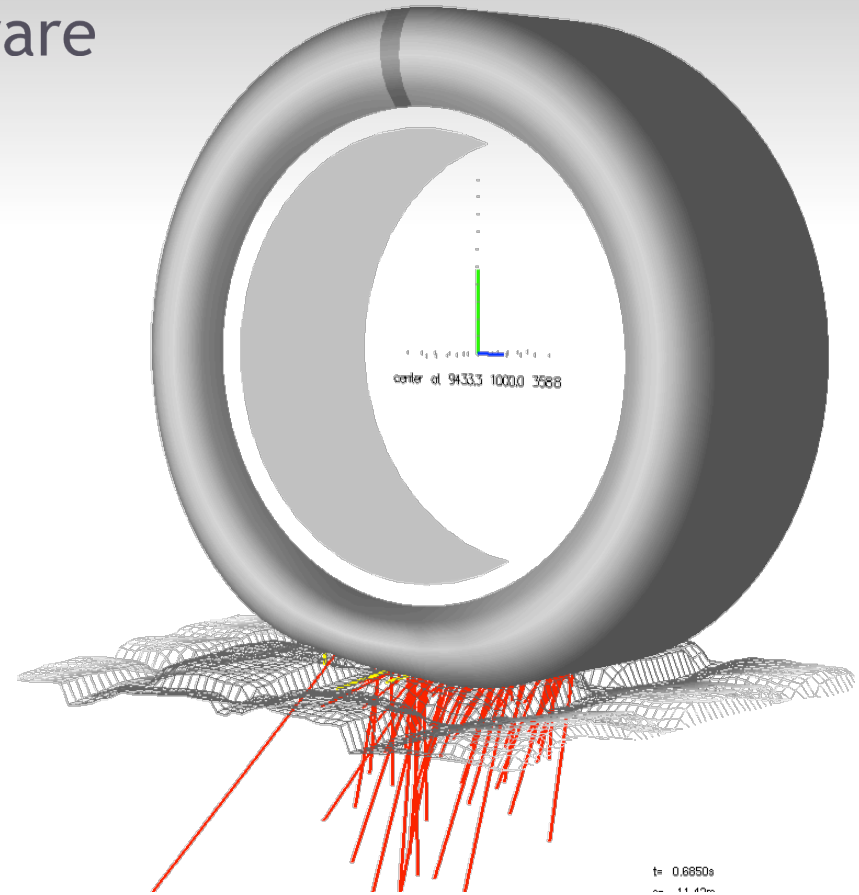
cosin
scientific software



FTire: a Physically Based Tire Model for Handling, Ride, and Durability

Part 1: Introduction

Michael Gipser
Esslingen University of Applied Sciences
& cosin scientific software

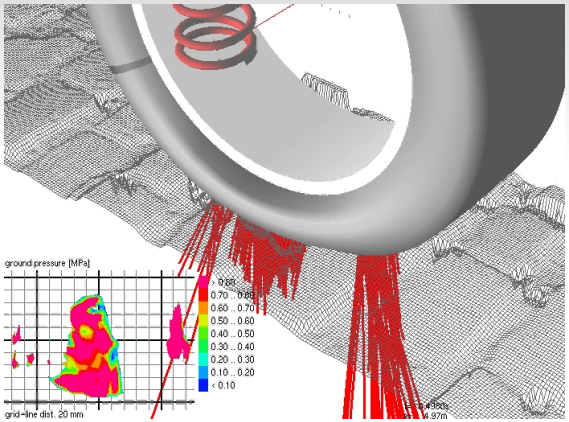
cosin
scientific software

Who we are..

