University of ULSTER

The static contact patch of some friction measuring devices

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This paper

- Tyre / asphalt surface contact patch.
- Influences surface characteristics such as:
  - friction, noise, rolling resistance
- Static contact patch of three devices commonly used around the world to measure highway or airfield friction:
  - the pendulum tester
  - GripTester
  - SCRIM


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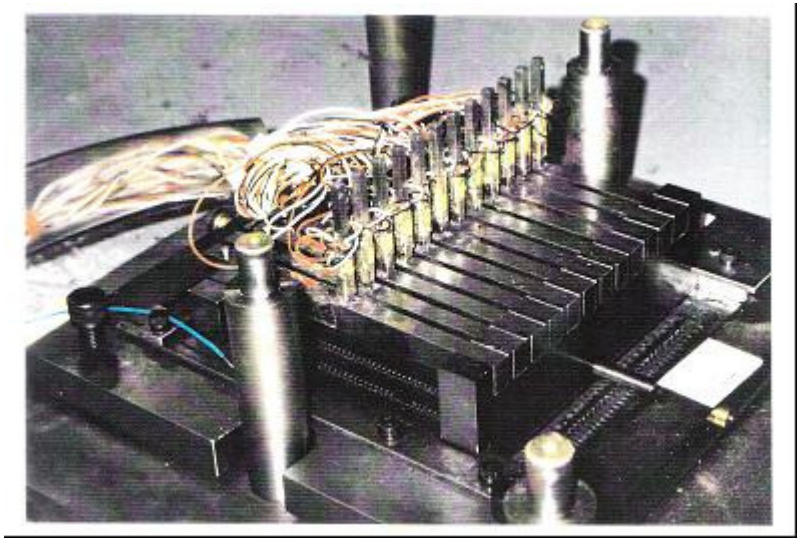
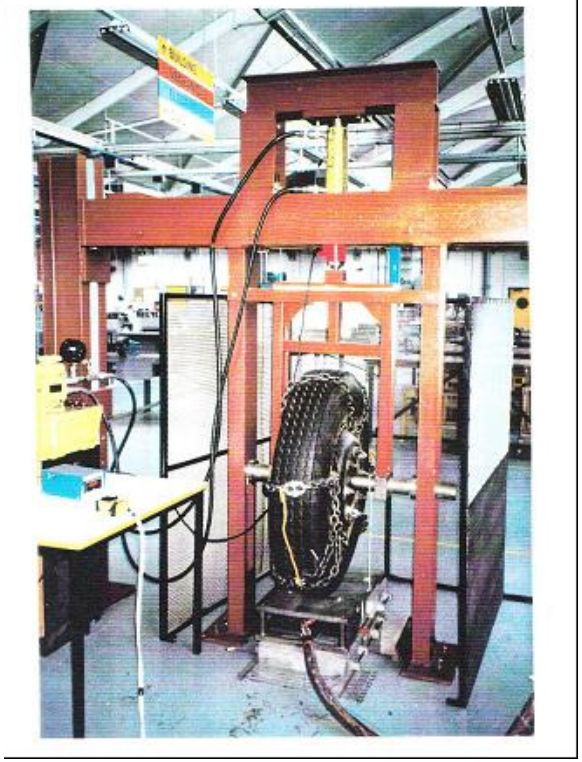
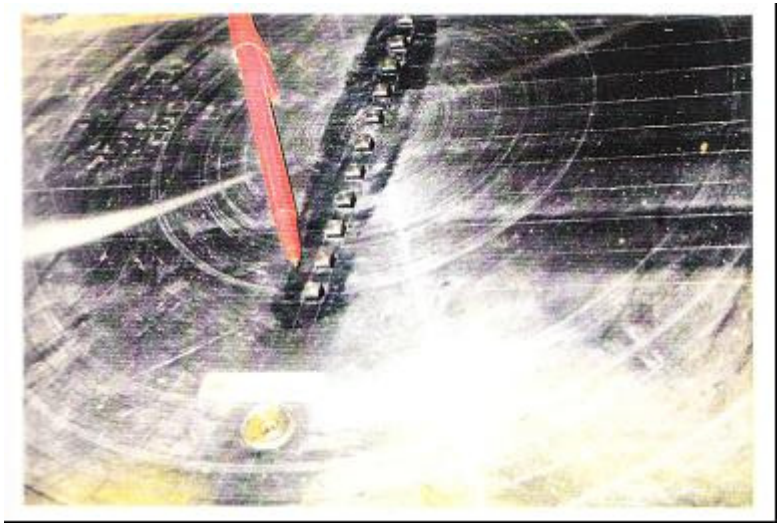
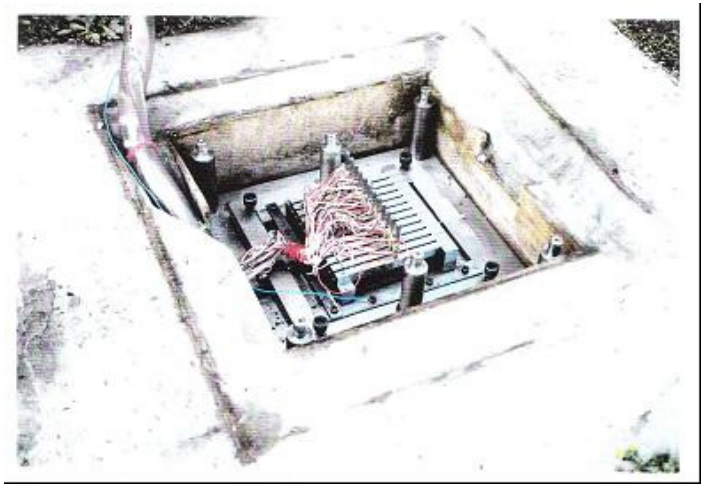
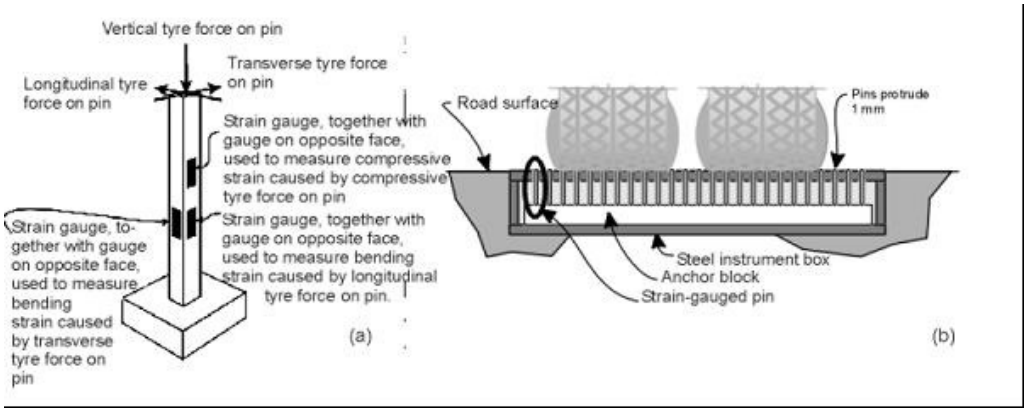
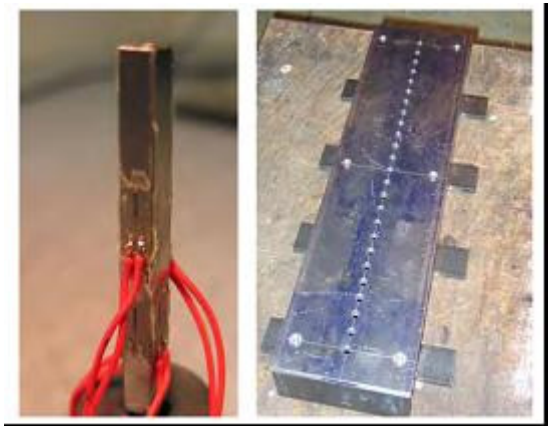


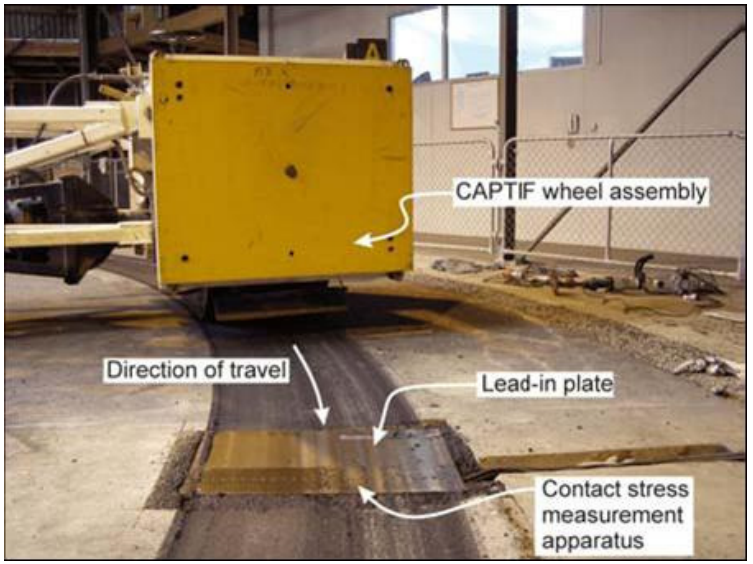







Vertical tyre force on pin
Transverse tyre force on pin
Longitudinal tyre force on pin
Strain gauge, together with gauge on opposite face, used to measure compressive strain caused by compressive tyre force on pin
Strain gauge, together with gauge on opposite face, used to measure bending strain caused by longitudinal tyre force on pin.
Strain gauge, together with gauge on opposite face, used to measure bending strain caused by transverse tyre force on pin
(a)
Road surface
Pins protrude 1 mm
Steel instrument box
Anchor block
Strain-gauged pin
(b)




