ILC Dover

Using SIMULIA solutions to virtually test astronaut habitats

Overview

Challenge

ILC Dover needed to design a lightweight, inflatable, soft goods habitat for astronauts that can be deployed, and withstand extended time, in the extreme environment of the Moon or Mars

Solution

Abaqus FEA is used to test virtual models of habitat fabric and webbing under varying load scenarios to evaluate the robustness of the structure's design

Benefits

Realistic simulation allows testing of design integrity on earth, avoids expensive prototyping of advanced materials and provides significant time savings

"Using Abaqus FEA to identify the allowable limits of the fabric's performance was very useful. When we found one material that worked, we could use Abaqus to virtually test another, lighter material to see how much we could save on total weight and still provide the right factor of safety."

Ric Timmers
Senior Analysis Engineer
ILC Dover

Designing products for earth and beyond

Leader in the development of flexible material systems that withstand extreme environments, Delaware-based ILC Dover designs both hardware and soft goods for the wide-ranging challenges of space exploration. It made spacesuits for NASA's Apollo astronauts in the 1960s and 70s and gear for the space shuttle crew that repaired the Hubble telescope. ILC Dover makes a multitude of earthbound commercial products as well, from innovative containment systems for packaging powder pharmaceuticals to highly advanced protective military gear.

ILC Dover's latest out-of-this-world product is inflatable houses designed for future outposts on the Moon - or even Mars. NASA's Constellation program, to return to the Moon, set up a permanent base, and from there send people to Mars - has created a host of interesting challenges, including the most basic one: if you are living on the Moon for months on end, where is everyone going to sleep?

Launching a house into space

ILC Dover's engineers are working on the answer to that down-to-earth question. In partnership with several different branches of NASA, including Langley and the Johnson Space Center, the company has been developing ideas for different configurations of lightweight space habitat structures. "There's a keen interest among the Constellation management and engineers for soft goods solutions," said Cliff Willey, ILC Dover program manager of space inflatables. "When you are launching equipment into space on a rocket, everything needs to be as lightweight as possible, packed densely and easily expanded once on the moon's surface. An inflatable, soft item is very good for that."

Harsh lunar environment poses unique risks

The Moon's environment contains a host of external hazards, including extreme temperature fluctuations - which soft goods withstand much better than metals - radiation, dust, and low gravity. While all these are taken into account by engineers designing the lunar habitat, it was the inflation pressure on the two innermost layers of the structure that presented the biggest challenge to ILC Dover's design engineers.

"You have to come up with a pretty clever design to handle the high loads inside a dwelling that is pressurized to a level in which astronauts can live," said Ric Timmers, ILC Dover Senior Analysis Engineer. "Any significant fabric failure would result in a devastating outward explosion of the structure."

Physical prototyping would send costs out of orbit

Testing the integrity of the design on the Moon's surface was obviously impossible and building numerous prototypes out of custom fabric, and pushing habitat models to destruction, would be expensive and time-consuming. "That's when we decided," said Willey, "to go with realistic simulation. Trial and error was out of the question. We had to be able to build a reliable, finished product design the first time out."

Realistic simulation eliminates trial and error

So the group turned to Abaqus finite element analysis (FEA) software from SIMULIA, to test virtual models of the fabric and webbing under varying load scenarios and to evaluate the robustness of some minor structural components, such as the metal brackets holding the webbings. "We relied heavily on analysis with Abaqus for this project," said Timmers.

Abaqus/CAE, the pre- and post-processor for the Abaqus Unified FEA product suite, was used to model the 3D geometry of the design as the basis for the simulation. The group then ran their simulation models using Abaqus/Standard, which provided all the material, geometry, and loading nonlinearity needed to simulate fabric structures.

FEA helps identify safe limits of fabric yield strength

ILC Dover analyzed the fabric/webbing system by first modeling the fabric itself, raising the temperature until the fabric expanded to a set percentage, applying pressure to the model and having Abaqus calculate the resulting stress in the material. "Using Abaqus FEA to identify the allowable limits of the fabric's performance was very useful," said Timmers. "When we found one material that worked, we could use Abaqus to virtually test another lighter material to see how much we could save on total weight and still provide the right factor of safety."

Camping on the Moon, Mars - or even just the Antarctic

With their habitat design complete, ILC Dover teamed with NASA to build a prototype of it, but real-world verification tests of a full model are pending further funding. "We may very well run these tests ahead of time with Abaqus," said Timmers. "It's ideal to use a combination of modeling and testing back and forth, applying FEA to dial into just a few possible scenarios."

Whatever the timeline for deploying astronaut habitats on the Moon or Mars, ILC Dover's unique approach to such structures has applications closer to home such as dwellings for polar or desert-based scientists. A similar habitat designed with Abaqus Unified FEA has been tested in the harsh environment of the Antarctic and will be going to the Arctic as well.

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Cliff Willey
Program manager of space inflatables
ILC Dover

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