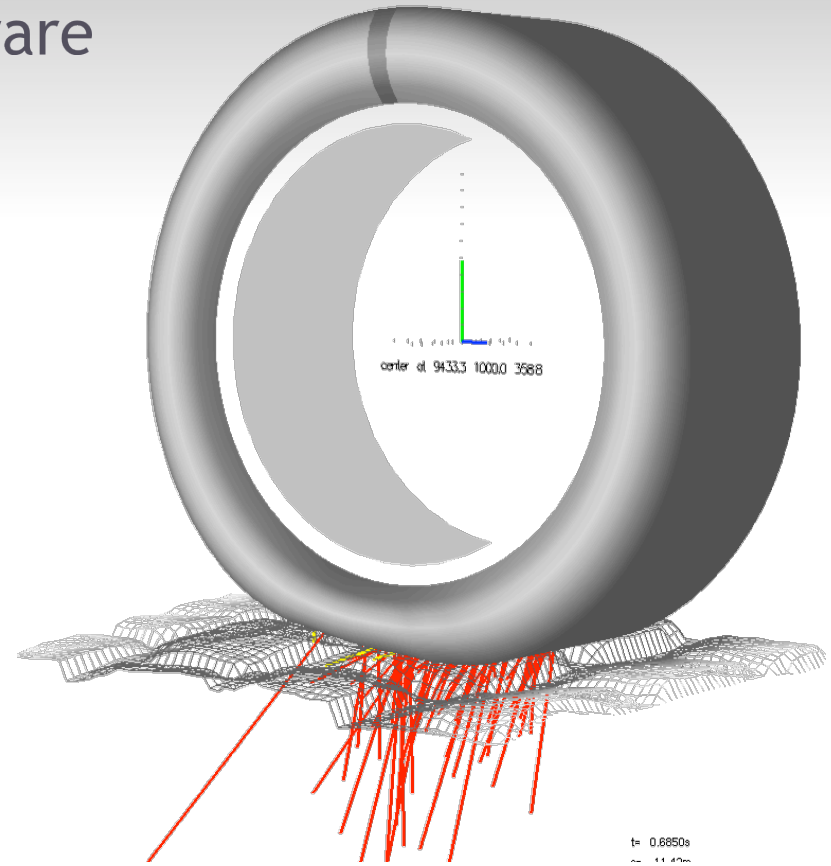
cosin
scientific software



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

Part 3: Data

Michael Gipser
Esslingen University of Applied Sciences
& cosin scientific software

Data:
Size, Specification etc.

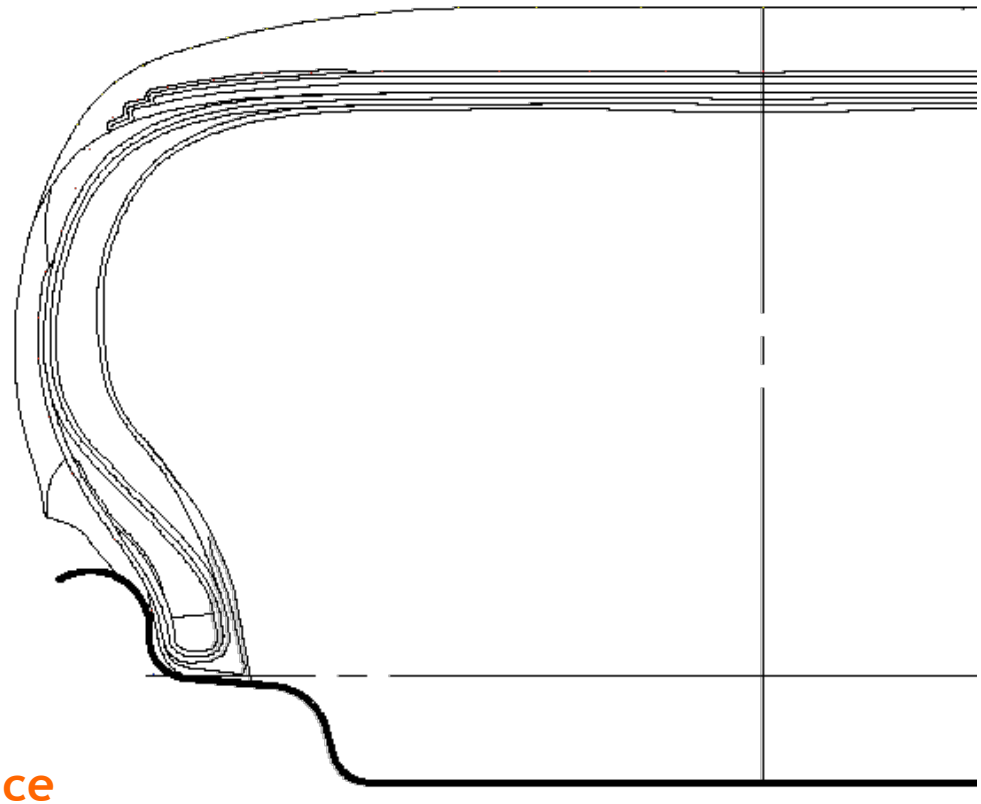
- Manufacturer
- Brand
- Tire and rim size
- Load index
- Speed symbol
- Total mass
- Nominal inflation pressure(s)