CAPTIF wheel assembly
Direction of travel
Lead-in plate
Contact stress measurement apparatus

Using paint (ASTM F870-94, 2010)

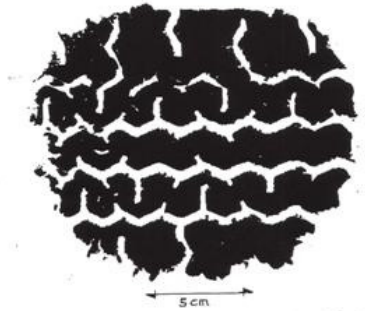


Figure A.4.2 Car tyre footprint at load of 1.5 kN and tyre inflation pressure of 172.5 kPa

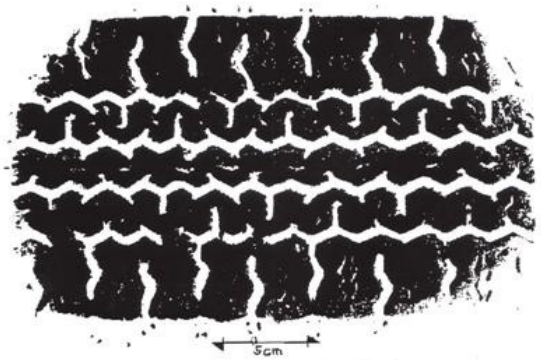
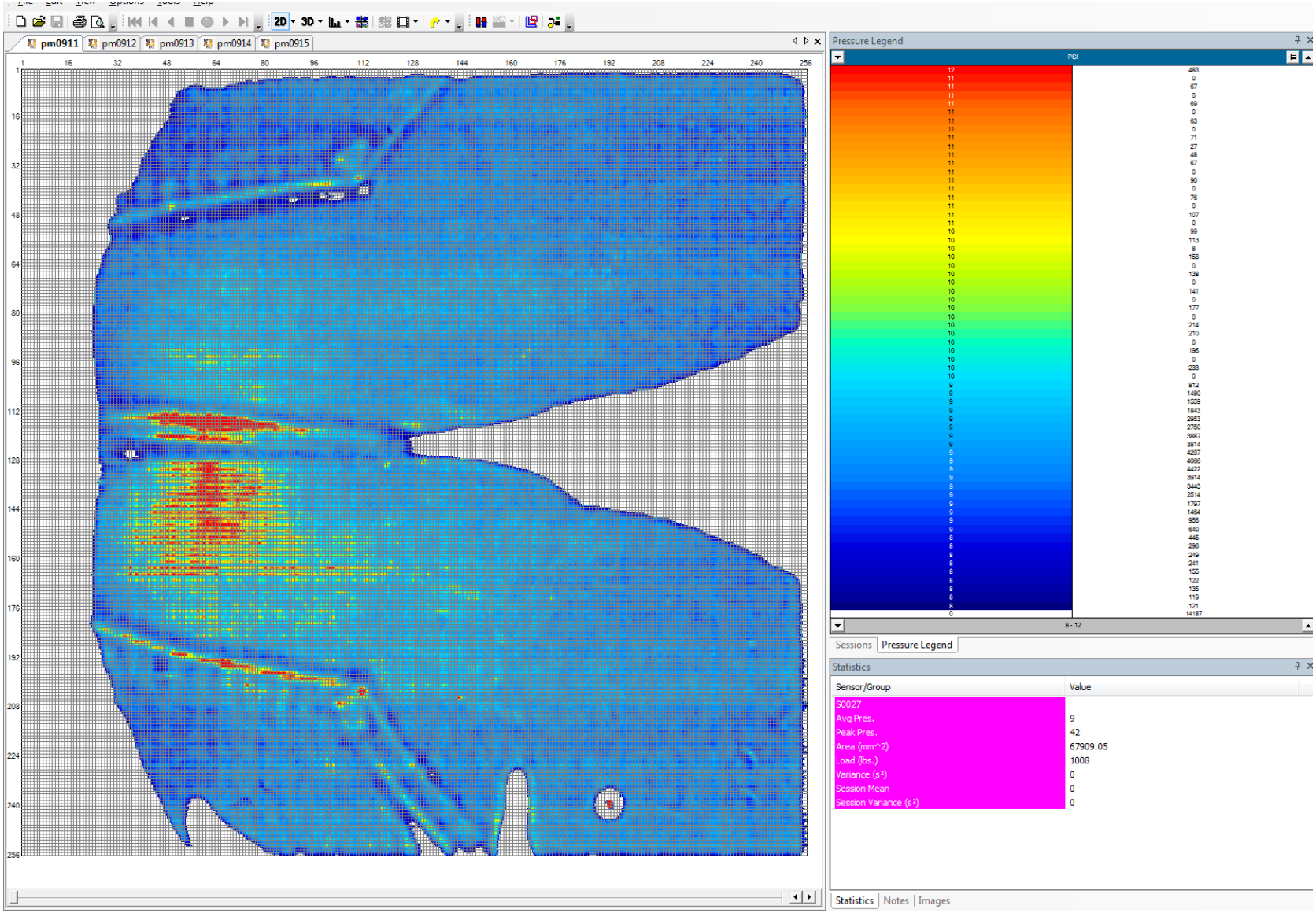
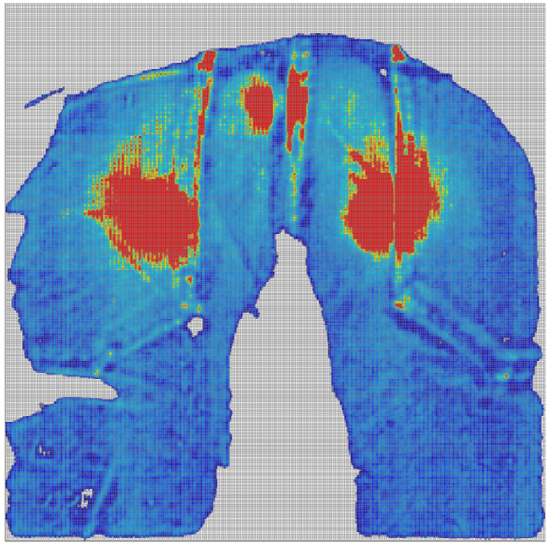


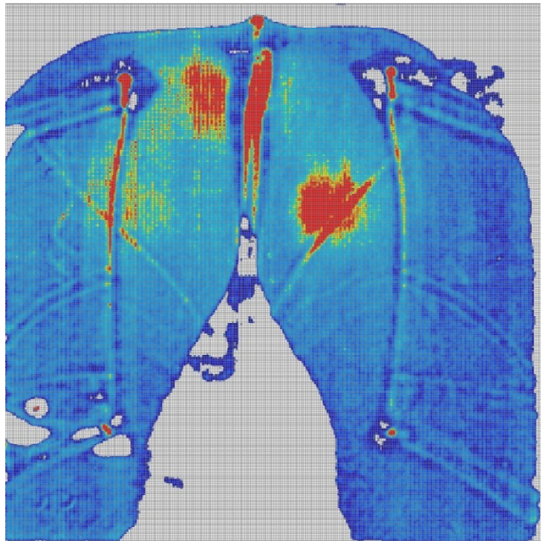
Figure A.4.3 Car tyre footprint at load of 2.8 kN and tyre inflation pressure of 103.5 kPa

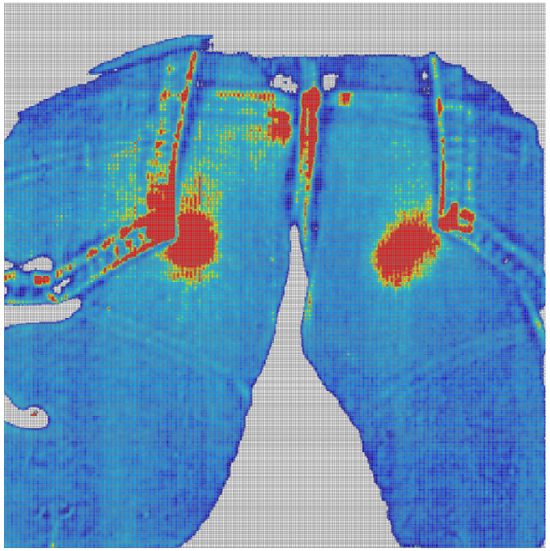
Surface contact – are you sitting comfortably?

