Tools of the trade

A new software package offers a suite of real time, robust physical tire models and procedures, helping vehicle and tire manufacturers to achieve more reliable test results

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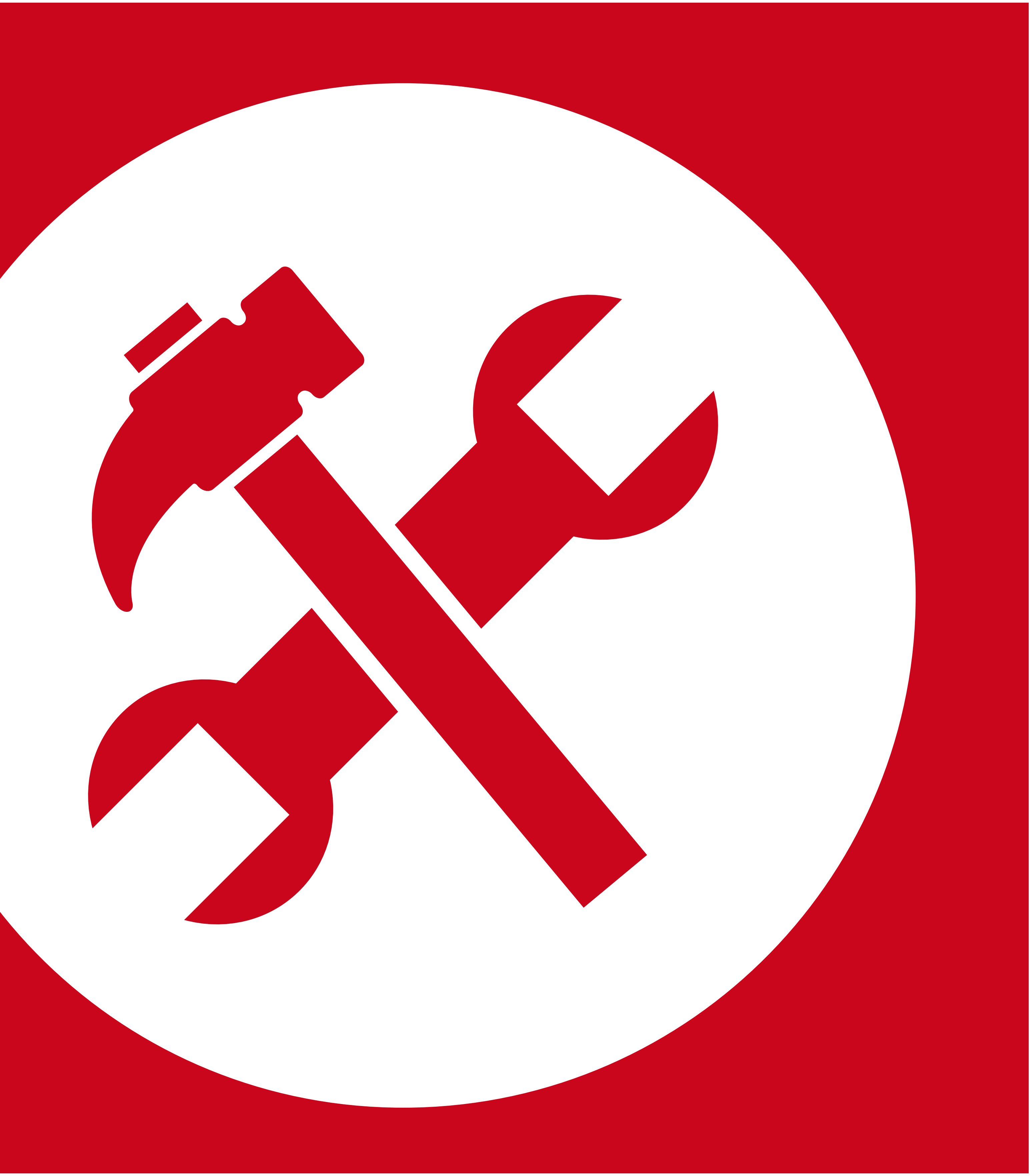
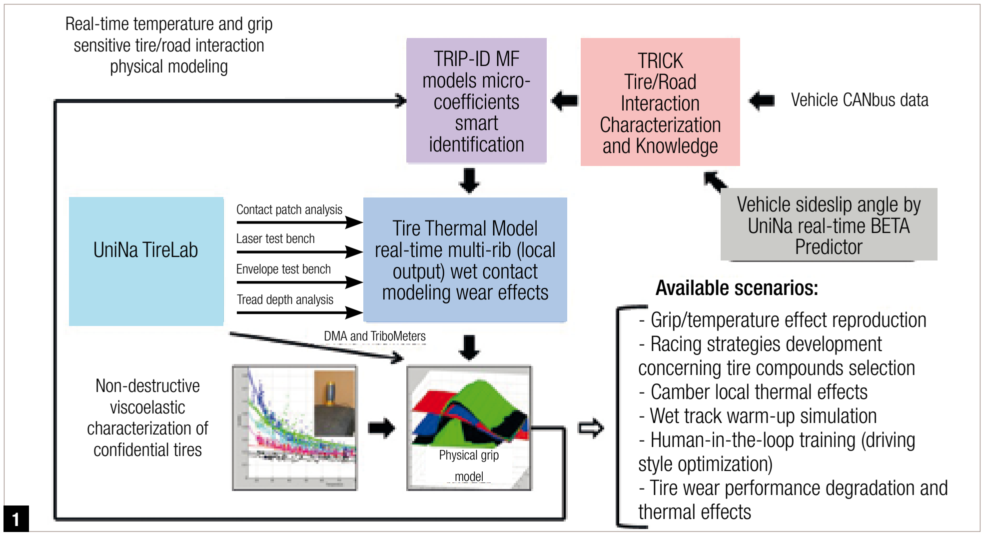
Tire and vehicle companies continually strive to establish the optimal tire model that describes a tire's behavior in the experimental and simulation environments. The Vehicle Dynamics UniNa Research Group has created testing procedures and development tools able to do this.

