MA, 02451, USA
2 Endurica LLC, 1219 West Main Cross St., Suite 201, Findlay, Ohio 45840, USA
*Presenting Author: jason.barr@3ds.com

Jason Barr

SIMULIA Structures, Industry Process Senior Consultant, Dassault Systèmes Americas Corp

Jason has a passion for democratizing digital engineering tools and enjoys assisting customers with the development of predictive methods and simulation workflows. He has over 20 years of experience in the tire industry, focusing primarily on tire simulation, vehicle dynamics, and software development. Jason is a lifelong resident of Akron Ohio, where he lives with his wife and two high-school-aged daughters. When not working, Jason spends most of his time keeping up with his daughter's sporting events and enjoys building things (software, electronics, woodworking).



Tire Deformation

Simpack

Tire Fatigue Life

What is Dassault Systèmes? We like to say our products touch nearly everything in your life! We're in the business of innovation. We're not just a software company, a PLM (Product Lifecycle Management) company, DMU (Digital Mock-Up) company, or a 3D Design company. We're unique in that we're a science-based and technology-powered company that provides virtual twins to drive human-centric experiences that allow customers to create innovative new products and services.

COMPANION MATERIAL COMPARATOR

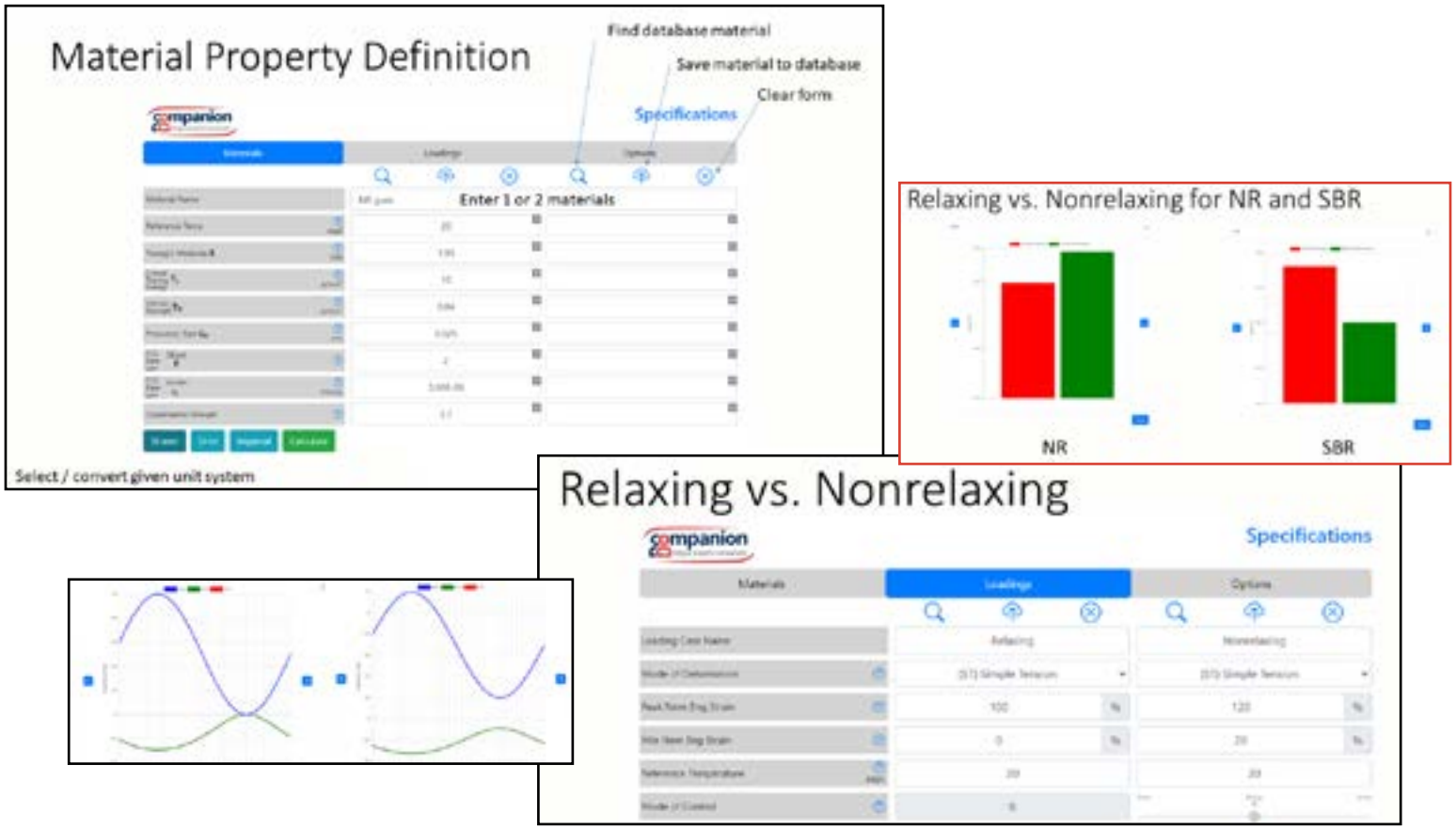
CONFERENCE HOST

ABSTRACT

Endurica Companion is the standalone web app that makes it easy to find the right rubber properties to ensure durability in your application. Specify any two materials by entering modulus, intrinsic strength, crack growth rate properties, and crack precursor size. Then specify your application by entering the mode of deformation (simple, planar or biaxial tension/compression or simple shear), the limits (max and min) of the dynamic loading cycle, the mode of control (strain control, energy control, stress control) and the temperature. Companion uses Endurica's Critical Plane Analysis to rank your compounds for fatigue performance in your specific application. Also, Companion provides plots showing your materials' stress-strain behavior, crack growth behavior, sensitivity to crack precursor size, strain-life/Haigh diagram, and crack orientation. Go to companion.endurica.com to try it today!