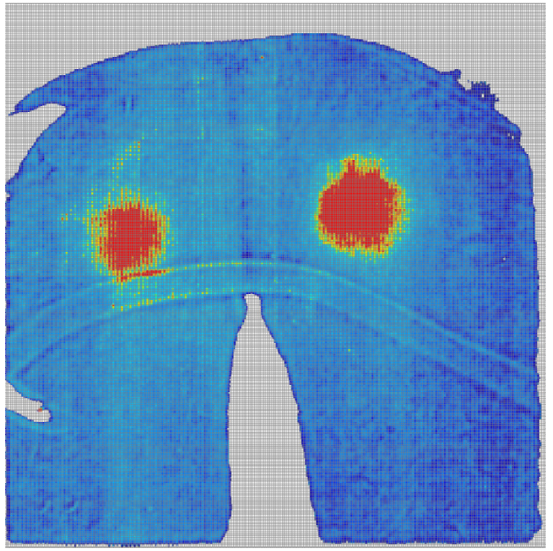


Odd one out?

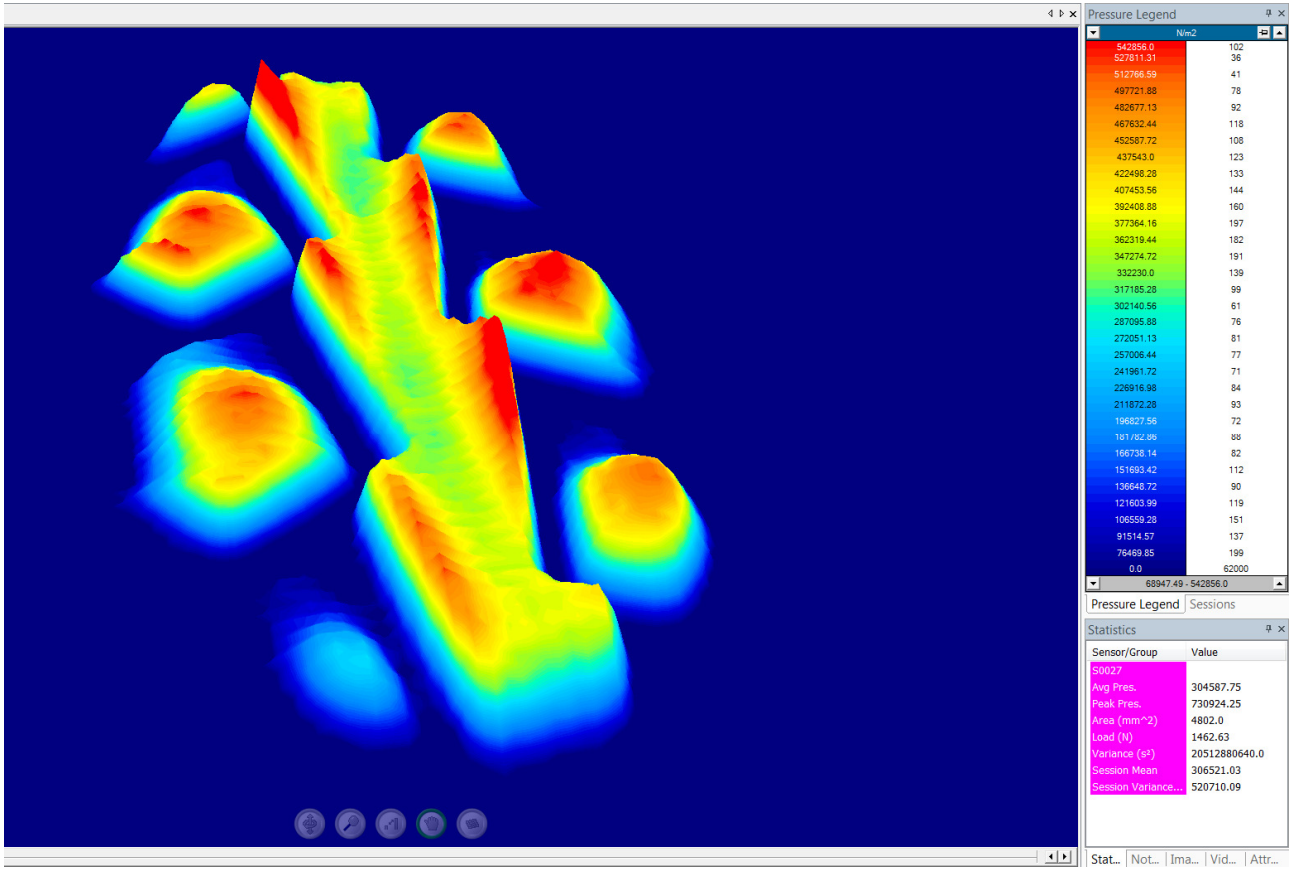




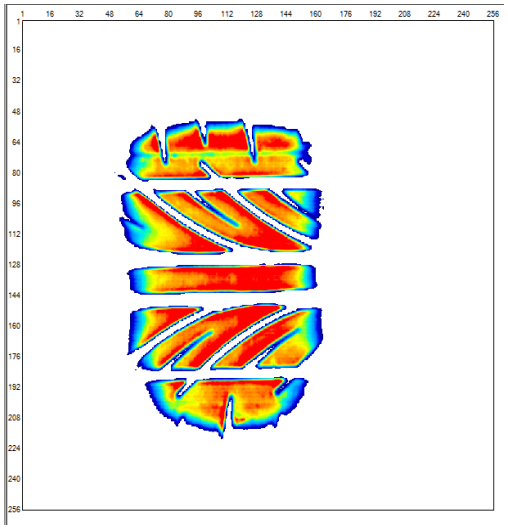


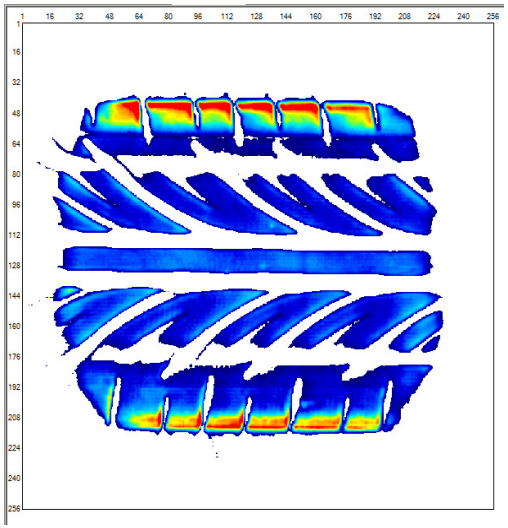


From paint to pressure mapping

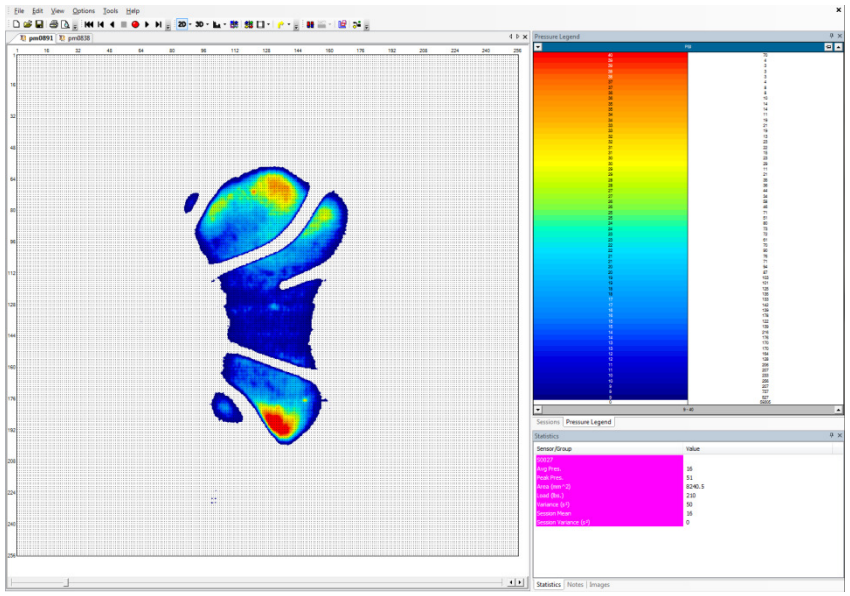


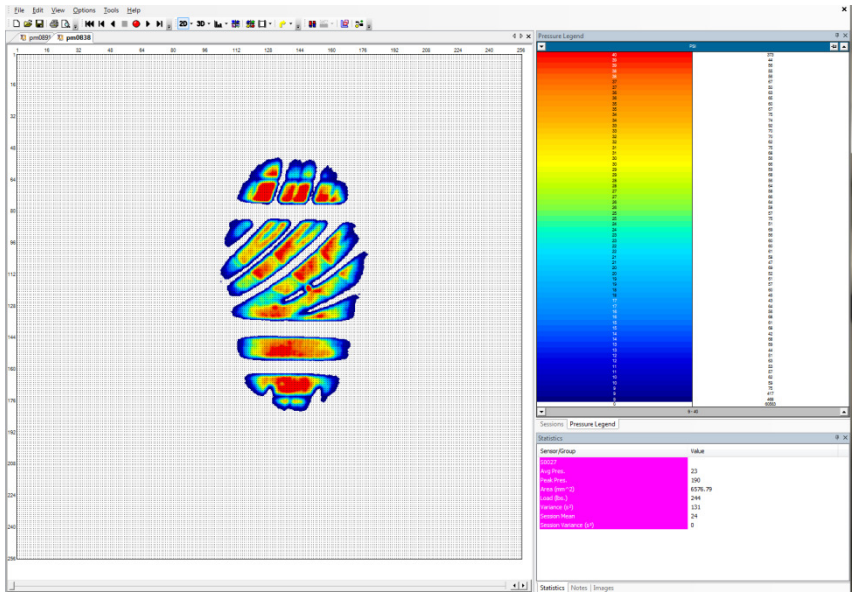
Pressure mapping





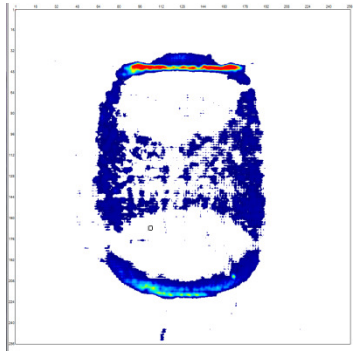
Toyo v. Avon – rear right @ 20psi



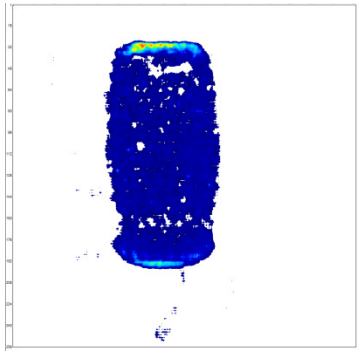


Formula Student rear slick

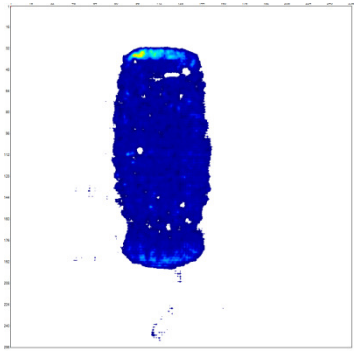
flat



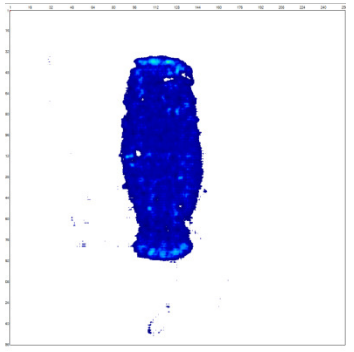
1psi



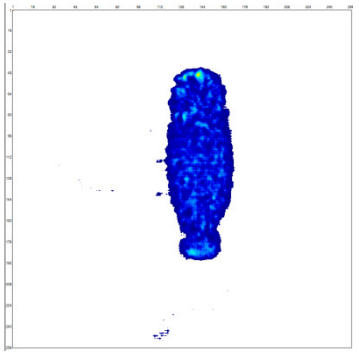
3psi



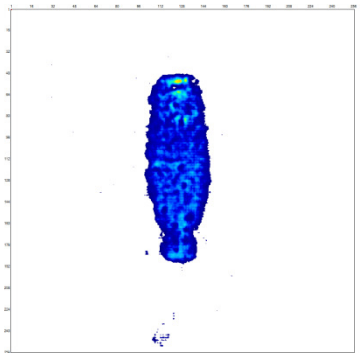
5psi



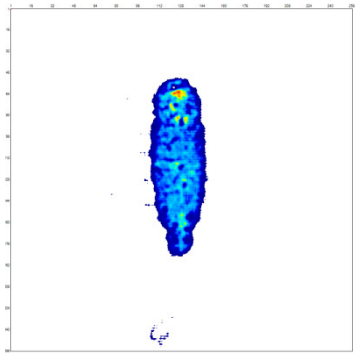
8psi



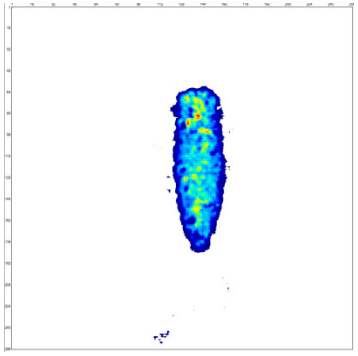
10psi