- cosin scientific software has been founded in 2009, to advance the development and application of *FTire*, the market-leading high-frequency tire model
- *FTire* has its roots in the late 1980s, when Prof Gipser started developing physics-based tire models
- The key product *FTire* has established its position as the leading tire model for vehicle comfort, road loads and NVH analysis over the past years
- Complementary to *FTire*, cosin scientific software provides high-end simulation software for suspensions and components, road surface models, as well as general CAE tools
- Together with several partners, cosin scientific software offers full range support for tire data measurement, parameter identification, and road surface measurement
- cosin scientific software is located in Munich, Germany; next to BMW HQ and Olympic Parc

www.cosin.eu

MTZ Munich, hosting cosin



- **Structural dynamics based tire model**
  - handling and ride comfort
  - extremely rough roads
  - tire imperfections
  - temperature distribution
  - tread wear
  - misuse

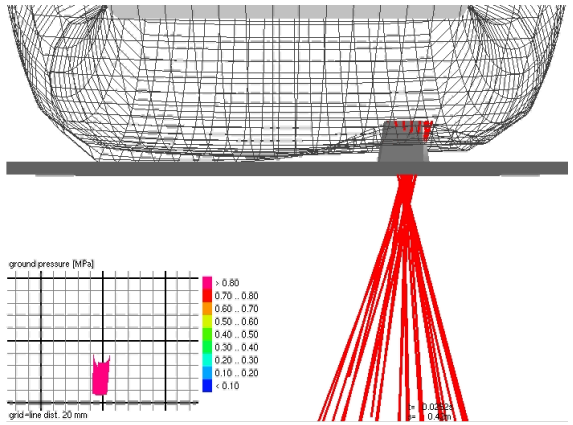
- **Faster than 5-times real-time, up to real-time**
  robust, multi-core system enabled solver engine

- **Very good correlation** to measurements

- Integrated models of time-invariant, time-variant, and dynamic deformable **road surfaces**

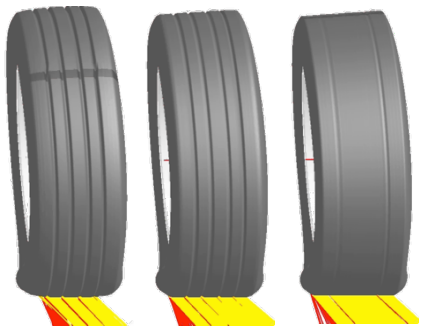
- Detailed **animation window**
  - belt deformation
  - contact force distribution
  - ground pressure distribution
  - road surface visualization

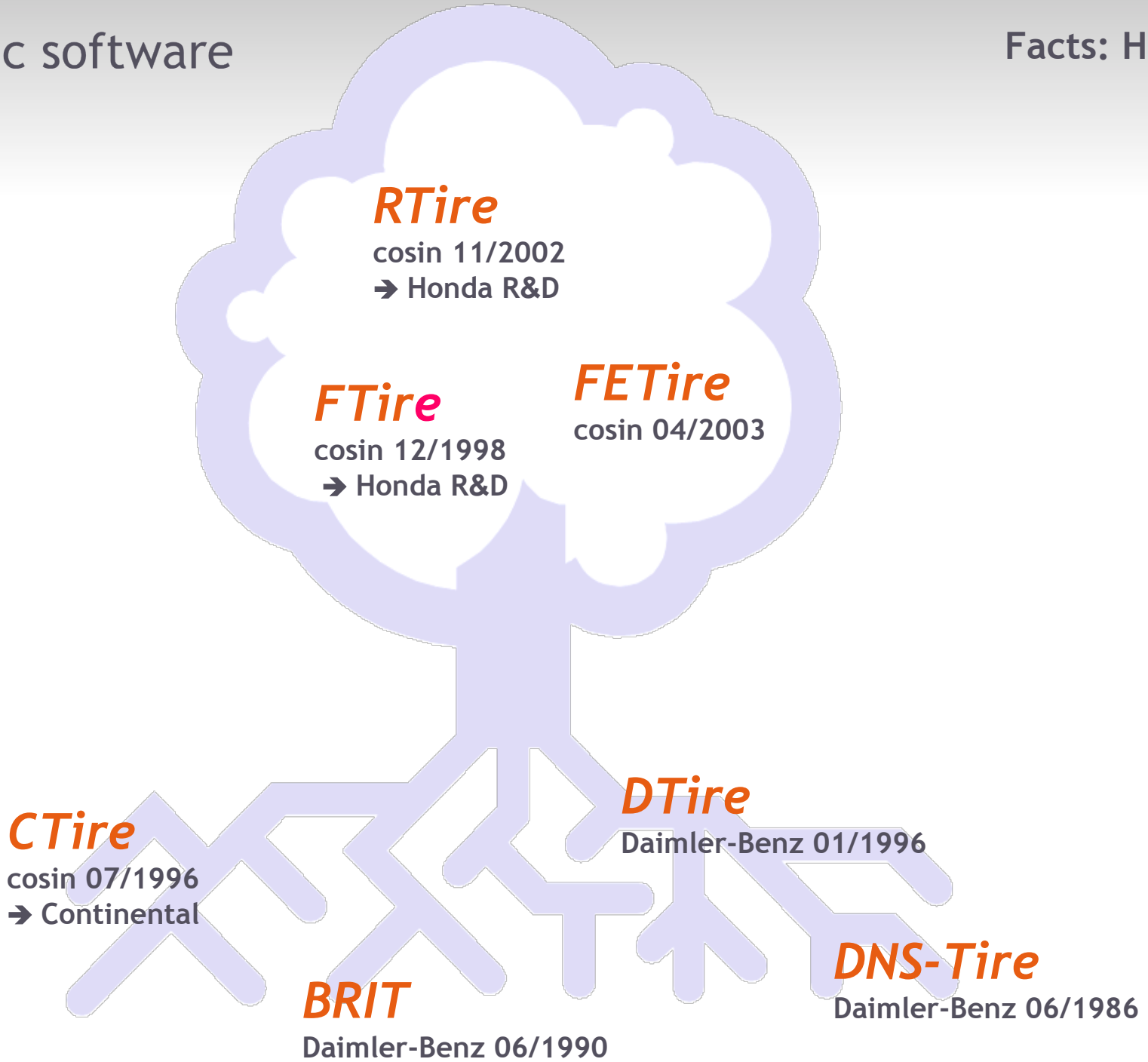
- Powerful **add-on tools**
  for analysis, visualization, validation, and parameterization



