Possibility for Application of 3D Scanning to Evaluate the Opening Behavior of Side Airbags in Interaction with the Human Body Model and Car Seat

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Abstract

To ensure the protection of an occupant in the event of a side impact, the side airbags play an important aspect of protection. The airbags interact directly with the occupant's body to prevent injuries in den area of the hip-thorax zone. Due to the small impact zone of an side impact, the side airbags need to be open approximately in less than 5 ms and be in position in about less than 20 ms. As a standard checking the performance of a side airbag during the development 2D high-speed cameras are used. The investigation of this study is based on the evaluation of the possibility of using an alternative 3D technique for the application of testing the side airbag deployment. This already known 3D measurement technique was developed in a cooperation between Fraunhofer IOF, Fraunhofer SCAI and Volkswagen AG.

Keywords: 3D scanning, dynamic deployment, side airbag test bench

1. Introduction

Vehicle safety systems are subject to a high level of attention, especially with constantly increasing legal and consumer test requirements and the ever-increasing awareness of vehicle occupants of the benefits of protective systems. Airbags in particular, which are installed in numerous areas of the car, contribute to consumer safety. Depending on where they are installed, these occupant restraint systems basically consist of an individual airbag design and a gas generator. The aim is to generate dynamic airbag inflation, i.e. the inflation of the airbag in the event of a crash. In the event of a side impact, side airbag systems protect the head and thorax area of the vehicle occupants. The side airbag systems consist of different airbag variants. On the one hand, there is a head airbag, installed in the headlining to protect the head area.[1] Side airbags are seat-mounted protection systems, which prevent injuries of the occupants during car side impacts. The fundamental principle of side airbags is to inflate rapidly within milliseconds.[2] Centre airbag, also usually triggered from the seat backrest, protects the front occupants from collisions.[1] For the development of side airbags, the execution of safety tests plays a key role in testing and securing the suitability and integrity of the airbags. The aim of these investigations is to minimize and prevent potential dangers for vehicle occupants, as well as the functional suitability of the airbag module. Under defined temperature ranges (for example, up to -40°C to +90°C), the airbags are triggered and evaluated according to trigger times or inflation times. Potentially detachable components that could pose a danger to the occupant should be identified and eliminated early. High-speed cameras capture the highly dynamic triggering of these airbags.[3] For the documentation and analysis of safety tests, high-speed cameras play a central role. The high-speed cameras, primarily used for 2D recordings, allow a high temporal resolution of dynamically moving objects or deformation measurements. In addition to the two-dimensional measurement purposes, the camera systems can also support image measurements in the field of three-dimensional measurement systems. These photogrammetric systems consist of camera systems and a projector that projects a pattern surface, e.g., in the form of stripes, onto the surface of a test object.[4] Converting real test recordings into a three-dimensional data set, without touching or preparing the objects, in order to then obtain precise, high-resolution and reproducible 3D size information, represents the area of application of optical 3D measurement technology. It serves as a medium to convert comprehensive information of the real events into digital signals, which can then be processed computationally and make an important contribution to the range of applications, including in the automotive industry.[5] In a joint project between Fraunhofer-Institut für Angewandte Optik und Feinmechanik (IOF), Fraunhofer-Institut für Algorithmen und Wissenschaftliches Rechnen (SCAI) and Volkswagen AG, the 3D high-speed measurement system was further developed for the area of dynamic safety test measurement and optimized according to the requirements of various test conditions.

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Basically, the 3D measurement system is based on the principle of the stripe projection system. In this process, patterns are projected onto the test object in succession and recorded by the camera technology, in order to then computationally generate a three-dimensional file from the surface data. The special feature of the 3D measurement system, unlike conventional stripe projection systems, is the ability to perform three-dimensional measurement of highly dynamic tests, such as the deployment of airbags within a few milliseconds. A dynamically changing pattern in front of a light source is projected onto the test object, which is captured by two high-speed cameras, in order to form a data set from eight to ten images for each sequence of the recording. The high recording frequency is realized by encoding the object points illuminated by the measuring system, which are generated by the pattern changing from image to image. The high-speed cameras record both image sequences. The encoding serves to identify the same object points in the image sequences via the temporal gray value sequence at the respective camera pixels. The assignment method is based on equations for gray value-based image assignment. The two high-speed cameras used (of the type Photron SA-X2) realize a recording frequency of 50 kHz with a usable resolution of 640 x 384 pixels. The already described, dynamic pattern is also changed at a speed of 50 kHz. The pattern generated by a lamp (40,000 lm) is formed by a GOBO system (GOBO = graphical optical blackout) by rotating a wheel in front of the lamp, see figures in paper [6]). As a result of the variety of stripe widths of the wheel, a aperiodic pattern is created in the test room. The dynamic rotation of the GOBO wheel thus allows the generation of a new pattern for each image of a 50 kHz sequence and thus the unique identification of the encoded object points. The measured three-dimensional point cloud at each test point requires subsequent data processing, as up to one million measurement points are generated. The three-dimensional points are not object-bound, as each camera pixel is assigned to an isolated measurement channel. The surface information of the points can belong to different objects at different times. The generated point cloud of the three-dimensional measurement data is subsequently processed further by meshing and segmenting the data according to objects in the environment, false recordings, and the temporal transformation of detected objects through morphing and tracking of objects by adjusting known geometry. [6]