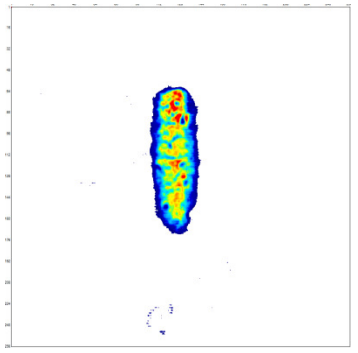
15psi



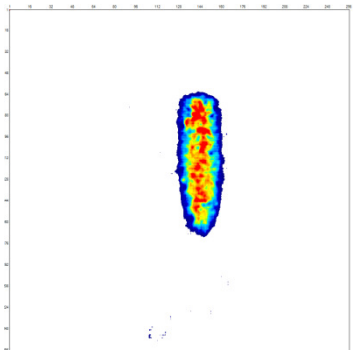
20psi



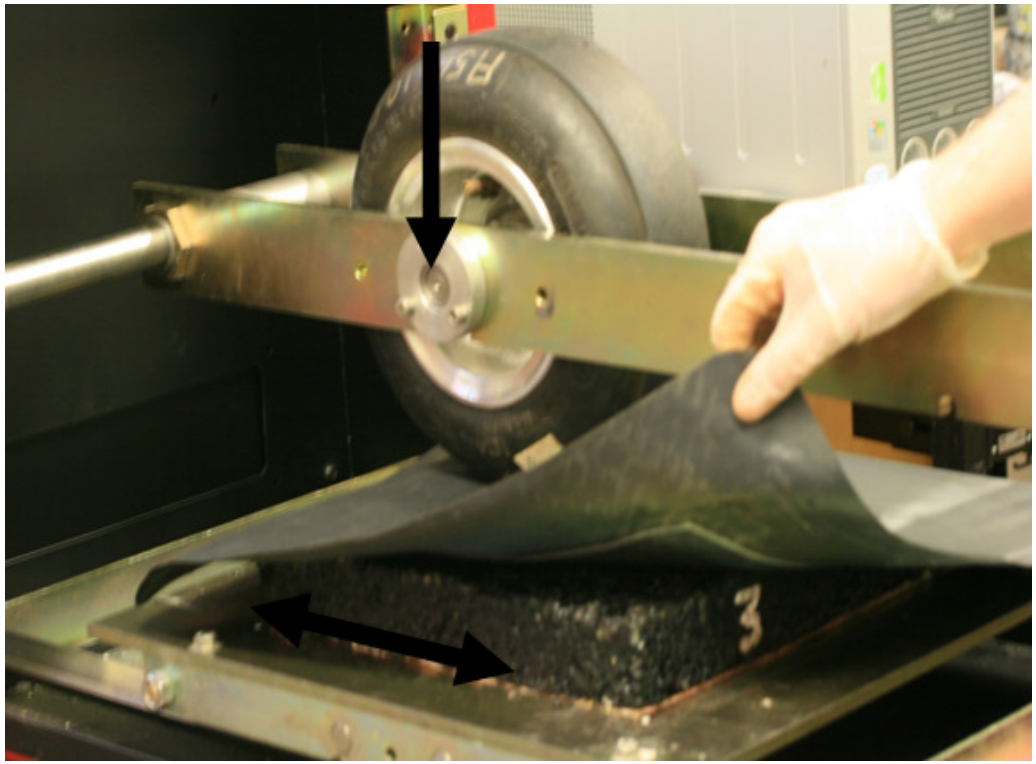
25psi



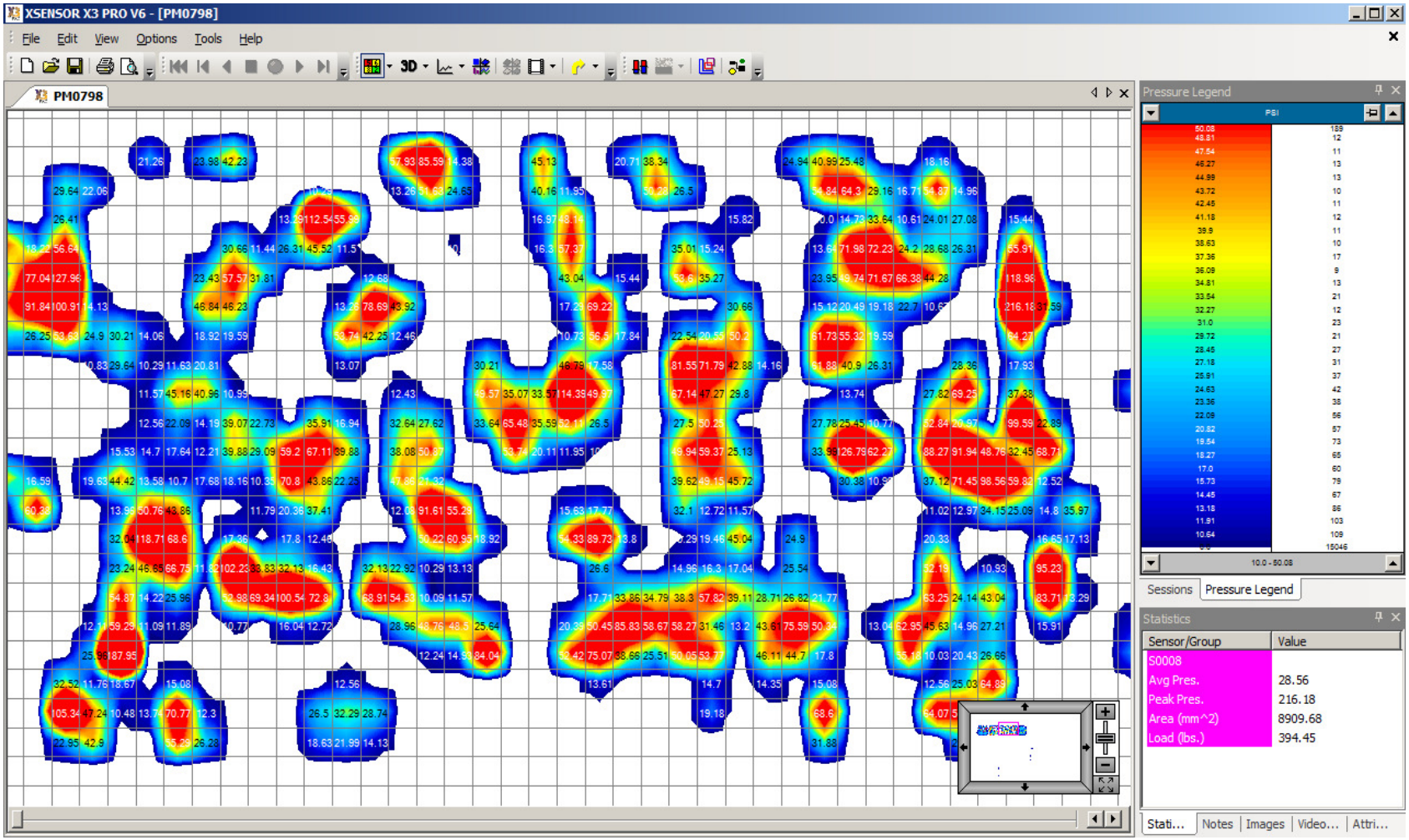
30psi



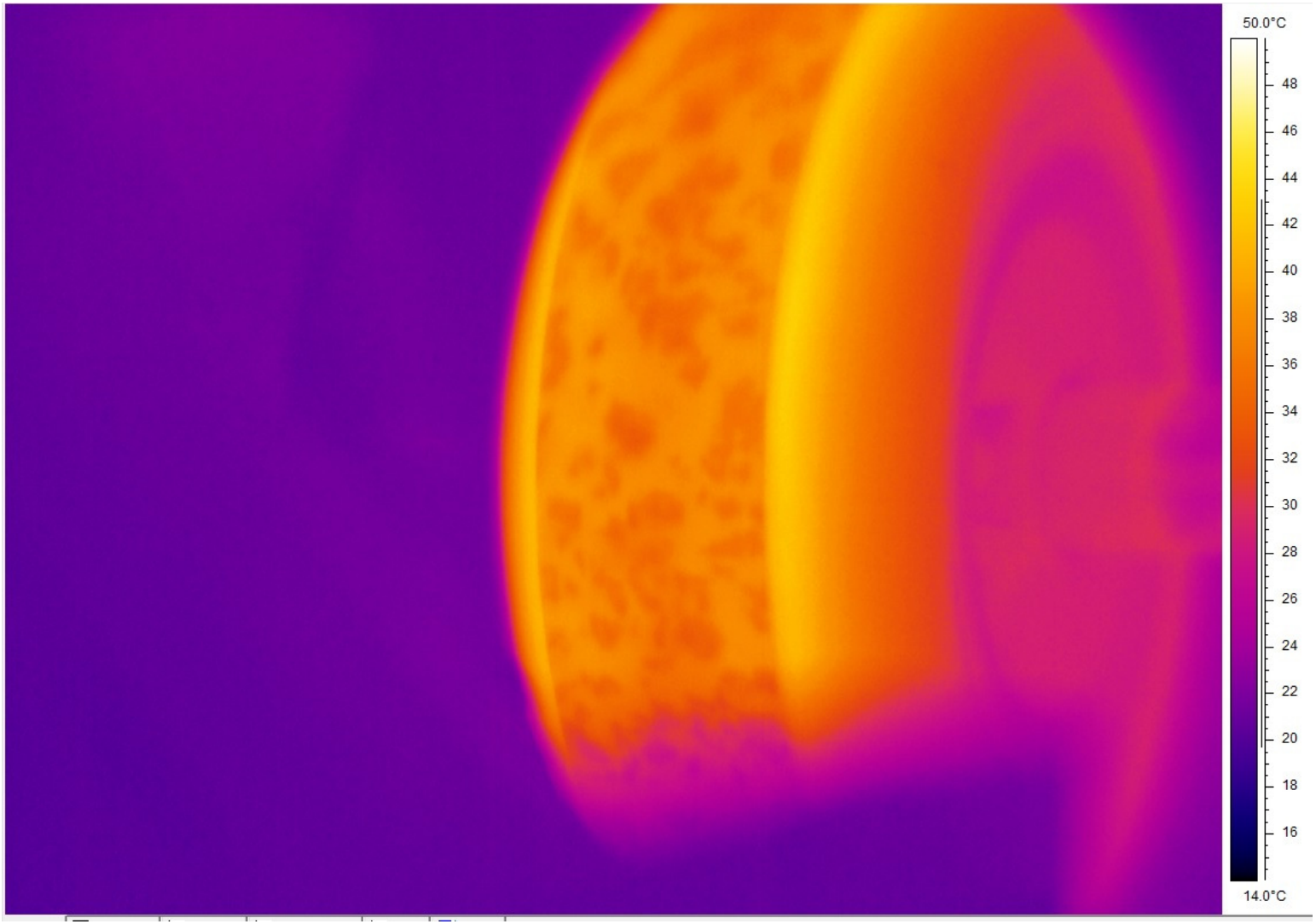
Contact patches for trafficked slabs



Variation in contact pressures for a new GripTester tire on 10mm SMA



Thermal image showing heat transfer from friction tyre



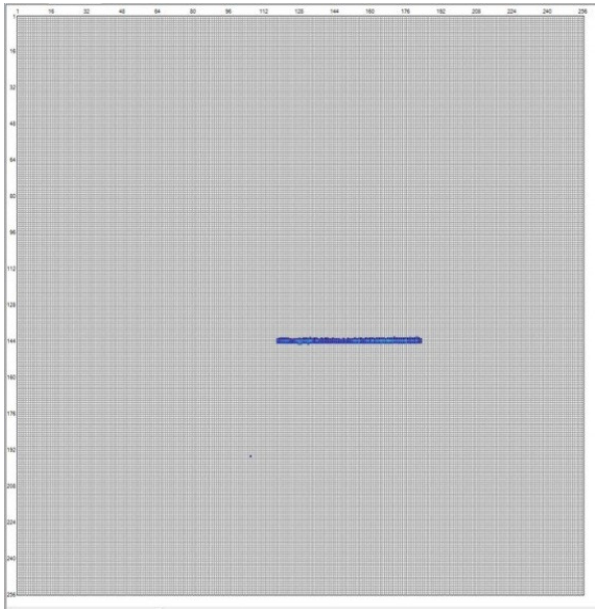
Pressure mapping used in this paper

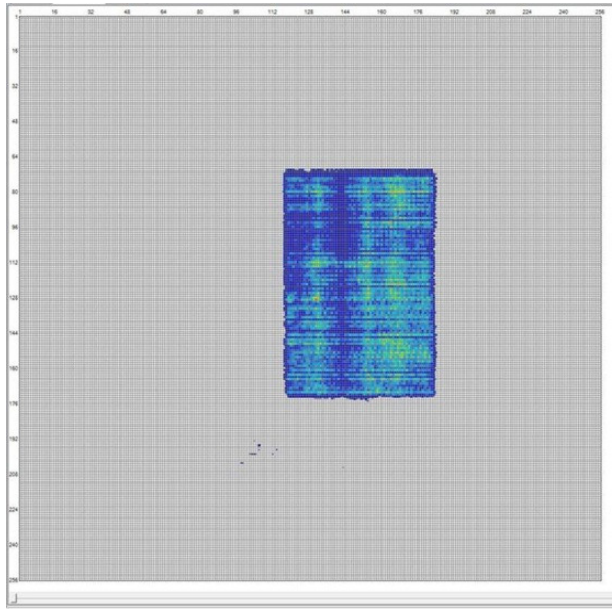
- XSensor IX500.256.256.22 pressure mapping system:
  - 1.15 mm spatial resolution and 65,536 sensing elements mounted on a rigid plexi-glass backing.
  - Pressure range of 10 – 200 psi
  - Data acquisition rate of 6.2 frames per second
- XSENSOR X3 PRO Version 6.0 software records and displays data from the sensor pad.
- Data can be displayed in 2D or 3D.
- Data relating to each of the 65,536 sensing elements can be exported into Excel, CAD or spatial GIS modelling software for further analysis.
- Only contact patch area, length, width and measured load are considered in this paper.

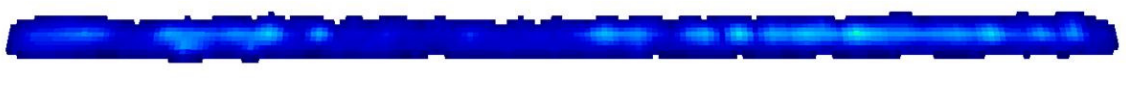
The pendulum tester

- Wide slider 57 consisting of a rubber pad 76.2 x 25.4 mm as normally used for surfaces subject to vehicular traffic. This is also known as the TRL slider.
- Wide slider 96 consisting of a rubber pad 76.2 x 25.4 mm as normally used for surfaces subject to shoe or foot usage. This is also known as the 4S slider.
- Narrow slider consisting of a rubber pad 31.75 x 25.4 mm as normally used in the PSV test method.