small obstacle enveloping

tread wear simulation




RTire
cosin 11/2002
➔ Honda R&D
FTire
cosin 12/1998
➔ Honda R&D
FETire
cosin 04/2003
DTire
Daimler-Benz 01/1996
CTire
cosin 07/1996
➔ Continental
DNS-Tire
Daimler-Benz 06/1986
BRIT
Daimler-Benz 06/1990

cosin
scientific software

FTire

Facts: Simulated Tire Types

cosin
scientific software

FTire
Facts: Customers

Airbus
AstonMartin
Audi
AVL
BAE
Bajaj
Bell
BMW
Bosch
Braunschweig University
Bridgestone Europe
Bridgestone Japan
Bridgestone USA
Caterpillar
Chalmers University
Chrysler
Continental
Cybernet
Daimler
Denmark Tech. University
Deere
Dresden University
Duisburg University
Firestone
FKA
Ford Europe
Ford USA
Fraunhofer
Freightliner
Fuji Heavy Industries
GM
Goodyear
Hamburg BW University
Hankook
Honda
Hutchinson
Hyundai
International
ISID
Isuzu
IVM
Jaguar/Landrover
Karlsruhe University
Kitami Inst. of Technology
Komatsu
Lockheed
Liebherr
Madras University
MagnaSteyr
Mahindra
MAN
Mazda
Michelin
Michigan Tech. University
MIRA
MIT
Mitsubishi
Mitsubishi Heavy Industries
Motorola
Munich Tech. University
Navistar
Neorium
Nissan
Opel
PATAC
Pirelli
Polaris
Porsche
Pratt&Miller
Renault
Scania
Seditec
Skoda
ThyssenKrupp
Toyo
Toyota
TR Engineering
VIF Graz University
Volvo Cars
Volvo Trucks
VW
Wisconsin University
Yamaha
Yokohama
ZF

list is incomplete!

