

**image**  
SYSTEMS

# DIC

NON-CONTACT  
OPTICAL MEASUREMENT



**image**  
SYSTEMS  
MOTION ANALYSIS

# DEFORMATION MEASUREMENT

## INTRODUCTION

In engineering, deformation refers to the change in size or shape of an object. Displacements are the absolute change in position of a point on the object. Strain is a normalized measure of deformation representing the displacement between particles in the body relative to a reference length.

The engineering strain is positive if the material is stretched and negative if compressed. Thus, we have

$$e = \frac{\Delta L}{L} = \frac{l - L}{L}$$

where  $e$  is the engineering normal strain,  $L$  is the original length and  $l$  is the final length. Measures of strain are often expressed in parts per million or micro-strains.

Strain gauge, whose resistance varies with applied force, is frequently used as a sensor in conventional deformation measurements. It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured.

In a test, all gauges shall be installed properly on the object surface, and wired to a data acquisition systems. To achieve high accuracy measurement, it requires skilled prediction of engineering concentration and judgement.

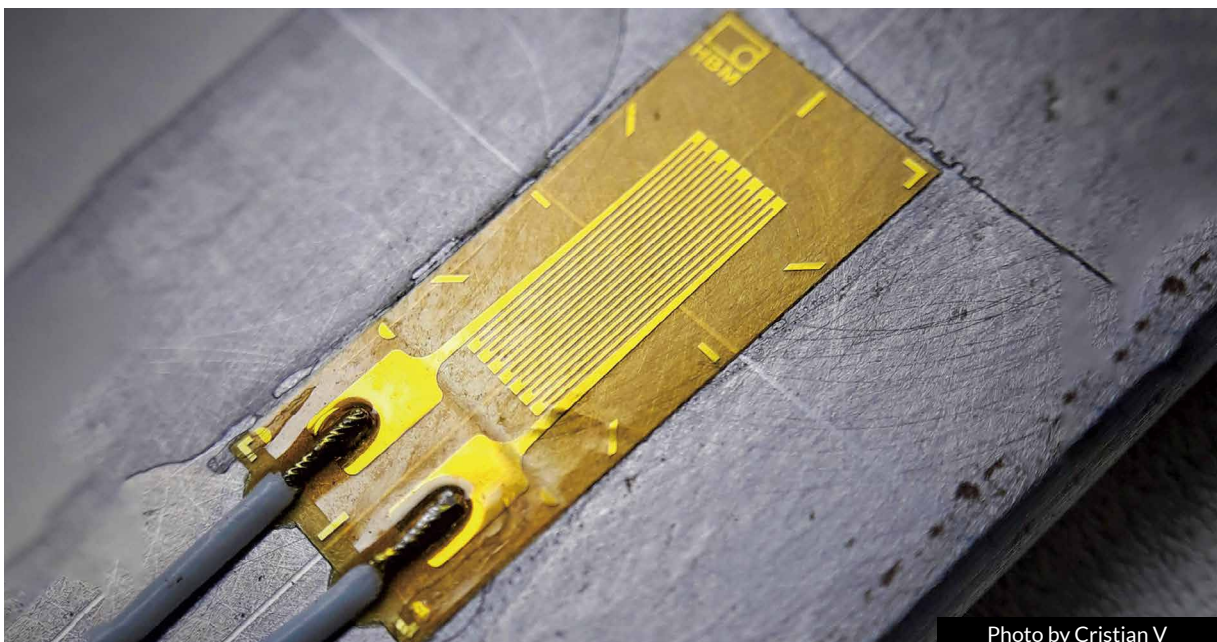


Photo by Cristian V



# TEMA PRO

## Motion and Deformation Analysis

### Digital Image Correlation (DIC)

Digital image correlation and tracking is an optical non-contact method that employs tracking and image registration techniques for accurate 2D and 3D measurements of changes in images.

It allows surface deformation and strain analyses in full field by tracking the movement and deformation of a speckle pattern painted on the object of interest. A set of specific DIC tools is part of this package such as inspection lines, virtual extensometers and local points of interest to provide even more statistics on the surface.

### TEMA Pro Motion & Deformation Analysis

TEMA Pro is a market-leading software suite for advanced Motion Analysis tests in research and industry.

Thanks to its high accuracy, modular structure, calculation speed and intuitive user interface - TEMA Pro is used by professionals across the globe in a wide range of applications from drop testing smart phones to improving sport performances or even optimizing processes in the automotive and aeronautical industry through the tracking of trajectories.

TEMA Pro has a wide library of tracking algorithms included in its default package which allows to track almost any kind of objects in any situation.

Digital Image Correlation module (DIC) is part of the default package. The algorithms are based on pattern recognition and/or levels of grey and allow tracking with sub-pixel accuracy.

It is ideal for fatigue testing, material characterization or to understand the behaviour of a structure under constrains, this non contact technique can be combined with strain gauges for even further accuracy.