Since the applicability of the 3D measurement system for the static test bench of the side airbag is to be discussed in this paper, some advantages and disadvantages can already be presented from the literature in advance. Previous commercial procedures for conducting safety tests are based on tracking markers, defined structures, or prepared surfaces with special textures, which are then captured by high-speed cameras. Subsequently, they are processed for three-dimensional data using various methods, e.g., subsequent triangulation. However, the preparation of test objects under the aspect of the technical feasibility of the texture application on certain materials, additional work effort in the preparation process as a cost factor, but also the aspect of reproducible measurement results due to changes in the original state and influence of potential interactions between the test object and surface treatment, proves to be problematic. The goal of the 3D measurement system is to eliminate the need for object marking or object preparation. The randomly generated pattern using a light cone and GOBO wheel avoids this necessity and thus represents a complement to previous systems.[6] A partially purely visual comparison of test data from high-speed recordings represents a subjectively biased measurement method. The generation of computational 3D data from the real test execution allows the recording of a reproducible data set, which can also be examined and processed according to different safety criteria in downstream post-processors. Due to the highly dynamic deployment processes of airbags in a few milliseconds, a measuring technique is needed that can still generate high-resolution data even during the very rapid deployment processes of the airbag. The 3D measurement system presented here manages to record an airbag deployment of appropriate quality using cameras (with 50 kHz). The setup of the measurement system is designed to be variably buildable, so it can be used at different measuring stations. Height differences up to a height of 2.70 m can be applied. The computer unit is movable and the cameras and projector technology are built on portable tripods. A disadvantage so far is the downstream algorithm, which so far does not allow the segmentation of different objects to be processed. The result is that there is a total recorded surface that does not differentiate between different components and may also assign objects to each other and does not form a demarcation in the subsequent representation. Thus, cables belonging to the test setup can be erroneously assigned to the test object to be tested. In addition, it has not yet been possible to distinguish which mechanical behavior is present in the material during dynamic testing, whether, for example, a strain or a tearing of a seat cover is visible. [6] Through further computational processing, the data is prepared into a simulation file for the Animator4 from GNS. To evaluate real components of its performance, both a module-only test and a test with a car seat and a human body model, are made in a special test setup. As a standard checking the performance of a side airbag during the development 2D high-speed cameras are used. The objective of this study was to use the known 3D measurement technology of

Fraunhofer IOF, Fraunhofer SCAI and Volkswagen AG and apply to as an alternative method of checking the deployment of these airbags. This work presents the application possibilities and challenges of using the 3D technology for the safety tests of side airbags. The application of 3D measurement technology in the area of side airbags presents various challenges that have been solved technically, still require a solution, or show the limits of this 3D technology. The determination of the advantages and disadvantages as well as the evaluation of the test setup for the special application of the side airbag area will be discussed in this study.

2. Method

The safety suitability of side airbags is evaluated at Volkswagen AG, among other things, using static safety tests. The aim of the test is to achieve previously defined inflation times of the side airbag module. In addition to a reproducible deployment in the construction position, no damage should occur to the component. If particles separate from the side airbag module or the surrounding components, this should be detectable. The static safety tests are carried out for example both on the airbag module alone, the so-called ‘Module-Only’ test, and in the installed state in the seat backrest, in order to comprehensively check the deployment behavior and material strength. In the system test of the seat, various seat cover variants within a vehicle project may are taken into account. Value is placed on the opening of the airbag seam, the seat foam behavior, and the cover stretch for both synthetic leather and fabric variants of the backrest. The static deployment test is carried out under the influence of various temperature levels. The components to be tested are conditioned under a defined time and temperature. Between removal from the climatic chamber and test execution, a time window is set to maintain the temperature of the components. The setup of the regular static airbag test bench consists of a closed plexiglass box built on a base plate and topped with a centrally positioned holder for an interchangeable seat back frame. The setup is evident in the schematic representation in figure 4. The holder offers the possibility to either screw the side airbag modules into the pure backrest frame in the ‘Module-Only’ test or to build a complete backrest in the test bench. From a perspective, 2D high-speed cameras (at least with a frame rate of 2000 images/ second and 1280 x 1024 pixel resolution or 4000 images/ second at 800 x 800 pixel resolution) capture the deployment of the side airbag. For example a grid pattern positioned in the background with defined dimensions allows the visual evaluation of the deployment in x- and z- direction at defined inflation times. The main perspective of observation is the side view of the side airbag, in order to evaluate the deployment within prescribed times. A high-strength plastic pane is located at a fixed distance between the airbag and the side camera perspective, to simulate a narrowed installation space of the side paneling. The requirements for the plastic pane are transparency, so that the deployment can be filmed from the side perspective, while at the same time being strong and scratch-resistant against the force of the triggering airbag. In addition to the simulation of the side paneling, a vehicle occupant is also represented by a laterally swiveling body dummy that simulates the torso. In the current state of the art, this dummy is used with a contour-matching molding made of a hollow glass fibre reinforced plastic shell in accordance with SAE J 826.