Ethan Steiner
Sales Engineer

Ethan Steiner is a Sales Engineer with Endurica, responsible for technical support of sales activity in addition to project engineering and development. Ethan joined Endurica as an intern in August of 2020, completing tire modeling projects, benchmarking element types and discretization effects in an Abaqus simulation model, and making webinar presentations to both support client skill development and sales efforts. In December of 2022 he completed his Bachelor's of Science degree in Mechanical Engineering from the University of Toledo and joined us full-time in January 2023. Ethan enjoys building computers, gardening, and the antics of his mouse-catching cats and nap-taking dog. He and his wife, Susannah, have a daughter, Annabelle, who was born in November, and are active in their church's youth group ministry.



DURABILITY WORKFLOWS
WITH ANSYS

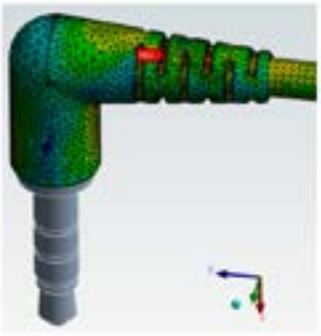
RESELLER

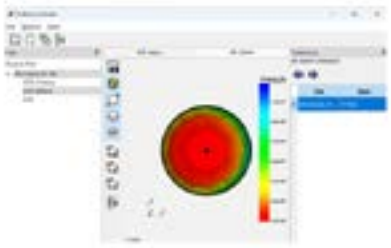
ABSTRACT

This presentation shares the initial experiences of a new Endurica user in assimilating and implementing durability workflows within the Ansys environment. Over the span of one month, I have adeptly employed the infinite life workflow (CL), the safe life workflow (CL), and the incremental workflow (DT). Additionally, I have leveraged the Endurica EIE tool to accurately simulate road loads on a mount.

Salim Yagoub
Structural Analysis Engineer

Salim Yagoub is a Finite Element Analysis Engineer at FE-TECH Advanced Engineering Solutions in Turkey, with over two years of experience in FEA and more than three years in mechanical design and material characterization. Proficient in Ansys, Hypermesh, Solidworks, and MCQ Composites, he holds a master's degree in Automotive Engineering from ULUDAG University in Turkey. Outside of work, Salim is passionate about Taekwondo and enjoys playing the guitar in his spare time.





The damage sphere shows the orientation of the crack growth, in this case the normal of the crack growth is towards the z axis.

Endurica

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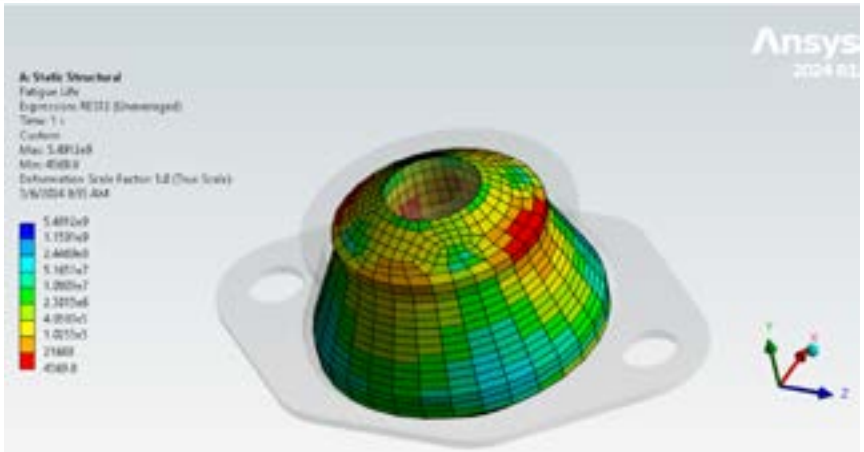

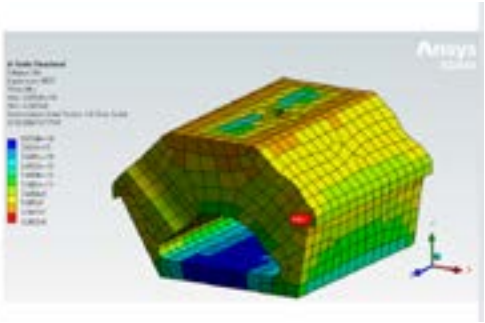

FE Technology Services Advanced Engineering Research and Development Ltd. specializes in computer-aided design (CAD), computer-aided engineering (CAE), finite element analysis (FEA), testing, and measurement. FE-TECH provides quality computer-aided engineering services to customers in almost every industry. Services span structural strength analyses, explicit dynamics (collision, explosion) analyses, vibration analyses, fatigue calculations, multi-body dynamics analyses, computational fluid dynamics analyses, and hydrodynamic analyses.

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