Strain Gauge

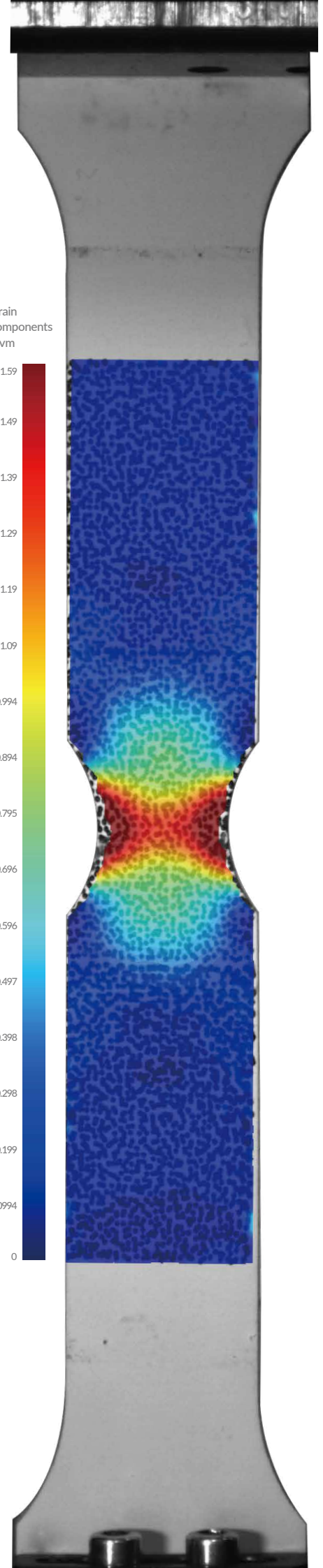
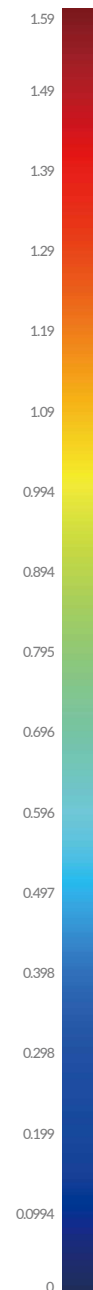
vs



TEMA DIC

- |  |  |
|--|--|
| ● Higher accuracy - up to several micro-strains    | ● Wide measuring range - 50 micro-strains to 2000%↑        |
| ○ Must be directly mounted on the measured surface | ● Non-contact solution, flexible to settle cameras         |
| ○ Specific and limited measuring area              | ● Full-field inspection, more than millions of data points |
| ○ Sensitive to humidity and temperature changes    | ● Friendly for tests in various harsh environments         |
| ○ Requires cable and Data acquisition system       | ● Spray paint on the surface, low costs, fast and flexible |

Strain Components /εvm





# TEMA PRO

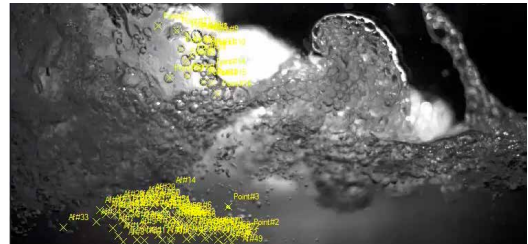
## Motion and Deformation Analysis

### Market Leading Features

#### Auto Speckles Tracking

The smart auto-tracker generator is capable of searching objects in the image sequence using various algorithms from the available library.

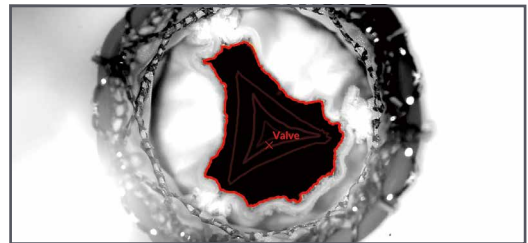
It's frequently used to track bubbles, droplets, sparks to measure velocity, trajectories, etc. In TrackEye Arena, it would be used for fragmentation analysis.



#### Novel Life Science Analysis

Heart valve opening and closing analysis is one of the most popular application for TEMA Pro.

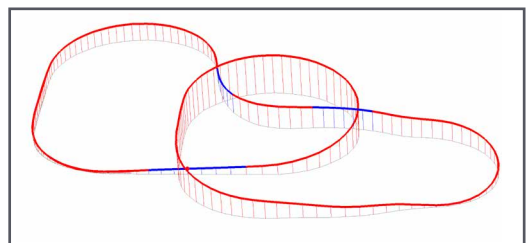
The outline algorithm was key to capture the contour defined by the heart valve at different stages of the opening/closing cycle. Then the dynamic area, circumference, extreme points and even rotation volume will be calculated.



#### Prediction Tracking

TEMA tracking algorithm is so robust that the marker can be tracked steadily even though it's masked.

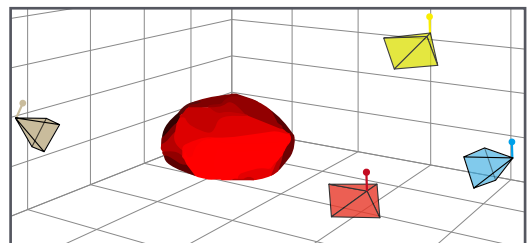
As the image shown, a toy car is running on a tortuous track and frequently obscured. The invisible trajectories (blue) are accurately fitted and presented according to those visible (red) parts.



#### Dynamic Volumn Analysis

TEMA Pro is possible to calculate the volume of an airbag, or other objects with similar structure, during deployment by combining at least 4 cameras.

The outline of the airbag is then analyzed in each camera view and the TEMA software computes a 3D volume based on the intersection of polygons.

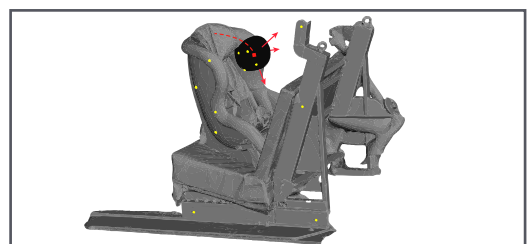


#### Advanced 6DoF Tracking

TEMA Pro 6DoF computes the position (x, y and z) and 3D orientation (roll, pitch and yaw) of a rigid tracked object.

