



Rob Blenkinsopp

Deformation Measurement in Sports  
Footwear

BSSM Seminar Presentation

9<sup>th</sup> May 2012

- Overview of sports shoe
- Challenges of footwear design and what to measure
- The use of DIC in shape and deformation measurement
- Selection of results for single and multiple camera pairs
- Validation of measurements



# Overview

- Big sports brands base their business on shoe sales
- Nike and adidas will sell 10's of millions of pairs of shoes every year.
- The most popular shoe type: athletic running shoe.
- Continuous innovation in shoe design:
  - Materials
  - Motion control
  - Mass
  - Aesthetics/design



# Challenges in Shoe Design

- Shoe's manufactured using unrepresentative 'foot' shapes
  - Shoe last
  - Static foot shapes
- Understanding of foot-shoe interactions limited (except plantar surface)
- Influence/dynamic-performance of shoe upper materials unknown
- Trend (or fad?) developing for 'barefoot' running shoes



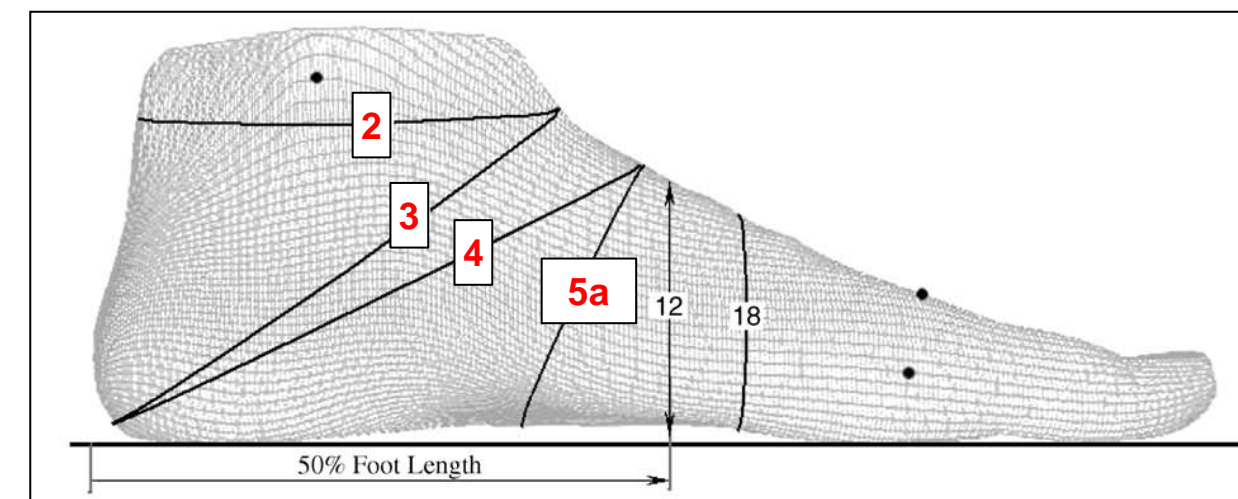
# Research Aims

- Measuring the dynamic deformation of the human foot during running
- Use knowledge base to improve shoe and foot interactions
- Improve sports shoe design



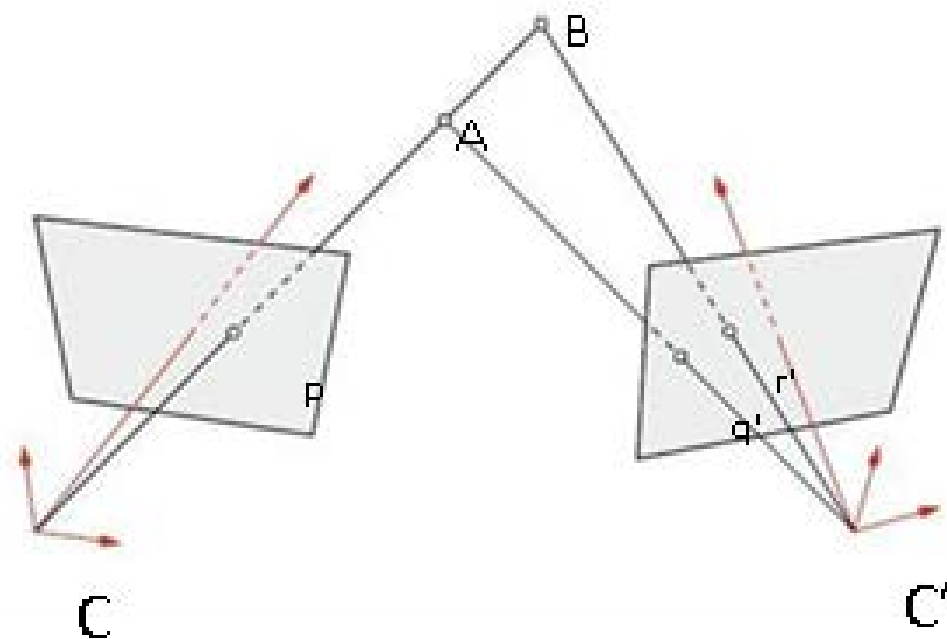
# Measuring Foot Shape

- 3D foot shape measurements linked to existing static shape measurements
- Informed by important shoe characteristics
- Foot shape at rear foot, midfoot and forefoot
- Cross sections - most useful for 3D shape
- Supplemented by singular length measurements where appropriate



