

# FTire

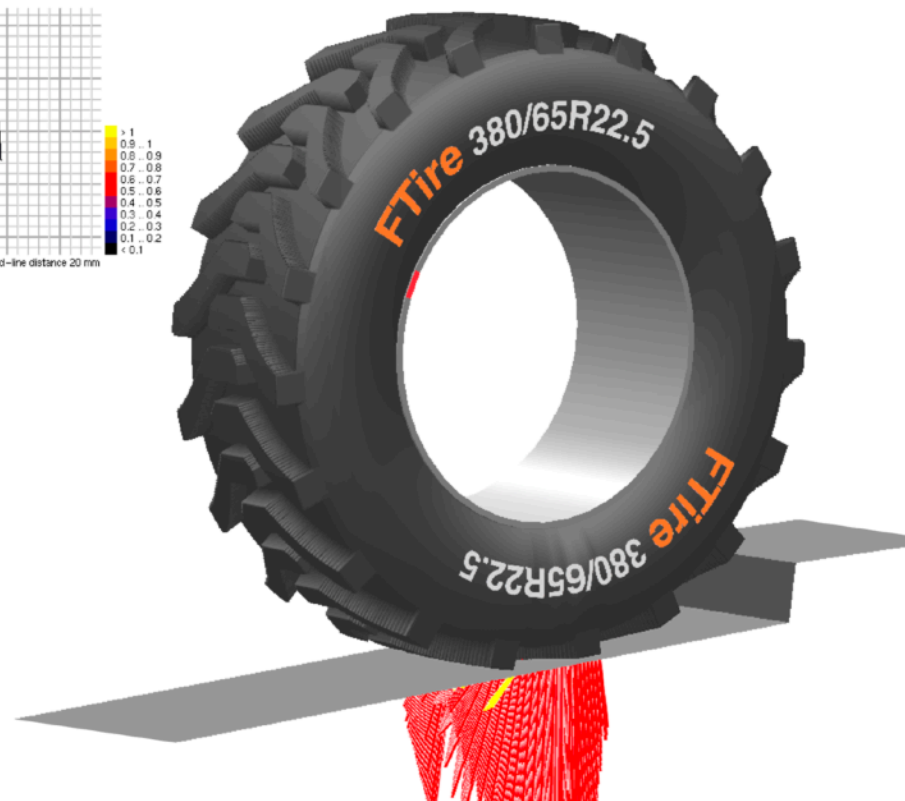
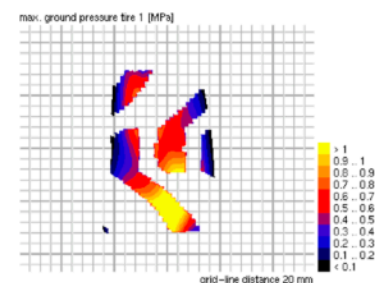
The Market-Leading  
Physics-Based Tire Model



# FTire - The Flexible Structure Tire Model

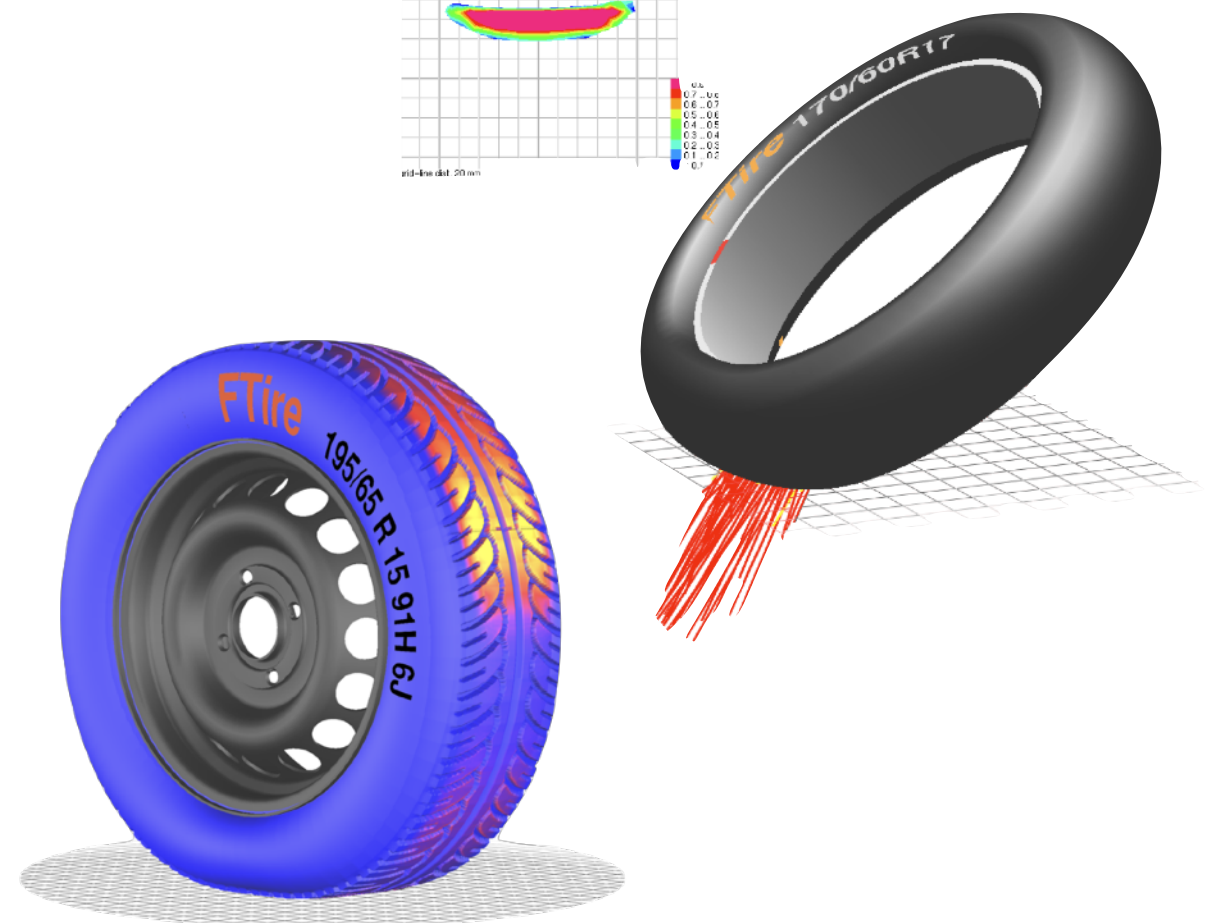
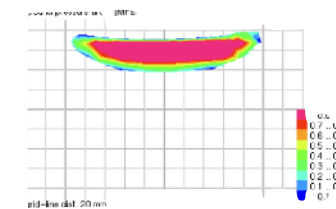
**cosin**  
scientific software

**FTire** is a highly accurate physics-based, 3D nonlinear tire simulation model developed by cosin Scientific Software. It is the multi purpose virtual tire software used in wide spread application fields. **FTire** is available in all important MBS, multi-physics system, and FEA simulation environments. **FTire** covers stiff, deformable, and time variant road surface descriptions. **FTire** provides virtual wheel assembly with rigid or flexible rim models. **FTire** comes with a very powerful toolbox for tire and road data pre- and post-processing. **FTire** is the most comprehensive software package for tire dynamics simulation in the market.