It's capable of using dense 3D targets with surface texture dramatically increases the understanding of any 3D or 6DOF analysis, but also adds more data.

Both single-cam and Multi-cam solutions are supported.





# DIC SYSTEMS

Motion and Deformation Analysis



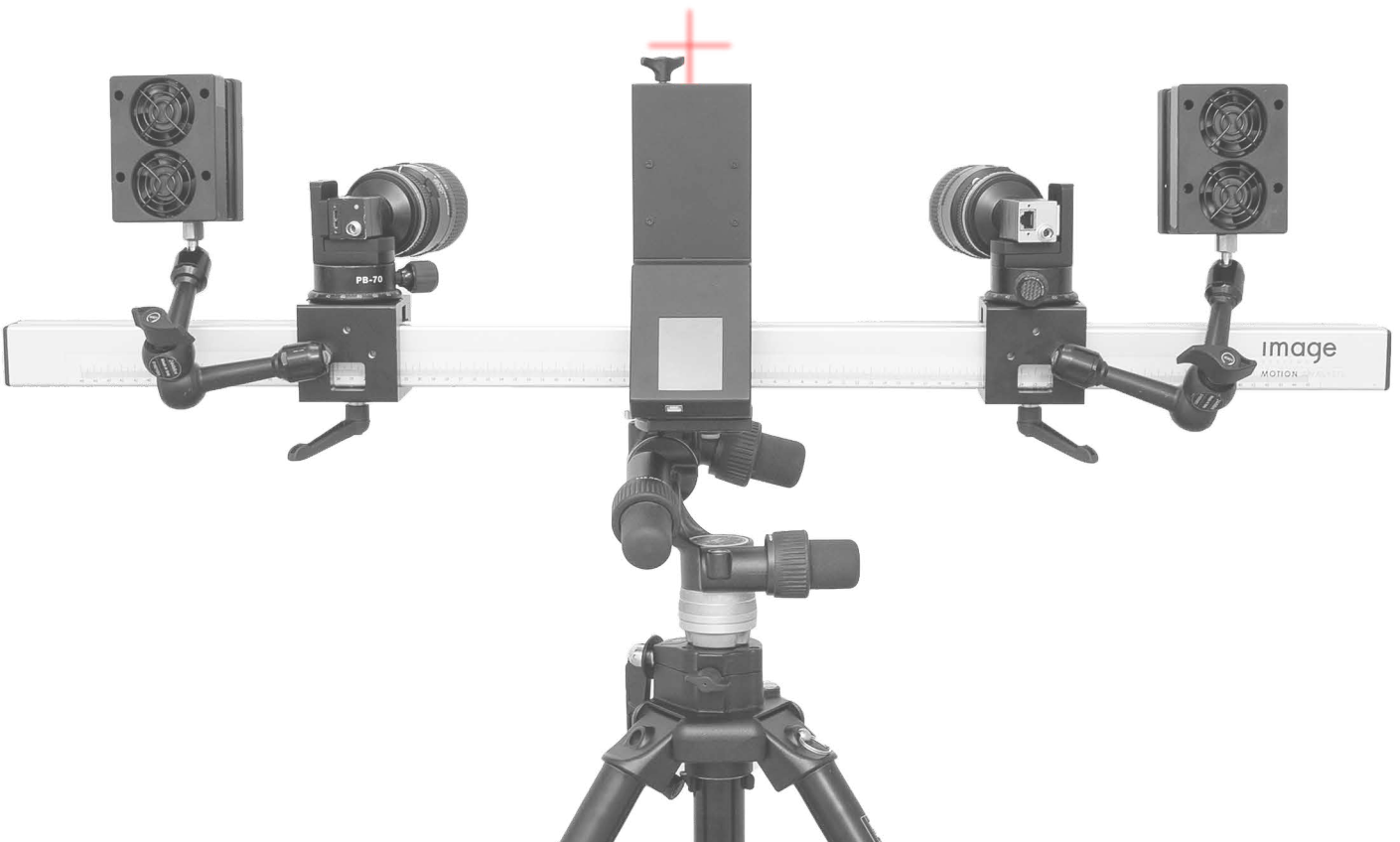
## DIC Embedded

- Robust design, easy setup
- Fixed stereo FOV with high resolution
- Low-medium frame rate available
- Calibrated lenses, low distortion
- Continuous lighting
- Compatible with DAQ systems
- Real-time measurement available
- Ideal for tensile and compression testing



