

Application Example:

Optical 3D Metrology supports Certification of Airbus A350 Airbus Supplier FACC and Subsidiary CoLT integrate non- contact Sensors in Fatigue and Structure Testing

Measuring System: PONTOS, TRITOP, ATOS, GOM Touch Probe

Keywords: Aerospace Industry, Fatigue and Structure Testing, dynamic Deformation, Simulation Verification, 6DoF Analyses, optical 3D Metrology



GOM mbH
Mittelweg 7-8
38106 Braunschweig
Germany
Phone +49 531 390 29 0
Fax +49 531 390 29 15
info@gom.com

GOM International AG
Bremgarterstrasse 89B
8967 Widen
Switzerland
Phone +41 5 66 31 04 04
Fax +41 5 66 31 04 07
international@gom.com

GOM UK Ltd
Unit 14, The Cobalt Centre
Coventry, CV3 4PE
United Kingdom
Phone +44 2476 639920
Fax +44 2476 516990
info-uk@gom.com

GOM Asia
Keyuan Road 88, Tower 2, Unit 731
201203 Shanghai
PR China
Phone +86 21 2898 6551
Fax +86 21 2898 6552
info-asia@gom.com

GOM France SAS
10 Quai de la Borde
91130 Ris Orangis
France
Phone +33 1 60 47 90 50
Fax +33 1 69 06 63 60
info-france@gom.com

GOM Branch Benelux
Interleuvenlaan 15 F
3001 Leuven
Belgium
Phone +32 16 408 034
Fax +32 16 408 734
info-benelux@gom.com

GOM Italia Srl
Via della Resistenza 121/A
20090 Buccinasco (MI)
Italy
Phone +39 02 457 01 564
Fax +39 02 457 12 801
info-italia@gom.com

www.gom.com

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To reduce weight and fuel consumption, the aerospace industry increasingly relies on lightweight materials and new material combinations. That's why the entire fuselage of the Airbus A350 XWB consists of carbon fiber composite (CFC) materials. In total, the long-haul aircraft reaches a CFC portion of 53%. In addition, Airbus uses materials such as titanium and new aluminum alloys. As a result, the A350 consumes about one quarter less fuel than conventionally constructed aircrafts and environmentally harmful CO2 emissions are reduced correspondingly.

Optical Metrology replaces conventional Methods

However, these lightweight materials and new material combinations must meet the same high standards of performance, safety and durability as traditional materials. Accordingly, the materials and the components manufactured from them are tested intensively. To this end, the aerospace industry increasingly relies on optical metrology. The non-contact systems provide data for part geometries as well as for 3D displacements and deformations. Static and dynamic deformations are determined based on individual points or full-field measurements. The measurement data optimize simulation and design processes and thus increase aircraft safety.

Before certification, the A350 had to pass intensive tests. Airbus supplier FACC examined fiber composite materials and components of the A350 at the Composites Lab & Test Center (CoLT), a subsidiary on the company's premises in St. Martin (Austria). Tests for the certification of the winglets and wingtips were especially extensive. The entire element, with a length of more than 6m, was analyzed statically and dynamically in a special testing facility for long-term and peak loading. The tests also included damage tolerance testing. These analyses were necessary because the component mainly consists of fiber composite materials with metal connections.

Non-contact Measurement of 3D Displacements and Deformations

The load, fatigue and damage tolerance tests provided information about the structural behavior of the component. Along with standard measurement techniques, for the first time, the FACC subsidiary fully integrated non-contact sensors from GOM in the test setup. Unlike conventional methods such as strain gauges the two PONTOS systems recorded 3D displacements and deformations of the winglet.

In total, the test object was 8m long, 2m high and 3m wide – around 110 tons of steel were used on the test stand (14m long, 8m high and 10m wide). (Fig. 1) Loads were achieved with 15 servo hydraulic push and pull cylinders, with the force transmitted by five yokes. The two non-contact sensors measured dynamic deformations at around 220 points, with each point being analyzed three-dimensionally in the x, y and z direction. In addition, more than 2,000 synchronized channels measured static strain, deformation, force, pressure and temperature. (Fig. 2)



Fig. 1: The winglet is 8m long, 2m high and 3m wide. Around 110 tons of steel were used on the test stand. For the first time, FACC fully integrated non-contact sensors from GOM in the test setup.

On the actual A350, the winglet and wingtip – the inside elements of the assembly – are fixed on the main wing box. In order to realistically reflect these connection points and the behavior of the main wing box during the test, a dummy wing box was used. It was specifically designed for the test and is identical to a real wing box in terms of material properties and connection of the winglet.

Complete 6DoF Analyses

During structure testing, the component was loaded statically across several stages to simulate the loads occurring during flight. In this way, the test engineers examined three scenarios: maximum torsion and maximum load upward and downward. During fatigue testing, the engineers ran through real flight profiles to analyze the behavior of the component within one life cycle. During static and fatigue testing, load factors were applied to account for variations in the material properties and possible weight increases in the component.



Fig. 2: The PONTOS sensors measure the dynamic deformations at around 220 points, each of which can be analyzed three-dimensionally.

For the damage tolerance tests, the winglet was damaged in advance at certain points. This way, the test engineers simulated manufacturing errors, as well as damage caused by hail impact and bird strikes in order to precisely analyze the effects on material and component behavior under load.

Unlike conventional measurement devices such as strain gauges and transducers optical systems such as PONTOS determined 3D displacements and deformations while additionally measuring real speed and acceleration. The evaluation of the point-based data enabled full 6DoF analyses. This way, test engineers could see exactly how the winglet moves in space and at which points it is particularly deformed. (Fig. 3) The PONTOS system can be easily integrated into the test setup, with inspection points identified by measurement markers. Using an optically tracked touch probe, nominal positions can be determined and adapters can be measured.