**FTire** is designed for versatile researches and in-depth studies. It can be used for primary and secondary ride comfort simulation, NVH, prediction of road loads on road irregularities even with extremely short wave-lengths. **FTire** is a highly nonlinear and dynamic tire model for vehicle handling studies on flat or bumpy roads, especially for demanding suspension control systems design.

**FTire** runs under hard realtime conditions.

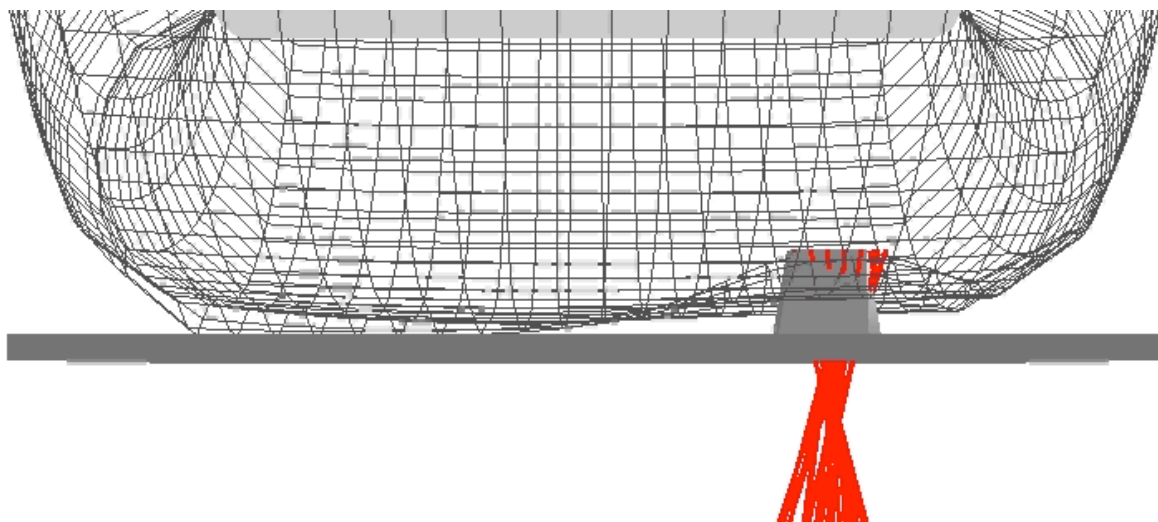


# FTire - Key Features

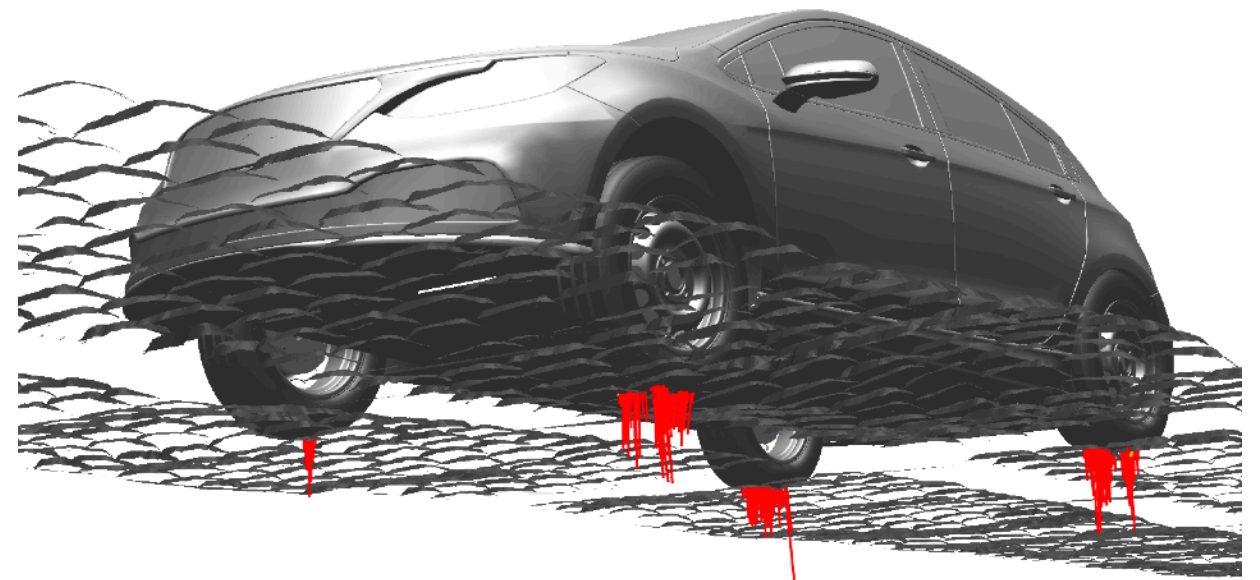
**FTire** predicts complex tire phenomena on a strictly mechanical and thermo-dynamical basis. It provides much more reliable results than any purely mathematical curve approximation ever can.

**FTire** comes with the following models and key features:

- Detailed fully nonlinear 3D tire structure deformation model covering all frequencies up to 250 Hz and higher
- Brush-type dynamic tread-road contact model with a resolution below 1 mm. Optional use of geometrical tread patterns is supported
- Tire imperfection models including tread gauge variation, imbalance effects, conicity and non-uniformity
- Optional misuse contact elements like rim-to-belt (bottoming), sidewall-to-road, and rim-to-road
- Solver extensions for tread wear, bulk and tread surface temperature, air volume vibration, flexible rim, and deformable road



- cosin's digital road models supporting rigid, flexible, time-invariant or time-variant road surfaces, and 3rd-party user-written road descriptions, e.g. OpenCRG, RDF, etc.
- Comprehensive tools for parameter editing, validation as well as statics, steady-state, modal, and linearization analyzes
- Online animation of detailed belt deformation, pressure distribution, and road surface attributes
- Interface to arbitrary user-defined FE-based rim flexibility models
- Interface to user-defined soft-soil and flexible road surface models
- Multi-core system enabled solver
- Solver extension for realtime execution on selected platforms
- Comprehensive parameter identification tool