Geometry

- **Cross section** drawing, including belt, carcass, and tread outer contour (inflated/unloaded)

- **Maximum radius** (inflated/unloaded)

- **Dynamic rolling circumference** (wheel speed / drum speed for free rolling tire at different speeds)



Footprint Bitmaps

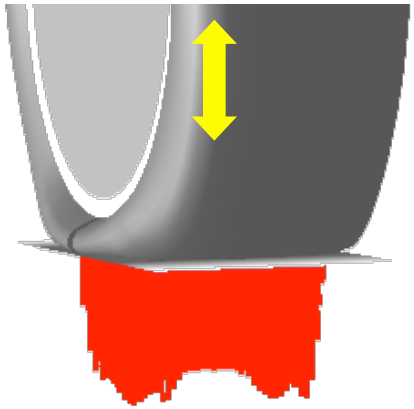
➔ Gray-scale or color-coded **footprint bitmaps**

- at half and full LI load
- at different camber angles

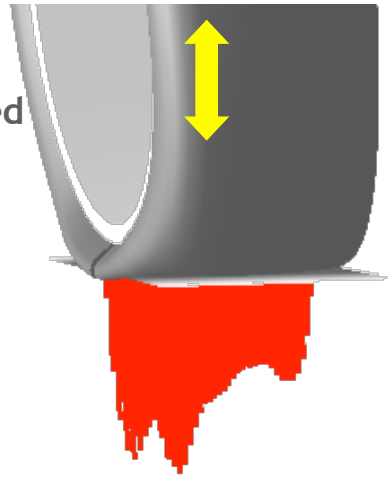
Statics: Radial Stiffness

wheel standing

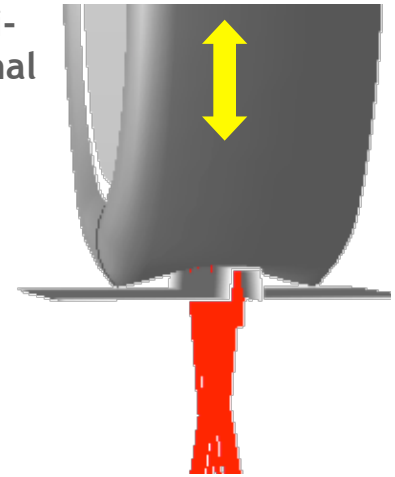
1. Flat surface



