Satellite technology: Lightweight construction for weightless conditions

Creating bionic structures for maximising payload of space equipment by means of generative design

The enormous efforts needed to send technical equipment into space require a particularly high degree of lightweight construction. Generative design allows these complex optimisation processes to be significantly simplified and automated. The potential offered by this approach is demonstrated by a case study from German satellite specialist Tesat-Spacecom.

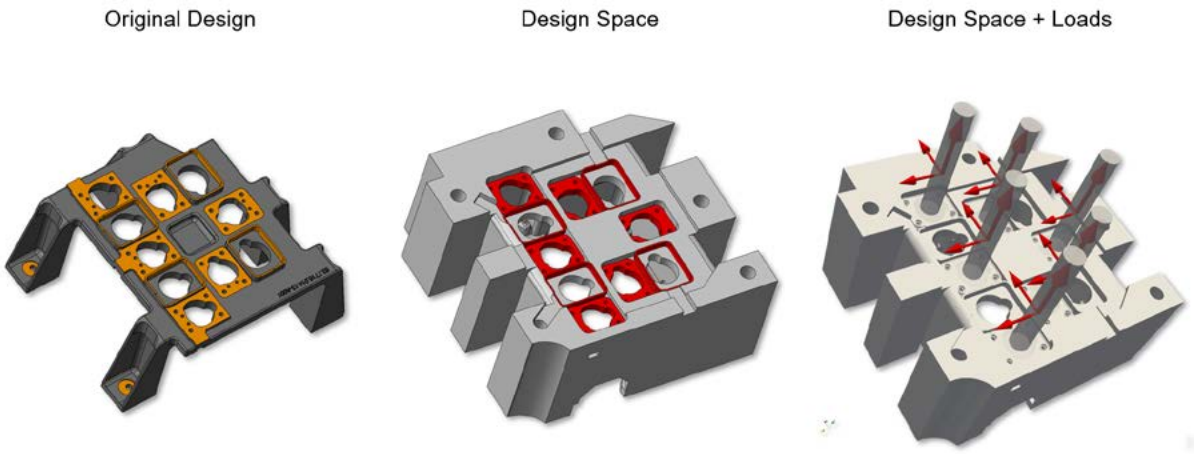
The launch of a rocket into space is not just an impressive event, it is also impressively costly. Huge volumes of special fuel are needed to generate sufficient thrust to allow the rocket's vast initial mass to reach a state of weightlessness. It is all the more vital that every satellite has the lowest possible weight in order to make best use of the available payload. Weight savings can enable further technology to be included on the satellite and thus garner additional knowledge or profit, or even allow it to transport a further satellite, thus lowering unit costs.

The problem is that structural components are not developed until the last stages of product development, but need to be available at a very early stage in the assembly process. Protracted optimisation cycles delay the time schedule and complicate the process.

The application

The Heinrich Hertz satellite from the German Aerospace Center (DLR) is intended for testing the space qualification of new communication technologies, and this includes the mounting for microwave filters and their drives. Tesat-Spacecom is responsible for the payload on this satellite and was faced with the task of generating a maximally lightweight but still stable component design. An existing conventional design weighing 164g was available as starting geometry.

The aluminium-alloy based component was imported into MSC Apex Generative Design and adapted using the software's intuitive modelling tools. First, the design and non-design areas had to be defined. The loads arising from the mounting of the filter and drives and further transport loads were then added with a few clicks on the appropriate specialized functions. Once the materials had been specified and various optimisation values set, optimisation could begin. The software automatically generates the mesh and, piece by piece, reduces the amount of material by calculating the stresses arising in each element.