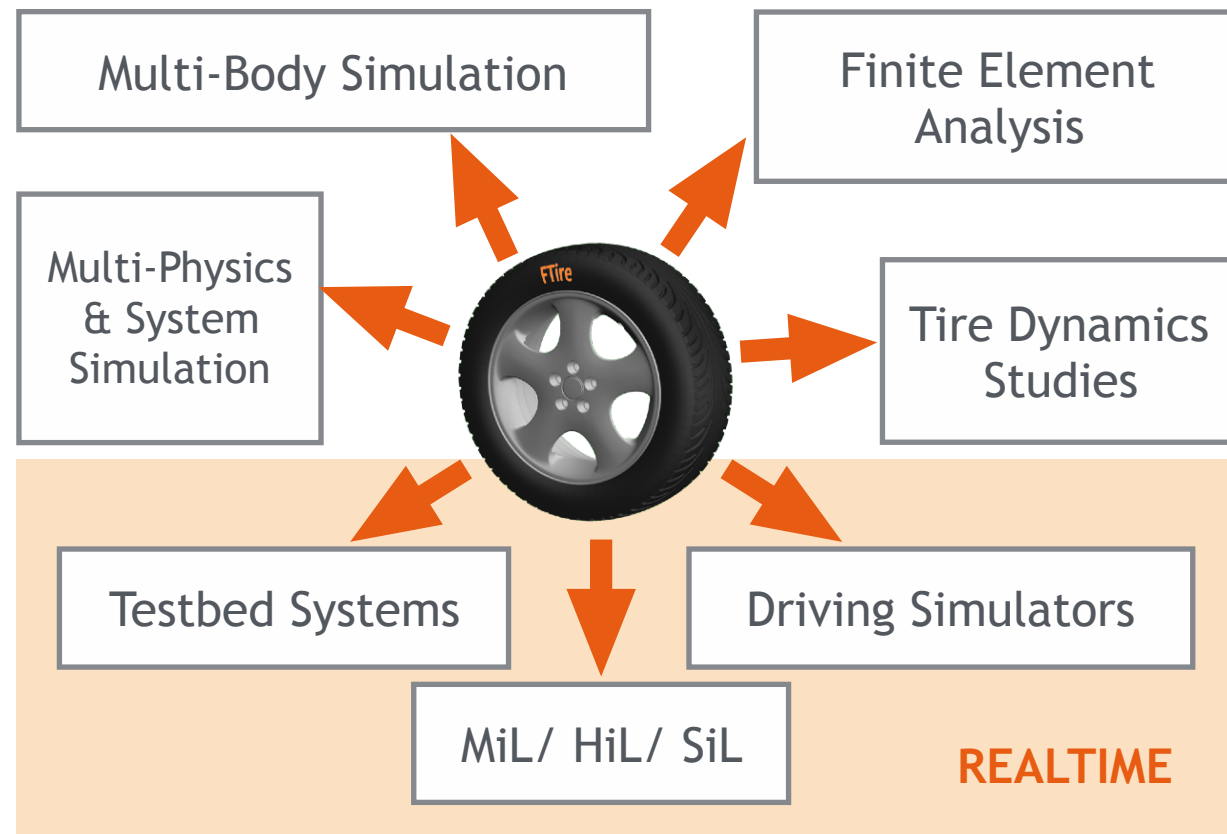




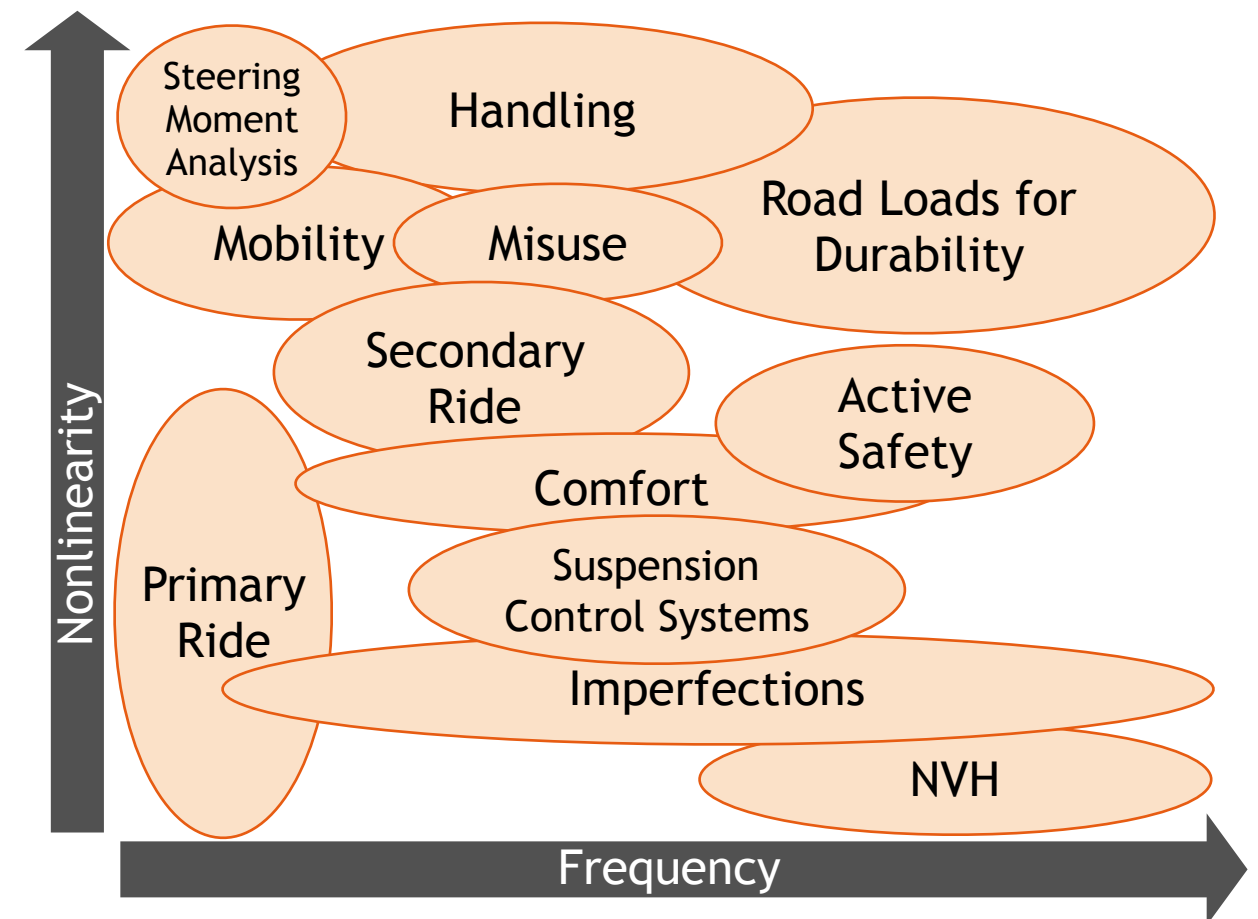
# FTire - Environments & Application Fields

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**FTire** is a 3D nonlinear tire simulation model, which is used in a wide field of CAE environments:



**FTire** is the most comprehensive and accurate tire simulation software used world wide in numerous applications:



## Benefits at a Glance

Seamless modelling approach:

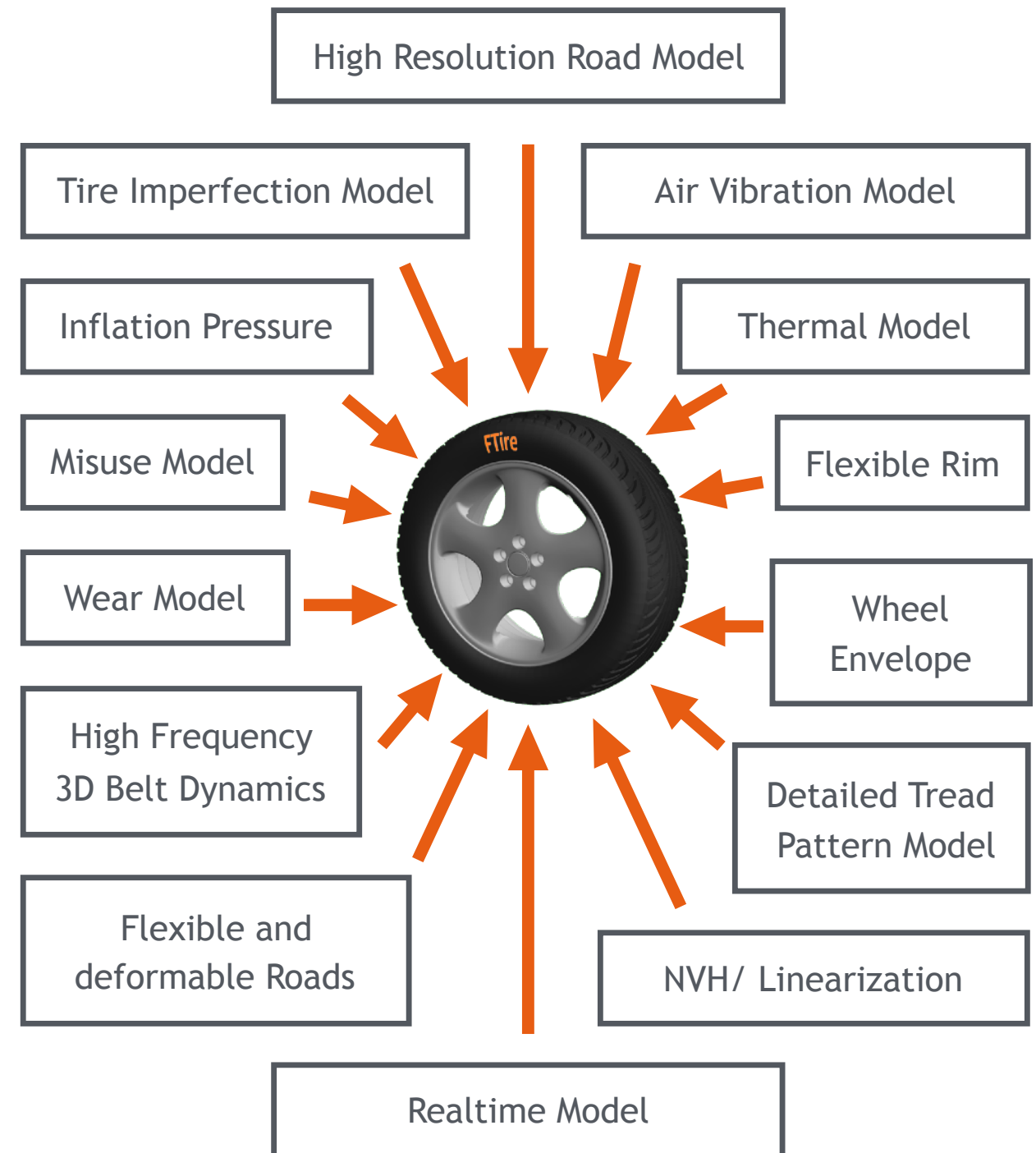
- One and the same high-quality tire model can be used throughout the entire tool chain and applications, i.e. for the whole development process, from the office, over HiL to the testbed systems across all development departments
- Only one product which covers most tire dynamics phenomena

# FTire - The Multi-Purpose Virtual Tire

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## Application Cases

- All kinds of vehicles: cars, SUVs, vans, trucks, combinations, race cars, motorcycles, scooters, aircrafts, heavy machinery, agricultural vehicles, etc.
- All kinds of analyses: handling, ride, durability, NVH, etc.
- Tire to road induced vibrations up to 250 Hz and higher
- Detailed tread surface and bulk temperature prediction
- Vibrational excitation through tire imperfections
- Variation of inflation pressure
- Traction & handling on extremely bumpy roads
- Realtime applications like Model-, Software-, and Hardware-in-the-Loop (MiL, SiL, HiL), testbed systems and simulators
- Tire misuse studies, impact on sharp and high obstacles, kerb strikes, tire puncture, run flat, and bottoming
- Steering torque prediction and parking manoeuvres
- Assessment of active suspension control systems
- ADAS, active and passive safety
- Moving ground; all kinds of test-bench simulation
- Non-rigid surface and soft soil simulation
- Harshness analysis on artificial, parameterised obstacles
- Tread wear estimation
- Side wall contact
- Rim-to-road contact with rigid or flexible rim
- Generation of load histories for durability simulation
- Export to acoustics software for noise emission prediction

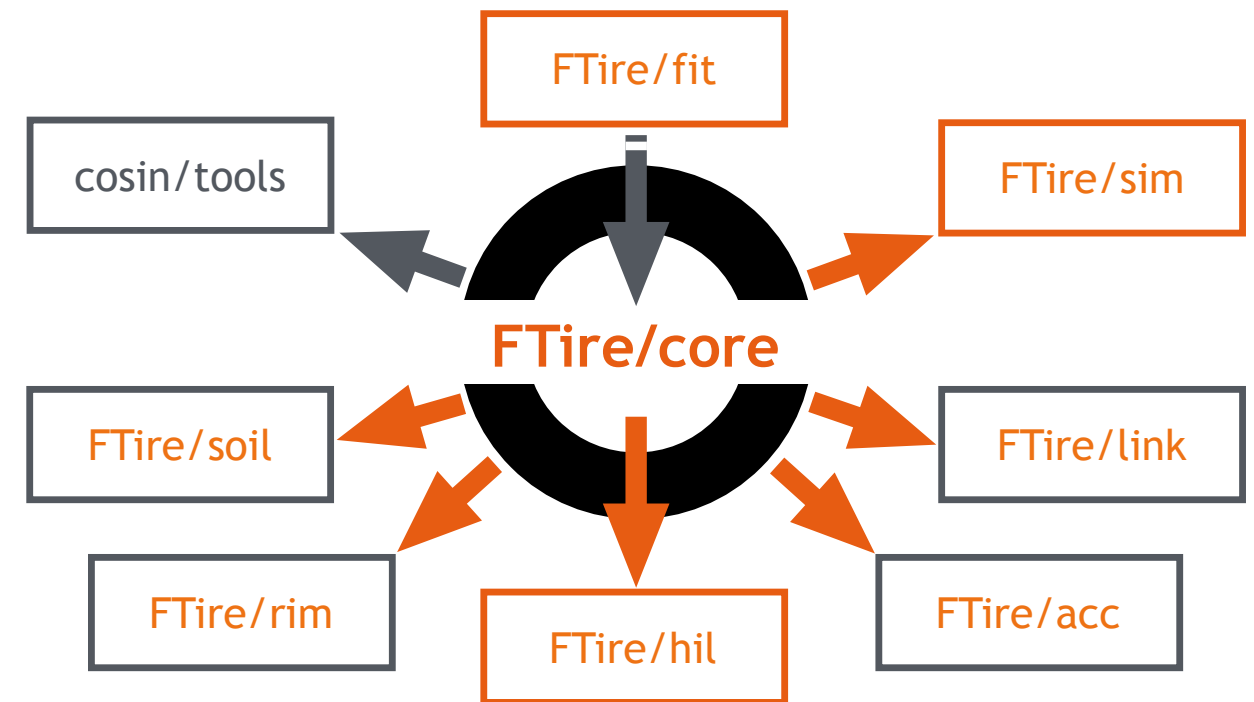


# FTire - Product Family

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## FTire/core

- Is available in a large number of 3rd-party environments
- Provides the easy-to-use CTI (cosin Tire Interface), which allows full access to all **FTire** features, and to user-written interfaces or solvers
- Supports a wide variety of road data formats including RGR, RDF, CAD formats, OpenCRG, and user-written road models
- Manages an unlimited number of tires and roads per simulation model
- Includes optional sub-models for detailed tire temperature and thermal effects, internal air flow and air vibrations, flexible rims, soft soil, tread wear, tire imperfections, and tire mis-use
- Allows easily C-based interfaces to user-written sub-models for deformable rims and road surfaces
- Provides online or offline animation, movie generation, data plotting, result export in a large variety of different output values and file formats
- Comes with a comprehensive set of example tire and road data files as well as detailed documentation



## FTire/core solver extensions:

**FTire/soil**, **FTire/rim**, **FTire/link**, and **FTire/acc** extend the modelling capabilities offered through **FTire/core**. These features add a more detailed description to tire and road simulation analysis, which covers all application fields from ride comfort and handling over durability to NVH. In addition, users are provided with the powerful **cosin/tools** to handle **FTire** data.