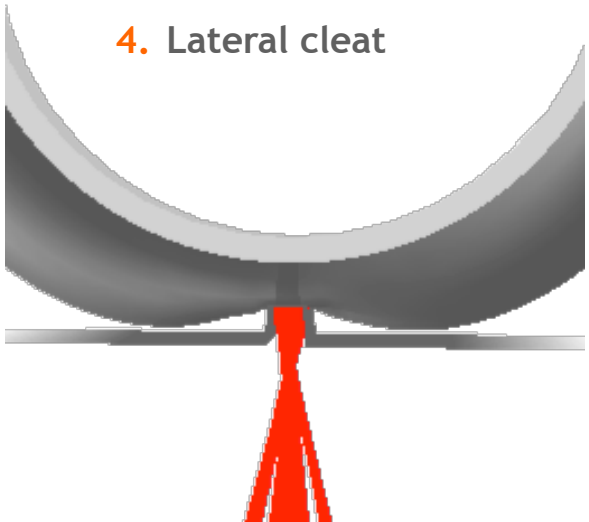
2. Flat surface, cambered



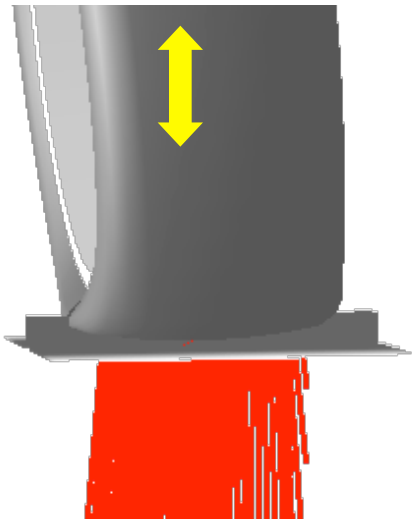
3. Longi-tudinal cleat



4. Lateral cleat



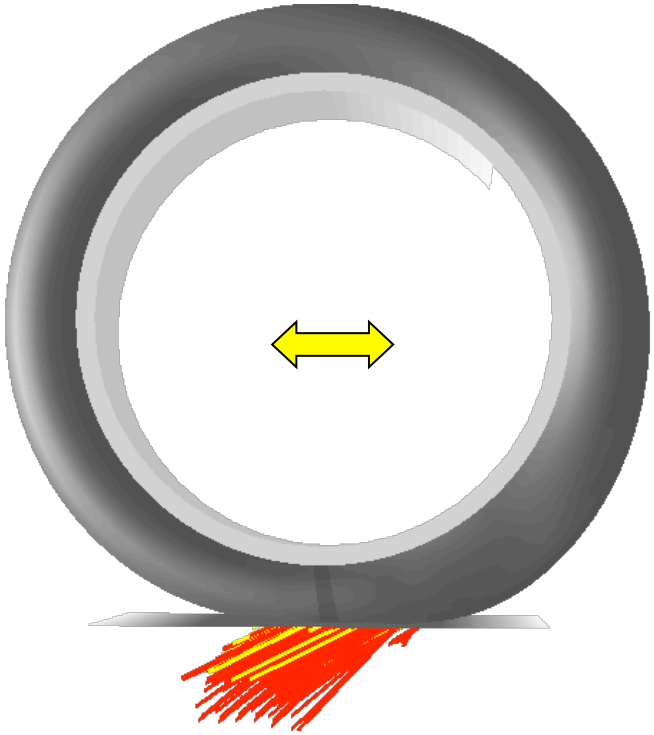
5. Lateral cleat, cambered



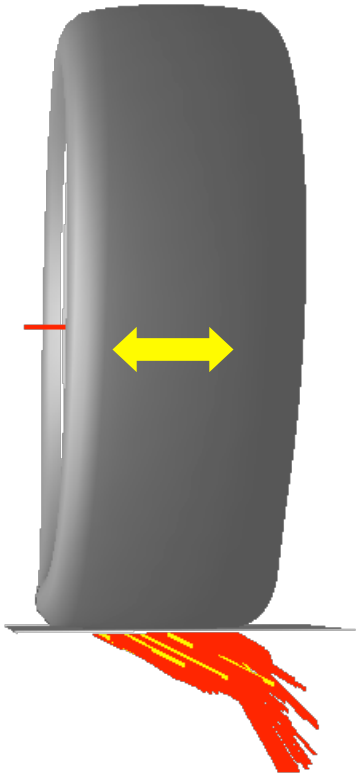
Statics: Horizontal Stiffness

wheel standing and blocked, displacement until full sliding

1. Longitudinal



2. Lateral

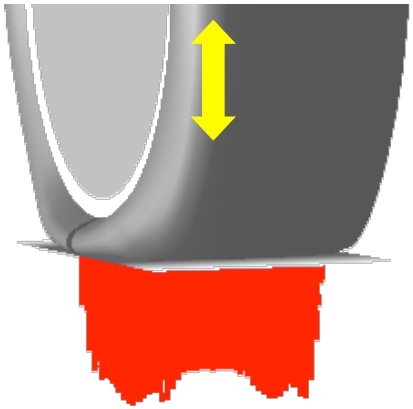


3. Torsional

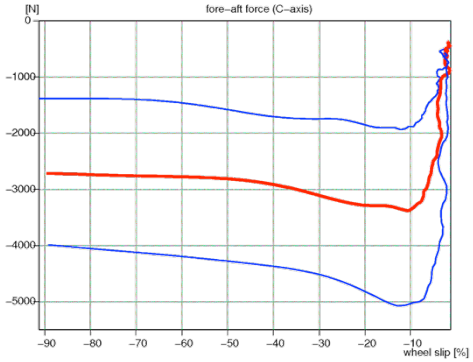
Steady-State Rolling

rolling at constant speed on drum without cleats

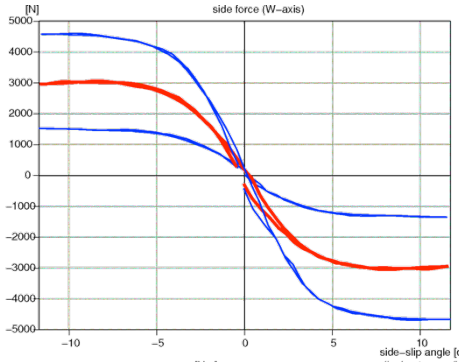
