Automotive Testing: Optical 3D Metrology Improves Safety and Comfort

GOM Measuring System: ARAMIS, TRITOP, GOM Touch Probe
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During crash tests with dummies or airbags, non-contact measurements are needed to avoid distorted measuring results and to measure data quickly. Thus, optical 3D metrology would be an ideal tool, rather than conventional measuring systems like strain gauges. GOM outlines the benefits of point-based and full-field measuring 3D cameras 3D cameras that help improve displacement analyses and passive safety.

Product development in the automotive sector is currently driven by strong competition, which causes shorter development cycles of passenger car models and high cost pressure. At the same time, the automotive industry has to respond to the stricter regulations aiming to reduce environmental emissions. As a result, automobile manufacturers need to implement lightweight construction materials and new material combinations to reduce vehicle weight and, in consequence, lower fuel consumption. Nevertheless, the new materials must also permanently meet the high requirements on performance, crash safety and durability.

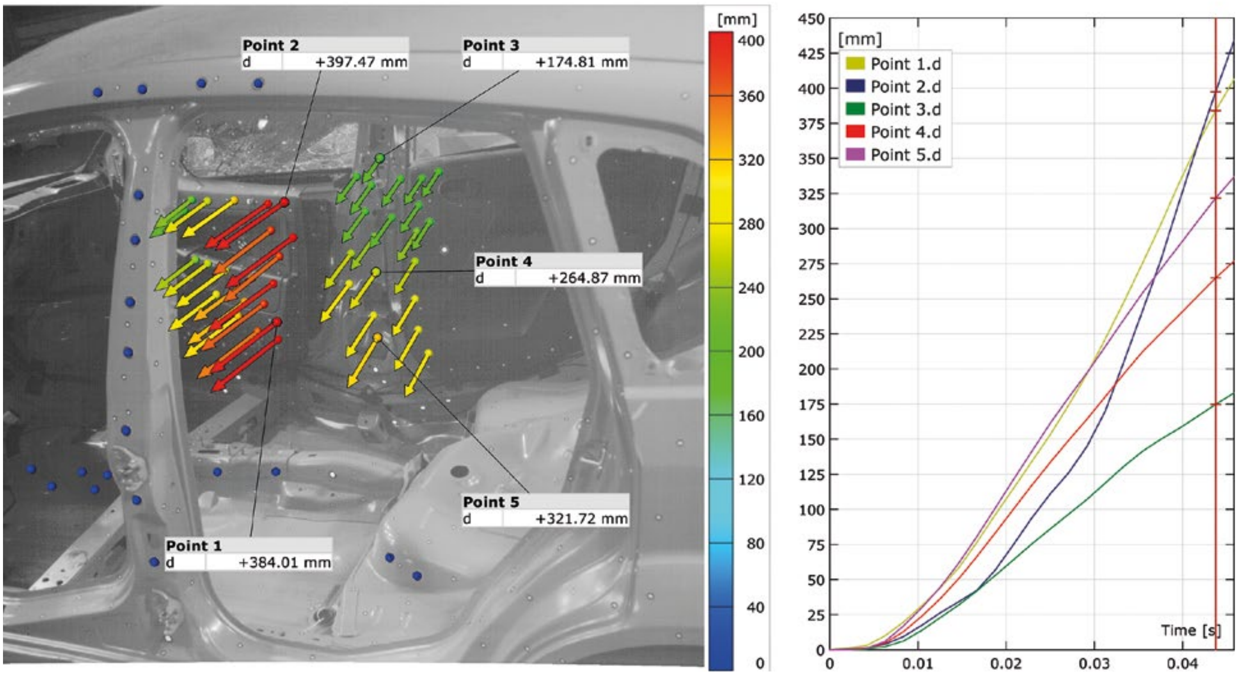

Figure 1: During a side impact crash test, ARAMIS shows 3D displacement vectors while additionally measuring real speed and acceleration. The results can be visualised in easy to understand reports.

Optical Measuring Methods Instead of Strain Gauges

To speed up design and simulation for shorter development cycles, the automotive industry now increasingly uses optical measuring systems instead of conventional strain gauges, accelerometers, transducers, or extensometers. Companies implement these non-contact systems not only in crash and impact tests but also in climate chamber, wind tunnel and fatigue testing. Particularly important for German car manufacturers like Audi, BMW, Daimler, Porsche and Volkswagen as well as suppliers such as Autoliv, Bosch, Faurecia, Brose, Continental, TRW and ZF is the fact that the optical measuring systems can be fully and effortlessly integrated in existing test facilities and test stands. As the ARAMIS 3D Camera from GOM combines point-based and full-field optical measurements within one measurement system, the integration gets even simpler and the setup effort decreases additionally[1]. To do so, multiple conventional measuring instruments were necessary in the past.

Non-Contact Measuring of Displacements

The optical sensors of the ARAMIS 3D Camera provide data of part and component geometries as well as of three-dimensional displacements and deformations. Static and dynamic deformations are determined on the basis of individual points as well as on entire surfaces. With this measurement data, safety and function of parts can be evaluated and simulation and design processes can be optimized.