## cosin/tools

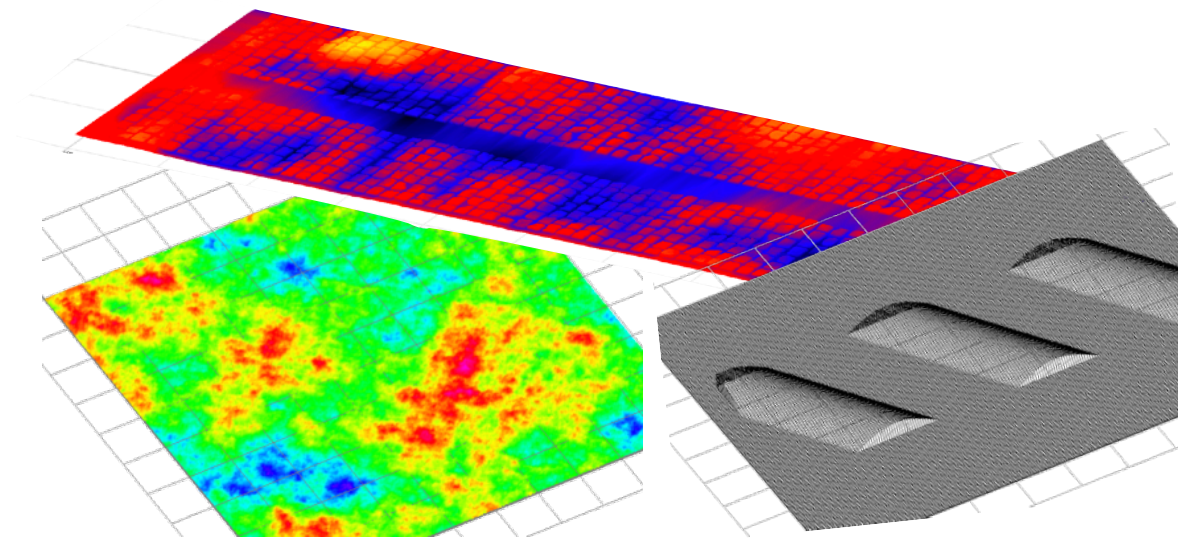
A suite of useful utilities to easily edit, analyze, debug and process **FTire** data files. This tool-box is included as standard with **FTire/core** or **FTire/fit**

- **cosin/tools** for tires is a GUI-based data file editor, which includes programs for static, modal, and steady-state analysis of **FTire** data files, as well as tool-kits for interactive simulation, linearization, reformatting of input files, and a lot more
- **cosin/tools** for roads is a comprehensive road data file generator, browser, and converter for all kinds of road formats (RGR, track data files, openCRG, RDF, ...)
- **cosin/ip** is an advanced simulation results viewer
- **FTire/record** is an offline replay simulation tool for **FTire** input signals
- **FTire/estimate** allows data file estimation (,morphing') based reference data and user-adjustable approximation formulas
- Additional MATLAB-based post-processing tools

## cosin/road

Time-invariant and time-variant rigid road surfaces library

- Rotating drum or flat belt with or without cleats
- General function expressions
- Hydro-pulser and 4-poster
- Plank/cleat, pothole, ramp, roof, sine, and swept sine
- Poly-lines with banking angle
- Stochastic ISO road classes
- Race tracks with large banking and general height profile



Regular grid based high-resolution 3D road surfaces with curved centerline including location-dependent friction and flexibility properties

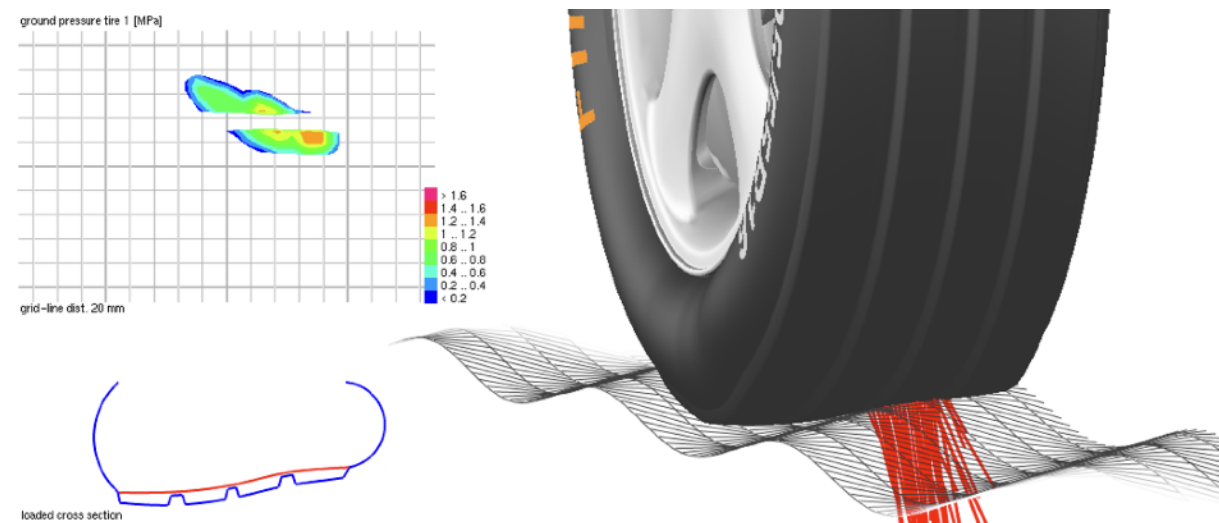
- Measured surfaces
- 2D PSD realizations
- Image-based surfaces
- Function expressions and combinations



## FTire/sim

Standalone user-friendly, fast, efficient tire dynamics and road-related simulation toolkit

- Parameterized simulation scripting
- Multi-dimensional parameter variation
- User-interactive simulation control
- Detailed nonlinear suspension models
- Convenient and scripted post-processing
- Wide variety of load-case templates included
- Includes **cosin/tools** and **cosin/road**