In 2015 the group's activities received important feedback from scientists and the wider automotive market. Encouraged by this feedback, which was extremely positive, the MegaRide University spin-off project was established with the aim of providing a direct link with the users of the developed tools, focused on the future of research in the mobility field.

The growing need for reliable vehicle simulations to improve safety and performance has led academia and industry to develop real time, robust and predictive physical tire and vehicle models. Meanwhile, the MegaRide group has created a simulation and analysis software package consisting of various physical models and procedures (Figure 1). Its basic structure is articulated as follows:





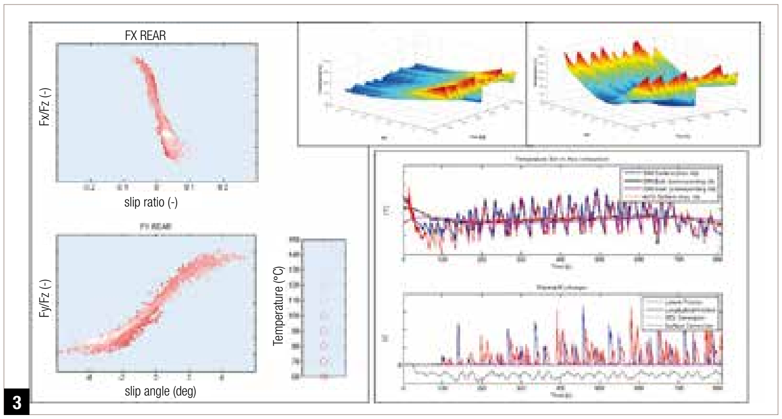
The TRICK (Tire/Road Interaction Characterization and Knowledge) tool. This is based on a vehicle model that can process signals acquired via CANbus during outdoor test sessions. As an output, the tool provides the tire interaction characteristic curves and enables users to carry out handling and performance optimization analyses. (Runner-up in the Vehicle Dynamics International Awards 2014 for Development Tool of the Year.)

The TRIP-ID (Tire/Road Interaction Parameters Identifier) tool. Using the TRICK output and the predictions of proper physical models, the TRIP-ID identifies the Pacejka Magic Formula coefficients taking into account the effects induced by temperature and grip variations on tire behavior (Figure 2). Specially developed procedures enable discrimination between thermal and wear effects, elimination of the outliers, and reliable reproduction of camber and load effects.

Figure 1: The core components of the software package

Figure 2: The Trip-ID user interface with the Smart MF Parameters Manager and some screenshots from the Plotter Tool