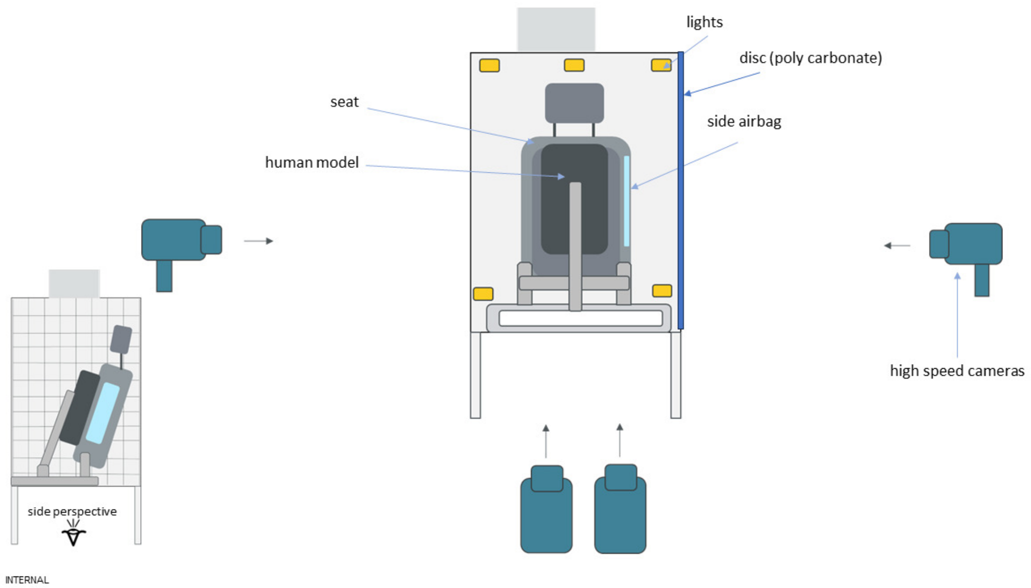

Figure 1 Test bench of the side airbags of VW standard

The test setup for testing the side airbag is modeled on the internal Volkswagen Group standard in terms of structure, requirements, and testing. Specifically, the requirements and the structure will be described in the following. On a rollable and statically fixable carrier base plate, a large, rectangular box made of item profiles is mounted. On one side, a transparent and scratch-resistant polycarbonate pane is permanently installed from the driver's perspective. The test setup is roughly based on internal Volkswagen standards (e.g., in positioning and installation of the dummy and the door dummy (polycarbonate pane)). The setting in this investigation for the recording frequency is about 3600 fps, with a recording sequence of 63 milliseconds duration. The maximum resolution of the 2D images for the 3D reconstruction is in this case 56,000 fps.
To test the basic applicability of the 3D measurement system on the static test bench of the side airbag, an iterative approach is taken using the execution of airbag deployment shots. First, two fully assembled passenger seats including seat cushion (because of availability) are installed in the test bench to achieve initial results as quickly as possible. Subsequently, a change of perspective of the test stand is made by taking the 3D recording looking frontally at the seat. The reasons for this will be explained later in the investigation. Following the change back to the side perspective, twelve system tests of the side airbag, installed in the driver's seat backrest, are carried out and technically recorded by the 3d measurement system. For this investigation the system tests of the side airbag in the seat backrest are divided into six airbag deployment shots at room temperature and six airbag deployment shots, which are pre-tempered in the backrest at about 85°C for approximately four hours in a climate chamber. For each temperature, three seat backrests are prepared with yellow chalk paint and three seat backrests per temperature are left in their original state. The background to the test configuration will be illuminated in more detail later. The test matrix is illustrated again in table 1. The initially configured test bench is shown in figure 1. This test setup is analyzed and optimized in the further course of the investigation. In addition, a background plate is implemented to avoid the recording of background artifacts by objects in the test room during the measurement. According to the standard, a defined angle of inclination of the backrest frame and the distance between the outer side of the backrest and the polycarbonate pane is set for each measurement. The distance between the test bench and the measuring system, more precisely between the polycarbonate pane and the outer edge of the 3D measurement system, is chosen to be 2.30m (empirical value). The measurement data is processed by an external company in the post-processor Animator4 from GNS. The inspection of the measurement data in Animator4 always takes place after the tests.

table 1 test matrix of airbag firing tests

test object	configuration	repetition
airbag in seat	side perspective, room temperature	2
airbag in seat	change of perspective - frontal perspective , room temperature	1
airbag in seat	side perspective, room temperature	3
airbag in seat	side perspective, pre-tempered to 85 degrees	3
airbab in seat	side perspective, Room temperature, colour preparation of the seat	3
airbag in seat	side perspective, pre-tempered to 85 degrees, colour preparation of the seat	3

3. Results

3.1 Construction of a replica test stand

To iteratively check the applicability of the 3D measurement system for the test bench setup of the side airbags, a replica of the original test stand is first realized (see figure 1). The reasons for this are the regular operation on the test benches. The 3D measurement system is flexible to set up, but due to its size, consisting of the projector with two cameras and the trolley, as well as the required distance between the test stand and camera system, it is too extensive for the given premises. The replica of the test stand must finally be rollable to avoid delays in the daily business. Thus, the base frame and background plate are equipped with lockable rollers, see figure 2.