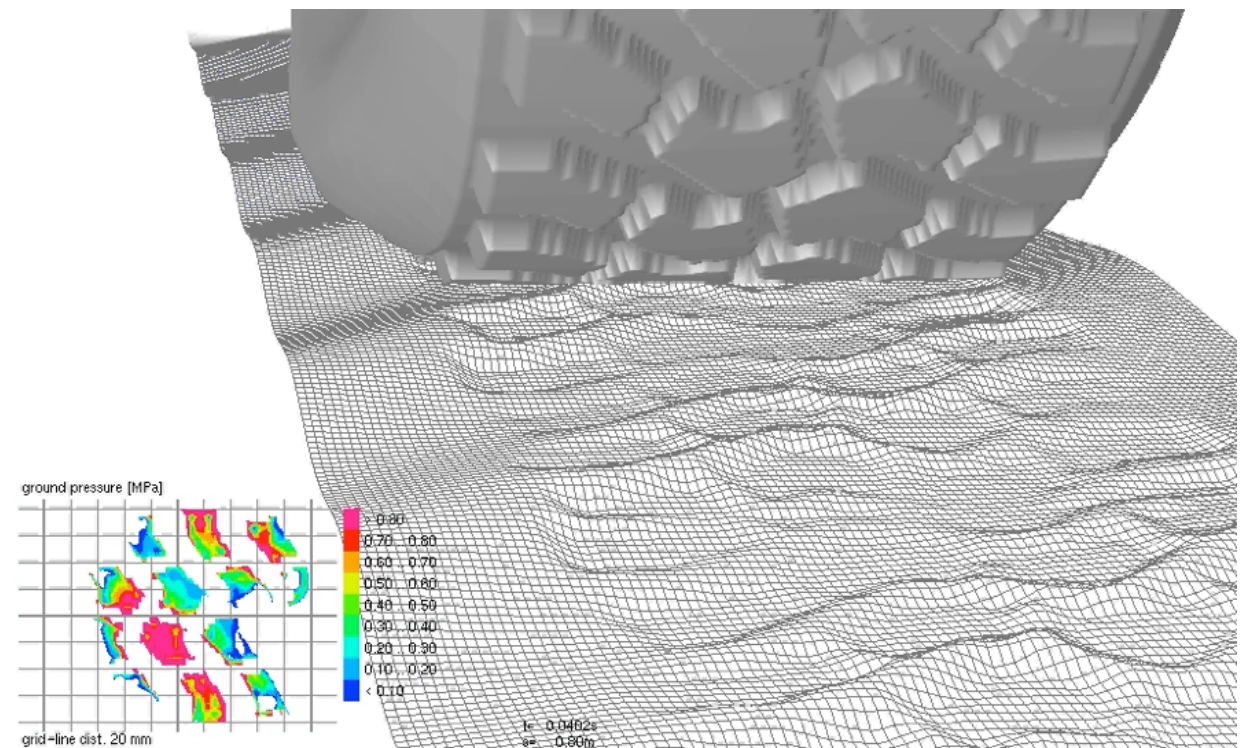
## Benefits at a Glance

- Comprehensive tire test rig models
- Scripted design of experiments (DoE) studies of all tire parameters

## FTire/soil

Extension to FTire/core for visco-elastic road modelling including the following deformable road surface models:

- cosin soil model
- Bekker/Wong soil model
- interface to user-defined FE-based soil models



## Benefits at a Glance

- Basic approach for elasto-plastically deformable surfaces
- Terrain surface properties such as snow, mud, and loam
- Agricultural tires on soil



# FTire - Tools & Extensions

## FTire/rim

Extension to **FTire/core** for flexible and visco-plastic rim modelling

- Internal elastic and plastic rim deformation model on basis of FE load cases import
- Interface to user-defined rim models
- Rim-to-tire friction and slip models



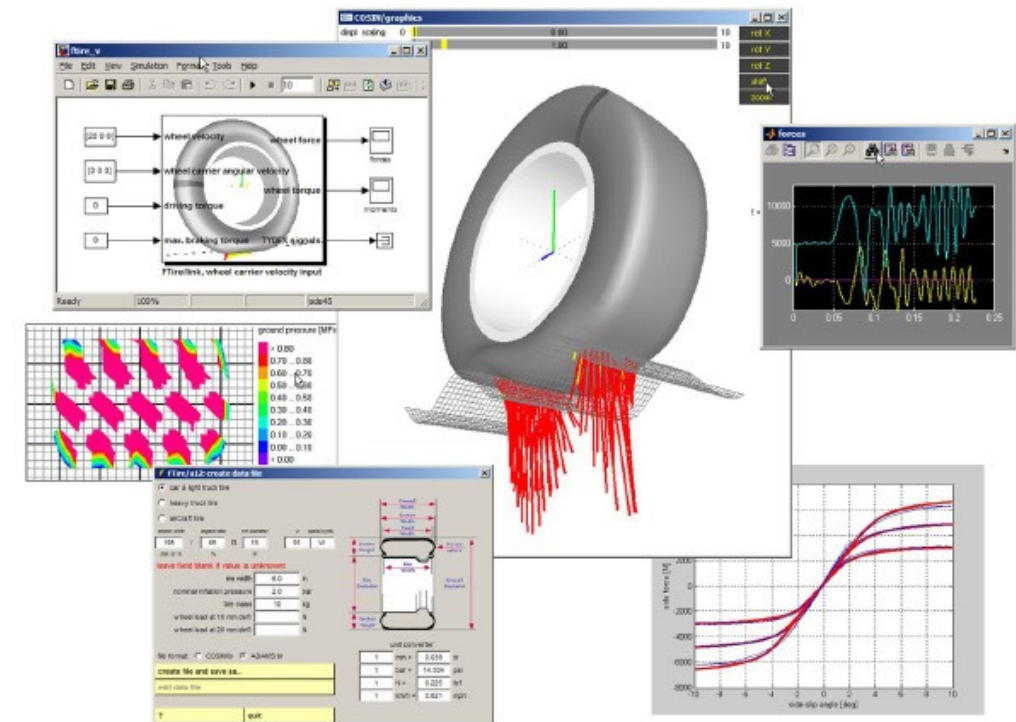
## Benefits at a Glance

- Fast approach for elastically deformable rim
- Enhanced misuse events
- Rim-to-belt and rim-to-road contact
- **FTire** / FEA (finite element analysis) coupling

## FTire/link

MATLAB/Simulink blockset as extension to **FTire/core**

- Connects **FTire** and cosin road models to general Simulink models, even in the fast multi-threading call mode
- Provides all **FTire** features in a Simulink environment including a tire and road animation window



## Benefits at a Glance

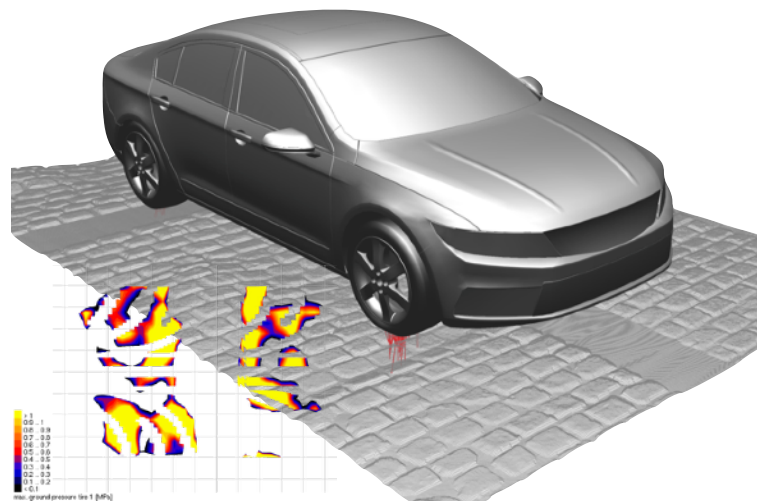
- Easy to use blockset for system-dynamics Simulink as well as multi-domain Simscape models
- General road evaluation made available in Simulink

# FTire - Tools & Extensions

## FTire/acc

Extension to **FTire/core** for execution time reduction of offline simulation runs on commercial of the shelf hardware with no need to meet hard realtime requirements