Licensees

>45 OEMs

>11 Tire Manufacturers

> 5 Tier-1

>10 Engineering Companies

>21 Universities

Key Cooperation Partners

- MSC Software
- Altair Engineering
- FKA Aachen
- Simpack
- IFFMA KIT
- Mathworks

Other Partners

in alphabetical sequence

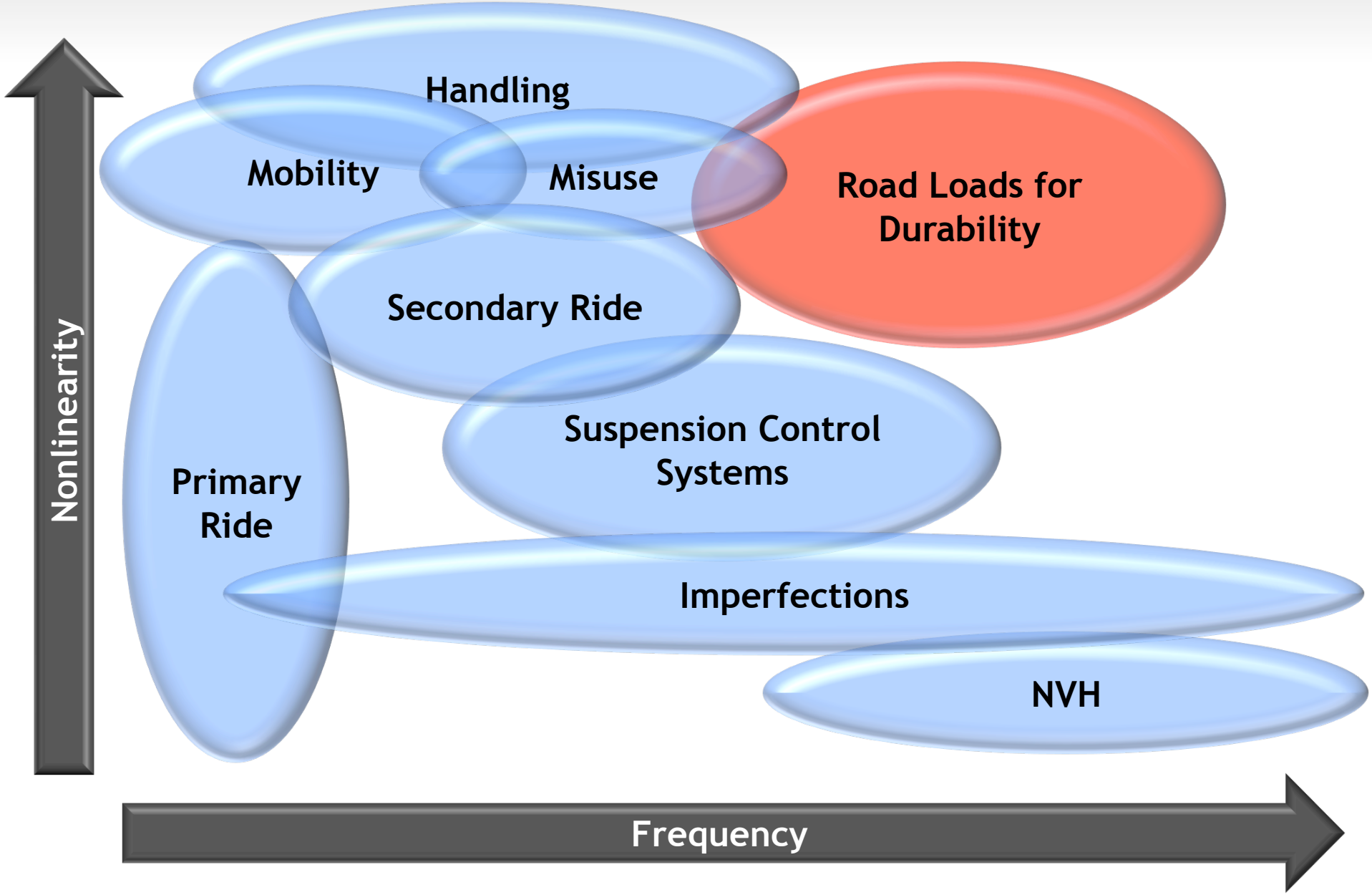
- 3D-Mapping
- Dassault Systemes
- ESI
- FEDEM
- Function Bay
- isiD
- LMS
- MTS
- Neorium
- SAMTECH
- TESIS Dynaware
- VI-grade