The most interesting aspect for test engineers is how parts and components react during crash and impact tests – this is the only way to guarantee the safety of occupants and pedestrians. Therefore, a precise analysis of the dynamic behaviour of individual parts and components is necessary. For this, point-based as well as full-field measurement techniques are provided. The camera is applied not only in crash and impact tests but also in wind tunnel tests, chassis and engine test stands, in vibration and oscillation analysis as well as in doors, bonnet and closures testing.

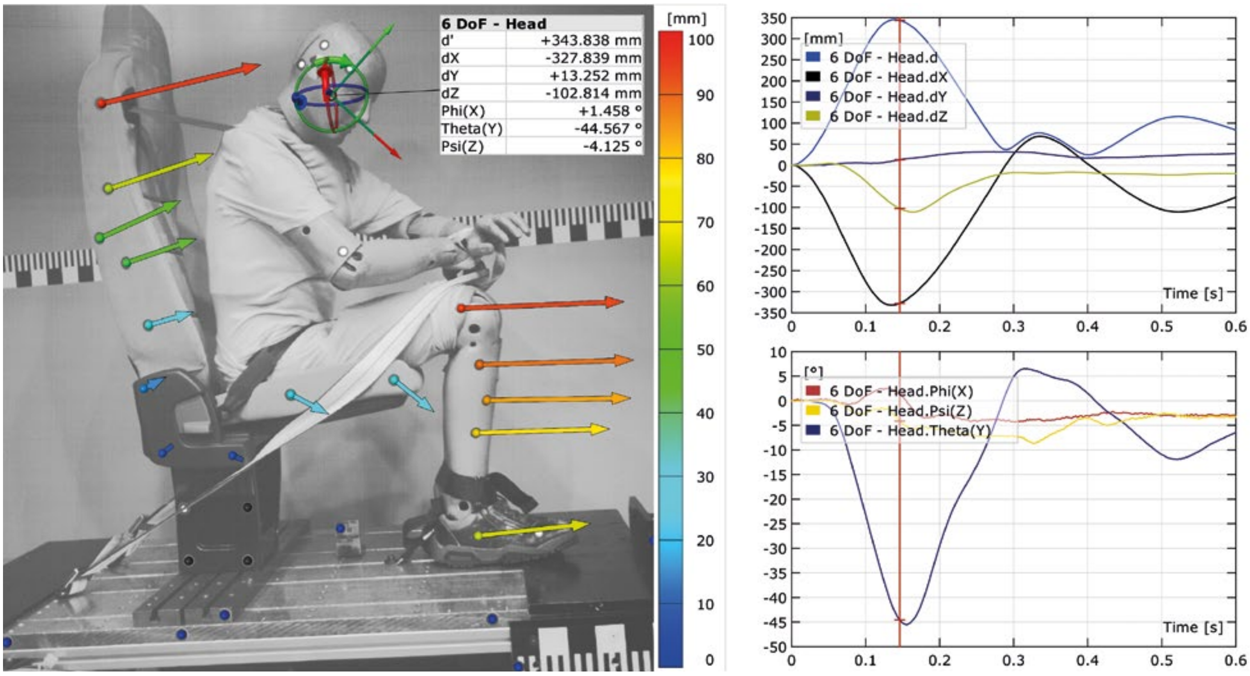

Figure 2: ARAMIS combines point-based and full-field deformation measurements within one measurement system and shows 3D displacement vectors (left) and a full 6DoF analysis (right) of the rotatory and translatory movements of the dummy's head. Trajectories of the head can also be evaluated.

Analyses in Crash Tests

Sled experiments in crash testing, for example, typically use point-based measuring procedures as a fast method for testing seats, body restraint systems and interior trim components. These test setups do not involve the destruction of costly prototypes or entire vehicles, as these are simply accelerated to predefined speeds. This makes it possible to demonstrate the impact of frontal, side and rear crashes at low cost. Optical systems like the ARAMIS 3D Camera show three-dimensional displacement vectors while additionally measuring real speed and acceleration in any test setup (figure 1).

The collected measuring data are used, for example, to determine the movement of seats and crash test dummies. The evaluation enables full analysis of movements in six degrees of freedom (6DoF) including the rotatory and translatory movements of a dummy's head (figure 2). Additionally, body movements and rotation are measured as well as the speed at which the head hits the headrest, and leg movements. During this process, displacements in the measured points are displayed in three dimensions.

Test engineers use the data to analyse precisely how the dummy's head and body will move within a given space (figure 3). This in turn makes it possible to draw conclusions about the safety of seat and belt systems, but also shows whether there is a risk of head impact inside the vehicle.