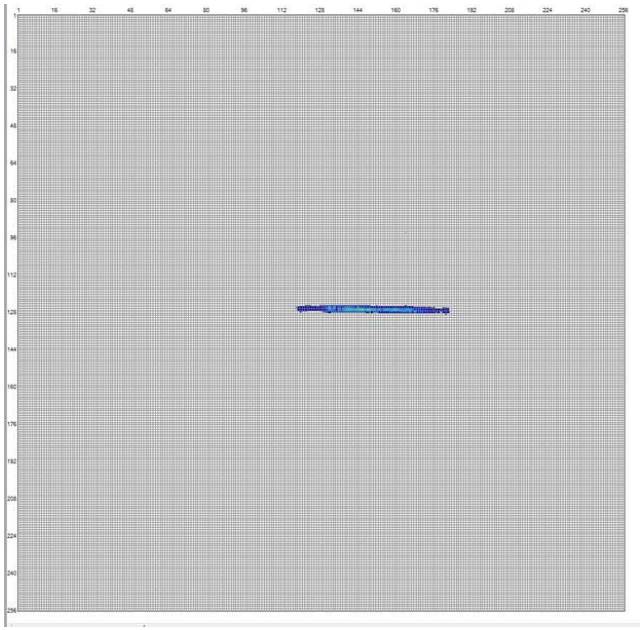
Wide slider 57 contact patch

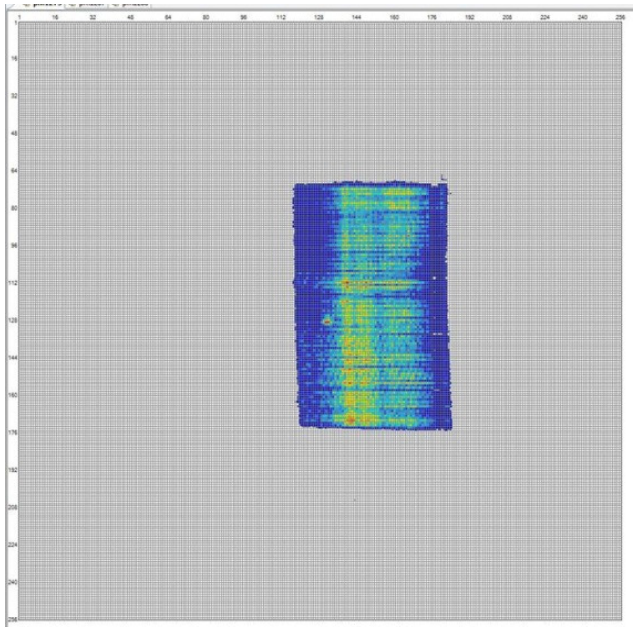


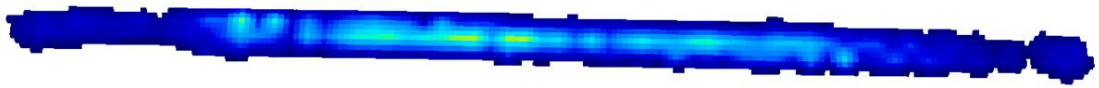




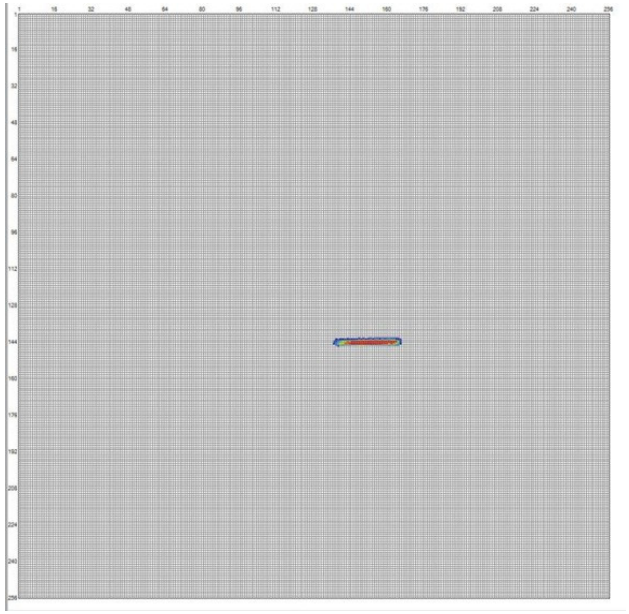
Wide slider 96 contact patch

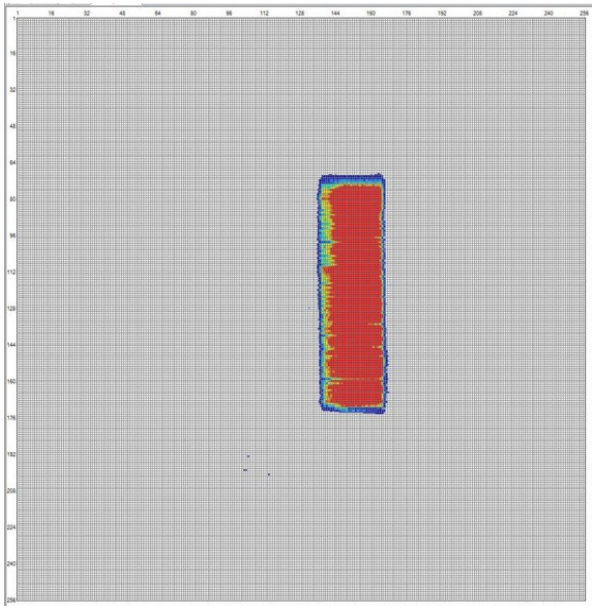


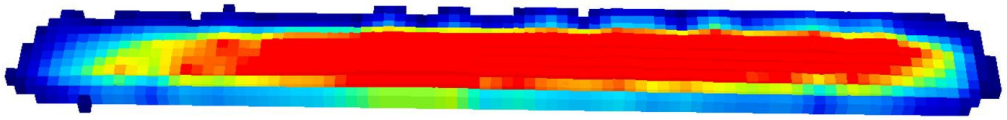