- Adjustable acceleration levels
- Parallel solver execution for multiple tire instances- taking full advantage of multi-core systems
- Simulation setup remains unchanged



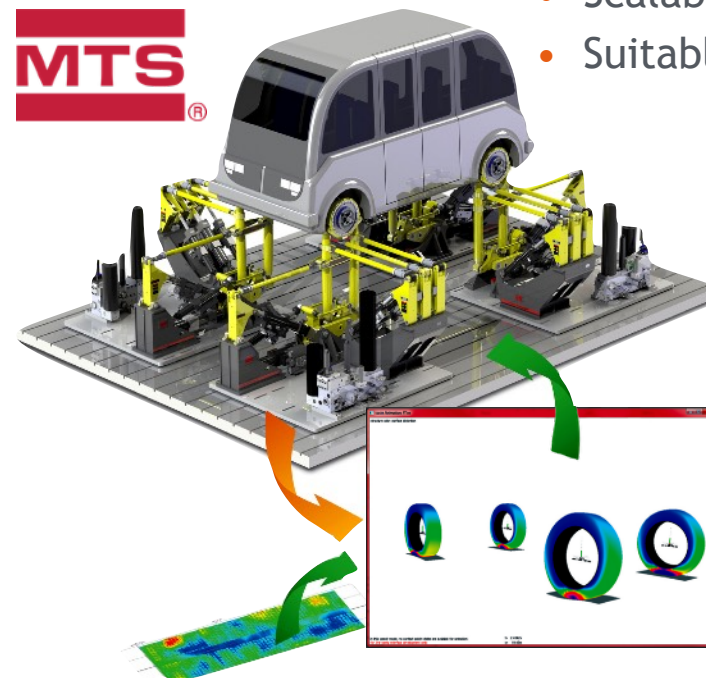
## Benefits at a Glance

- Tremendous solver speed up
- Re-use of the same high-quality tire models

## FTire/hil

Enables Hardware-in-the-Loop (HiL) simulations running **FTire** realtime applications on testbed systems, driving simulators and more

- Hard realtime conditions (guaranteed response times)
- Parallel solver execution for multiple tire instances
- Taking full advantage of multi-core systems
- Simulation setup remains unchanged
- High accurate in frequency range up to 200 Hz
- Scalable time and spatial resolution
- Suitable for all applications from ride/comfort to durability



## Benefits at a Glance

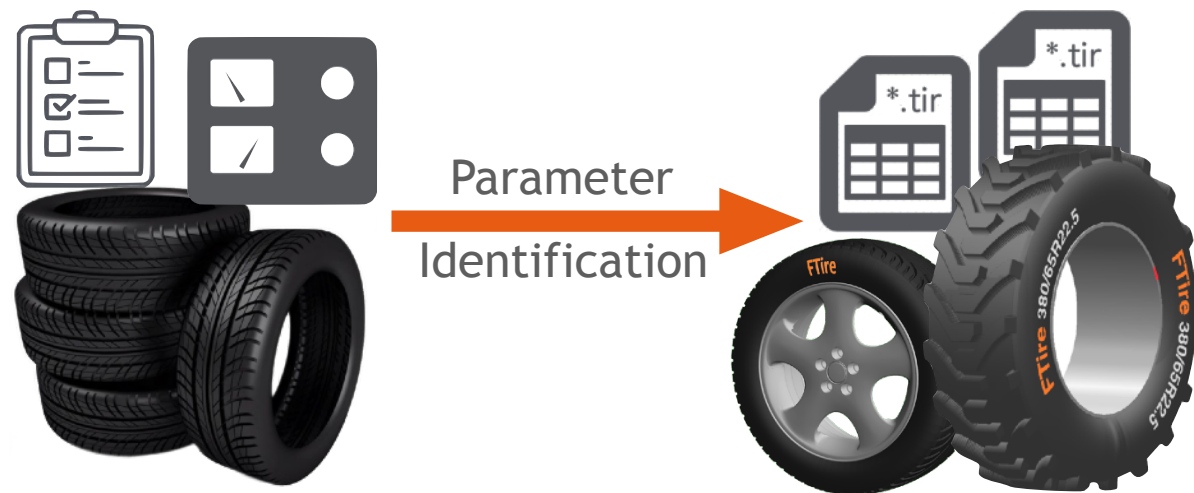
- Makes **FTire** available to HiL, testbed system and simulator applications under hard realtime conditions
- Re-use of high-quality tire models as in all other simulations guarantees a seamless workflow across all applications

# FTire - Additional Product Portfolio

## FTire/fit

Standalone product designed for identification and optimization of **FTire** data on basis of static and steady-state measurements, footprint geometry, cleat tests and virtual measurements such as finite-element-analysis (FEA) results

- Wide support for input data formats like TYDEX data files, ASCII tables, bitmaps, graphs, MF tire model data, etc.
- Automated generation of fitting reports
- Tuning of numerical properties
- Result file analysis

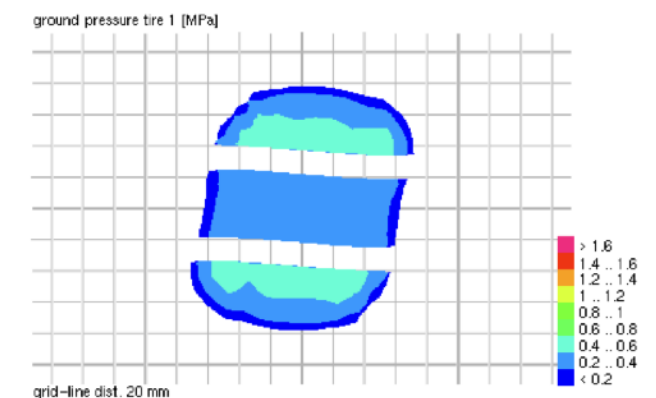
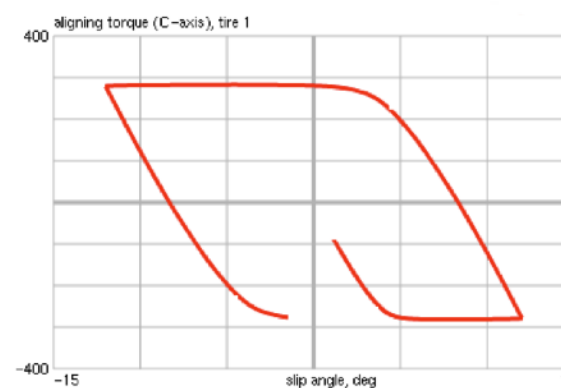


## Benefits at a Glance

- **FTire/fit** is the powerful parameter identification and validation toolbox for **FTire**
- Much more than just a mathematical parameter fitting procedure

## FTire/fit Features

- Convenient tool for processing, identification, and validation of geometrical, static, steady-state, handling, dynamic, and modal data
- Automatic measurement data format recognition and conversion
- Automated footprint comparison
- Automated cross-section geometry import
- Automated stiffness determination (radial, longitudinal, lateral, torsion, cornering stiffness, pneumatic trail, and slip stiffness)
- Automated static and steady-state validation by time domain simulation
- Dynamic identification using least squares fits of cleat tests in time and/or frequency domain
- Fully automatic HTML/PDF-based report creator, including generation and illustration of steady-state and handling simulation results