## DIC Elite Kit

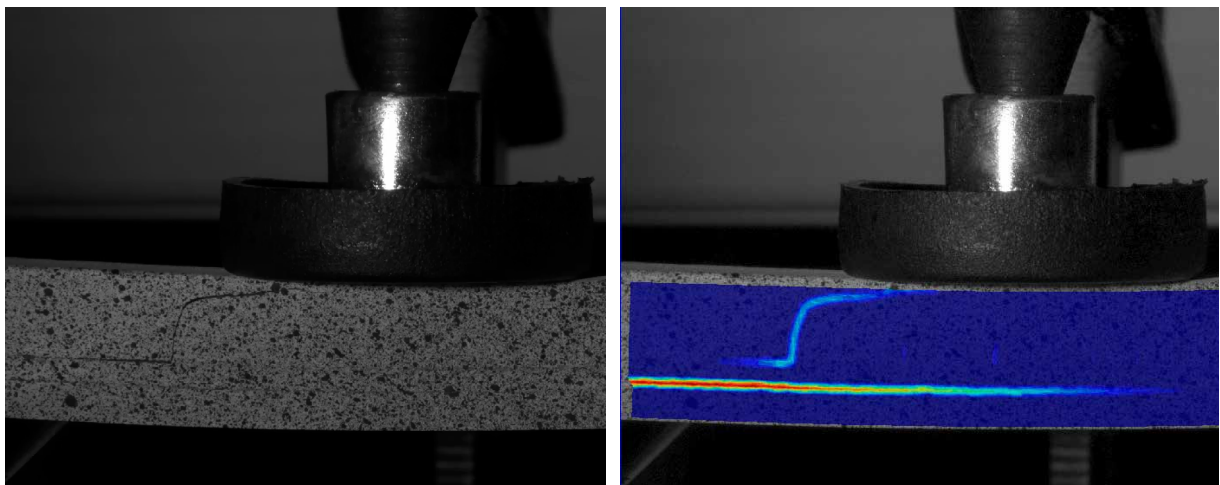
- Flexible design, smart laser alignment tool ensures easy setup and quality results
- Customized positioning with various resolutions
- Industrial, high-speed (streaming) cameras supported
- Interchangeable lenses, flexible FOV
- Customizable lighting
- Compatible with DAQ systems
- Real-time measurement available



### Polycarbonate

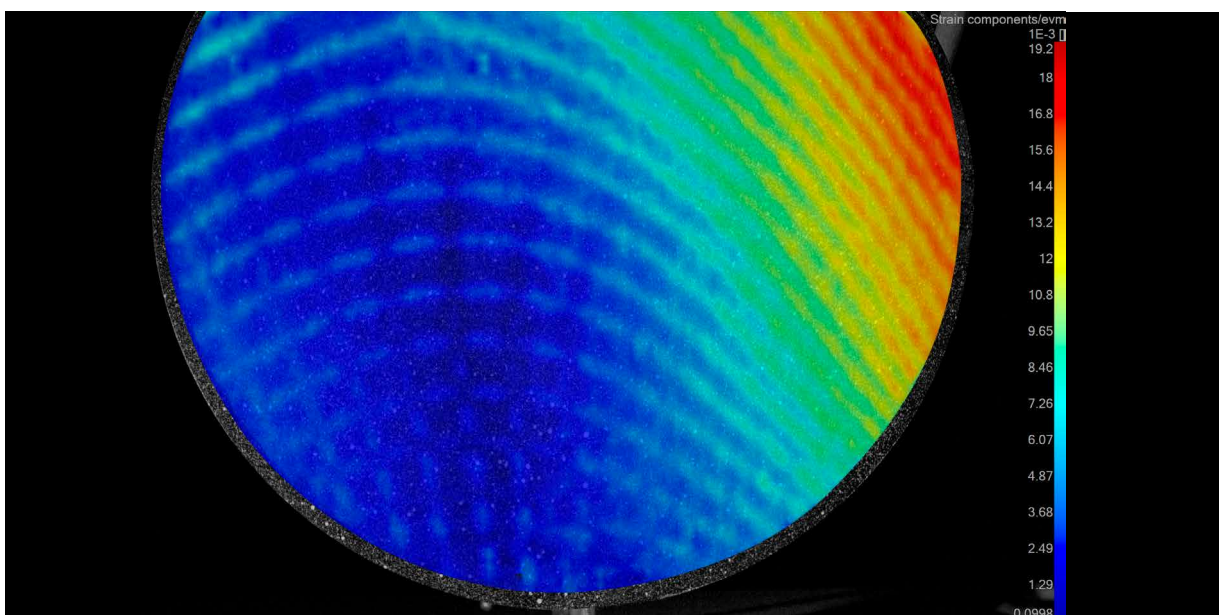
Polycarbonates (PC) used in engineering are strong, tough materials that can be found in various applications. For novel material developments, deformation measurements could provide valuable data for elastic modulus, stiffness and fatigue tests.

Comparing with strain gauges with certain size and cyanoacrylate, which could possibly change the mechanical properties of the specimens, TEMA DIC is a flexible solution that could analyse a small scale object without touching it.



### Alloy

Alloy materials are usually more stiff than most of polycarbonates. With high-speed imaging solutions, the DIC Elite kit offers more possibility for analysis during ultra-fast deformation, even detecting the shock waves reverberate inside the specimen.