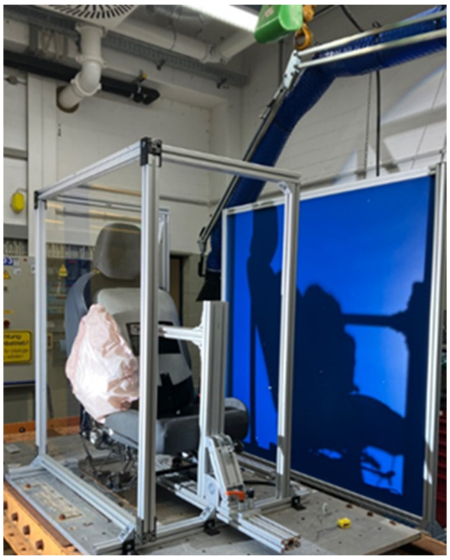

Figure 2 First replica of the test bench

3.2 First optimization loop of the test stand to minimize reflection elements

After setting up the 3D measurement system and the side airbag test bench, two preliminary tests are carried out. Side airbags, installed in seat backs, are tested by igniting the airbags and simultaneously starting the measurement with the ignition time of the airbag. In the further processed files in Animator4, numerous fragments appear that do not belong to the actual test object of the seat including airbag, see figure 3 and figure 4. In addition, the polycarbonate pane reflects the incoming light of the projector, which is mandatory for the test bench to limit the installation space for the airbag. A round area wandering centrally on the airbag fabric becomes visible. As a first interim status, it is noted that the test stand shows strongly reflecting elements. The brighter the components of the test stand are, the better visibility is given in the 3D data set in Animator4. The shinier a component, the more disturbing are highlights to be found. Dark, matte components disappear in the 3D data set. The silver-shiny item profiles existing for the test stand frame, as well as the high-gloss polycarbonate pane, cause disturbing fragments in the processed file in Animator4. This is followed by the first optimization of the test setup, by covering all brightly reflecting components of the test stand with a matte black foil. In addition, a likewise matte black foiled background plate is created on rollable supports for a neutral background, which can also be removed for everyday business, see figure 5.