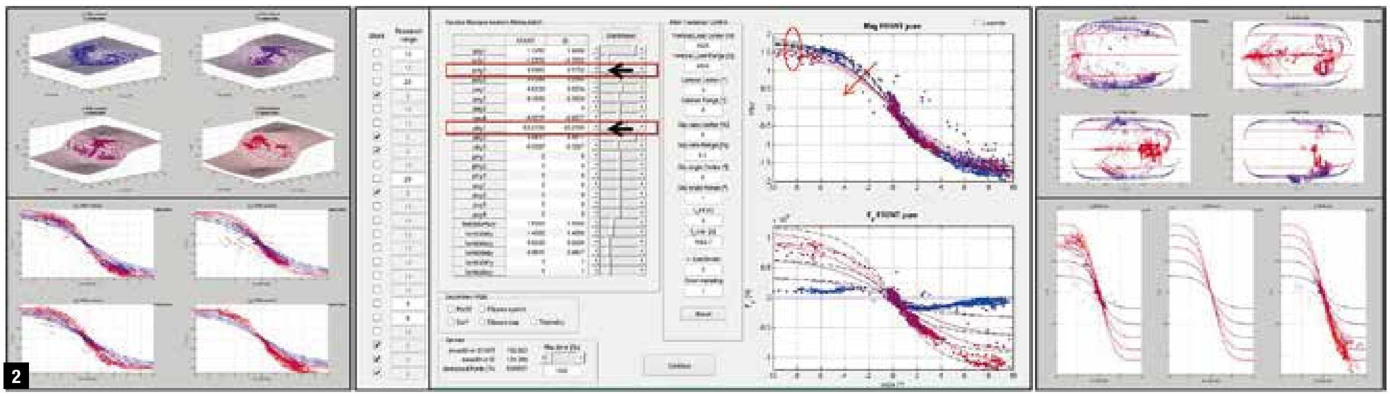
Figure 3: Results of analysis carried out using the Tire Thermal Model. Temperature effects on grip, stiffness and MF microparameters are predicted by the model, which is able to estimate local heat distribution in real time

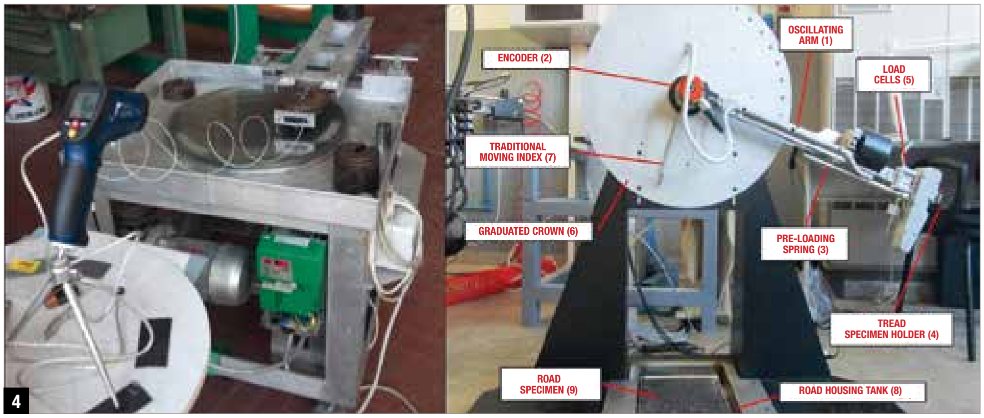


The TTR (Tire ThermoRide) tool. This physical-analytical thermal model predicts and simulates in real time the temperature of tire layers based on telemetry data-processing techniques (Figure 3). The model provides local temperature distribution, with particular reference to the deep layers that measurement instruments are typically unable to reach. It can also be employed to study the dissipative phenomena induced by cyclic deformations and the thermal flows acting during working phases. New features in the tool include wear effect prediction, a ribs model and real-time mode.

The AdheRide model. This is a physical-analytical tire grip model. It calculates the power dissipated in a polymeric material indented by a road asperity, taking into account the adhesive/hysteretic effects and the viscoelastic experimental characteristics.

The UniNa real-time BETA Predictor. One of the group's most recent research activities focused on the development of a procedure, based on correlations, Kalman filters, statistical evaluations, genetic algorithms and neural networks, to estimate in real time, vehicle sideslip angle (β) by processing data from CANbus. The potential applications of such an instrument





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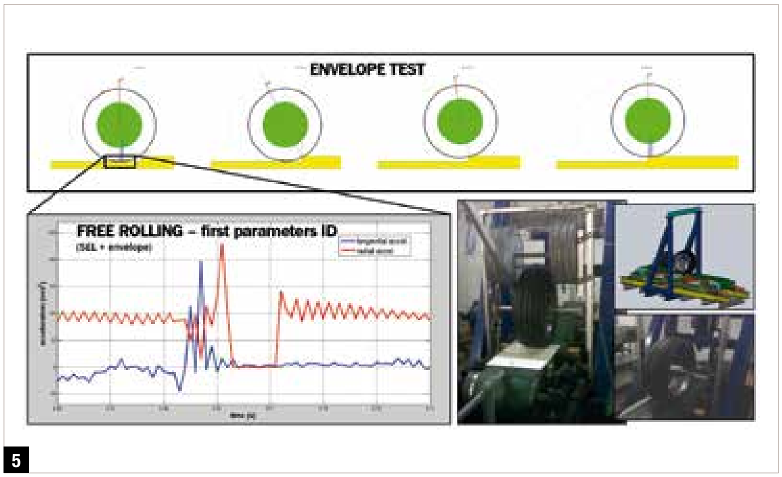