# Digital Image Correlation

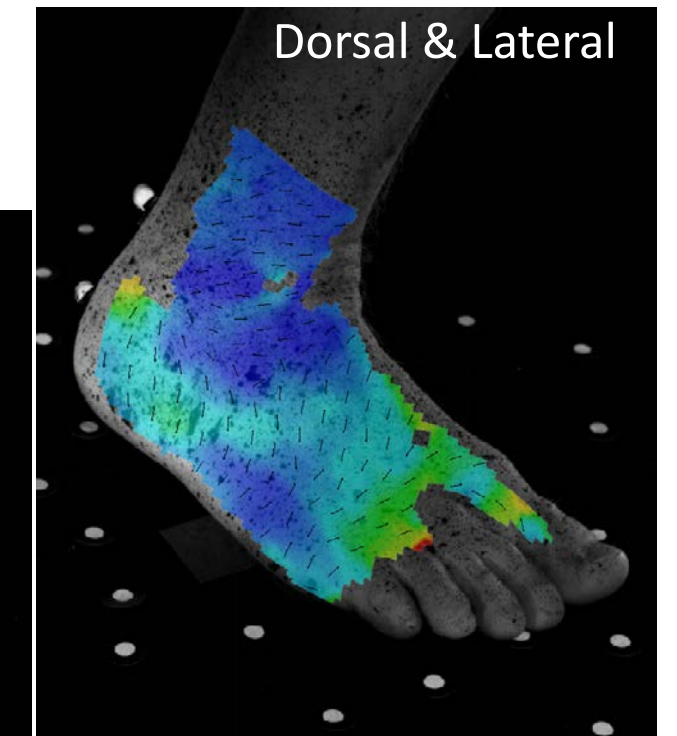
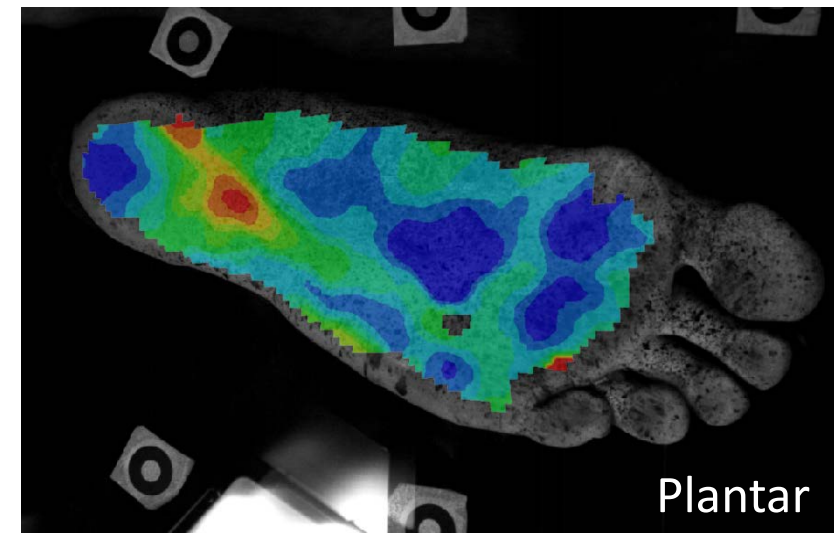
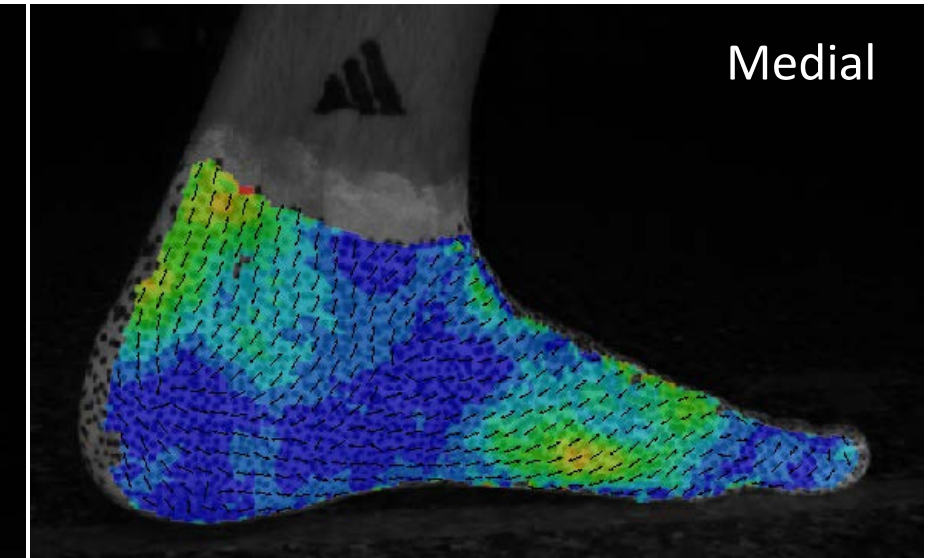
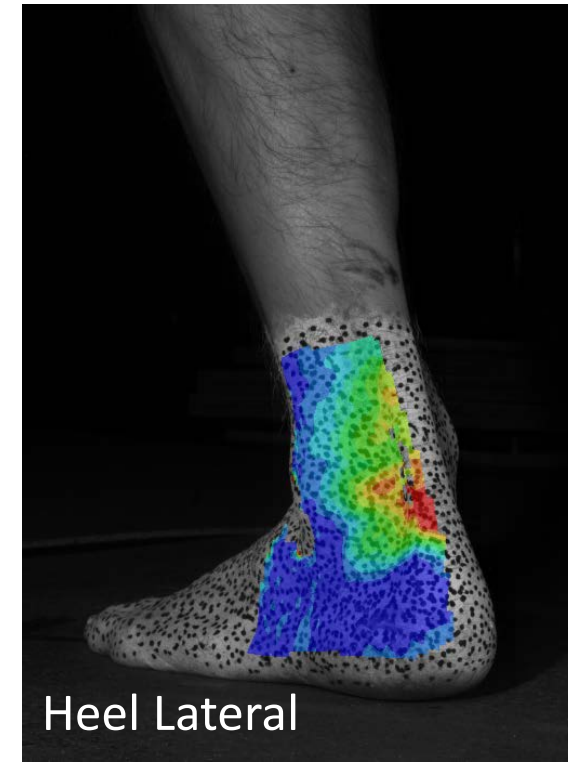
- Methodology required to measure the dynamic shape of the human foot
- 3D Digital Image Correlation (DIC-3D) provides full field surface and deformation measurement
- Higher resolution achievable than with marker systems or strain gauges
- High speed camera system - high speed dynamic strain measurements
- GOM system - potential to integrate sister systems (PONTOS and TRITOP)



adapted from Sutton et al. (2009)



