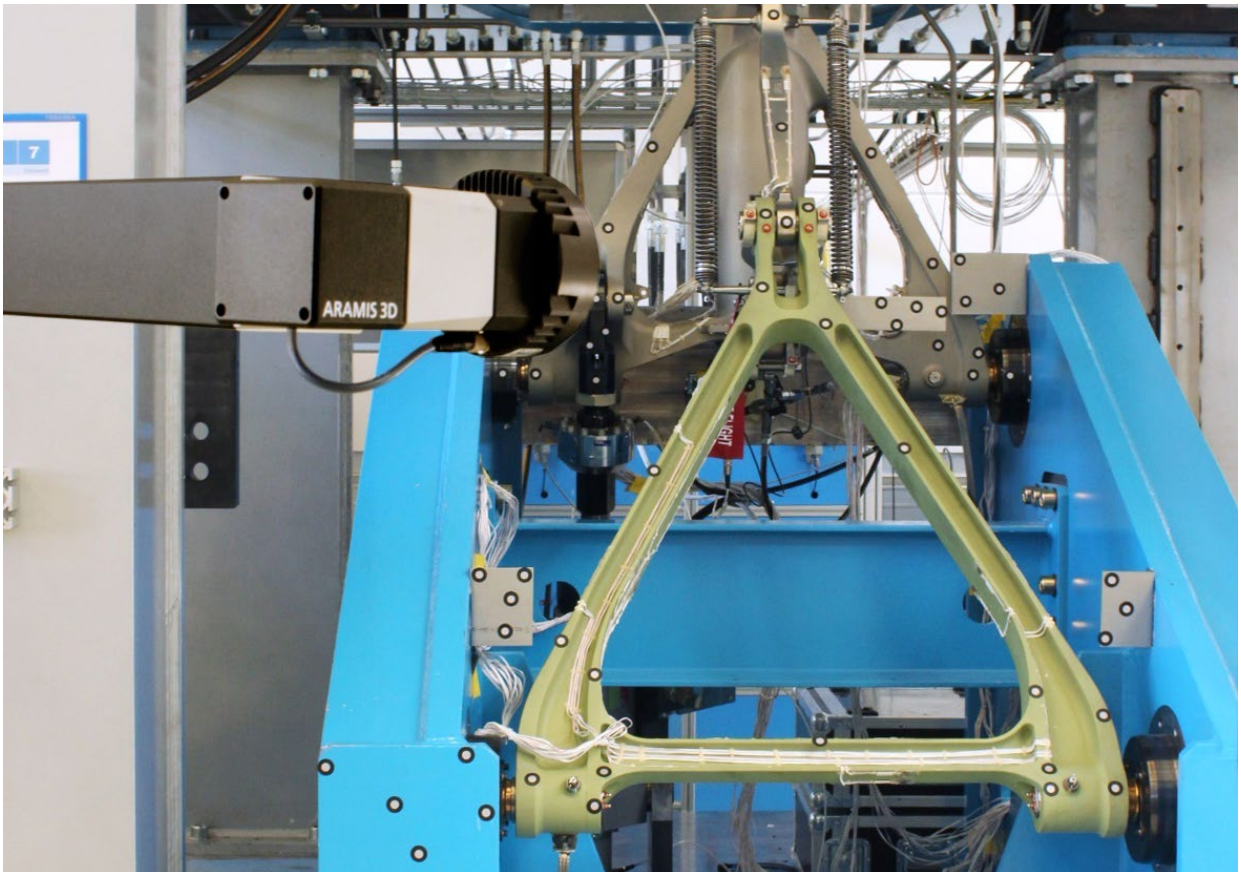
Application Note

Liebherr-Aerospace: Optical Metrology from GOM Accelerates Certification Tests for New Landing Gears

Location/Country: Lindenberg, Deutschland
GOM system: ARAMIS
GOM software: ARAMIS Professional
Company's field of work: Aerospace Industries

Liebherr-Aerospace uses GOM's ARAMIS 3D Camera for structural testing on landing gear components. As a result, the company is able to determine point-based and full-field component deformations during static or dynamic load tests.



Innovative test methods for validating simulation methods and the latest approaches in virtual testing have enabled Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), a leading supplier of systems for the aerospace industry, to further exhaust material properties and develop new design concepts for their landing gear systems. Optimized processes that enable lean design are becoming increasingly important in the aerospace industry and ensure competitive advantages.

Before landing gear systems are certified for use, intensive test campaigns are required to demonstrate their ability to meet strict requirements with regard to function, safety and service life. To this end, the aerospace industry increasingly relies on optical measuring systems and evaluation software from GOM. The company's non-contact systems provide data for surfaces as well as for 3D displacements and deformations. Component deformations are determined point-based as well as on a full-field basis during static or dynamic load tests. Using this measuring data, simulation and design processes are continually optimized to ensure that structural parts meet increasingly demanding requirements while complying with strict safety regulations.

