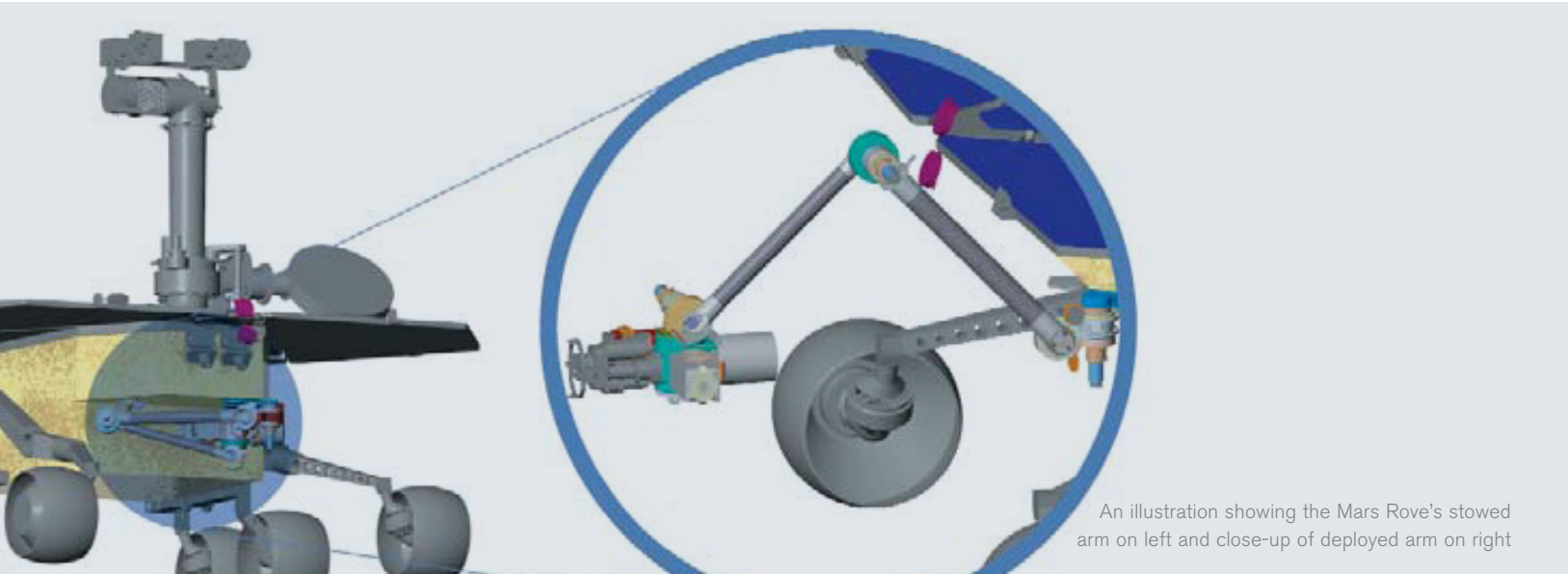


Alliance Spacesystems, Inc.

SURVIVING THE RIGORS OF DEEP SPACE WITH SOLIDWORKS



An illustration showing the Mars Rover's stowed arm on left and close-up of deployed arm on right

- Reduced turnaround time from three months to three weeks
- Decreased mass by 15 to 20 percent using optimization features

One project of the Jet Propulsion Laboratory (JPL) is MER, the Mars Exploration Rover. JPL launched two missions to Mars dropping essentially identical rovers on the planet. Similar to the Mars Pathfinder mission, they deployed airbags to bounce to a safe landing.

Alliance Spacesystems, Inc. (ASI) designed the robotic arm that is attached to the front of each rover. These arms are one meter in length with four primary scientific instruments at the end. The MER Rover will drive to a likely location, extend its mechanical arm, and hold the instruments near a rock. The last joint of the arm rotates so each instrument can scan the spot in turn.

The robotic arms weigh only 4.2 kilograms (less than 10 pounds). The arm has a five degree range of freedom and must meet exacting requirements from NASA. The structure and five actuators (which are also stressed structural components) have been designed for strength, stiffness, and low mass.