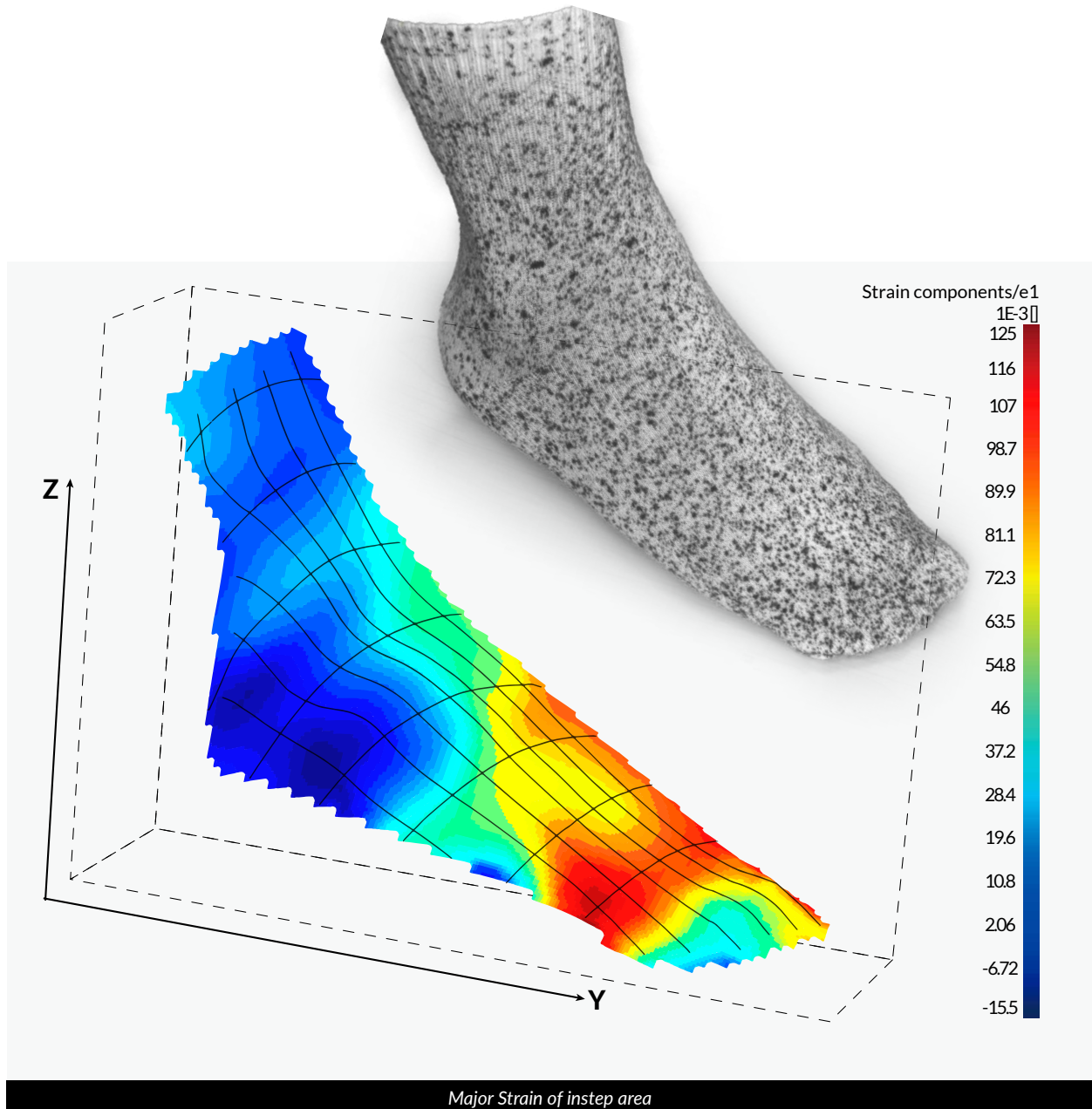


### Sports shoes Development

In sports goods industry, the studies of insoles with excellent shock absorption and re-bounce performance, uppers with robust structure and air permeability, outsoles with superior slip resistance and durability, etc., are always hot topics for shoes manufacturing.

With DIC Elite Kit, the tester is able to set up high-speed cameras alone to capture the foot movement in a test runway with a laser or wireless trigger. The foot model could be generated after stereo DIC matching, of course, full field displacement and various strain diagrams would be presented for further information.

With outstanding 3D and 2.5D analysis, TEMA is frequently used to measure the 3D and projection angle of the ankles to evaluate the protective performance of the running shoes.

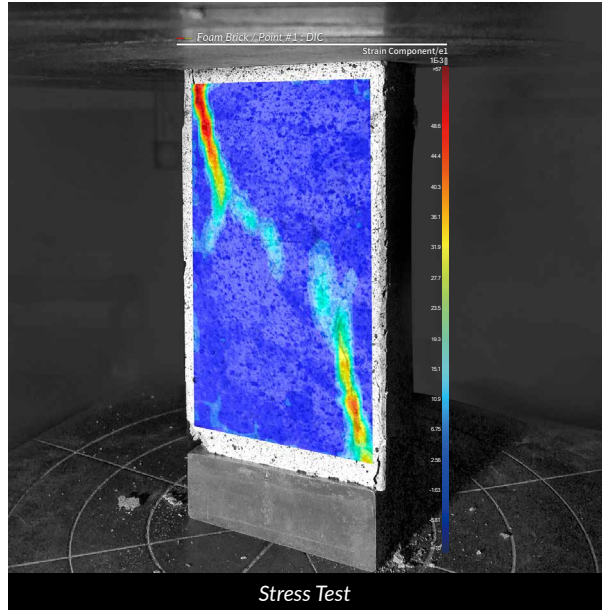


### Foam Concrete Brick

Foam concrete is a versatile building material for its lower cost, light weight, excellent drainage capacity and so on. DIC Embedded becomes a fast kit to verify the performance of different densities and eternal structures.