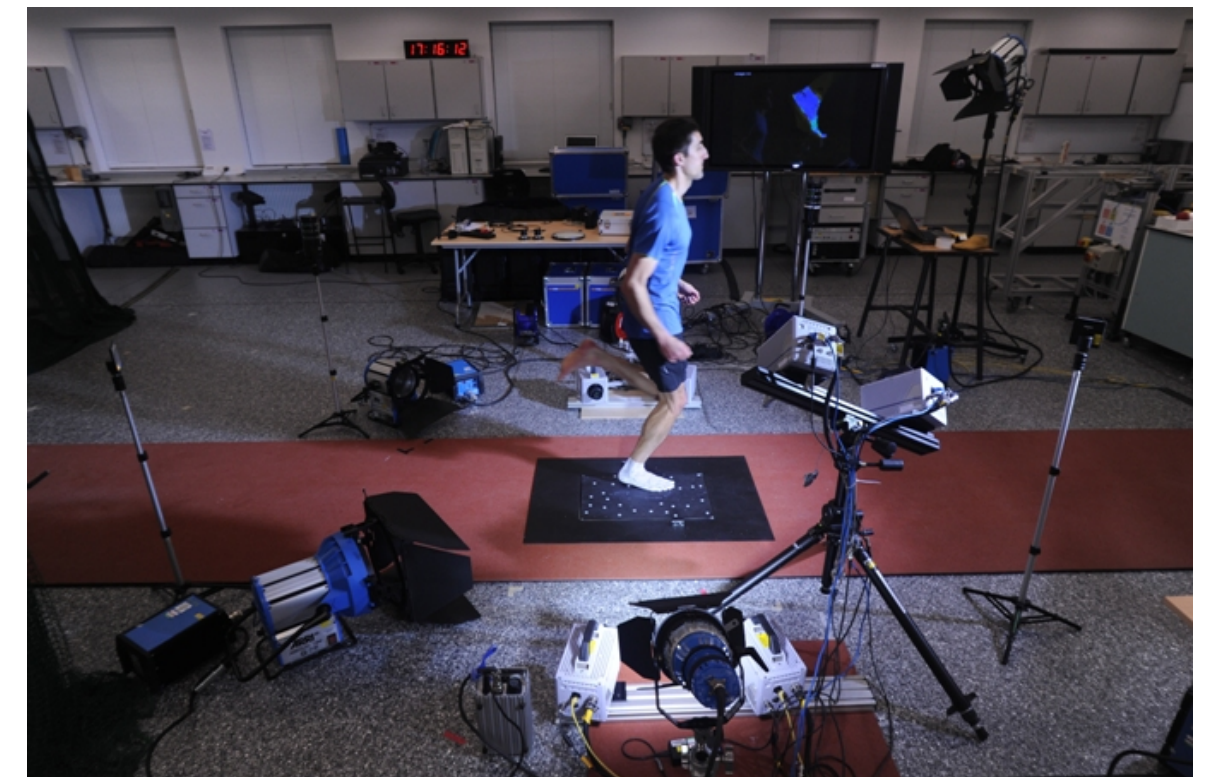
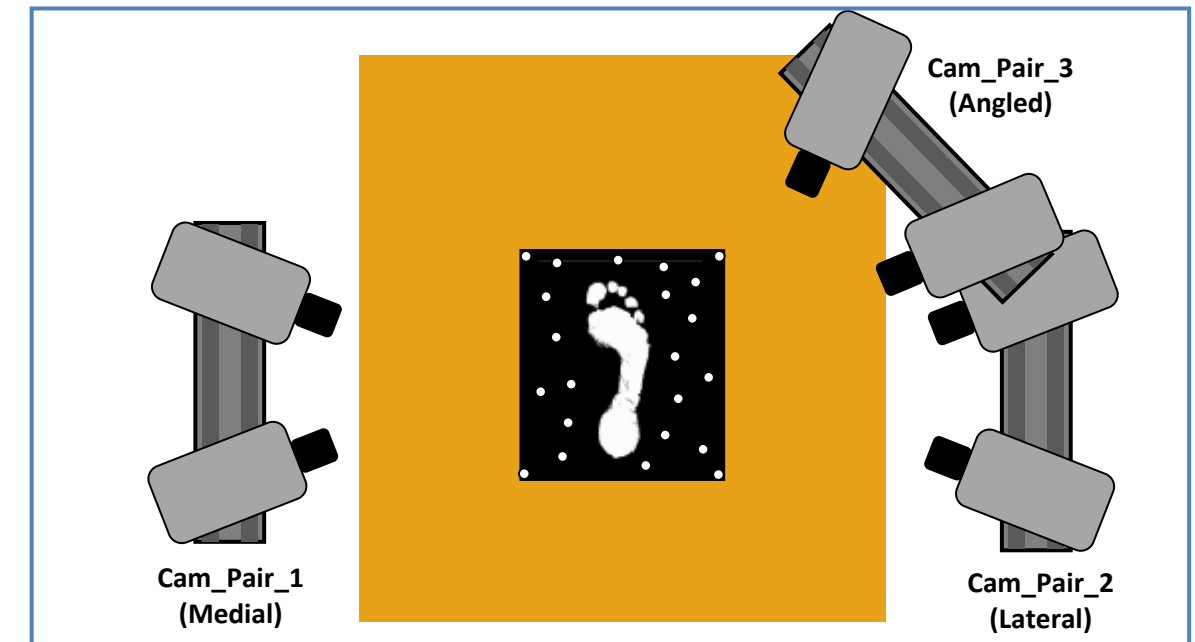
# Using DIC for Foot