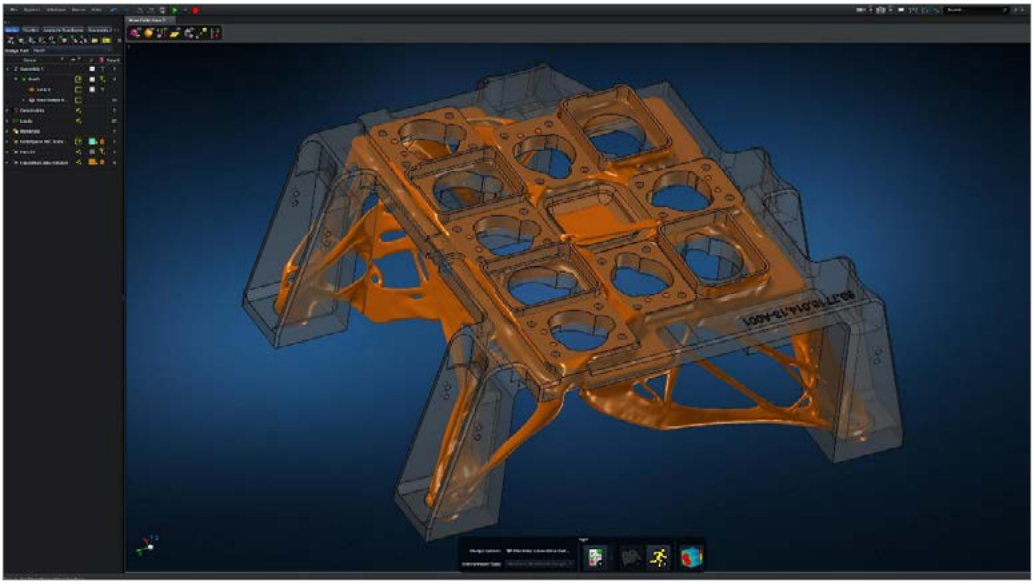


The existing conventional design was divided into design and non-design areas and was provided with loads in preparation for optimisation with MSC Apex Generative Design.

The solution

The realization of lightweight construction concepts in short development cycles is very hard to achieve with classic topology optimisation. But the innovative optimisation algorithms in MSC Apex Generative Design now allow optimised structural components for satellite construction to be realized even under severe time pressure.

If these are less than the target stress, the software lessens the weight, while always ensuring a homogeneous stress distribution throughout the component. After each iteration, the smoothing algorithm further generates a smooth and uniform surface, taking into account the generated structure and the underlying mechanics of the component.



Comparison of a design variant with the original design in MSC Apex Generative Design

Key highlights:
Product: MSC Apex Generative Design
Industry: Satellite technology
Benefits:
55% weight reduction for higher payload
31% stress reduction
79% stiffness Increase

The result

The result is a lightweight design that reduces the weight by 55%, down to 75g. This is all the more remarkable because the classic component design was already designed to be lightweight for use in satellite technology. Alongside the weight reduction, a stress reduction of 31% can be observed, while, at the same time, stiffness has increased by 79%. The design was developed in just a few days, and can be exported directly from MSC Apex Generative Design for manufacture.

The newly generated complex lightweight design in this form can so far only be fabricated by additive manufacture. Despite the high freedom of geometry, certain important design guidelines must be followed. In particular the solid structures and hard transitions of classic constructions are very difficult or impossible to reproduce. As a result, MSC Apex Generative Design directly generates structures which are eminently suitable for this special manufacturing method. By the use of manufacturing simulation software such as Simufact Additive, the geometry can be adjusted and optimised to the production machinery in a very targeted manner. A direct import into the software and problem-free processing of the optimisation result is possible.

Conclusion

MSC Apex Generative Design is optimally positioned for the high demands of space travel. Extreme lightweight construction alongside improvements in stress and stiffness values allow for a better exploitation of the available payload in this area. Intensive weight optimisation can now be carried out on time-critical components, while the innovative automated optimisation process offered by MSC Apex Generative Design allows for rapid development of lightweight designs. No complex manual reworking is necessary, and designs can be directly exported and further processed. MSC Software provides all the necessary tools for validation and simulation.

Final design of the structural component with a weight reduction of 55%, while increasing the part's stiffness. The fine structure with its smooth

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