Shear Failure Test

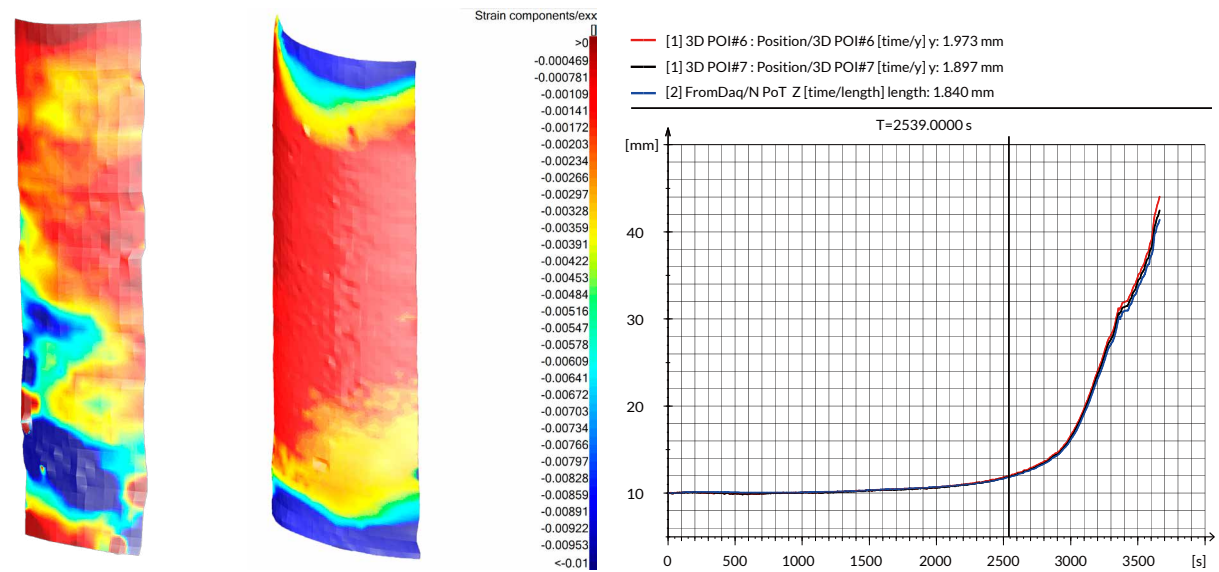


Stress Test

### GRC Improvement

Glass fiber-reinforced concrete (GRC) consists of high-strength, alkali-resistant glass fiber embedded in a concrete matrix. Recently, a university research group was trying to wrap GRC with carbon fiber for improvements.

In this compress test, TEMA DIC was showing 3D strain fields with light and shadow for advanced visualization helping users to identify the unwrapped positions. The synced data comparison between TEMA and sensor was satisfying.



Comparison of Half Wrapped and Full Wrapped GRC

Comparison of DIC Value and DAQ Value



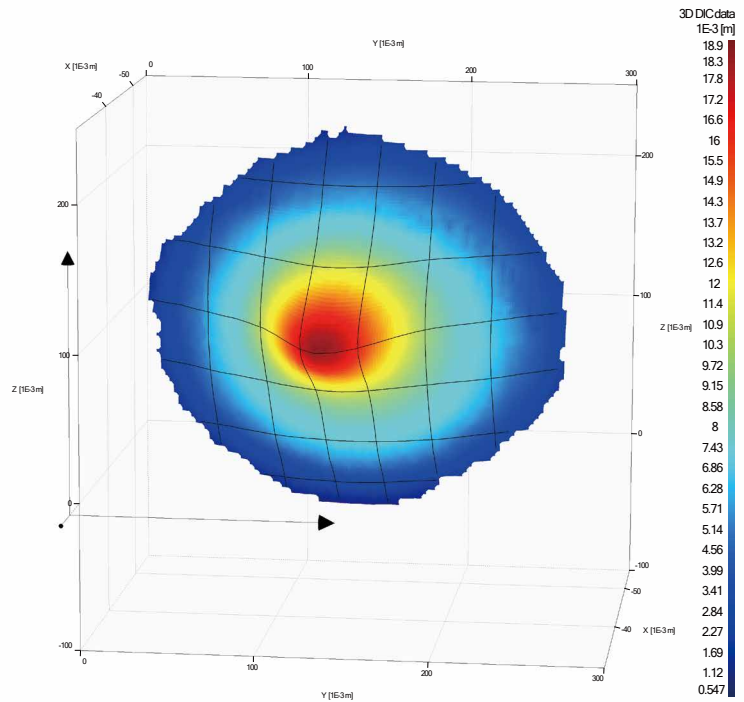
## Blast Resistant Materials

Blast protection is a research area that is highly relevant in modern structures because of the prevalence of terrorism and war attacks.

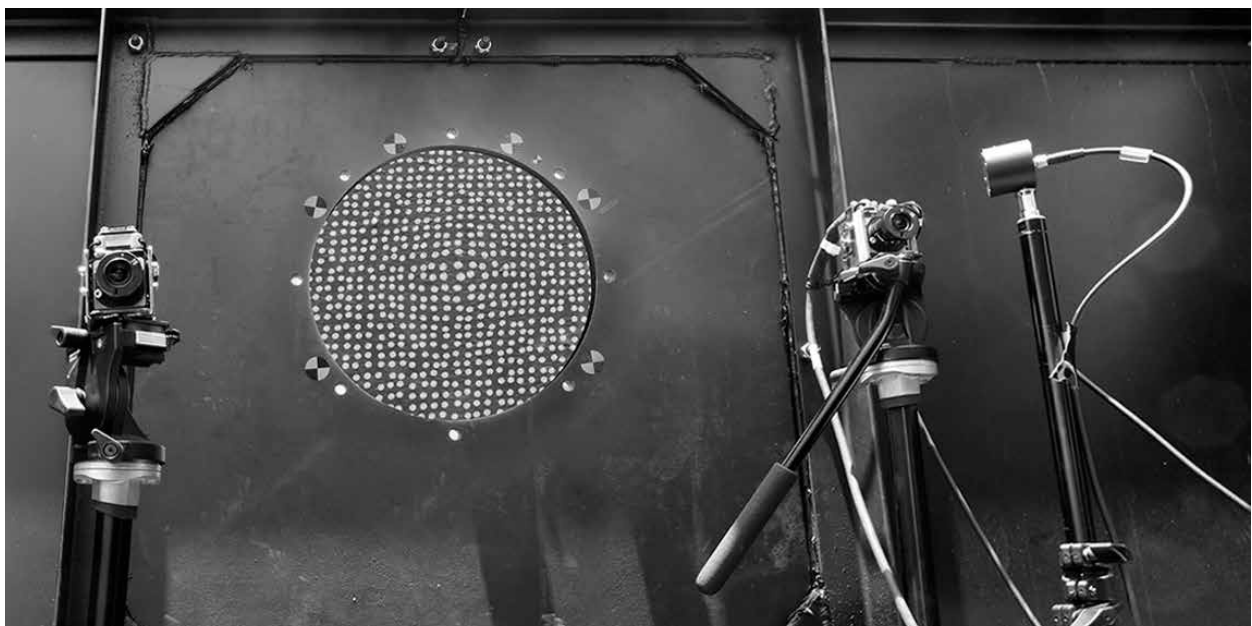
Landward Sciences (LS), a competency area within the Council for Scientific and Industrial Research (CSIR), perform research on military vehicles subjected to blast loading. The gathered data is used to gain a better understanding of the loading and target response in order to enhance the protection that can be offered to the South African National Defence Force (SANDF) soldiers.