Deformation Measurement



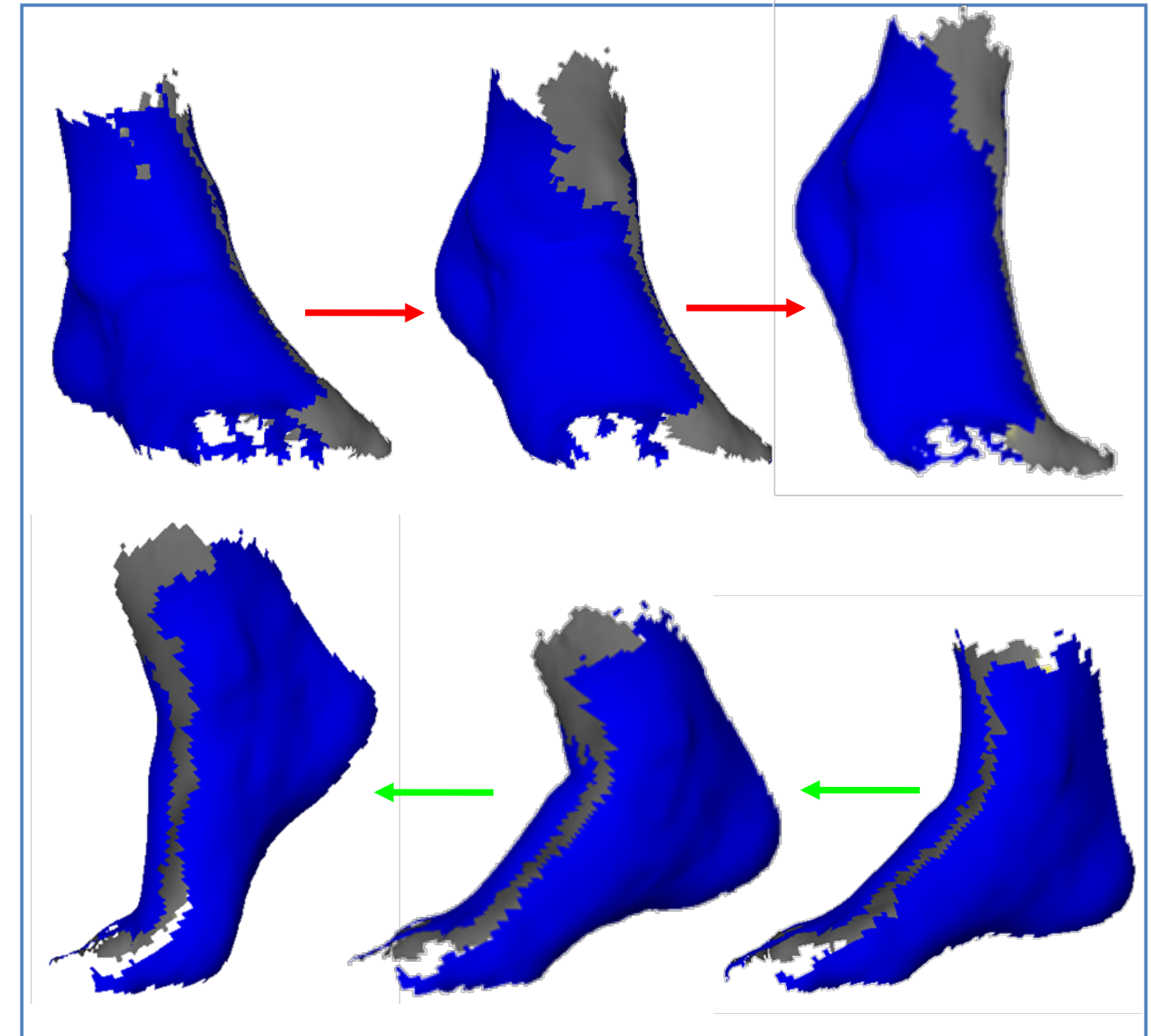
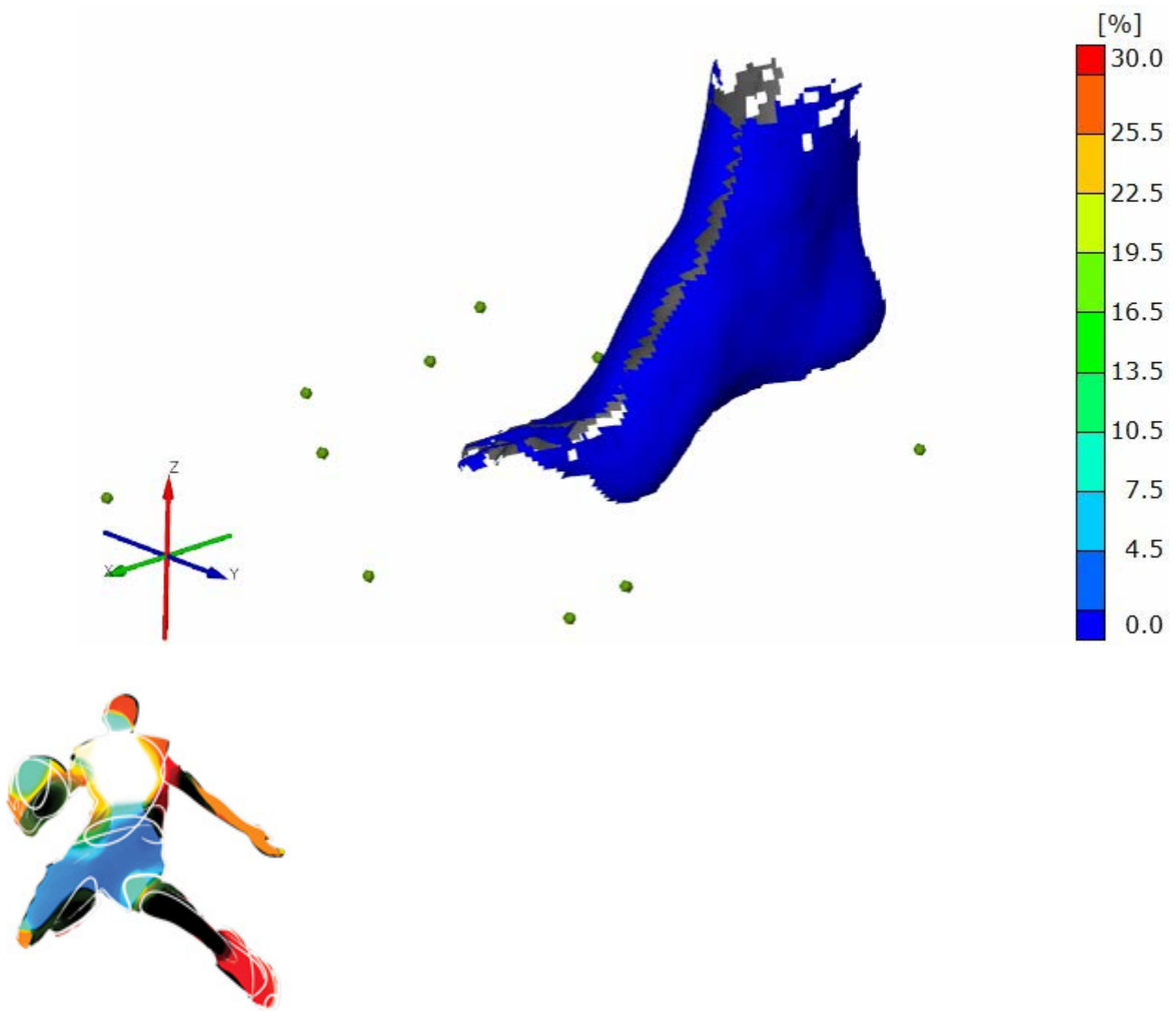