Narrow PSV slider contact patch

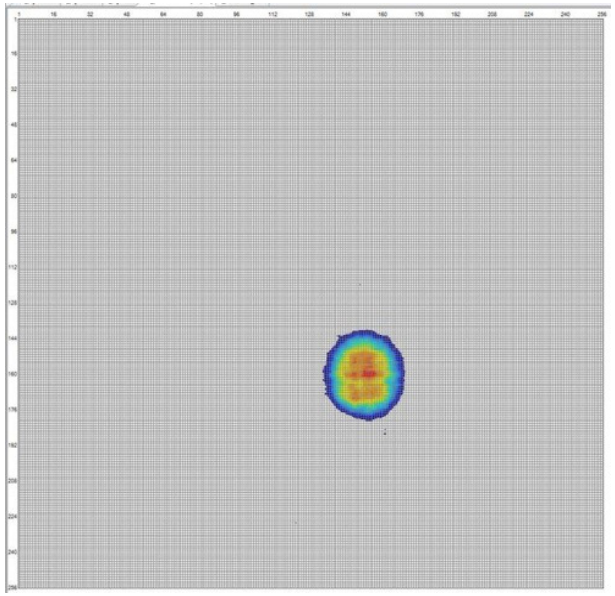


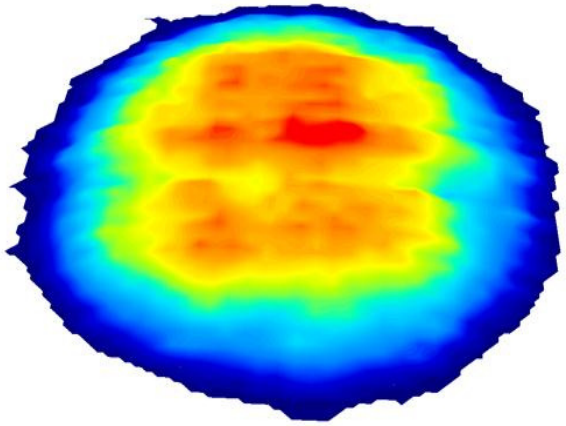


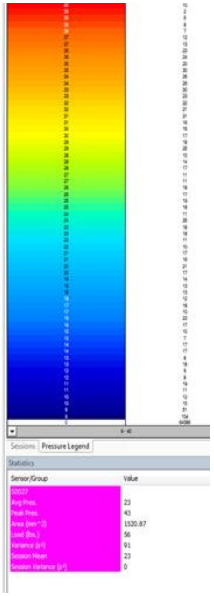


GripTester resting on the XSENSOR pressure pad

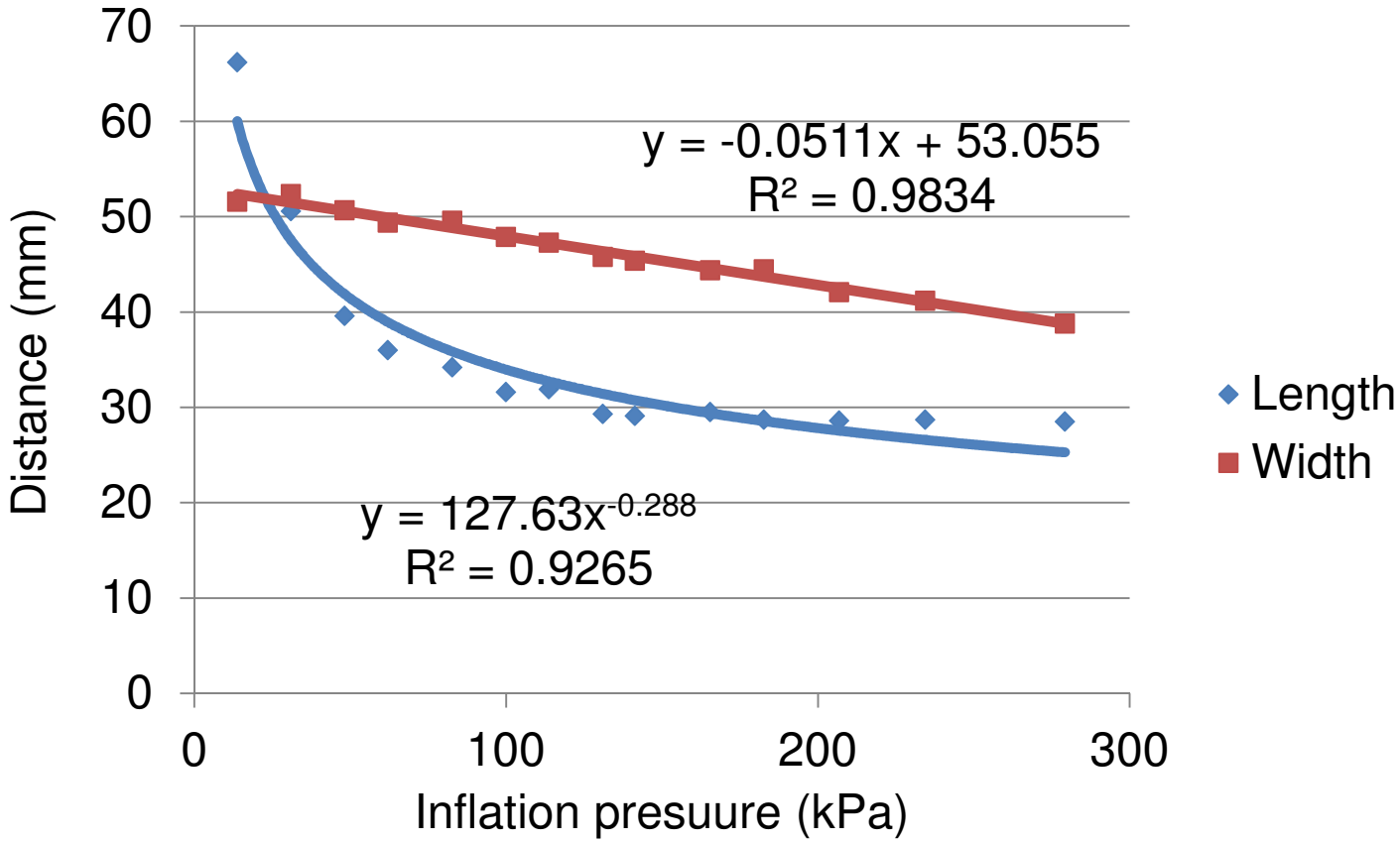
GripTester tyre contact patch at 20 psi inflation pressure