With DIC Elite Kit, the image acquisition rate reached 40,000 fps. The slow motion of the metal plate was captured with detailed information. Thanks to the dynamic camera orientation, the camera movement generated by the shock wave was compensated properly.

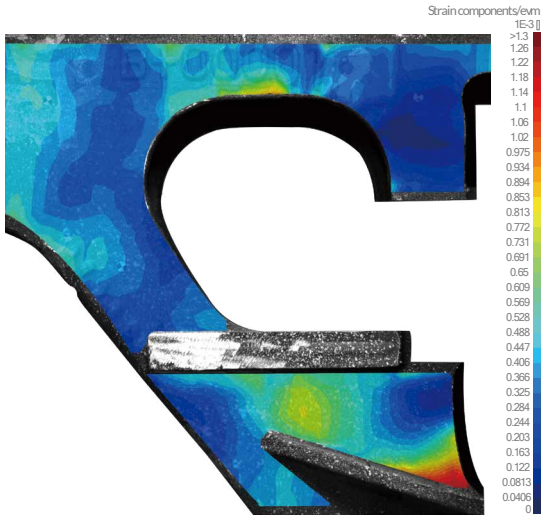
Besides the full field displacement and strain diagrams, the velocity and acceleration filed can be presented. Moreover, FFT diagram presents the frequency spectrum of the bulged position.



Full-field Displacement

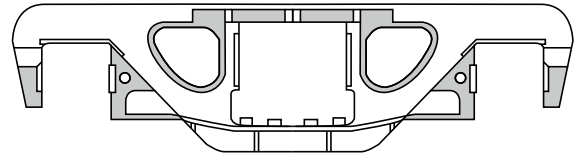


### Bogie Side Frame

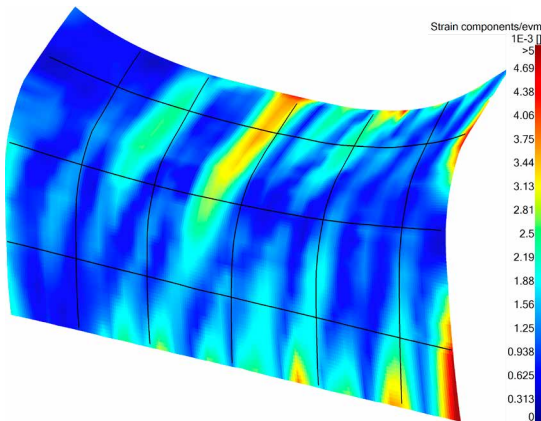


A bogie is a chassis or framework that carries a wheelset, attached to a vehicle. It improves ride quality by absorbing vibration and minimizing the impact of centrifugal forces when the train runs on curves at high speed.

As a result, it requires significant high redundancy (ultra-high stiffness) to ensure the supreme durability. In this case, DIC Elite Kit offers ultra-high resolution cameras to achieve higher accuracy in micro-strain scale.



### Wagon Bolster

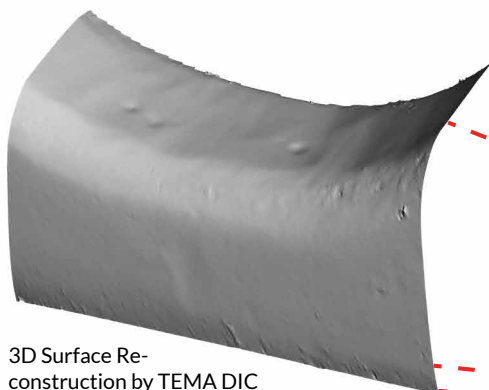


Static load test and fatigue test are two necessary steps for wagon bolster durability validation.

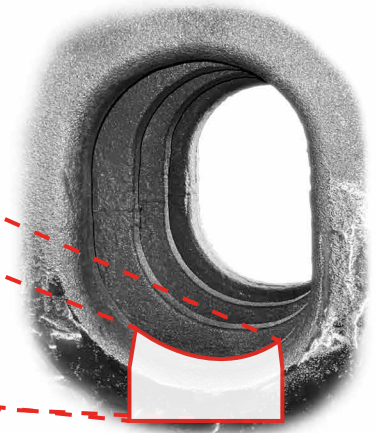
Comparing with placing strain gauges, it saves quite a lot of time to spray paint on the specimen.

After stereo matching, the surface of the object can be re-constructed with detailed texture, proving the high accuracy of DIC algorithm.

DIC Elite Kit offers robust object tracking and anti-interference features during stereo deformation analysis, even a bit motion blur due to slow shutter, or a bit reflection on the surface, can be automatically fixed after parameter adjustments.