# Multiple Camera Approach

- Multiple camera approach enables single trial measurements
- Three high speed camera pairs
- Common co-ordinate system created from force plate markers
- Composite measurement created
- Improved accuracy
- More comprehensive foot shape created

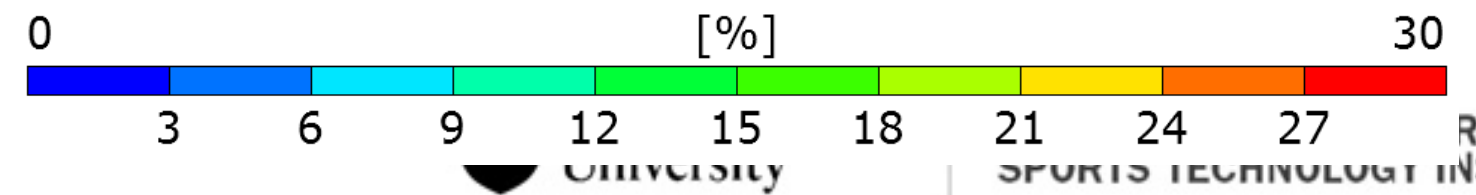
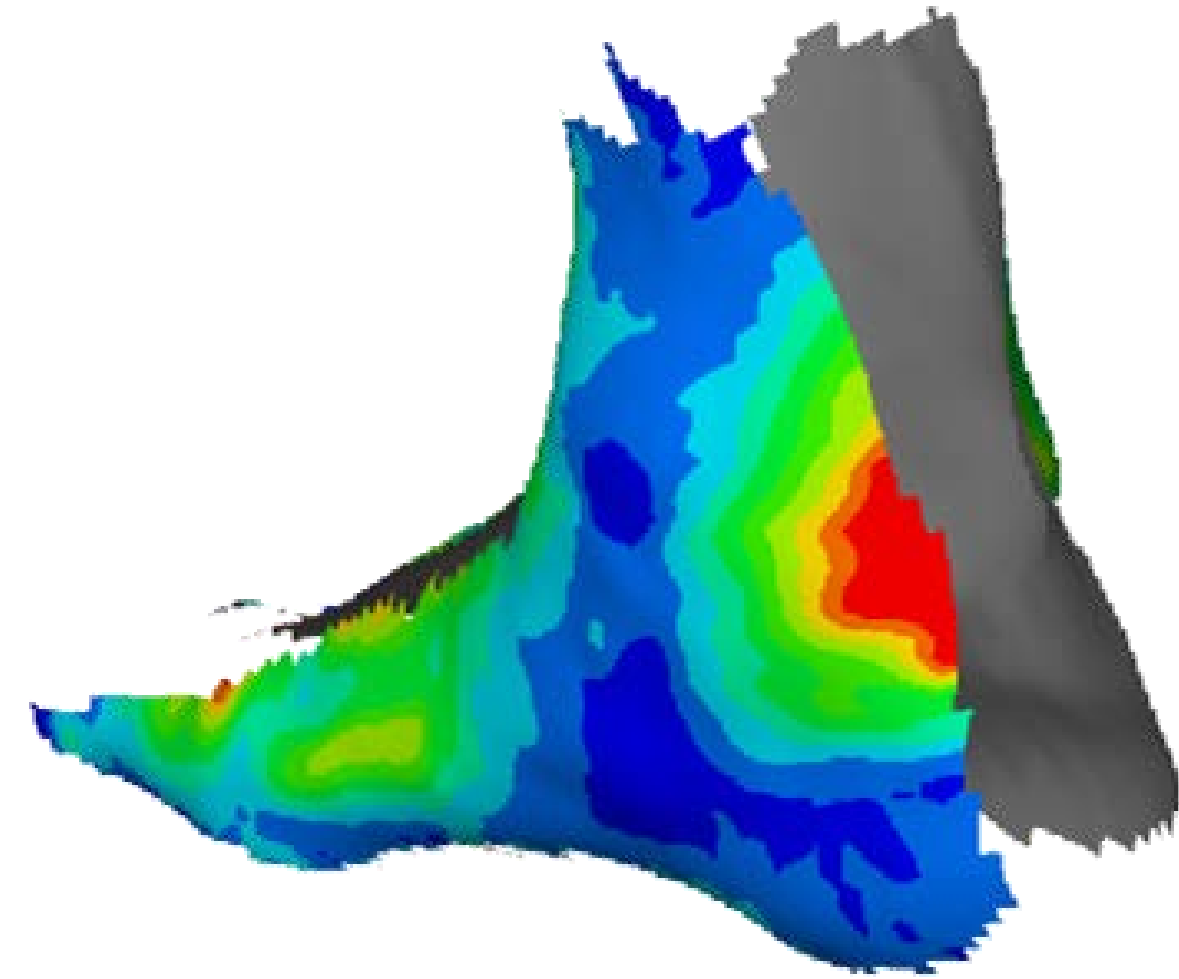
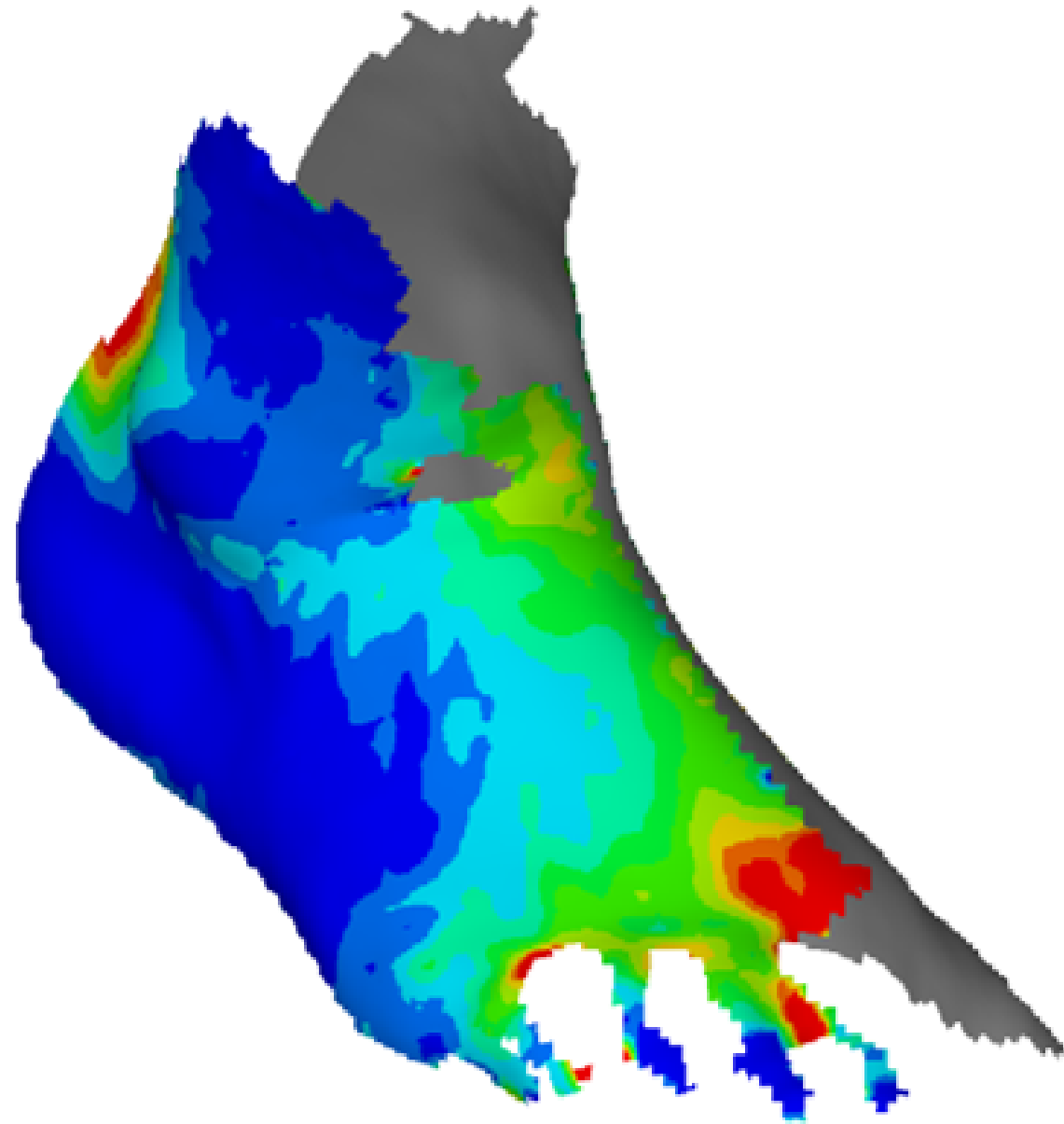