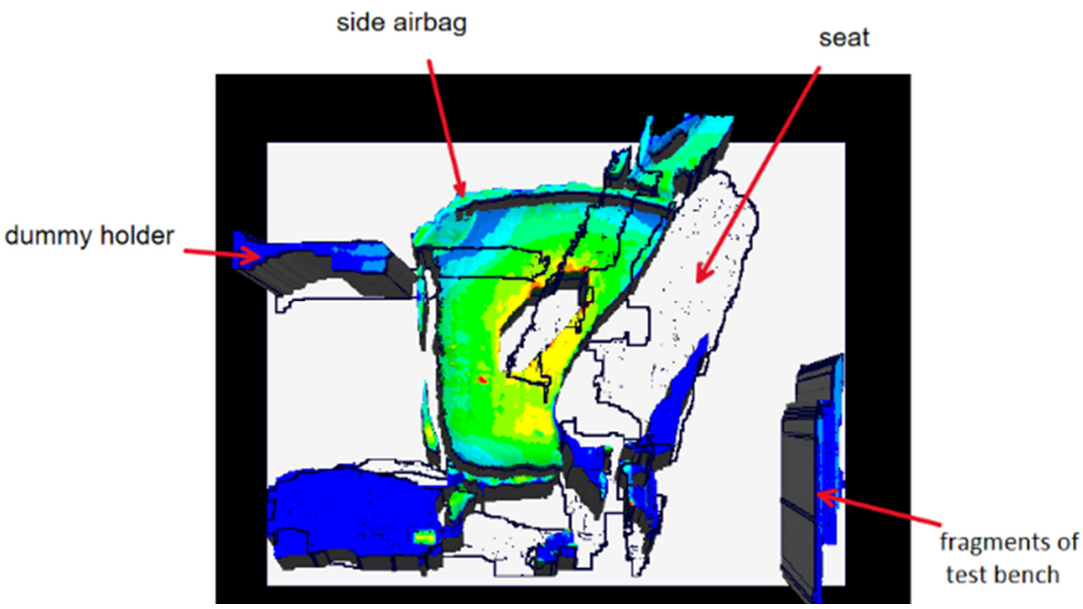

Figure 3 First unprocessed preliminary tests of the data

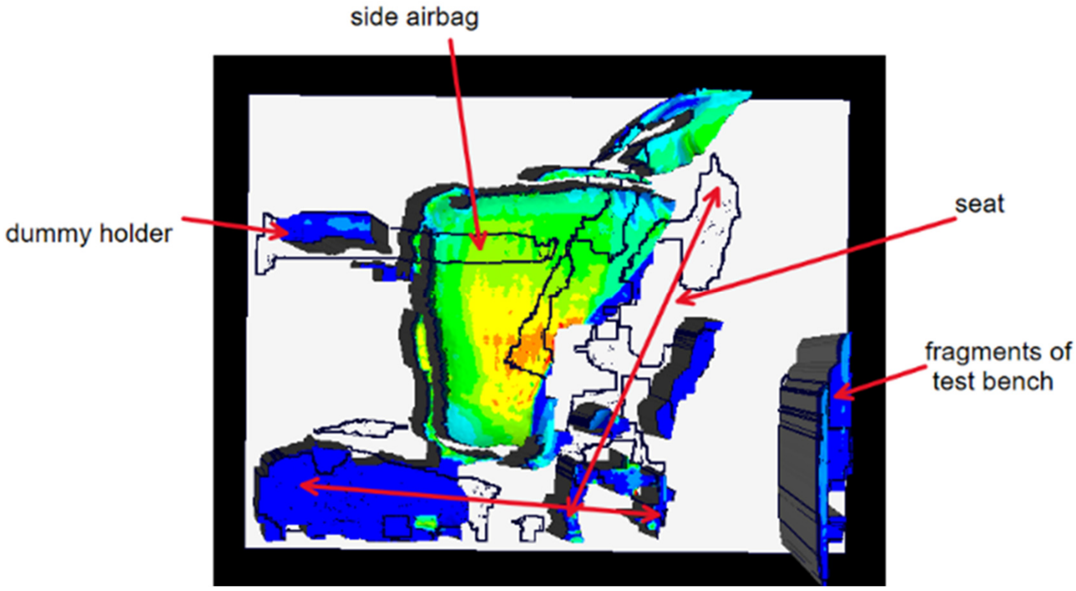

Figure 4 First unprocessed preliminary tests of the data

Figure 5 modified replica of the test bench for the side airbag

An anti-reflective coating and foiling for the polycarbonate pane, which causes reflection fragments in the recording, cannot be found and realized at the current state, as previous inquiries would lead to changes in the properties of the polycarbonate pane. Alternatively, a change of perspective is made in a preliminary test, see figure 6. The visibility of the side airbag in the data set, without reflective or vibrating fragments through the polycarbonate pane, is increased. However, the evaluation in the analysis for the deployment in x- and z- direction, as well as the potential behavior of the seat cover opening and stretching is no longer fully visible. The inflated airbag cushion obscures the area of the seat backrest. In addition, the holder of the dummy torso is positioned in such a way that it appears as a large, disturbing beam in the data set. The holder of the dummy torso cannot be removed in the current setup without making a major intervention in the statics of the dummy construction. For this reason, the approach of changing the perspective to surround the measurement through the polycarbonate pane is not pursued further at first. In figure 6 on the right, you can see the deployed airbag on the left hand side, the holder of the dummy construction in the middle, and the hip contour of the dummy silhouette on the right hand side.

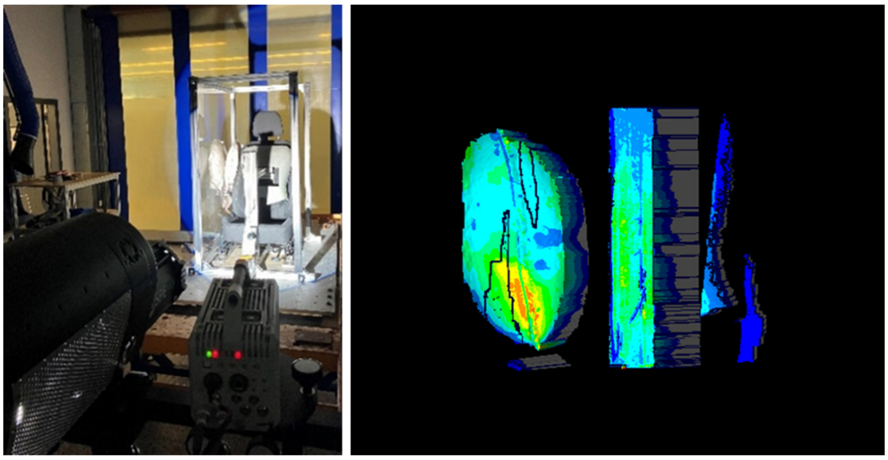

Figure 6 Frontal perspective of the side airbag in the test bench and postprocessor

3.3 Comparability of a test series

A fundamental problem of comparability between several test executions goes hand in hand with the basic requirement of a flexible setup, due to the regular operation of the test bench. The comparability of reproducible results must be ensured. Between the different test executions, a change of the test objects (backrests or airbag modules) is necessary. This change potentially poses the difficulty that the change of the test objects leads to vibrations or a shifting of the test bench, as the backrests are mounted in a holder and the polycarbonate pane must be cleaned of dust before each test. To ensure that the comparability of the data within a test series is given, the method is initially chosen to measure fixed points using lasers and markers, which are adjusted before each test, in order to ensure a constant position of the seat backrest frame. The markers are chosen with standard markers from the crash area (see figure 7) at three different positions (see figure 7, markers labeled 1-3), which can be measured regardless of the seat variant and the type of test (‘Module-Only’ or system test). The positions are chosen on the backrest wheel, a separate holder of the headrest, and on the holder of the dummy. Point one of the headrest can be chosen as a fixed point due to a constant headrest holder of a seat variant. Point two of the backrest wheel serves to adjust the backrest position. Point three is chosen on the dummy holder as a seat-neutral point. The measurement is only carried out once before each test start, until the crosshair of the laser is positioned centrally.

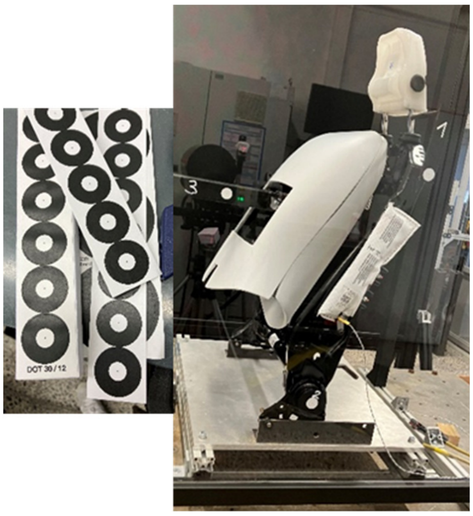

Figure 7 Crash stickers positioned on three points

3.4 Execution of first airbag deployment shots

After initial optimizations of the test bench have been twelve system tests (side airbag installed in seat backrest) are fired. Of these, six system tests are ignited at room temperature and six system tests, which are pre-tempered at about 85°C for approximately four hours each. Figure 8 shows the processed data of the test series of the system tests with the seat backrest. The seat backrest is not visible in the data set, while the airbag shows a smooth contour and recognizable shape. Furthermore, in all recordings, the centrally wandering defect of the light cone can be seen.