Optical measuring systems are very easy to integrate in various test stands. Inspection points are identified via measurement markers. In addition, test setup is accelerated due to a positioning function integrated in the camera: An optically tracked GOM Touch Probe quickly determines and marks the positions specified by testing regulations, for example for dummies and seats. The measurements themselves are easily performed also in rough environments, because of the integrated so-called Blue Light Technology and a flexible image recording trigger, controlled by the GOM Testing Controller. Image recordings are achieved for setups ranging from long term tests to high-speed applications. Furthermore, analog channels (force, distance, angle, temperature, etc.) can be recorded and digitized simultaneously and shown in real time.

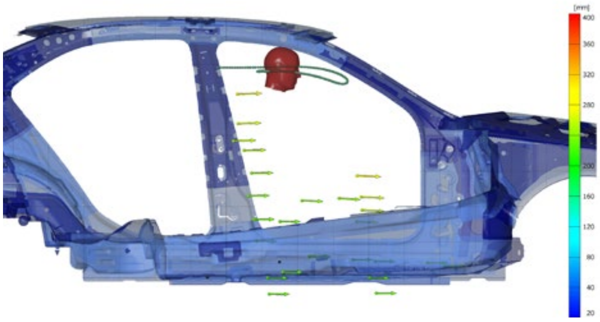

Figure 3: Based on the measuring data, test engineers can analyze precisely how the dummy's head and body will move inside the car. This in turn makes it possible to draw conclusions about the safety of seat and belt systems, but also shows whether there is a risk of head impact inside the vehicle.

Strains in Airbag Housings and Windshields

Full-field information relating to dynamic deformations is vital for components that are of relevance to safety. In consequence, full-field measuring systems are frequently used in crash and impact tests, as well as in component testing, for instance on airbags, and on tyre test rigs.

Airbag housing and airbag inflation characteristics are analysed with high-speed cameras. The full-field measuring data are then used to calculate surface strain and planar displacements for all axes. Crash tests are another area in which full-field measuring systems are deployed, for components such as windshields. Since the materials used for modern car windows consist of several material layers, numerical simulations are often inaccurate for determining their behaviour under load. The full-field measuring data recorded by the ARAMIS 3D Camera can then be used to draw reliable conclusions on crack propagation in a windshield which otherwise stays invisible (figure 4).

Climate Chamber Tests

R&D work covers not only dynamic part and component behaviour but also static deformations in a before/after comparison. Portable optical systems such as TRITOP from GOM determine the coordinates of three-dimensional objects by means of photogrammetry. Systems of this type are used in climate chamber tests to analyze point-based deformations and changes in gap and flush dimensions under various temperature and environmental conditions. Measurements allow conclusions to be drawn on material stiffness as well as on design quality.

These photogrammetry systems are also used to document the state of a vehicle before and after a frontal crash test. Based on 3D coordinates from the two measurement series, point deformation vectors on the x, y and z axes can be determined, making it possible to understand deformations, for example on A, B and C pillars.

More Safety, Improved Comfort

Safety regulations have been tightened in the automotive sector in recent years; varying standards also exist at international level. This leads to the need for numerous different tests, which makes it necessary to have a metrology system that is flexible and easy to adapt. Today's optical measuring systems perform static, dynamic, point-based and full-field analyses in a non-contact way. Measurement areas, frame rates and resolution can be adjusted to the different test setups. This replaces conventional strain gauges, accelerometers, transducers and extensometers.

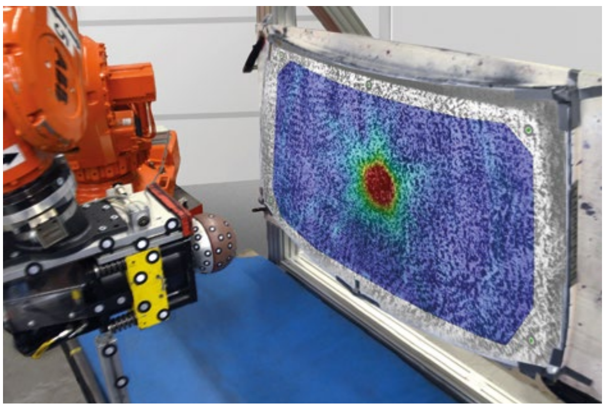

Figure 4: The full-field measuring data recorded by the ARAMIS system can be used to draw reliable conclusions on crack propagation in a windshield.

The recorded 3D measuring data are permanently available and can be evaluated after testing and in different contexts. The measuring results can be displayed in charts, videos and images. These measuring data are used to draw conclusions on safety risks, part durability, creep and aging processes and on changes to outer appearance during part lifetime and usage. This results in more safety and improved comfort as well as in longer durability and attractive product design.

Simulation Verification
One important area in which optical measuring data are used is computational simulation verification. The results enable users to review and improve simulation parameters, as well as to optimize their current and future design processes. As a result, they can reduce additional test runs and consequently speed up product development. This means a competitive advantage for automobile manufacturers and suppliers in a market that is subject to high cost and innovation pressure.

[1] GOM Webinar „Optical 3D Metrology for Automotive Testing“ on March 16, 2016.
Online: http://www.gom.com/events/webinars/webinar-automotive-testing.html