# Multiple Camera Results

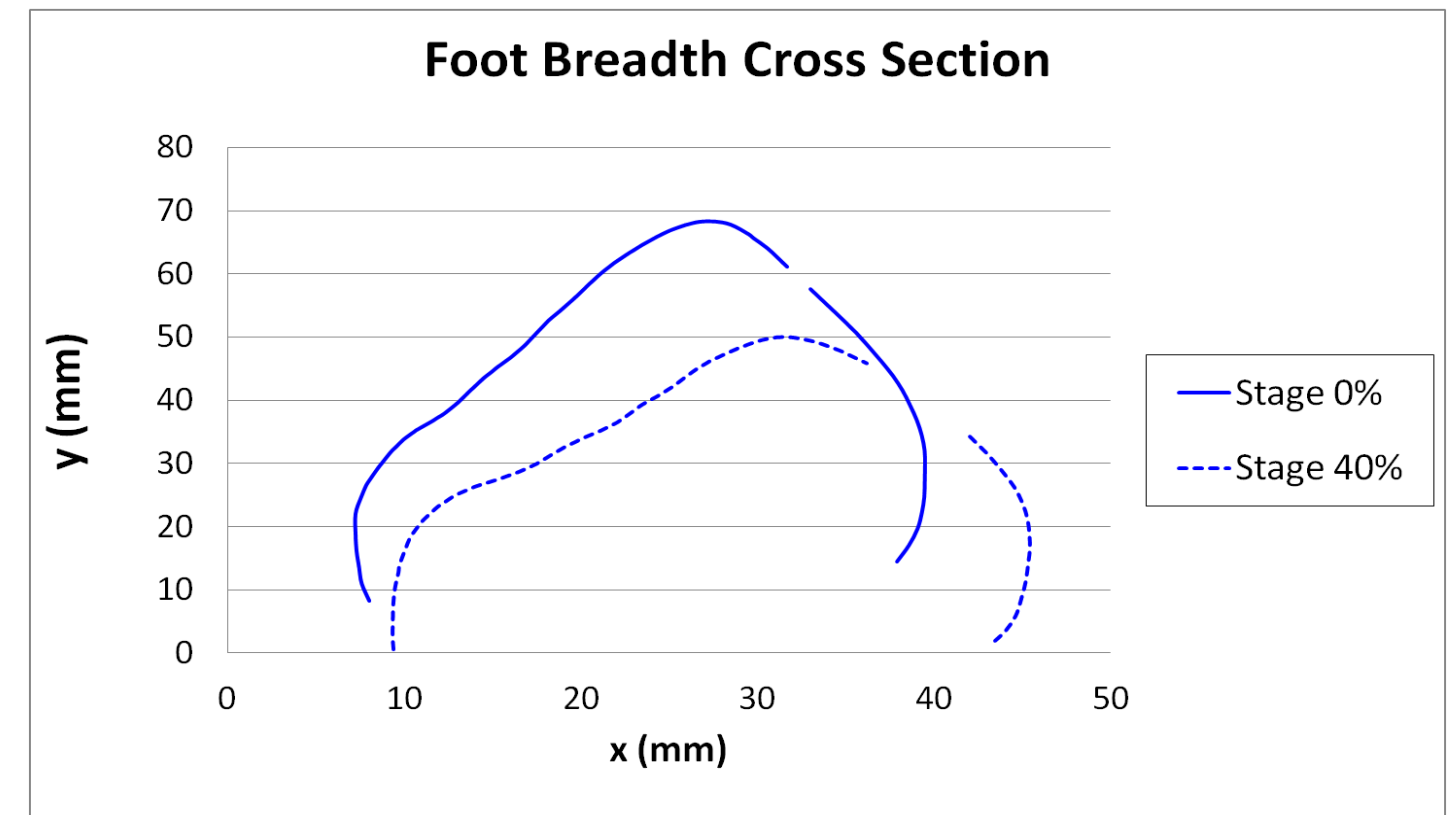
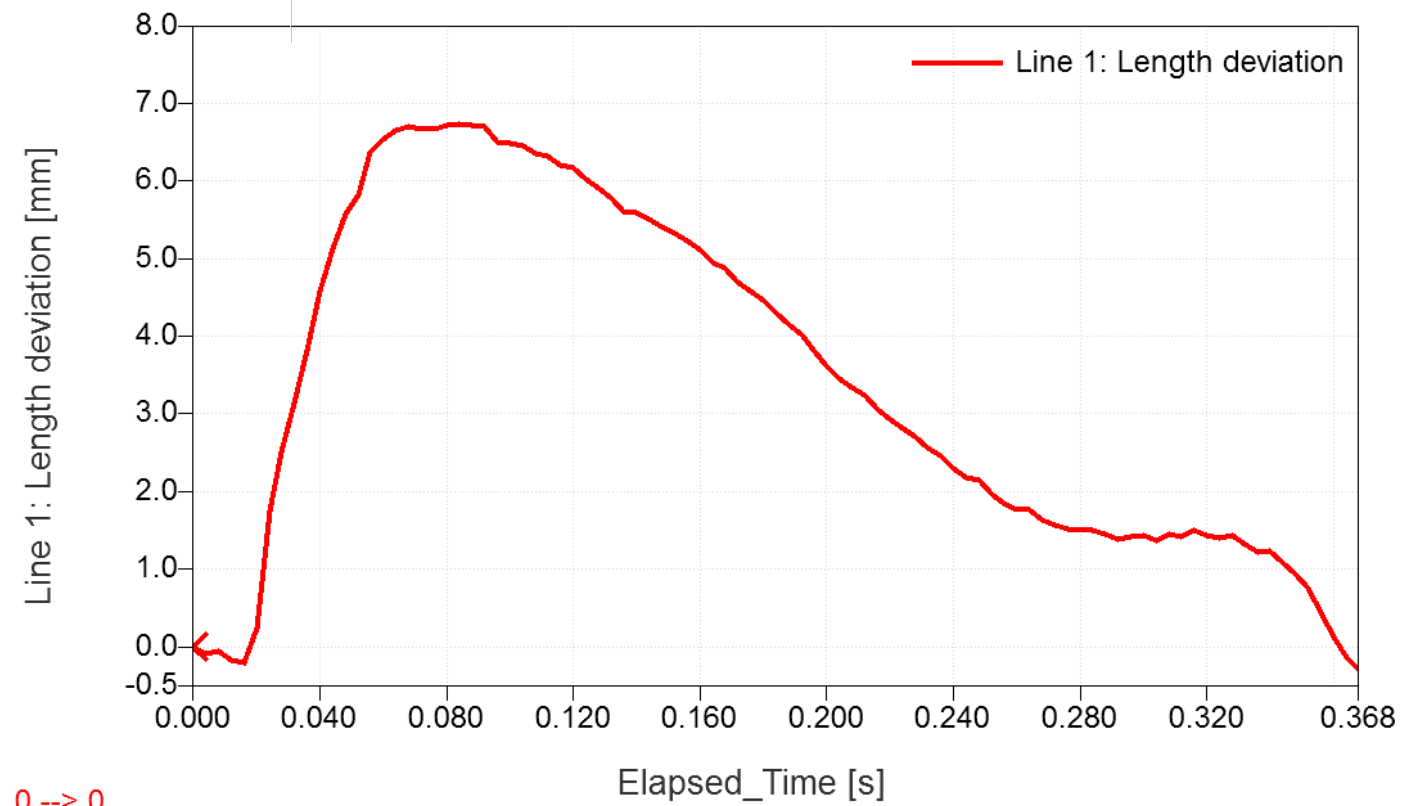
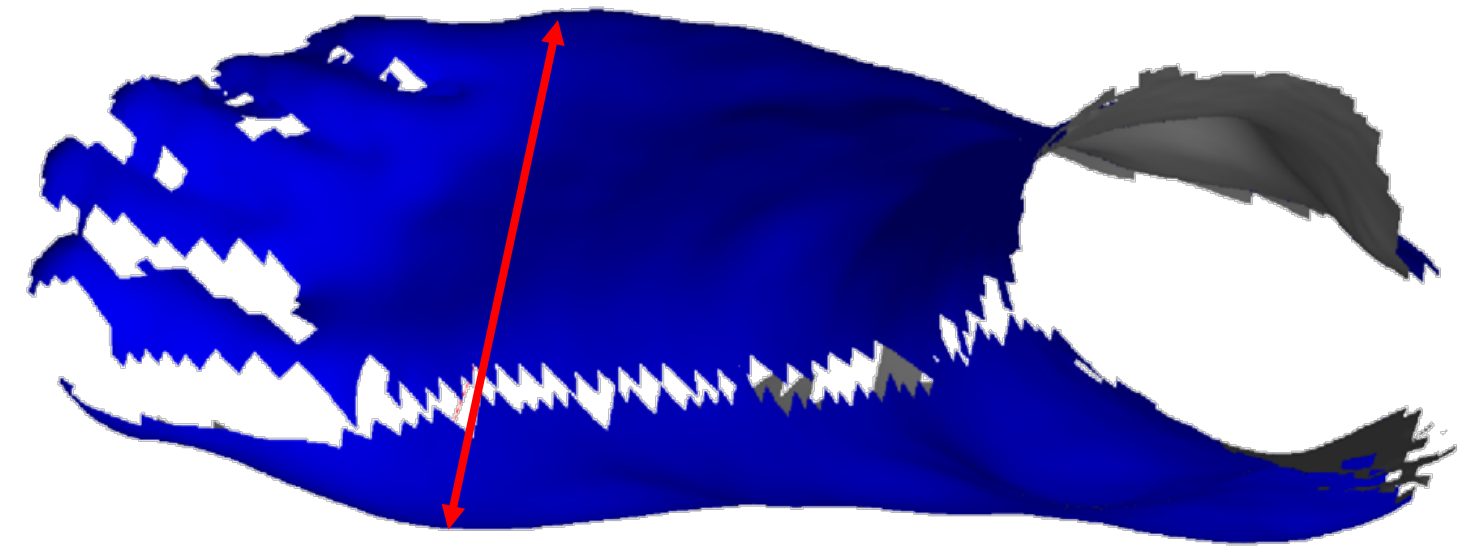
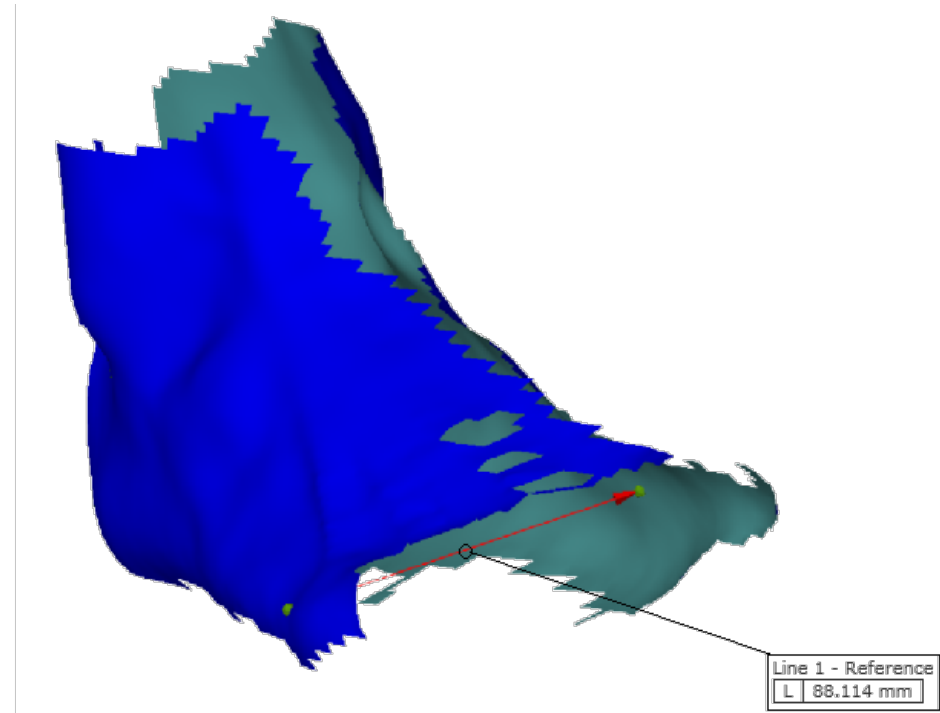