At its test center in Lindenberg, Germany, Liebherr-Aerospace uses the ARAMIS 3D Camera to perform structural tests at the subsystem level on newly developed landing gear systems. These structural compliance tests fall into two categories: limit and ultimate strength tests, and fatigue tests. During limit and ultimate strength tests, the landing gear system must demonstrate its structural integrity under quasi-static loads, whereas during endurance tests, cyclical operating loads are applied to verify the finite life fatigue strength of the landing gears in relation to the specifications. For this purpose, exterior loads are applied to the landing gear structure using hydraulic cylinders and representative load testing systems in order to analyze displacements throughout the landing gear under various load conditions.

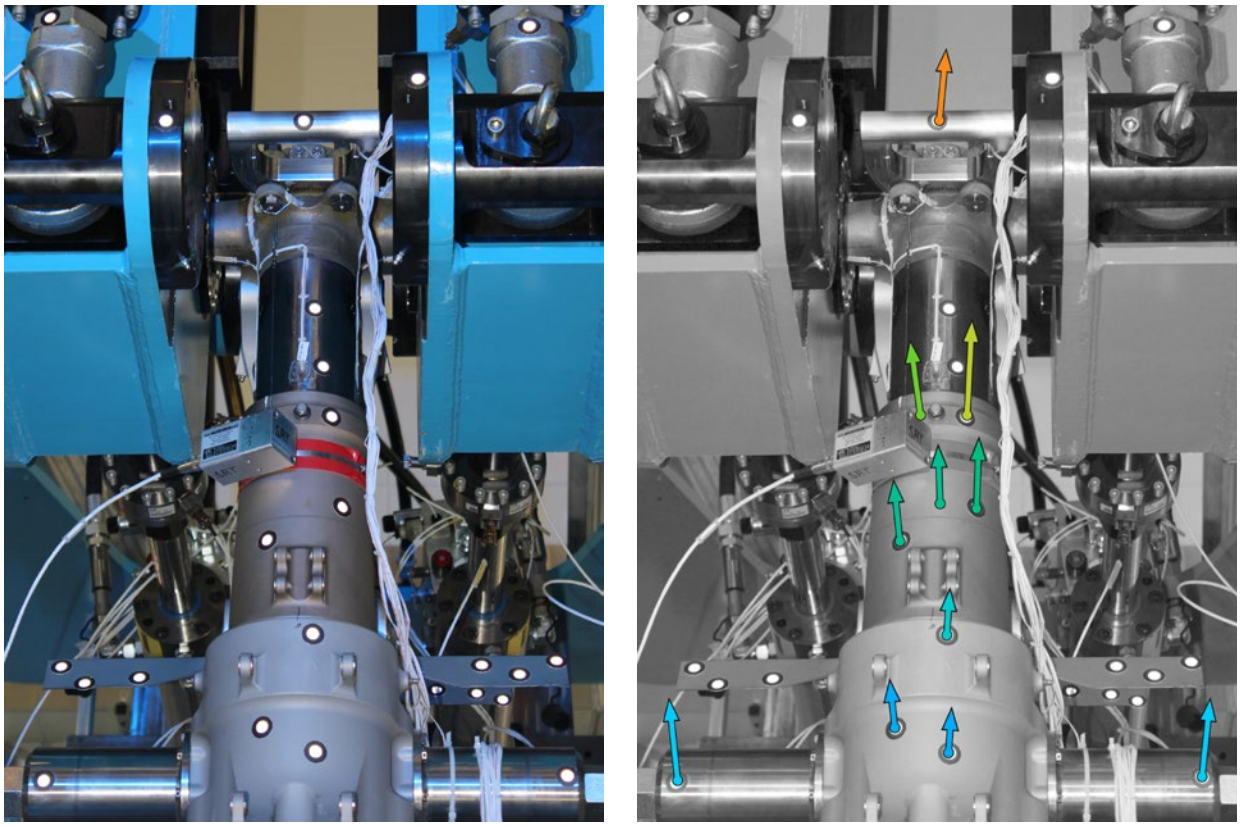


Fig. 1: ARAMIS delivers measuring data for part geometries as well as three-dimensional displacements and provides information about the behavior of the components under load.

The test campaigns on these test objects, which can be up to 5 meters in size, are performed in specially designed test stands with corresponding load testing and measuring equipment. In addition to ongoing limit strength tests, Liebherr-Aerospace is also performing fatigue tests for certification purposes. Each test can last more than 12 months and has 2 million load cycles.