1. Radial stiffness at several speeds

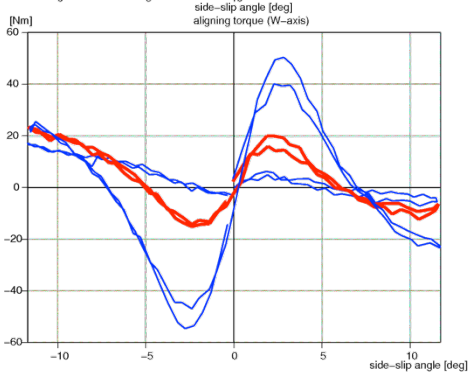


2. Braking/Traction at several loads



3. Handling at several loads and camber angles

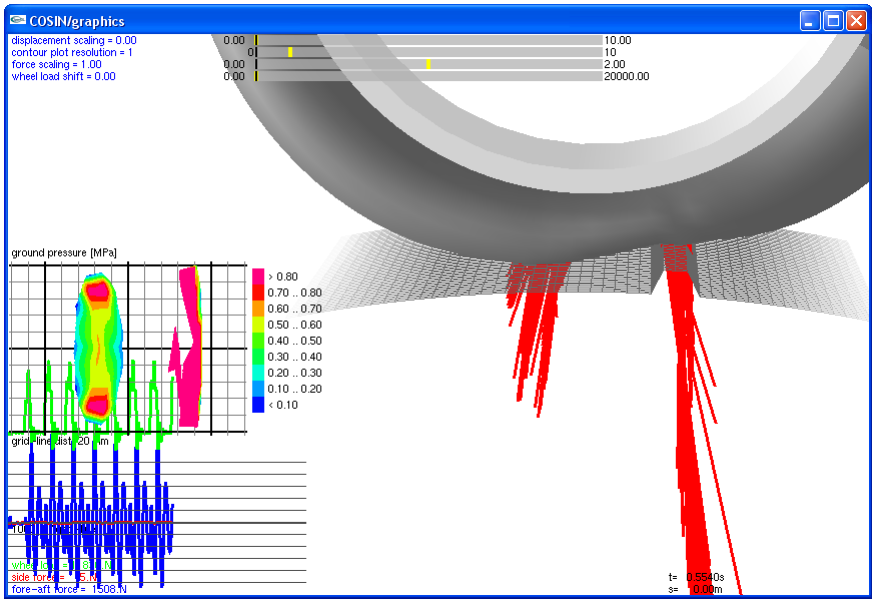




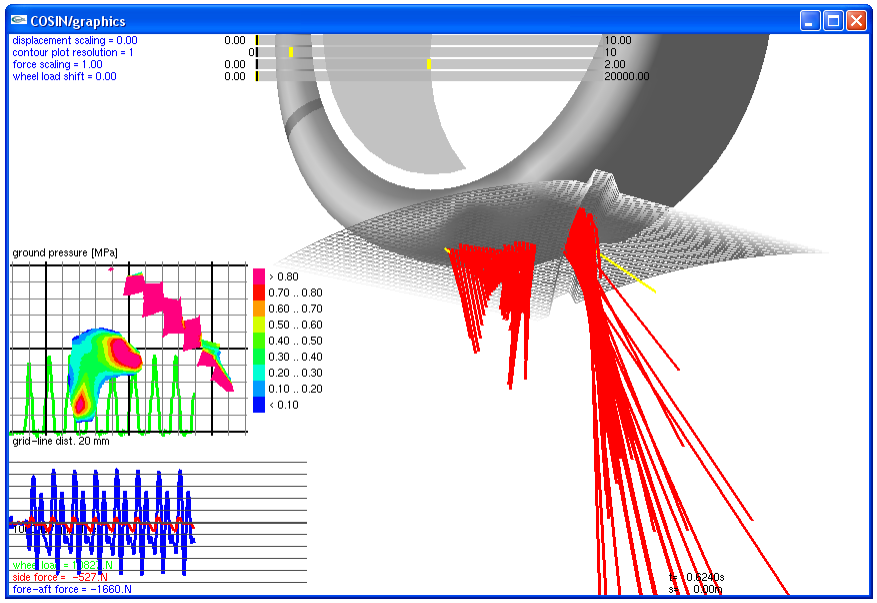
Cleat Tests

at several speeds, loads, cleat heights

1. In-plane (transversal cleats)



2. Out-of-plane (oblique cleats)



FTire Parameterization

is very flexible with respect to the kind of available experimental data: several different combinations of static, steady-state, and modal data are possible.