Accounting for mass and temperature

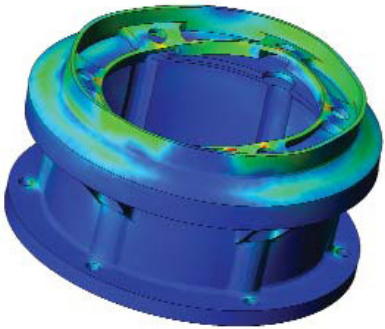
Jim Staats, chief engineer, notes that mass is the crucial component of any space mission. "You just can't get there from here if you can't get the mass within the envelope. Because its protective aeroshell can hold only so much mass, the MER lander must be within limits. If it isn't, it will either burn up or hit the ground like a bullet."

ASI uses SolidWorks® Simulation software and its optimization functions for detailed stress analysis and mass minimization of the arms' parts. The engineers varied the parts' geometry to reduce mass while controlling the maximum allowable stress or deflection. The results are often striking.

"Using some of the optimization features, we can typically take 15 to 20 percent additional mass out," says Staats. "That doesn't sound like much, but if you wanted to reduce your car's mass by 20 percent," he observes, "you'd have to take the whole engine and transmission and throw it out. So it's a big chunk." SolidWorks Simulation is the tool that makes that possible.

“With SolidWorks, analysts leave the equations intact and let the automatic meshing capabilities take care of them. The software generates tens of thousands, even hundreds of thousands, of equations in a short time.”

Jim Staats, Chief Engineer



Using SolidWorks to design the robotic arm on the front of the Mars Exploration Rovers, ASI met NASA's requirements.

Other critical design factors also demand powerful software capabilities. For example, Mars's severe extremes of temperature can range from a low of -120°C to 27°C on a balmy summer day. Another example is the bone-crunching impact of landing – 50 to 60 mph with a deceleration of 40 Gs.

ASI's engineers use SolidWorks software for design and SolidWorks Simulation analysis whenever they can, says Staats. The programs were instrumental in designing other ASI products, including a hopping exploratory robot for Caltech, and part of the nanorover for the MUSES-CN asteroid mission. Staats calls the integrated software “a very straightforward and efficient tool, less complex but very powerful.”

Sold from the beginning

From the first SolidWorks and SolidWorks Simulation demos, the ASI team was convinced that integrated CAD and FEA would save them time and effort. Upon implementing the solution, they discovered that training time was virtually nil. Members of the team could perform useful operations within an hour.

The engineers were impressed with SolidWorks Simulation's efficient equation-solving capability, which made large models easy to analyze. “It used to be that you'd have to reduce the number of equations to something manageable,” says Staats. With SolidWorks Simulation, analysts leave the equations intact and let the automatic meshing capabilities take care of them. The software generates tens of thousands, even hundreds of thousands, of equations in a short time. “Ten minutes is a long run for SolidWorks,” he adds.

Another advantage is how SolidWorks Simulation has streamlined ASI's design process. Most aerospace companies have a design group, as well as a stress or analysis group. When a conceptual design is created, it usually requires many iterations of analysis to see if it's in the right ballpark. For each round, the design engineers throw the design “over the fence” and into the queue for analysis jobs, where it may languish for several days or a week because the analysts are busy.

With SolidWorks Simulation software, ASI's engineers don't have to manipulate CAD data to get it into a form suitable for FEA. The data transfer is automatic and doesn't require the usually cumbersome file export and import. “This is the smoothest connection between any of these tools that I've personally seen,” says Staats.

The upshot? Iterations take only a couple of hours rather than a couple of days or more. ASI's design engineers are routinely performing their own analysis – applying loads to equipment designs to ensure proper strength and durability. Team members are not delayed by the need to share analysis resources. “You have very young engineers doing what I believe are very advanced analyses,” says Staats, “and we're getting better designs as a result.”

In addition to ASI's design engineers doing more analysis, its analysts are also becoming more familiar with CAD tools. They routinely use SolidWorks to take dimensions, model small parts, and look at assemblies. “These tools have become a communication tool between the two types of engineers,” says Staats. “They both speak each other's language better than I've ever seen before.”



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