# Full foot strains

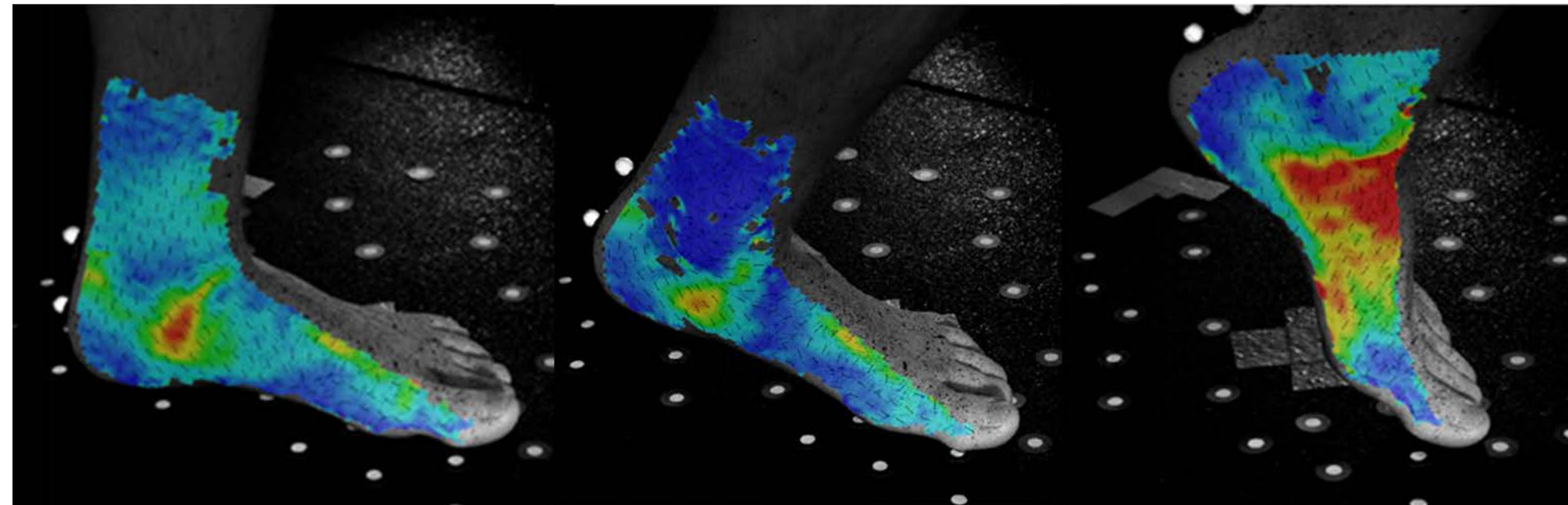
- Reference - Beginning of support phase of gait (Touch down)



# Some results



- First time dynamic foot shape measured at running speeds
- Study of repeatability of dynamic foot shape
- Influence of running variables – running speed, style, foot size, surface, midsole, person type etc...





## *Annual Report 2011*

stronger, smarter and natural – we will unveil new product and consumer experiences like never seen before. Building on our multi-category leadership in lightweight technologies, which are part of our faster pillar, in 2012 we are going to fuse various elements of our other technology pillars to create more holistic and exciting experiences for the consumer. For example, in football and running, you have already seen the beginning of this through the introduction of the smarter element with our new Speed\_Cell technology and miCoach platform extensions in products such as the adizero f50 miCoach and adizero Feather. These capabilities will be rolled out in other categories like basketball, American football and tennis this year. In addition, we are going to bring revolutionary new products in natural motion, extending the adipure franchise we introduced in 2011 with the adipure trainer. This will start in the running category. Over the course of three years, our adidas Innovation Team has carried out extensive research and testing to develop the adipure running range. This is a collection of three shoes with a variety of heel gradients that mimic the natural movement of the foot, by helping the body gradually adapt to the demands of mid- to forefoot running. Using 500 sensors located on the bare foot, our engineers have measured exactly where the foot stretches on impact and where the maximum stress occurs. On the back of these findings, we have created a new TechFit upper and outsole. These work as one to help the runner use their muscles more effectively, improving balance and flow without sacrificing stability, for a more natural running experience.