Parameters can be:

- ➔ known in advance (size, inflation pressure, etc.)
- ➔ measured directly (mass, radial stiffness, etc.)
- ➔ computed (if FE model is available)
- ➔ 'manually' tuned, using general related measurements
- ➔ mathematically identified, using measurements + least squares fit
- ➔ roughly estimated

Principles

1. Observe physical meaning and reasonable ranges of parameters. Avoid 'black-box identification'. Don't misuse physically well-defined parameters as abstract 'tuning' parameters.

   FTire is a physical tire model, and not just a mathematical approximation of measurements.

2. If possible, use measurements that cover the operating conditions under which the tire model will be used later.

   This is to reduce the amount of extrapolation (load, speed, excitation amplitude, inflation pressure,..) in later application.

Principles

3. Select those types of measurements that are feasible, reliable, accurate, repeatable, and cheap at the test facility in use.

   There is not just one fixed parameterization procedure. The procedure may be adapted to the circumstances.

4. Automate data acquisition and processing.

   This is to improve the process chain's comparability and repeatability.

Parameterization Tools

a) ***FTire/estim***
'rough estimation' of *FTire* data, using a similar reference tire

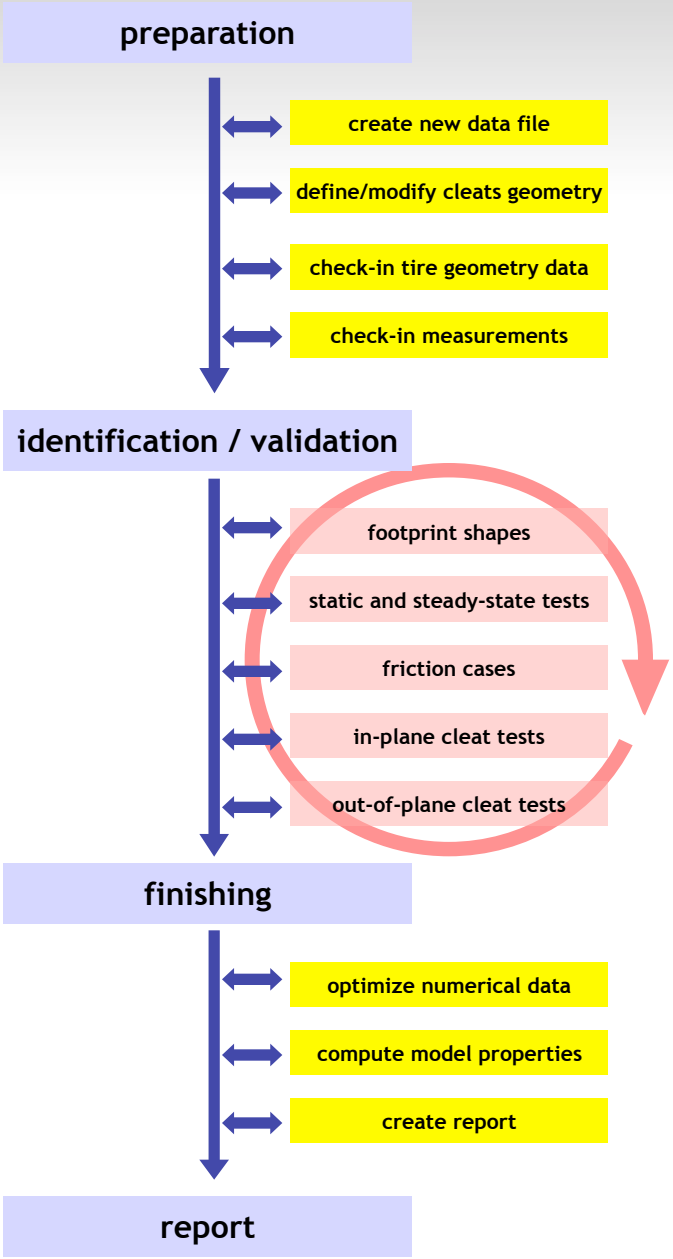
b) ***FTire/fit***
combination of a) with
- direct measurement of certain geometry and stiffness data,
- identification and /or validation
  of other mass, stiffness, damping, and friction data,
  using static, steady-state, and dynamic cleat tests

c) ***FTire/calc***
processing detailed tire design data with *FETire*, a parameterized coarse FE model

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, slip stiffness)
- automated static and steady-state validation by time domain simulation
- dynamic identification: least squares cleat test fit in time and/or frequency domain
- fully automatic HTML/PDF-based report generator, including generation and display of steady-state and handling simulation results