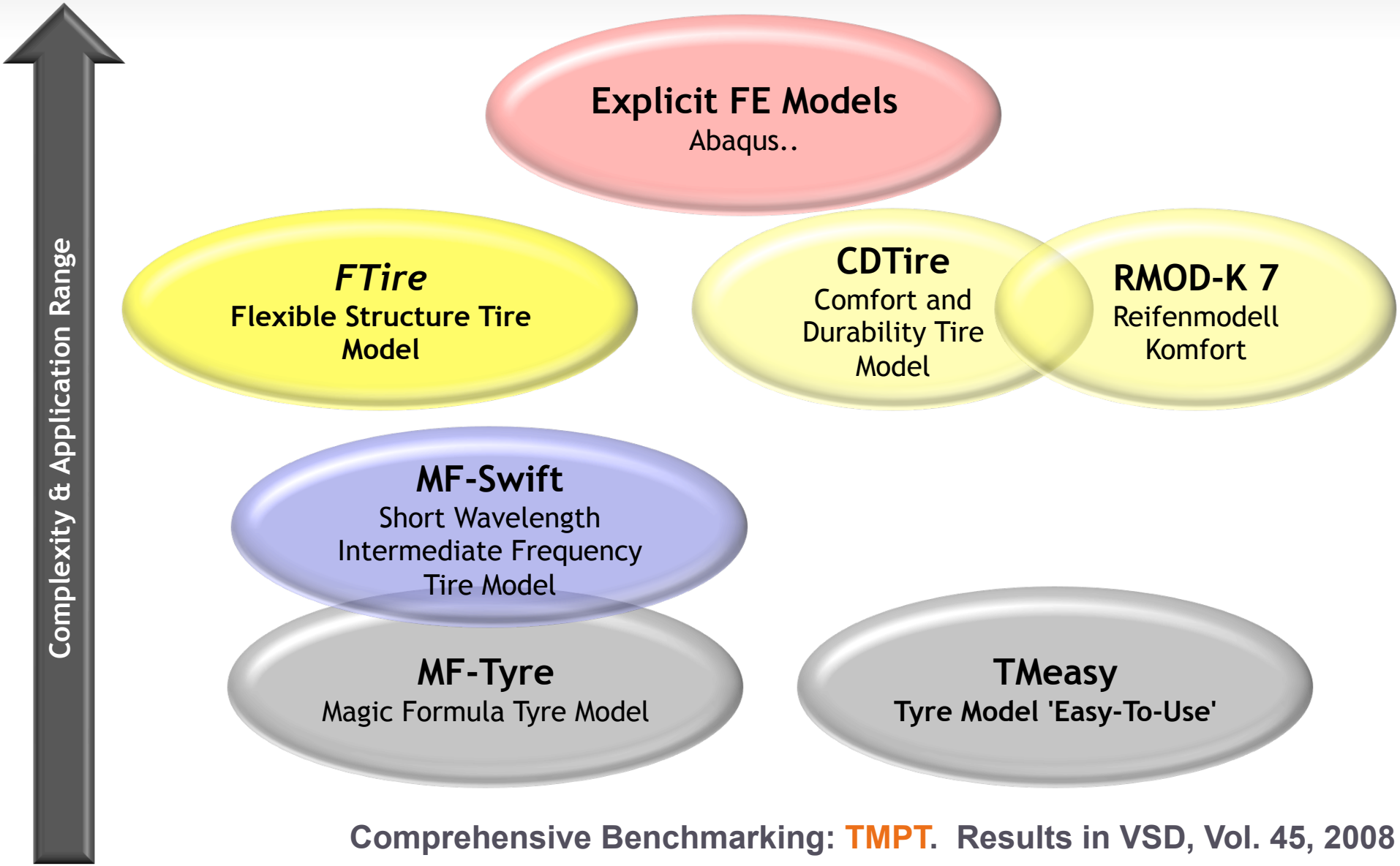
Simulation Environments

- Adams/View™, Adams/Car™, Adams/Chassis™
- Vi-CarRealTime™
- Altair MotionSolve™
- Abaqus™
- CarSim™, TruckSim™, BikeSim™
- CASCaDE
- cosin/mbs
- Dymola/Modelica™
- FEDEM™
- MATLAB/Simulink™
- Mesa Verde
- PAM-CRASH™
- RecurDyn™
- SAMTECH™
- Simpack™
- veDyna™
- Virtual.Lab Motion™, DADS™