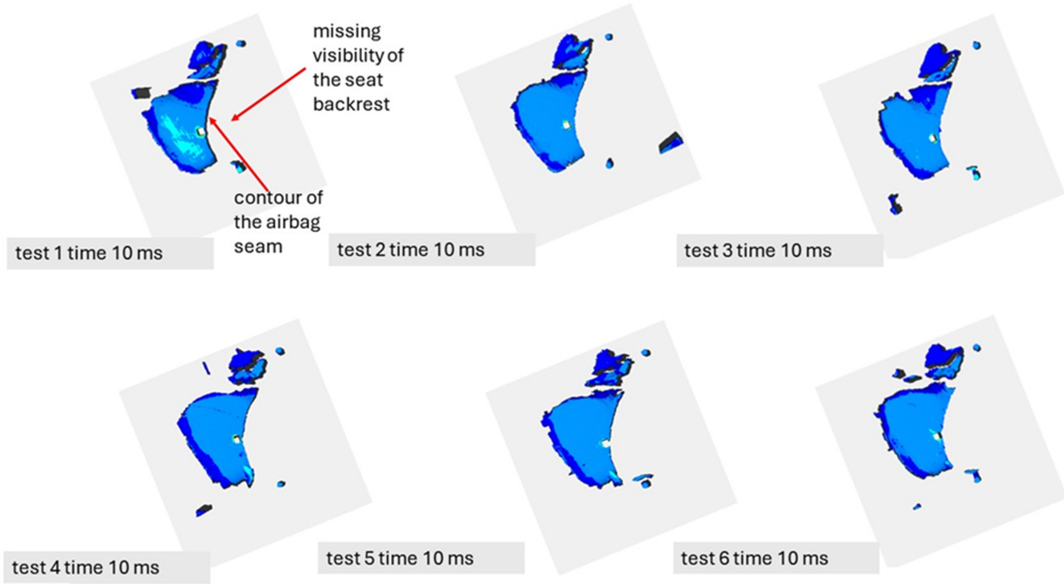

Figure 8 Test series, without any visibility of the seat but shows good visibility due to the white contrast of the fabric of the airbag cushion

3.5. Visibility of the test objects

In the system tests, with the additional factor of the seat backrest, the challenge arises that the white fabric of the airbag stands in strong contrast to the black, shiny synthetic leather cover of the seat backrest. The seat covers, which are used for the investigation, are regularly produced in black, shiny synthetic leather. To avoid the potential influence of a different type of seat cover and the lack of availability of lighter seat covers, value is placed on the use of the existing covers. This becomes noticeable, as despite the visibility of the side airbag in the data set, the seat backrest is not visible, see figure 8. First, using the setting variants of the camera aperture in test shots, various aperture settings are configured with regard to exposure, which remain unsuccessful. In the next approach, the backrest cover is painted with available, yellow-matte chalk paint (for standard crash tests) to increase the potential visibility of the backrest. As a result, the visibility of both components, both airbag and backrest cover, is increased in the data set, see figure 9. The contours of both the airbag air sack and the backrest cover do not show entirely sharp contours and still express a fragmentary representation. The primary expansion of the airbag module as it begins to unfold is visible through the rounded expansion of the seat backrest, see figure 10.