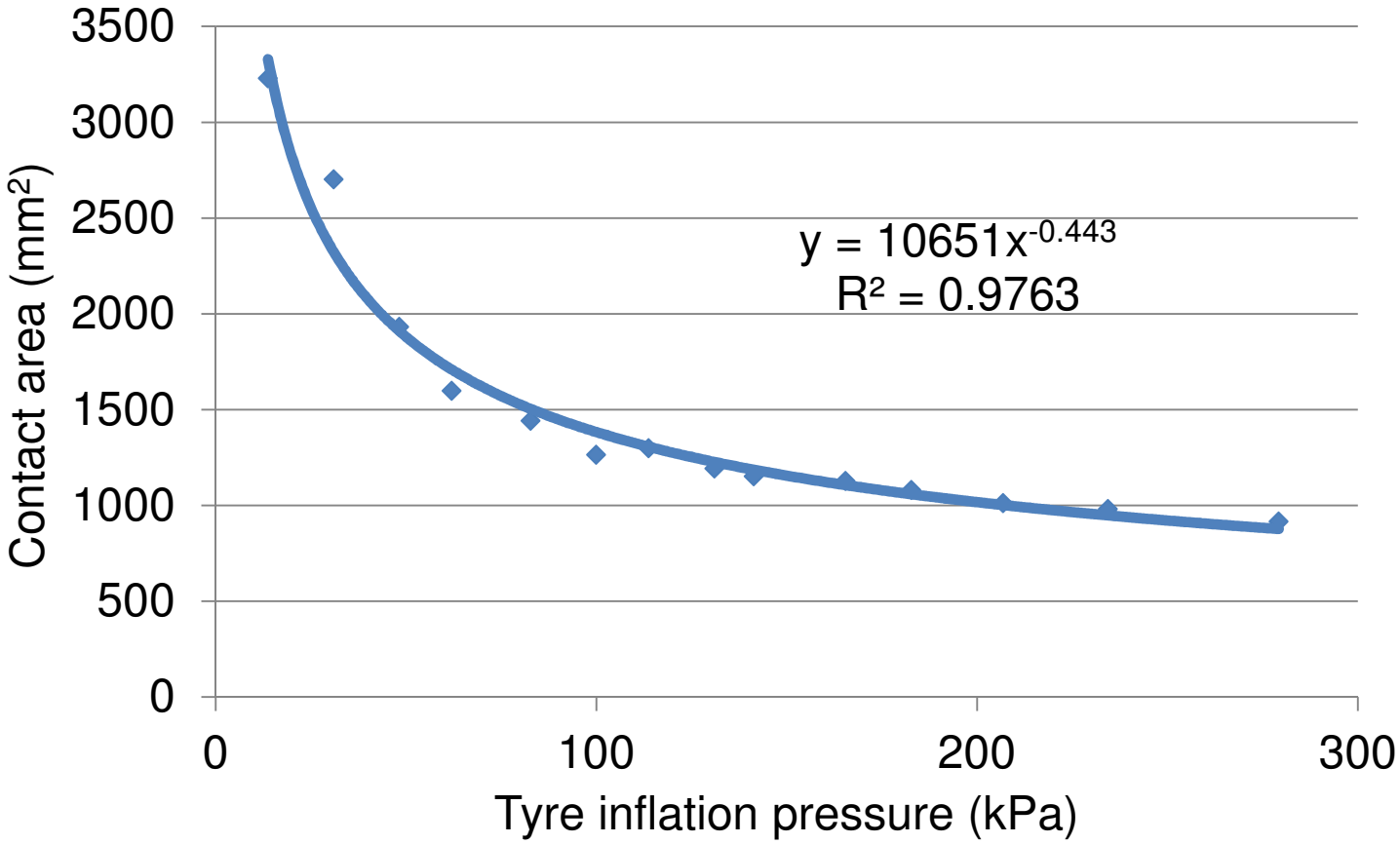




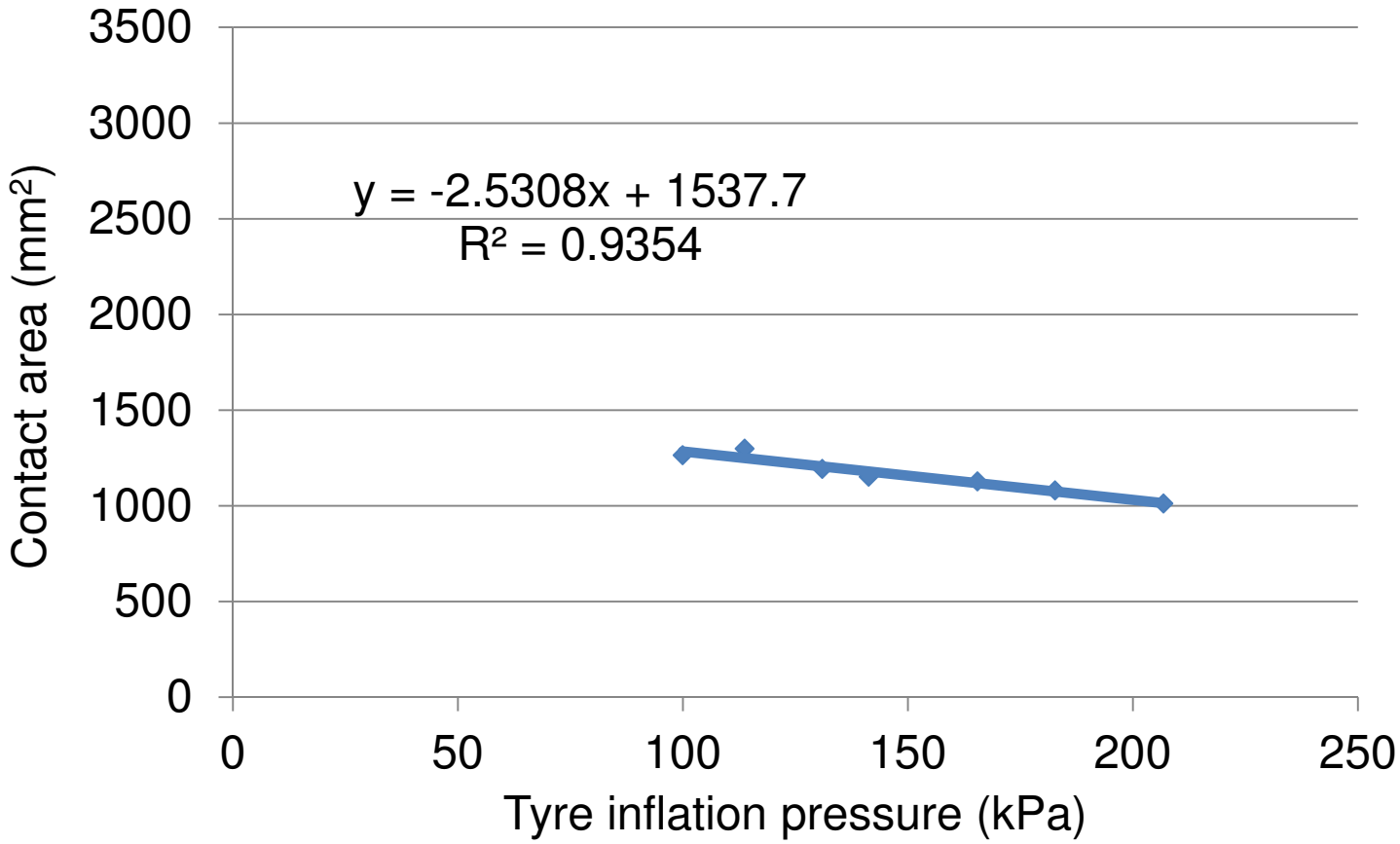
Contact length and width v. tyre inflation pressure for GT tyre



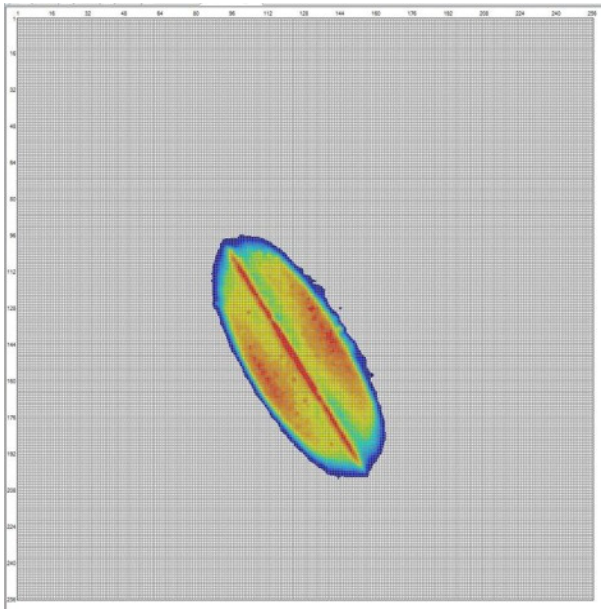
Contact area v. tyre inflation pressure for GT tyre

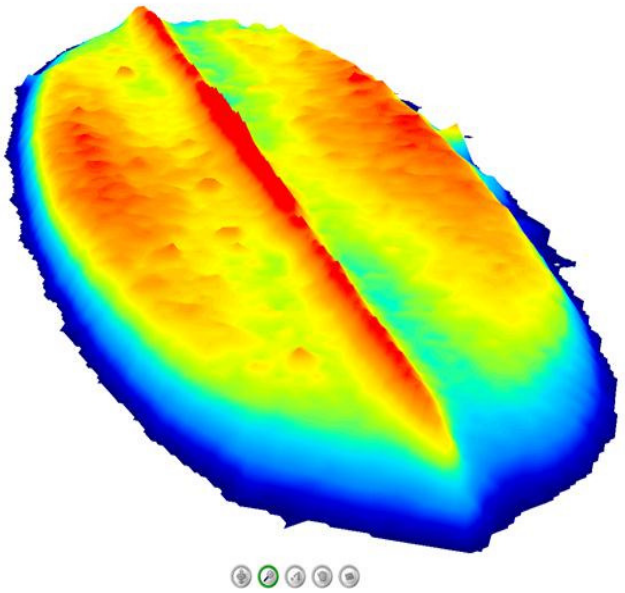


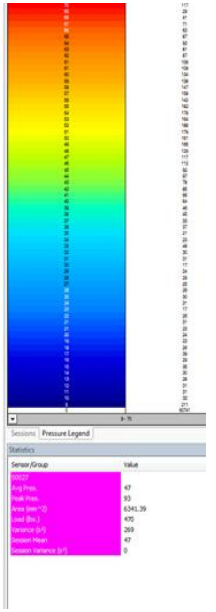
Contact area v. tyre inflation pressure – excluding lower and higher inflation data



SCRIM tyre contact patch







Some general points:

- Pendulum tester:
  - Differences between the three rubber sliders
  - Contact pressure for the narrow PSV slider was greater than for the 2 wide sliders
  - Non-uniform pressure distribution along the width of the three sliders used in the investigation
- GripTester:
  - Relationships similar to previous researchers using other types of tyre
  - Main difference between this and previous research was the simplicity and speed of high quality data acquisition
  - The found relationships show contact area and length to behave in a parabolic manner whereas contact width behaves in a linear manner with tire inflation pressure
- SCRIM:
  - Higher contact pressures compared to the GripTester tyre reflecting the greater static loading and inflation pressure.
  - A central rib of higher contact pressure was found for the SCRIM tyre assessed
  - How this influences the measurement of friction as the tyre rolls down a road is still to be determined

Conclusions

- This paper shows how pressure mapping can help to improve understanding of what happens when a friction measuring device is used.
- Measurement is now relatively easy.
- It does in hours what would take weeks using the paint / card board technique.
- With regard to better understanding and so improvement in any modelling scenario:
  - these simple examples show how pressure distribution varies within the contact patch of the measuring device
  - they show that measurement or prediction of friction is not simply related to factors such as contact area
- This area needs further research.