5

Figure 4: Pin on disk tribometer (left) and BP EVO test bench (right). Both are used for tire tread friction testing over real road surfaces

Figure 5: Envelope test bench used for rolling evaluations and validation of the UniNa Tire Envelope Model

Figure 6: Tire tan (δ) non-destructive evaluation by means of innovative algorithm processing signals from a commercial dial indicator. Markers: estimated values; lines: DMA lab characterizations (left). Non-destructive evaluation of tire layer thickness by means of ultrasonic probes (right)

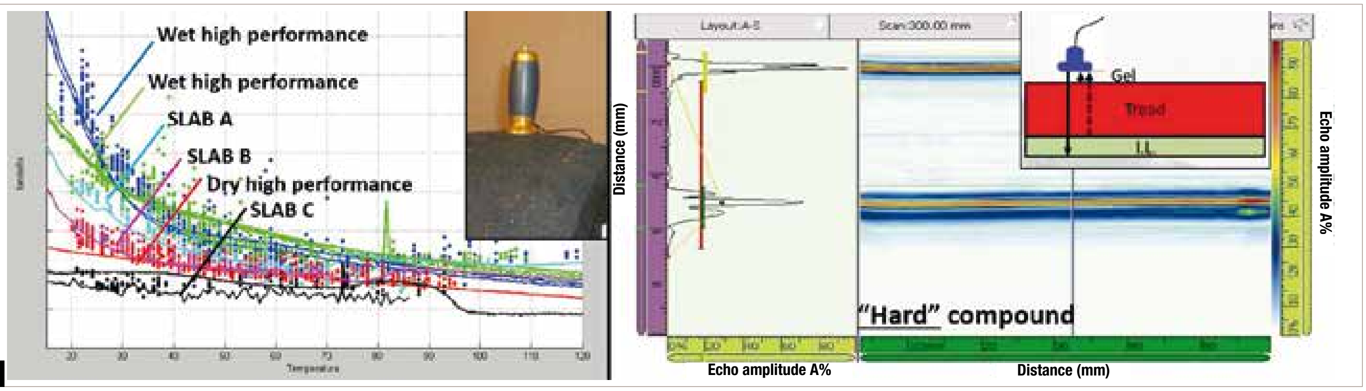
could involve the development of vehicle control logics based on the estimation of a fundamental variable that is typically difficult to measure.

Many organizations have already used these models and procedures in motorsport and passenger vehicle and tire design. The MegaRide group believes that this is proof of the adaptability of its activities, as these solutions can be tailored to the needs of a wide range of customers, from top-ranking racing teams with expensive dynamic driving simulators, to tire makers looking for innovative structures and compounds in order to increase vehicle and pedestrian safety, or those seeking algorithms for the estimation of tire and road conditions, which are communicated to the surrounding vehicle network.

With the aim of feeding physical and reliable data into the cited models, a specialized facility, named the Tire Lab, was established on the first two floors of the Mechanics Building of the Department of Industrial Engineering at the University of Naples. It houses a number of test benches for basic research, experimental investigations on vehicle components, and physical model parameterizations.

This includes a pneumatic press for strain energy loss and contact patch analyses; a laser thermal bench for thermal conductivity tests and heat evaluation; pin on disk and advanced British pendulum tribometers (Figure 4); a tire envelope dynamic test bench (Figure 5); and a test system for non-destructive characterizations of tires, which was recently used for developing racing tires (Figure 6a and 6b).

Conclusions and further developments related to the aforementioned themes could be analyzed from multiple perspectives. With a clear interest in high-performance vehicle tires and motorsport, huge importance has been attributed to the underdevelopment of real-time temperature-sensitive friction prediction techniques, which could enable improvements in tire/road contact optimization, in both dry and wet conditions, with the ultimate aim of increasing road safety. The impact that the employment of advanced techniques for the analysis and modeling of the interaction phenomena could have on the development of road asphalts, tires and vehicle control systems could represent a major incentive toward the evolution of autonomous driving and smart mobility systems. **tire**



6