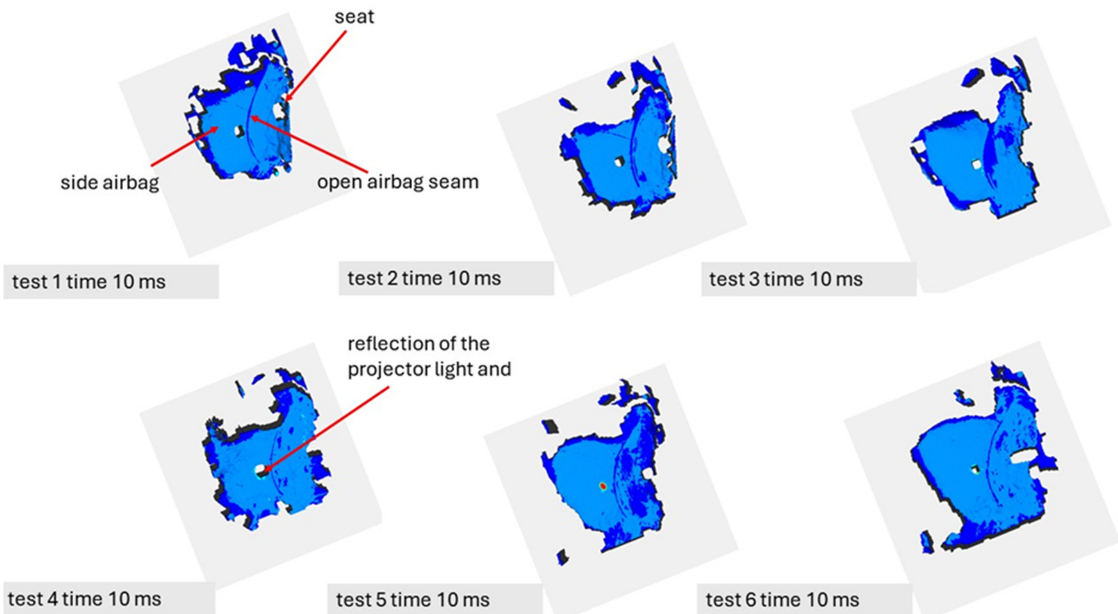

Figure 9 Test series of airbag deployment with visibility of the seat

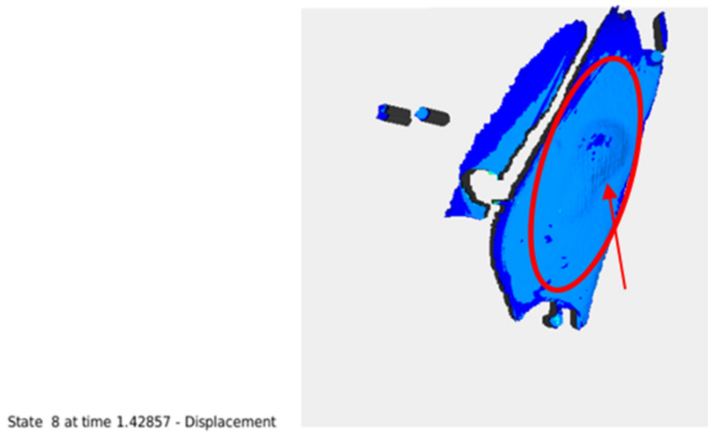

Figure 10 Stretching the seat cover in the middle of the seat backrest

In the system tests with the seat backs painted with chalk, see figure 10, the tearing behavior of the airbag seam can be tracked. In the example in figure 11, a problem becomes apparent. At the suspected time of the first seam opening (first picture of the series, time slot 4,64 ms), a fragment is missing in the data set at this opening point of the seam. In the next time steps, the seam opening is visible again. The fragment in the recording moves across the file from the reference point to the airbag opening.

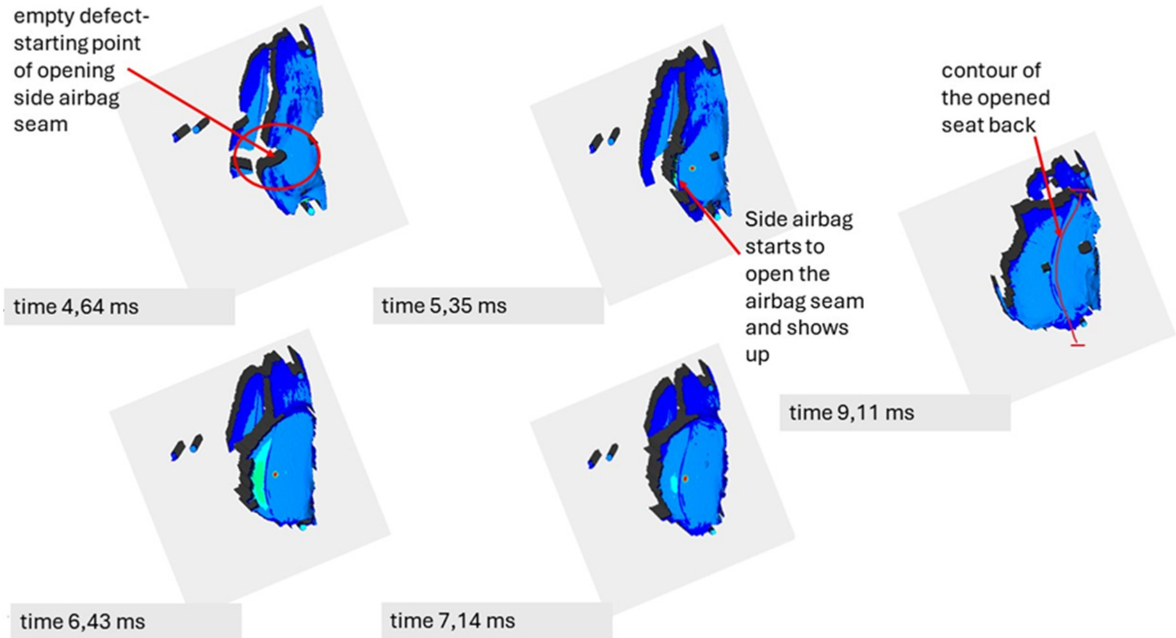

Figure 11 Opening airbag seam with fragments

In the recordings, there are always frequencies that show diffuse fragments of the airbag deployment from the seat. The influence of the chalk color on the deployment of the airbag and the stretching of the seat cover is not verified. The color application in the preparation is limited to a few minutes by a quick drying of the chalk paint. Handling the seat backs painted with chalk causes contamination of both the test stand, the personnel, and the climate chamber, as the chalk paint crumbles in the dried state. In addition, there is the aspect that due to the porous structure of the chalk in the dry state, upon triggering of the airbag and stretching of the cover, the color pigments, like a kind of dust cloud, spread in the chamber, see figure 12.

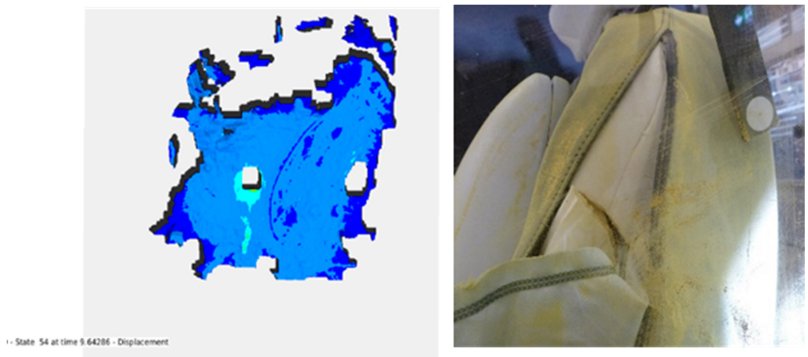

Figure 12 Spreading powder cloud of chalk causes fragments

In addition to a side airbag, a center airbag is also often installed in modern driver’s seat backrest. Seat backrests are complex components that may have center airbags in modern equipment. At the moment it is technically not possible triggering the combination of side airbag and center airbag at the same time while filming with the 3d measurement system, as the side airbag visually covers the center airbag from the side evaluation perspective.