Each landing gear structure is subjected to multiple critical load cases during static certification tests. These tests focus on a point-based analysis of the component behavior under ground loads, which describe the load condition of the landing gear while the aircraft is landing and taxiing. The optical sensors deliver measuring data for part geometries as well as three-dimensional displacements and provide information about the behavior of the components under load. For test engineers, the most interesting question is whether the parts and components develop lasting deformations while under load, and how great the certainties are regarding these deformations. The measuring data obtained is used not only to test specific success factors, but also to verify and, if necessary, adjust simulation and design processes to model reality as closely as possible. This accelerates product development, for which detailed analyses of part behavior are required. ARAMIS provides a suitable method for creating, presenting and visualizing these analyses.

Liebherr-Aerospace has fully integrated GOM's non-contact sensors into the test setup. Unlike conventional methods like cable transducers or strain gauges, the ARAMIS 3D Camera captures both point-based and full-field three-dimensional displacements and strains in each landing gear component.

During a fatigue test, real landing and taxiing operations are simulated in order to analyze the fatigue strength behavior of the system over its entire lifetime. In addition, during static and fatigue testing, officially prescribed load factors are applied to account for variations in material properties and production.

Three Test Rigs in Use

Each test rig is specially designed for a specific procedure. They are up to 6 m wide, 7 m tall and 5 m deep and occupy a total space of 70 m². The test rigs are powered by a central hydraulic system that can deliver loads of up to 4000 psi and 560 kN, which is equivalent to 57 t. In addition to the ARAMIS 3D Camera for dynamic measuring of deformations, 100 synchronized channels measure forces, pressures and temperatures.

The specimen is subjected to multiple maximum-load scenarios during the structural test, including maximum torsion, braking torque as well as upward and downward vertical loads. The test engineers increase the loads in multiple stages and analyze component behavior using the measuring data obtained. The landing gear is mounted in the test rig exactly as it would be in the aircraft. Original aircraft parts are also used. Up to 13 servohydraulic load cylinders are used simultaneously to apply the loads. The wheels of the landing gear are replaced by wheel dummies that apply the simulated ground loads to the wheel axles.

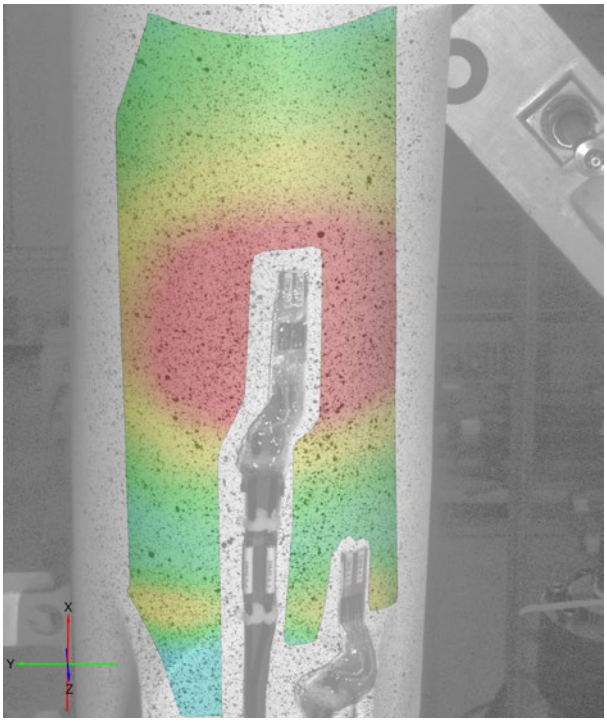


Fig. 2: Full-Field displacement and strain measurement.

Fig. 3: The optical system can be easily integrated into the test setup, with inspection points identified by measurement markers.

Advantages of Optical Measuring Systems

Unlike conventional measurement devices such as strain gauges and one-dimensional transducers, optical systems such as ARAMIS determine three-dimensional displacements and deformations. At the same time, they also measure speed and acceleration. Using point-based measuring data, 6DoF analyses (six degrees of freedom) are performed to determine translational and rotational motions in relationship to each other or as absolute movements in all directions in space. In this way, the test engineers can pinpoint the exact locations at which the landing gear becomes heavily deformed. The ARAMIS system can be easily integrated into the test setup, with inspection points identified by measurement markers. Using an optically tracked GOM Touch Probe, nominal positions can be determined and adapters can be measured.

The measuring data are evaluated with ARAMIS Professional, which simplifies the workflow and represents an essential advantage of the new parametric system. Thus, changes can be made during the entire stage evaluation, both during the test run and during post processing. At the push of a button, all corresponding elements are updated automatically.

Optical measuring systems also accelerate the test setup. ARAMIS Professional allows Liebherr to set up the measuring task once at the beginning of the test campaign and conduct the remaining tests using reliable project templates. Liebherr-Aerospace also uses the ARAMIS system to check that the load cylinders are correctly aligned in accordance with specifications before and during the series of tests.