## Simulation Environments

- Abaqus (Dassault Systèmes)
- Adams, Adams/Car (MSC Software)
- ASM Vehicle Dynamics/ASM on SCALEXIO (dSPACE)
- ANSA (BETA CAE Systems)
- CarMaker/TruckMaker/MotorcycleMaker (IPG)
- CarSim/TruckSim/BikeSim (Mechanical Simulation)
- cosin/mbs (cosin scientific software)
- Dymola (Dassault Systèmes)
- DYNA4, veDYNA, enDYNA (Tesis GmbH)
- GT-Suite (Gamma Technologies)
- LMS Imagine.Lab Amesim (Siemens)
- LMS Virtual.Lab Motion (Siemens)
- MATLAB/Simulink (Mathworks)
- MotionSolve (Altair)
- PAM-CRASH (ESI)
- RecurDyn (FunctionBay)
- SamTech (Siemens)
- SIMPACK (Dassault Systèmes)
- Vehicle Dynamics Library (Modelon)
- VI-CarRealTime/VI-CarRealTime on VI-DriveSim (VI-grade)

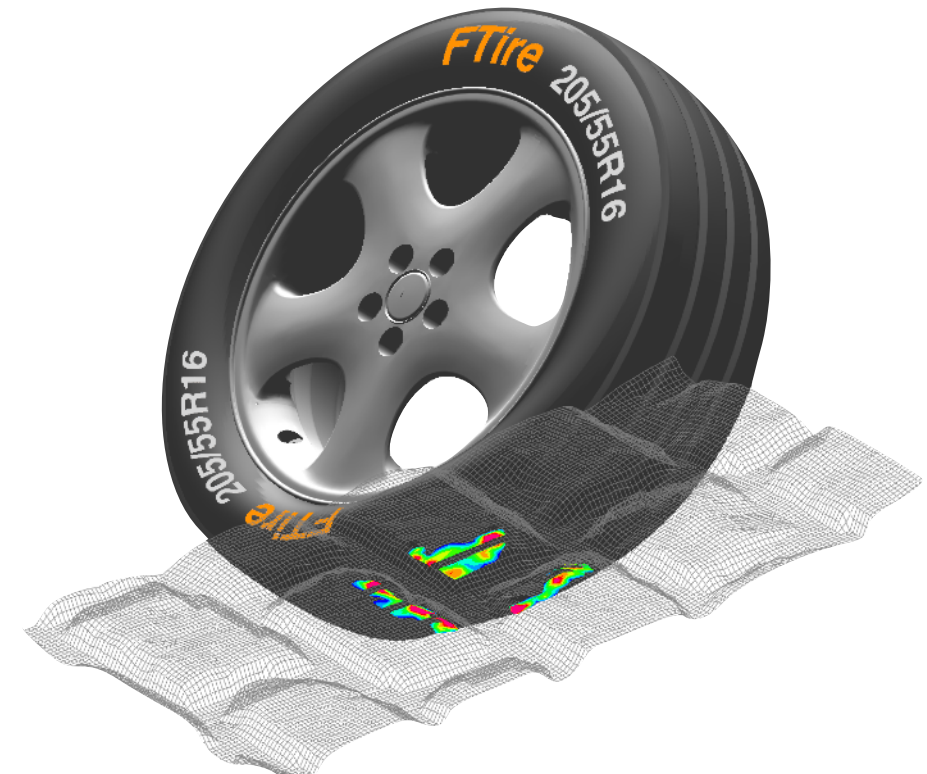
## Platforms

- Microsoft Windows XP SP 3, 7, 8, 10
- RedHat Enterprise Linux 5, 6, 7
- macOS 10.9, 10.10, 10.11, 10.12

All platform builds are available for 32 and 64 bit operating systems.

## Realtime Targets

- Concurrent RedHawk 6, 7
- dSPACE



## Benefits at a Glance

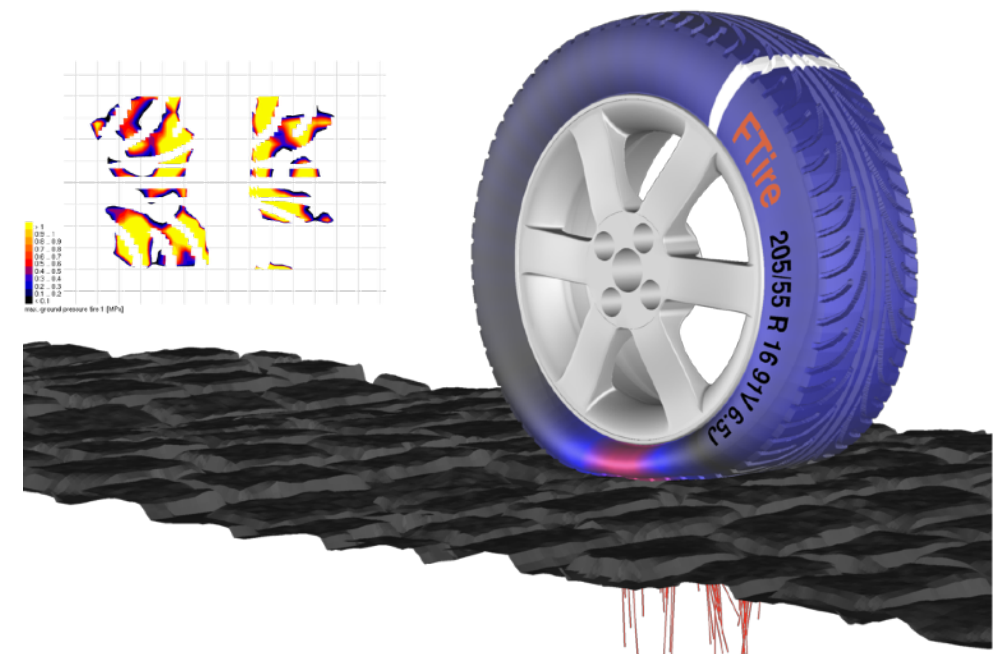
- **FTire** is the industry-leading physics-based tire model for simulating nearly all tire dynamics phenomena
- **cosin** is dedicated to deliver the most diverse and accurate tire simulation software and to provide our customers with outstanding engineering know-how and support

## The added Value

- Model accuracy is extensively validated with test data
- Change tire operating conditions at simulation runtime
- Support component development by providing highly accurate load profiles during all development stages
- Hard realtime capability with no need to change or adapt data files
- Connectivity and interfaces for leading simulation tools (Abaqus, Adams, Dymola, GT-Suite, Matlab/Simulink, Simpack, VI-CarRealTime, etc.)
- **cosin** Tire Interface (CTI) for easy connection to customer-specific vehicle dynamics software
- Valuable tools like **cosin/tools** for tires and for roads, **FTire/record**, and **FTire/estimate** (,morphing')

## What is UNIQUE?

- **FTire** predicts complex tire phenomena on a strictly mechanical and thermo-dynamical basis. It provides much more reliable results than any purely mathematical curve approximation ever can
- **FTire** features powerful model parameterization tools and scripted simulation prospects. In addition it comes with online monitoring, result analysis, and reporting capabilities as well as advanced pre- and post-processing features
- Re-use of the same high-quality tire models throughout the entire tool chain and the whole development process, from the office, over HiL to the testbed systems across all departments
- Even a full featured FTire structural dynamics model can run under hard realtime conditions



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