4. Discussion

In the current state of the art, the evaluation of the deployment behavior of the side airbags among other is done visually in the 2D high-speed video recordings, i.e., evaluated by the examiner by comparing films. Partially, 2D recordings are also carried out, in which the contour of the airbag shape in the recordings is captured and tracked over the sequence using image processing algorithms. For the testing of the side airbags, the usability of the three-dimensional measurement technology should be tested. Working with an iterative approach to testing the applicability of the 3D measurement system for the test bench setup of the side airbags. The main topic is the visibility of the test objects in the downstream data set of the post-processor. The further processing of the data set for the analysis of inflation times, deployment in construction position, damages, scatter in the test series, as well as strains will be discussed in a later paper. Overall, it is shown that the recording qualities are not yet consistent. Diffuse fragments cannot be classified due to the lack of segmentation. This mainly affects the system tests, in which, in addition to the airbag module, the elements of the seat backrest also have an influence on the deployment of the airbag module. In addition, the center airbag cannot be fired, as the side airbag visually covers the center airbag from the side evaluation perspective. Also an issue of the missing segmentation in the current state of the art. One thesis is that to evaluate both airbags, center airbag and side airbag, a change of perspective or implementing an assessment standard would have to be developed in order to be able to evaluate the deployment according to the desired specifications. The measure between the general requirements of having a flexible setup due to daily business and still achieving reproducible results is still a task to be solved. The comparability within a test series by measuring the components, with the variant of laser adjustment, is a first approach. The exact comparability of the data between different test series, which for example take place at an offset of two weeks due to daily business and require the dismantling of the test stand, is still difficult for series use as a test method. After dismantling the test stand and later further tests, there is so far no guarantee of generating a hundred percent overlay of the data and thus reproducible results. Due to slight displacements of the test stand or the camera system, the overlay between the previous and new test series cannot yet be guaranteed. The initial foiling of the silver item profiles, as well as a neutral background with black matte foil, has reduced disturbing reflections and was thus a helpful optimization. In the first viewing of the data, a round area wandering centrally on the airbag fabric becomes visible. On the one hand, the incoming light cone of the projector produces highly reflective reflections and disturbing specular highlights. On the other hand, this area of reflection moves across the data set during the recording. This migration indicates that the polycarbonate pane is subject to vibrations due to the impact of the side airbag, which would have to be measured in future steps in order to analyze the influence on the recordings.
The goal and the great advantage of the 3D measurement system is the capture of movements and deformations without signaling the test objects, for example by markers. In particular, the preparation of airbag fabric is a critical point of consideration out of experience, as any unfolding of the airbag package and application of marking textures has a potential influence on the airbag deployment.

The recordings of the ‘Module-Only’ airbag shots are a promising approach to expand the use of the system for the side airbag area. Solutions would have to be found with regard to the reflection and vibration of the polycarbonate pane, but the general resolution so far promises a traceable method development. Perhaps it would be an idea in future investigations to position polarization filters from the camera lens to avoid reflective reflections. To maintain the great advantage of the contactless and unprepared structure, the decision in the current state of the art is that one must either opt for the visibility of the side airbag or in favor of the black seat backrest. Currently, the white airbag fabric and the black, shiny synthetic leather backrest are not visible in the data set of the post-processor without prior preparation. The test methodology, in this case the 3D measurement system, must subordinate itself to the test object in priority. The test must ultimately prove the suitability of the safety component, here the seat backrest and the side airbag in the standard equipment. In the case of the system test of the side airbag in the seat, in most cases the standard equipment includes dark-colored fabric or synthetic leather seat covers.
Since the assignment procedure of the measuring system is based on gray value-based image assignment, black components in grayscale images have very low gray values, while white components express high gray values. The first approach, using the aperture to control the amount of light responsible for the exposure, shows no success. Overexposure leads to the loss of details in the bright areas, e.g., airbag fabric. Underexposure leads to the fact that details in the dark area, the black seat cover, are even less visible, as they merge with the environment and make the recognition and assignment of the algorithm more difficult. Overexposure also impairs differentiation and analysis. A dark environmental condition for better visibility of the GOBO stripe projection leads to the fact that the black seat backrest cover does not have sufficient contrasts to its environment and makes it difficult for the algorithm to recognize and track the component. The gray value information is not correctly recorded. The black synthetic leather absorbs more light compared to the white airbag fabric and leads to a loss of information.
The white airbag fabric, on the other hand, leads to higher gray values due to stronger reflection of the light and a stronger contrast to the dark environmental conditions, which can probably be better recognized by the image processing algorithm. In addition, in the comparison between the resolution quality of the airbag and the backrest painted with yellow chalk, fewer disturbing fragments are noticeable. The white, radiant fabric with its tight canvas binding probably leads to a diffuse light scattering and less shadow formation and thus better visibility and resolution quality of the recordings. High-gloss, black components are therefore not suitable for recordings with the 3D measurement system if a white component also plays an equally important role at the same time.

5. Conclusions

The potential of the 3D measurement system for use on the side airbag test bench depends on the application in the current state of the art. With improvements regarding the disturbing polycarbonate pane, the technology offers an interesting approach to analyze the deployment behavior of the pure side airbag module. The analyze the interaction between the side airbag module and the seat in the system test is at the moment limitedly possible. The necessity of a prior preparation of the component would negate the actual advantage of the measuring system. The findings are also reflected in the studies by [Raguse, K., Lutzke, P., Oeckerath, A.]. It currently remains a question of the use case. Furthermore, a single proof to preserve a development status or an explicit question, for example the comparability and scatter of a production batch to analyze, is the more interesting use case. The analysis of the data set with regard to the evaluation criteria of the performance of the side airbag will be examined subsequently.

6. References

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