Computer Platforms

- Windows™ XP, Vista, 7 32 bit
- Windows™ XP, Vista, 7 64 bit
- Linux RHEL5, RHEL6 32 bit
- Linux RHEL5, RHEL6 64 bit
- MAC OS X


Handling
Mobility
Misuse
Road Loads for Durability
Secondary Ride
Suspension Control Systems
Primary Ride
Imperfections
NVH
Nonlinearity
Frequency



Comprehensive Benchmarking: TMPT. Results in VSD, Vol. 45, 2008

Code Size

- ***FTire* libraries** (*FTire/tools* and other add-ons **not** included)
  62 000 executable Fortran 90 lines
  3 100 executable C++ lines

- **Magic Formula 2002 kernel** (F&M)
  410 executable Fortran lines

- **Magic Formula 2002 complete** (Road Contact + F&M)
  1 350 executable Fortran lines

Model Size and Computational Load

FTire with standard numerical resolution:

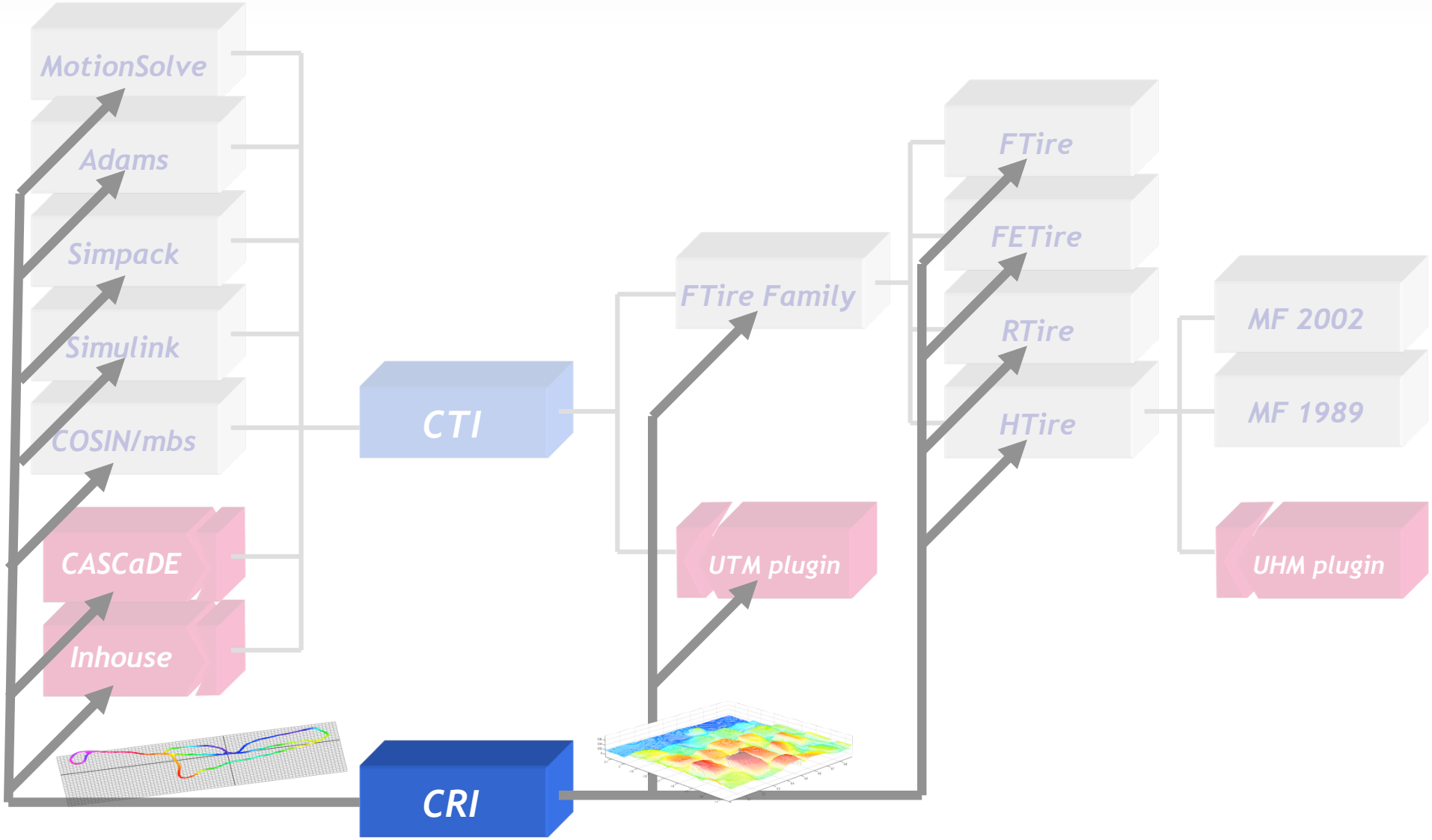
80 segments
20 contact elements per segment
0.25 ms local time-step:

- → 355 single parameters *(w/o geometry and imperfection data)*
- → 16320 pre-processed parameters
- → 17454 state variables, each refreshed 4000x per s
- → 20754 additional output signals
- → 5.5 mio road evaluations per s
- → 8.9 mio vectors/nodes animated per s

→ but takes only 5.2 CPU s / real-time s *(w/o animation, single thread)*

→ *FTire* is thread-safe and runs in parallel at maximum possible speed

→ *Ftire* has real-time capable special version


MotionSolve
Adams
Simpack
Simulink
COSIN/mbs
CASCaDE
Inhouse
CTI
CRI
FTire Family
UTM plugin
FTire
FETire
RTire
HTire
MF 2002
MF 1989
UHM plugin

→ **cosin/2Droad**: Time-invariant and time-variant rigid road surfaces:

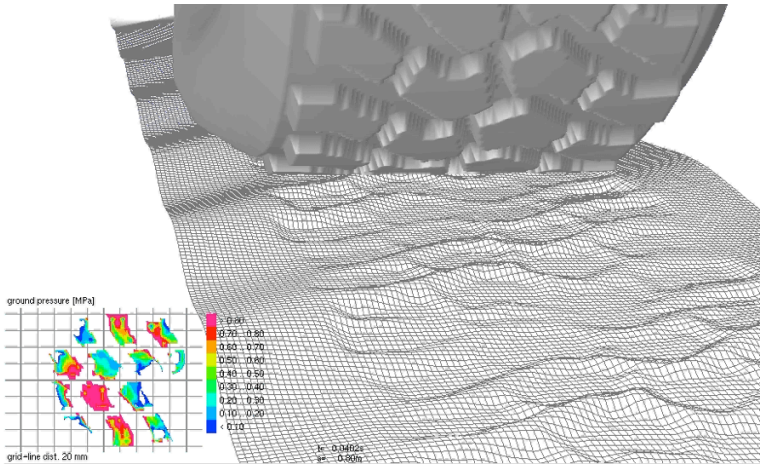
- rotating drum with cleats, flat belt
- function expressions
- hydro-pulse and 4-poster
- plank/cleat, pothole, ramp, roof, swept sine
- poly-lines with banking angle
- stochastic ISO road classes

→ **cosin/3Droad**: Regular grid based high-resolution 3D road surfaces with curved centerline:

- measured surfaces
- 2D PSD realizations
- image-based surfaces
- 3D time-dependent function expressions