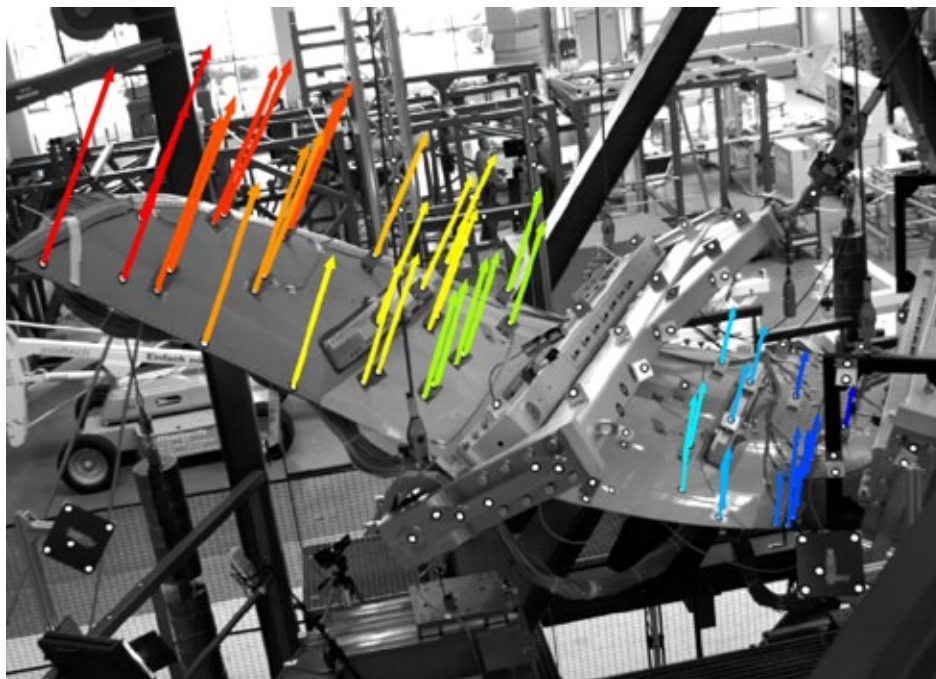


Fig. 3: The evaluation of the point-based data enabled full 6DoF analyses. This way, test engineers could see exactly how the winglet moves in space and at which points it is particularly deformed.

Back Projection of Strain Gauge Positions with ATOS

With the new PONTOS Live software module, the test run could also be measured online, enabling users to see directly in the software what happens during testing. Additionally, the measuring data could be communicated to other programs via a digital interface and could directly be processed by them. It was also possible to record and process analog signals from external measuring devices.

Optical measuring systems also accelerated test setup. For instance, 200 strain gauge positions, which were defined in advance by Airbus and CoLT test engineers, were marked and applied to the component within one working day. (Fig. 4) To do so, the company Westcam, GOM's distributor and service provider in Austria, first measured winglet and its components with the portable photogrammetry system TRITOP, which captures 3D coordinates of objects. After the measuring data was aligned to CAD, the 3D scanner ATOS performed a back projection of the strain gauge positions. During this process, the sensor projected the positions directly on the winglet based on the measurements. The positions are visualized as 3D elements in the CAD software. Staff from CoLT simply marked the correct points, which led to considerable time savings. Up to then it was very work-intensive to determine the positions with measuring tapes, starting from the edges or bore holes. For demanding geometries, such as at the inner side of a leading edge, positioning using conventional methods was very complicated, due to the strong bending. Using GOM systems it was possible in a fraction of the time. Optical metrology also allowed the positions of the applied strain gauges to be checked. They could be measured again with TRITOP photogrammetry or the handheld GOM Touch Probe and compared with the CAD data.



Fig. 4: For an accelerated test setup, the ATOS 3D scanner performed a back projection of the strain gauge positions.

Simulation Verification based on 3D Measurement Data

Lightweight materials are an essential part of the aerospace industry. Correspondingly, OEMs and suppliers test the new materials intensively to guarantee their performance, safety and durability. Optical measuring systems can be easily integrated in different test stands; at the same time, they determine static and dynamic deformations via point-based and full-field inspections. The results are available immediately after the measurement and can be displayed in easy to understand charts, videos and images.

One important area in which 3D measurement data is used is simulation verification. Modern flight vehicles are extremely complex, so everything is simulated during the development process. To compare the simulations with reality, comprehensive 3D measurement data is necessary instead of just a few individual signals. The results enable users to review and improve simulation parameters, as well as to optimize current and future design processes. Therefore they can reduce the number of costly test runs and consequently speed up product development. At the same time, the 3D measurement results allow conclusions to be drawn on safety risks, part durability, as well as creep and aging processes. This increases not only the safety, but also the lifetime of products.

CoLT Composites Lab and Test Center

FACC Operations is one of the world's leading companies in the design, development and production of fiber reinforced composite components and systems for the aviation industry. Its range of products reaches from structural components for the fuselage and wings, to engine components, to complete passenger cabins for commercial aircraft, business jets and helicopters. FACC is a supplier to all large aircraft manufacturers, including Airbus, Boeing, Bombardier, Embraer, Sukhoi, and COMAC, as well as to engine manufacturers and their suppliers. The Composites Lab & Test Center on FACC's premises in St. Martin (Austria) has started operation in 2013. It gives FACC one of the most modern facilities for analyzing, testing and certifying fiber composite materials and components.