3D Surface Re-  
construction by TEMA DIC



## Wing Bend Test

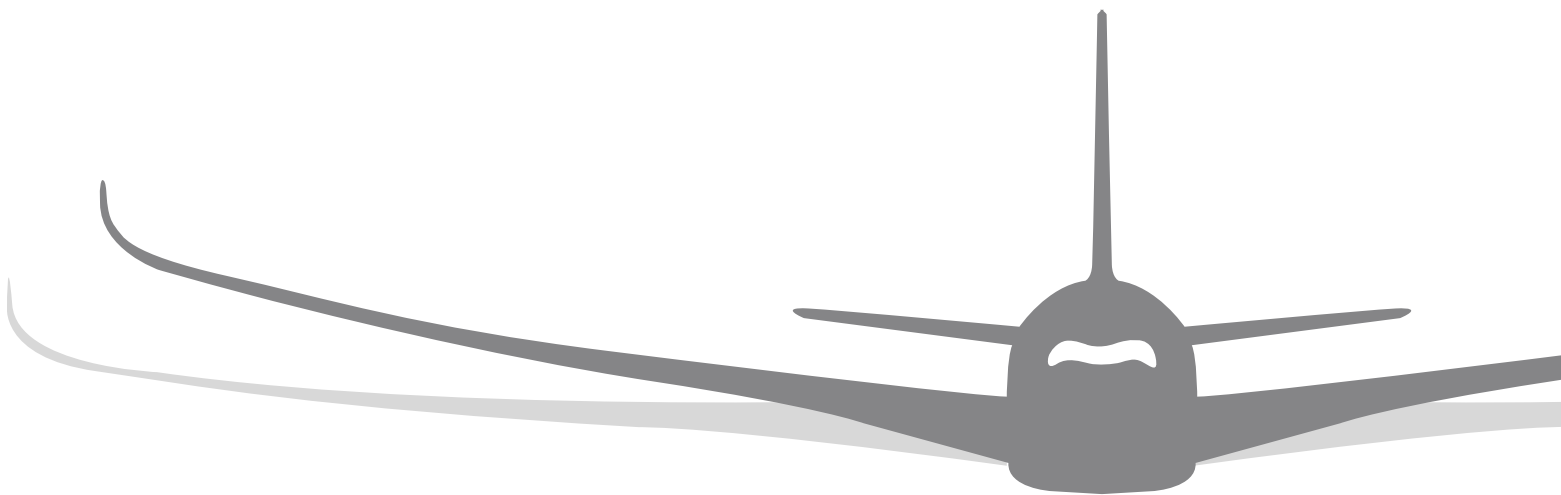
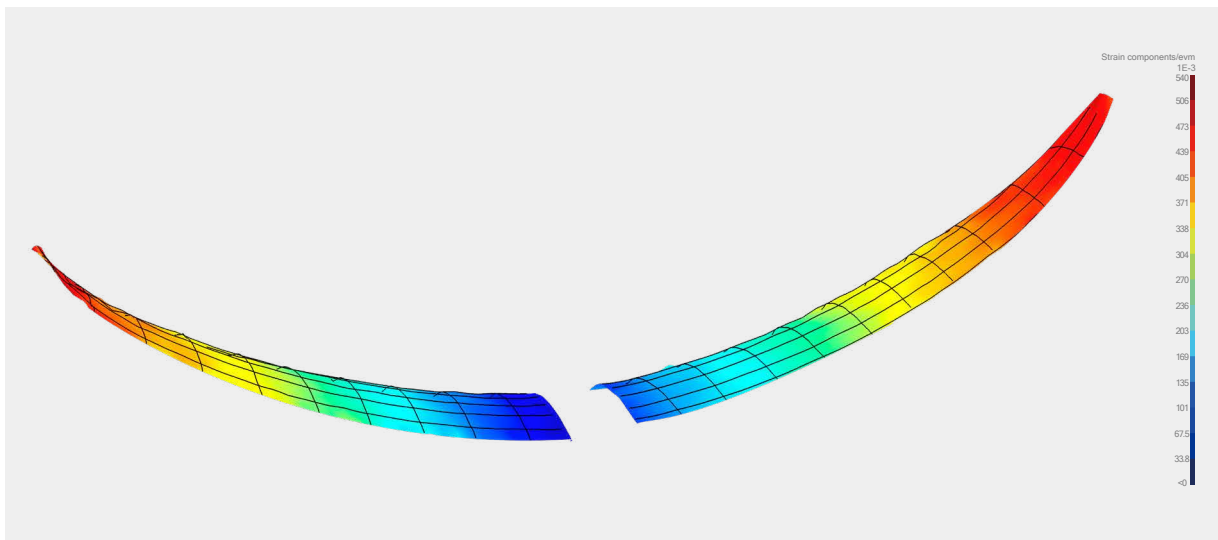
Before any aircraft can be approved for flight, it must first go through rigorous testing on the ground.

For commercial airliners, this process includes everything from wing bend and structure temperature tests, to engine ingestion, windshield impact, and even lightning tests.

Wing bend test is used to demonstrate a safety margin for the design and is part of the certification process to show the airplane can withstand extreme forces.

Unlike normal stereo DIC tests, the wing bend test goes with huge FOV and requires camera array to cover as much as the wing. With flexible camera orientation solutions, it is possible for TEMA to dynamically align all the stereo-camera views in the 3D deformation diagram with a unified legend.

Like normal elastic tests, external data import is available to import tensile values of different positions on the wing to plot the elastic curve. The inspection lines help to present the linearity of displacement and strain.





# DIC

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