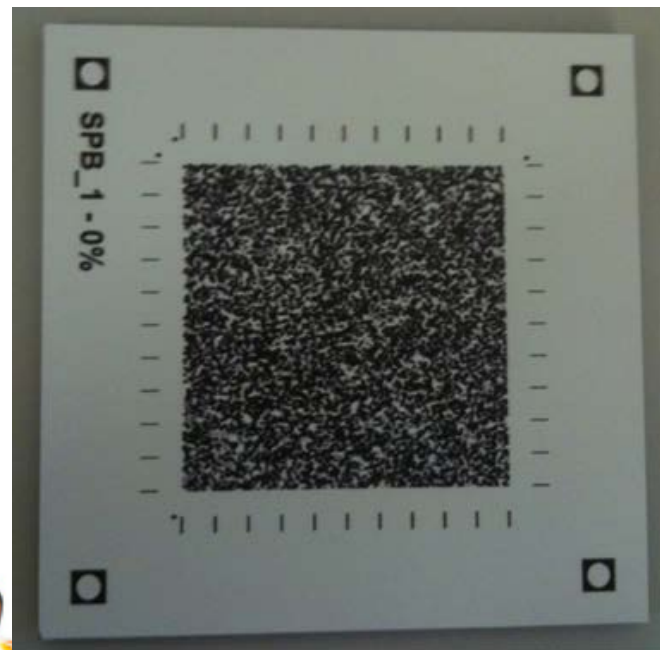


# The Impact

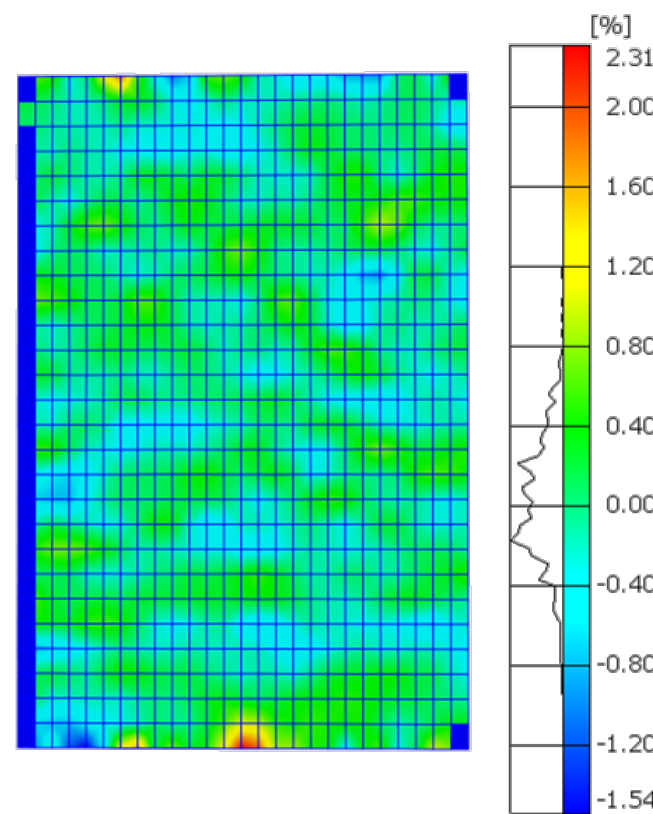


# Measurement Calibration

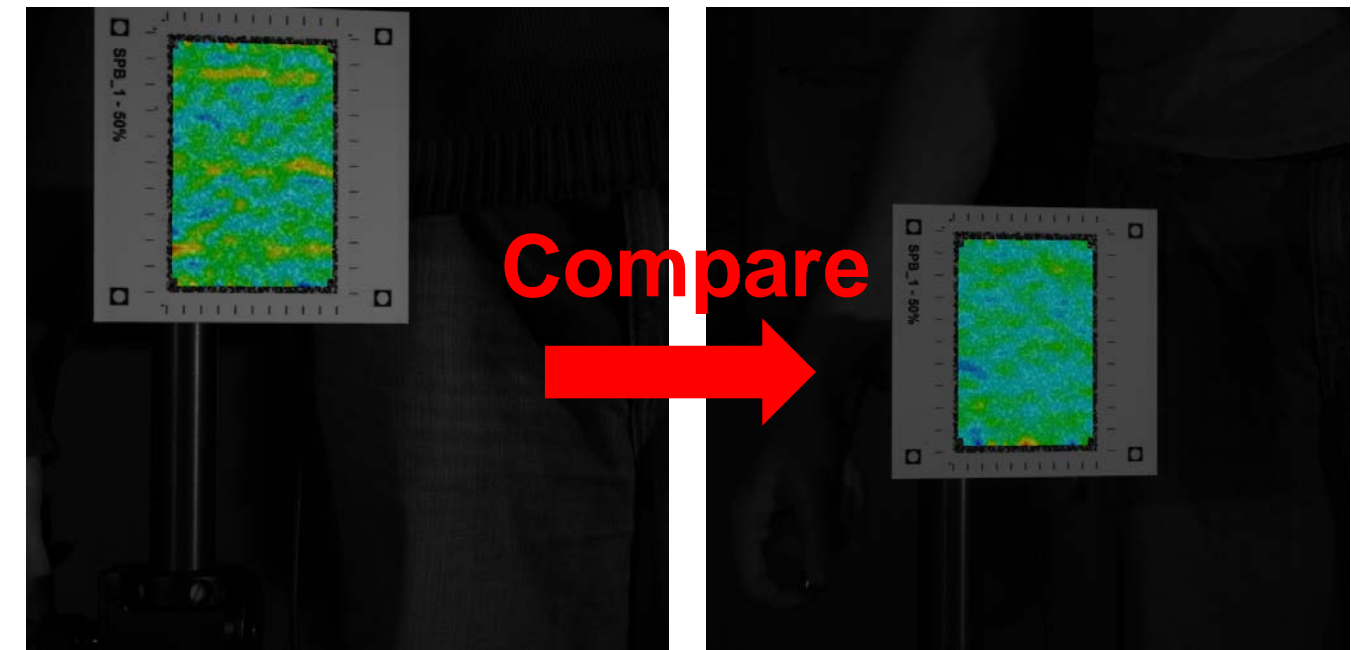
- Applied experimental work to understand the influence of set up and processing parameters on measurement accuracy.
- Employs simulated deformations embodied in a hard gauge with traceable accuracy
- Tests variables that are controllable – e.g. position in volume, lens type.
- Initial results indicate inaccuracy (<2% of measurement) and good repeatability between variables.



Material Measure



Example Result



Comparison of 2 different positions





- Measurement of dynamic foot shape at running speeds
- Opens up a number of research avenues as yet unexplored
- Feeds directly into shoe design – through well thought out measurements
- Has potential to guide future shoe design
- Accuracies known through a traceable validation





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