FTire
FTire/fit: Work-Flow



FTire/fit: De-Coupling of Identification Phases

Directly measured data

size & geometry, mass, vertical stiffness…

In-plane statics

belt in-plane and lateral bending stiffness, belt longitudinal stiffness…

Traction/Braking
small slip values

tread stiffness…

In-plane cleat tests

belt extensibility, in-plane damping, more tread rubber properties…

Out-of-plane statics

belt lateral and torsional stiffness…

Handling (F&M)
small slip values

belt out-of-plane bending stiffness…

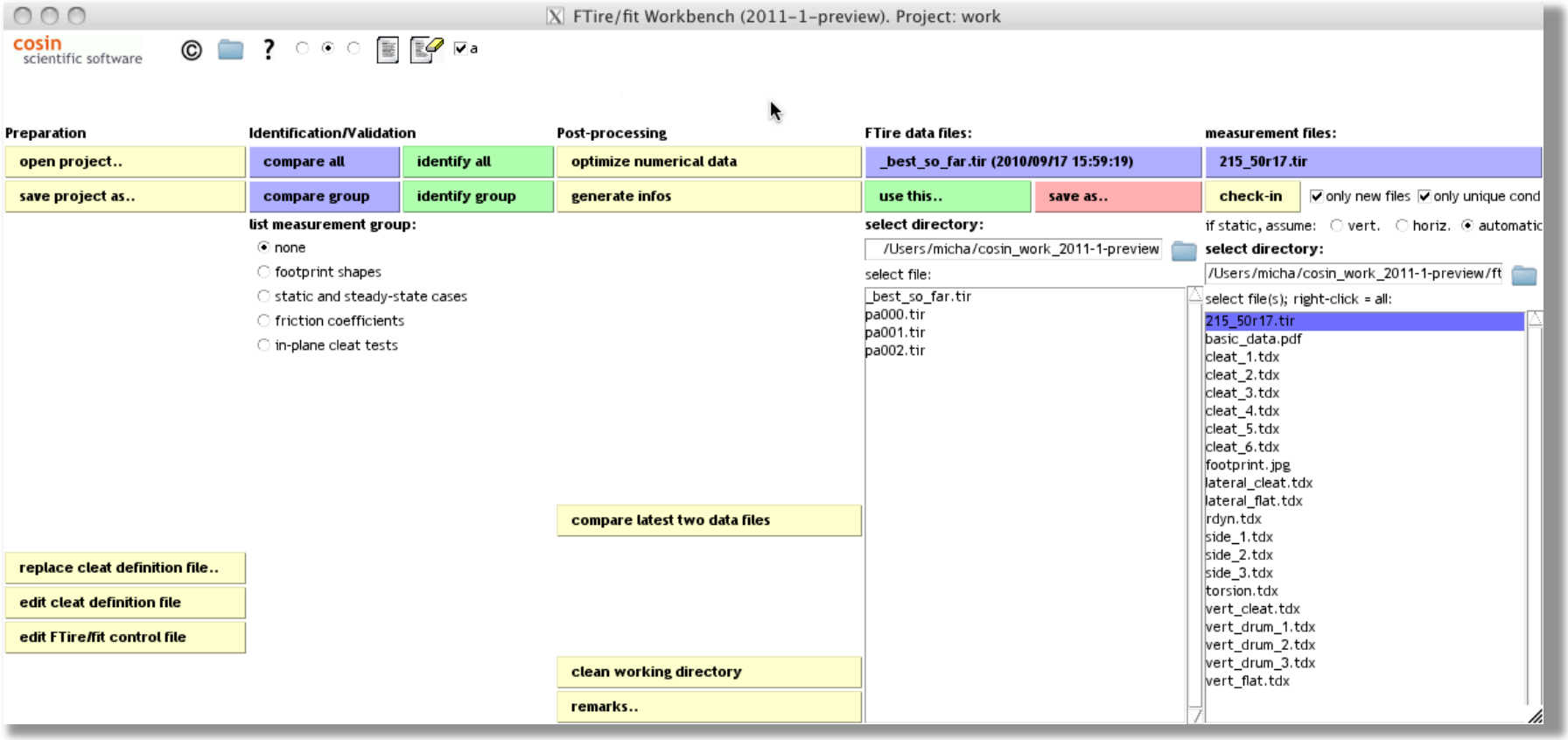
Out-of-plane cleat tests

out-of-plane damping, belt out-of-plane flexibility kinematics…

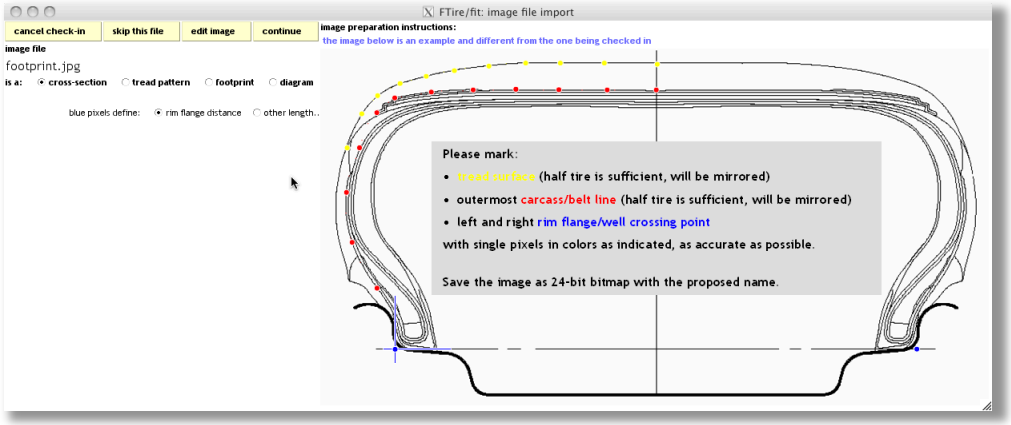
Friction characteristics
large slip values

