Together ahead. RUAG citim

Facts

Challenge

To develop an extremely lightweight and robust antenna bracket for Sentinel satellites.

Solution

Production of a component using additive manufacturing, which, by virtue of to its complex structures, fulfills all requirements of weight and stability.

Results

- Intelligent: freedom of design enables uniform distribution of forces
- Robust: minimum rigidity requirements exceeded by over 30%
- Lightweight: design contributes to a weight reduction of 40%
- Accredited: requirements of aerospace sector verified by comprehensive testing

Lightweight and highly stable: The topologically optimized antenna bracket for Sentinel satellites with EOS Aluminium AlSi10Mg using additive manufacturing. (Source: EOS GmbH)

Certified for Universal Success: Additive Manufacturing of Satellite Components

EOS

Antenna bracket for RUAG's Sentinel satellite - certified for use in outer space

Short profile

RUAG is a Swiss technology group with global operations, active in the fields of aerospace, defense and security. Its customers are drawn from both civilian companies and government agencies.

As a manufacturing service provider, citim GmbH serves the entire production chain, providing rapid prototyping, additive manufacturing and small-series production, from initial construction through to component finishing.

Further information

www.ruag.com
www.citim.de

For many people, talking of the infinite vastness of the universe conjures up stories of science fiction, usually told by a Hollywood film studio. However, in real life, more than in any other area, it is arguably in space travel that a strong will and clear vision are vital for creating the necessary technology and readying it for deployment in the cosmos. This was the challenge faced by Swiss technology group RUAG in the construction of its Sentinel satellite, designed for observing our planet from on high. Even here, beyond the Earth's atmosphere, additive manufacturing is playing a key role.

Challenge

According to reports by the German Center for Aerospace (DLR) from 2016, the mission costs of space exploration per kilogram of transported payload are upwards of € 20,000. Every single gram saved reduces total launch costs, as the system requires less fuel for the ascent. As a result, aerospace engineers need to shave every possible gram from every component – as excess weight accumulates rapidly. In this case, the Swiss RUAG group were in need of an optimally designed antenna bracket.

Yet weight optimization alone is not enough. During a rocket launch, the payload gets well and truly shaken up and the level of vibration is considerable. Also, the enormous speeds of several thousand kilometers per hour, not to mention the high G-forces, mean that the flight will not be as smooth as you would expect on a passenger jet. Stability and rigidity form a second essential on any specification sheet. Unfortunately this requirement is usually diametrically opposed to the need for a lightweight design.

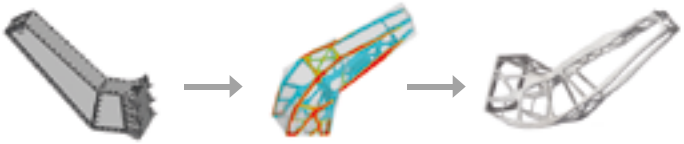
Engineers employ complex structures to identify a workable level of compromise between form and weight. The RUAG team sought the optimum combination of strength and weight for the structure of its antenna bracket, as conventional manufacturing methods had been exhausted. Thankfully, additive manufacturing provided the perfect possibility of achieving the necessary freedom of design. Component testing represented a particular challenge, not least because of the aforementioned vibration. In outer space, reliability counts, as repairs are generally not possible. This also explains why the authorization of such components is such a protracted and complex process. Every certification represents an accolade for the engineers who have achieved it.

Solution

In such cases, the complete production chain plays an important role, particularly in the aerospace sector. "Obviously, the immense advantages of producing components using additive manufacturing was of great interest to us," explained Franck Mouriaux, General Manager of Structures at RUAG. "For example, design freedom and complex components help us to save weight. The ability to integrate functions is also very helpful. In the end, however, it is a case of identifying these potential advantages, implementing them in an ideal fashion and acquiring the necessary authorization. The simplest component serves no purpose if it cannot be used."

Fundamental suitability and rigidity testing formed the

The technological symbiosis of topology optimization and additive manufacturing results in a halving in weight, reduced stress, increased stiffness and a minimum of design lead time.



Original design | Optimized topology | Redesigned antenna bracket

starting point of the antenna bracket's design. The next step comprised the selection of material, definition of processes and initial basic tests in respect of the material characteristics. The initial test structures were then constructed, to serve as the starting point for the topological optimization of the component. RUAG was eventually able to achieve the – theoretically – perfect form for the antenna bracket, through a combination of intensive work with a CAD and FEM system from Altair and guidance from EOS on design and construction using additive manufacturing.

The approximately 40 cm long antenna bracket was produced by citim GmbH from Barleben in Germany using the EOS M 400. With a construction volume of 400 x 400 x 400 mm, it was possible to produce two antennas, 30 tensile test pieces and various test items in a single construction order. The construction time was approximately 80 hours. The parameter set used was for a layer thickness of 60 µm, optimized for surface quality and productivity.

The aluminium alloy used, EOS Aluminium AlSi10Mg, is characterized by high strength and strong resistance to dynamic stress, making the material perfectly suited for use with high-stress components. Comprehensive tests were carried out to demonstrate the required characteristics, – in the aerospace sector, these comprise up to 80% of the total scope of a project. Specially manufactured test structures were used for testing. Among other things, engineers examined the brackets in computer tomographs. Various mechanical and physical procedures were also performed. At times, the stresses brought to bear on the component deliberately exceeded the load limits, ultimately leading to the destruction of the test pieces.

Results

The result of all these efforts was that the new antenna bracket for the Sentinel satellites exceeded all expectations. The component was awarded certification and with that, the approval for its utilization in outer space. The achievement is all the more remarkable considering that the use of additive manufacturing in space is still in its infancy.

For example, the component's minimum rigidity requirements were exceeded by more than 30% – a margin that is easily sufficient to ensure that, even after a turbulent flight, an ideal antenna position could be attained - and radio communication with Earth guaranteed. The required level of stability was achieved, in part because of the highly uniform stress distribution. Moreover, the use of additive manufacturing led to a significant reduction in the weight of the final component: down to 940 g from 1.6 kg, representing a saving of over 40%. In this instance, the use of innovative technology succeeded in achieving an unlikely combination: improved component characteristics and lower system costs.

"We are very happy with the results of this project. We entered unchartered territory on the process side and were rewarded with a stable, lightweight component," says Aerospace Engineer Mouriaux. "Additive manufacturing has shown that it can fulfill the fundamental procedural demands of space travel. The multiple design advantages and the characteristics of the component itself have certainly proven this. I see great potential for this technology going forward." So, while Hollywood tells exciting stories, innovative technology continues to live them everyday, extending the frontiers of design and construction.

"To some extent it squares the circle: we have been able to make a component significantly lighter and yet simultaneously more robust. The component characteristics have proven their worth in tests carried out with the requisite stringency for the aerospace sector. We will be hearing a lot more about additive manufacturing in the coming years – I'm convinced of that!"

Franck Mouriaux, General Manager Structures at RUAG

"EOS combines innovation with great experience in additive manufacturing. The systems offer really interesting possibilities for all markets across every sector."

Dipl.-Ing. Andreas Berkau, CEO at citim GmbH

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