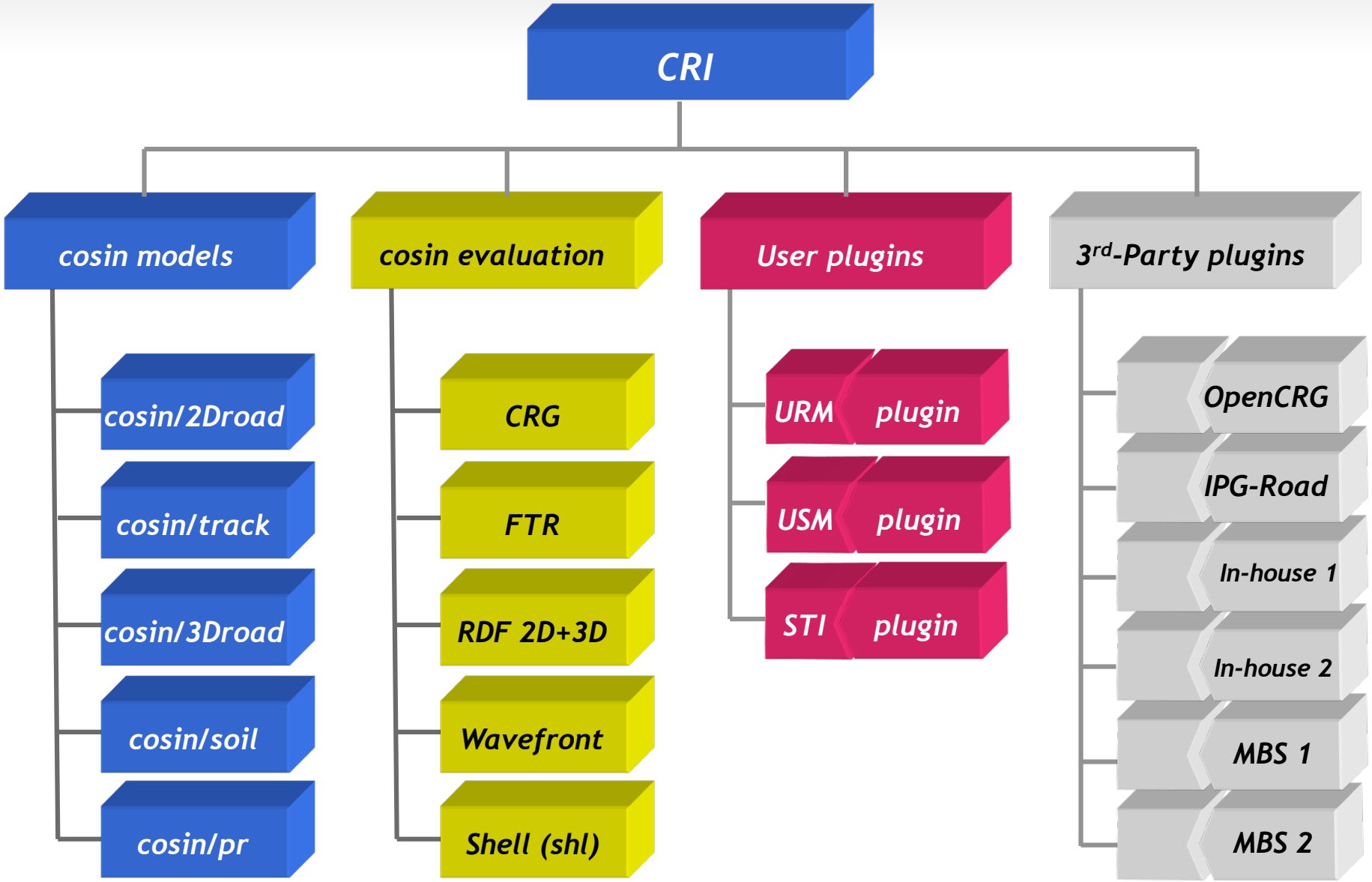
→ **cosin/soil**: Deformable road surface models:

- Bekker soil equation
- user-defined soil models



FTire on visco-elastic soil model

FTire
CRI: Road Model Interface



cosin
scientific software

..thank you for your attention!

Q & A

FTire **etc.**
demo versions,
papers,
animations,
documentation,
version updates,
and more:

www.cosin.eu