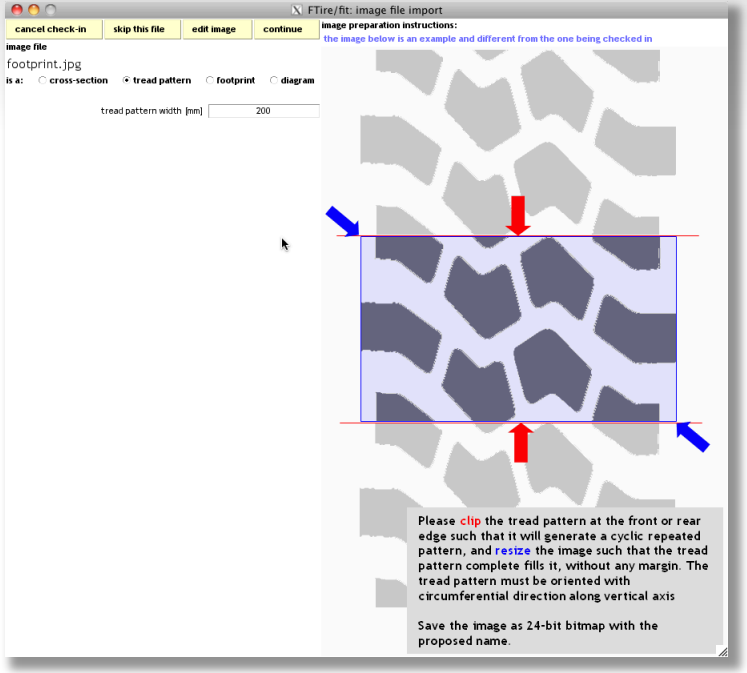
sliding friction coefficients

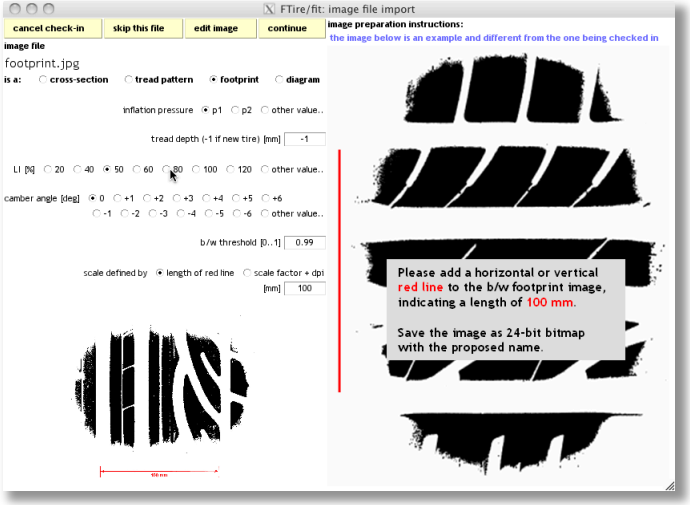
FTire
FTire/fit: GUI

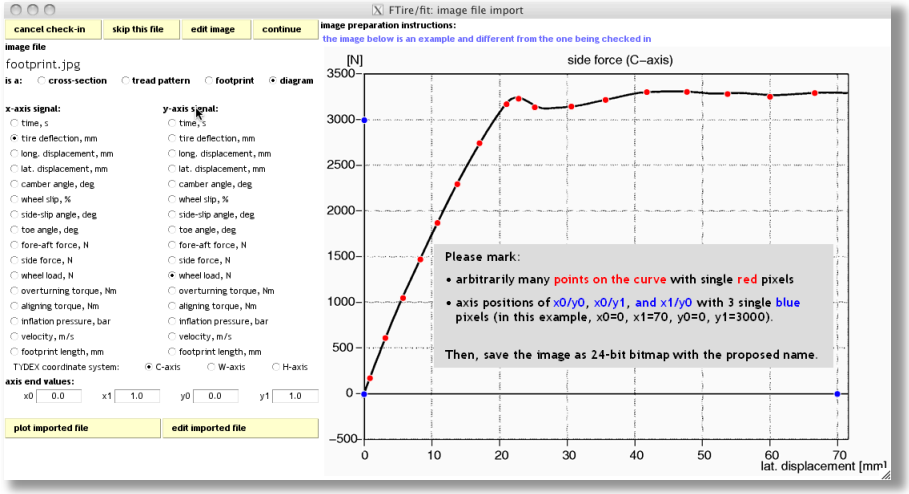


FTire/fit: Bitmap Check-In



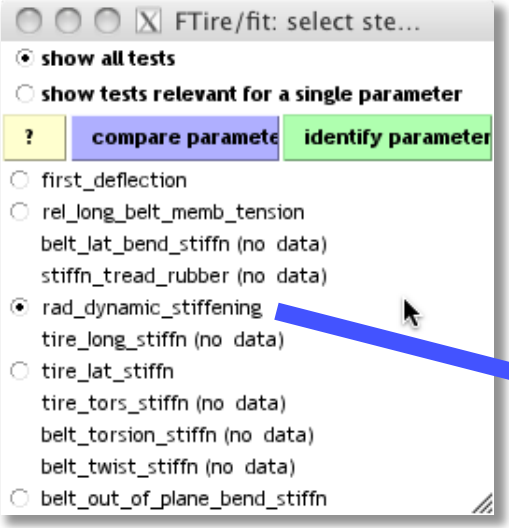