First, the measuring task is measured by GOM's TRITOP system, which uses photogrammetry to determine the coordinates of three-dimensional objects. After the data is aligned with CAD, the strain gauge positions are projected back. This saves a lot of time because otherwise the strain gauge positions would have to be manually determined beforehand. Once the measuring task has been set up, the ARAMIS 3D Camera with a measuring volume of 5 m is used as the 3D deformation measuring system for the actual test run – often with two sensors at the same time. The GOM Touch Probe is increasingly being used for determining deformation data in hard-to-reach positions and for tactile measurement of various adapters.

In addition, Liebherr is using the GOM Touch Probe to measure the test setup and demonstrate that interface points in the test rig match the drawings and therefore the original aircraft structure. If a lasting, global deformation is suspected during the test, the user can test it directly in the test setup using the GOM Touch Probe without having to remove the landing gear and take it to a coordinate measuring machine.
Liebherr plans to make greater use of full-field deformation measurement in future fatigue tests to achieve certainty regarding load hot spots.

Liebherr-Aerospace has been using GOM systems for landing gear tests since as early as 2010. The ARAMIS system, which has been in use at Liebherr since November 2015, facilitates the workflows significantly, in particular regarding the test setup. The system strongly reduces the effort per load case. Thanks to the Blue Light Technology and the simplified light management, measuring results are independent of ambient light conditions. "The perfectly integrated Tracking Spots and the simple light management of the new ARAMIS are the reason why I would describe ARAMIS as a true plug & measure system," says Thomas Pfeilschifter, an expert in structural testing at Liebherr-Aerospace in Lindenberg. "We no longer require a lot of setup time to obtain good and valid results." Optical measuring systems can be easily integrated into different test rigs; at the same time, they determine static and dynamic deformations via point-based and full-field inspections. The 3D measuring data is permanently available and can be evaluated long after testing and in different contexts. The results can be displayed in charts, videos and images.

3D measuring data from GOM are also being used to optimize test design and to measure only the specific loads of the flight cycles that affect the structures. At the same time, GOM systems are excellent for determining the root cause of failures since they support complex analysis methods and can even simplify or replace them entirely.

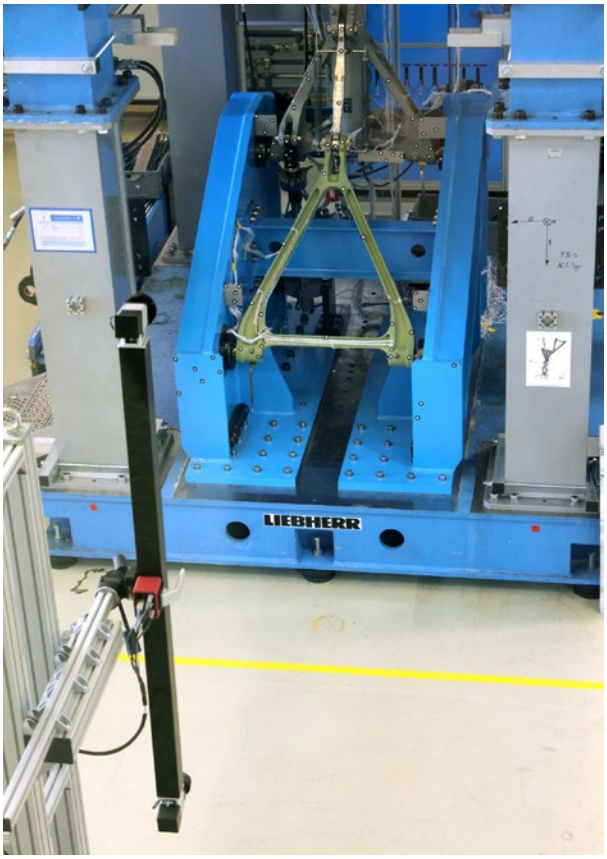


Fig. 4: The new landing gear – placed within an individually designed test rig at Liebherr Areospace`s testing facility in Lindenberg.

GOM – Precise Industrial 3D Metrology

GOM develops, produces and distributes software, machines and systems for 3D coordinate measuring technology and 3D testing based on latest research results and innovative technologies. With more than 60 sites and more than 1,000 metrology specialists, GOM guarantees profound advice as well as professional support and service. More than 10,000 system installations improve the product quality and manufacturing processes in the automotive, aerospace and consumer goods industries.

Liebherr-Aerospace Lindenberg GmbH

Liebherr-Aerospace Lindenberg GmbH in Lindenberg (Germany) is part of the divisional control company Aerospace and Transportation Systems within the Liebherr Group. The company is specialized in the development and manufacturing of flight control and actuation systems, landing gear systems as well as gears and gearboxes. These systems are deployed in a wide variety of aircraft and helicopter programs. Liebherr-Aerospace Lindenberg GmbH employs around 2,600 people at its facilities in Lindenberg and Friedrichshafen.