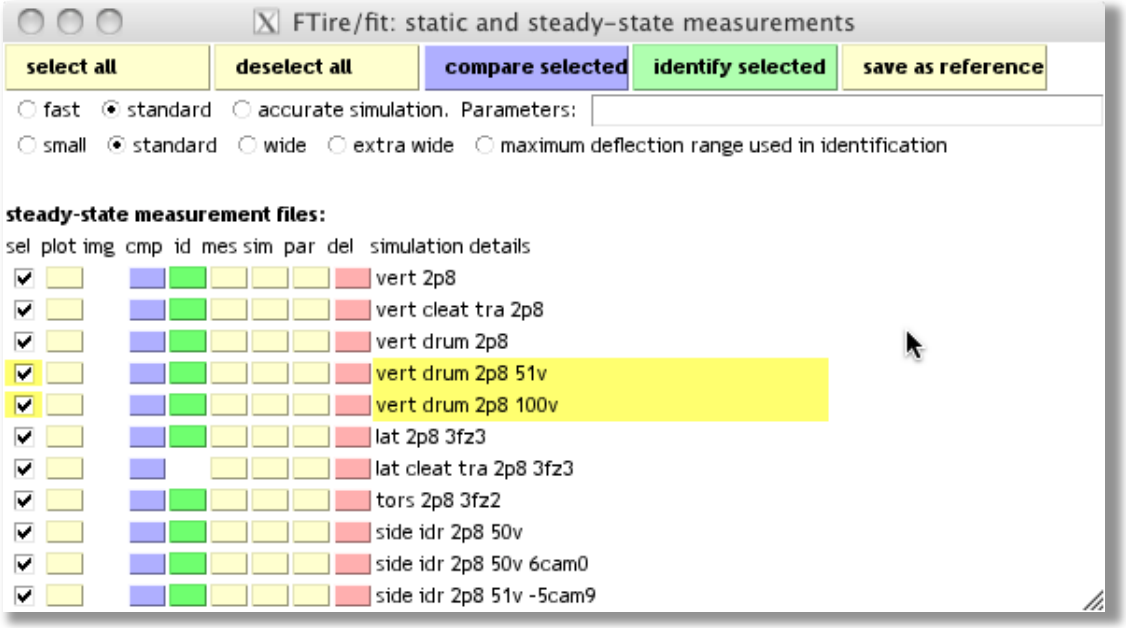




FTire

FTire/fit: Measurement / Data Dependencies





..thank you for your attention!

Q & A

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

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