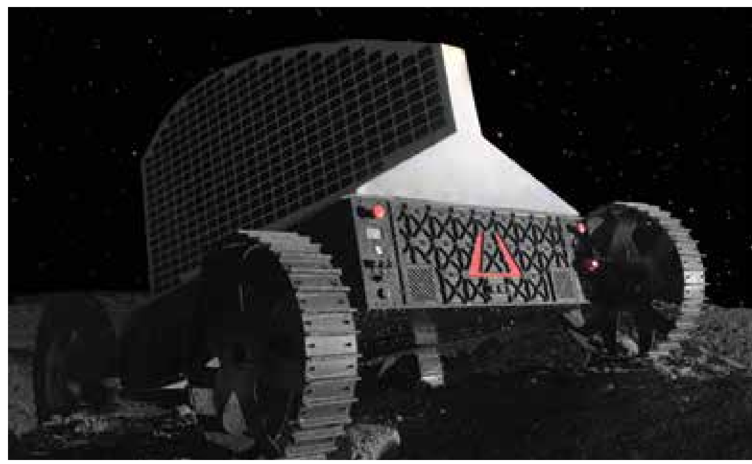
ASTROBOTIC TECHNOLOGY GAINS EDGE FOR GOOGLE'S LUNAR XPRIZE WITH NVIDIA GPUs

ASTROBOTIC
CASE STUDY

Astrobotic Technology, founded in 2008 as a spinoff of Carnegie Mellon University's Robotics Institute, is on the cutting edge of the emerging commercial space industry. The company is a pioneer in affordable space robotics technology, servicing commercial, scientific, and governmental organizations with lunar payload delivery and data collection. Astrobotic is currently one of 23 teams competing for Google's coveted Lunar XPRIZE – a total of $30 million for the first privately funded team to safely land a robot on the moon's surface, and have that robot travel 500 meters over the lunar surface while sending video, images and data back to earth. Teams have until the end of 2015 to meet these goals. A longtime NVIDIA customer, Astrobotic relies on GPU acceleration to meet its demanding design and analysis needs.



The Astrobotic lunar rover, designed with NVIDIA GPUs

CHALLENGE

As a Lunar XPRIZE team, Astrobotic's core activities revolve around the development of vision algorithms for autonomous landing, vehicle design, and simulations for landing and roving. The main task for Astrobotic's ten full-time engineers is to design a vessel that can survive both the launch and the landing, and still be fully operational once on the lunar surface – but the biggest obstacle for the engineering team is being stuck on earth.

"We can't actually reproduce the environment of the moon for any physical landing test," explained Kevin Peterson, Astrobotic's Director of Guidance, Navigation, and Control. "On earth we have atmosphere, we have clouds, we don't have the same topography – so the best we can do is use a 3D simulator. We have a number of cameras that fly by the moon and map the surface and track motion over time in an optical flow. Our plan is to use all of these data points as input for landing, where our lander can take pictures as it approaches the lunar surface and use all of this information to properly position itself. There is a ten second delay in communications from the lander, so it's imperative that it can guide and land itself autonomously. The challenge on our end is that with all this data, the simulations are very computationally-intense and must be photo-realistic."

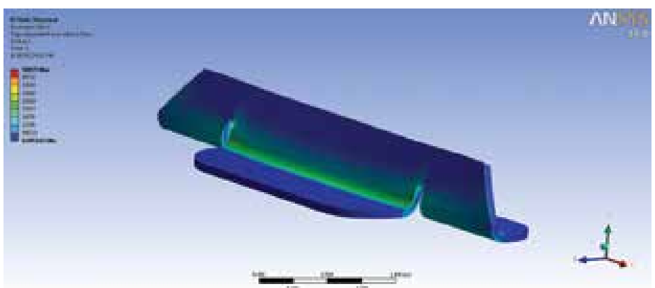
A secondary challenge is simulating accurate launch testing, to ensure that the vessel makes it off the ground in the first place. A typical spacecraft model includes 100's of unique parts with more than 4,000 fasteners – and testing must take into account how each individual element would perform when subjected to the vibration a spacecraft would experience during launch. Jason Calaiaro, Astrobotic's CIO and Director of Propulsion, needed a way to overcome computational bottlenecks that forced his team to run simulations using simplified shell CAD models.

"We often produce shell CAD models of our original designs for simulation analysis because they're less computationally intense so testing takes less time," explained Calaiaro. "But this simplification led to problems. The simplified models we used didn't always correlate to real-world test results, which meant that we had to go back and increase the complexity and do more tests. There was a lot of trial and error in trying to strike the right balance between the level of complexity and the quality of the results, and that, compounded with the time spent creating the shell models, was impacting our tight schedule."

SOLUTION

As NVIDIA customers, Astrobotic's engineers had already experienced significant performance benefits over the CPU by leveraging GPU acceleration for mechanical design in SolidWorks and finite element analysis in ANSYS. Peterson and Calaiaro opted to upgrade their NVIDIA GPUs from the older Fermi generation to the current Kepler generation – including one Quadro K2000 board and two Tesla K20 boards – in order to achieve further speed increases. And with ANSYS 14.5 now providing multi-GPU support, the second Tesla GPU would deliver an extra boost. They also switched to NVIDIA iray to leverage GPU acceleration for photo realistic rendering.

Peterson and Calaiaro saw immediate performance improvements with Kepler-based Quadro and Tesla GPUs. Calaiaro experienced significant performance increases in both SolidWorks and ANSYS. "Now I can easily just go straight from design to analysis without having to bother with building simplified shell CAD models; I can instead use a solid mesh calculated directly from my original CAD model, which streamlines my workflow and saves about 1-2 weeks in design time alone," he said. "On average, I see a 40% speed increase in analysis with the extra GPU – and even though each test only took 5 or 10 minutes on one GPU, when you have to test 100 different variables, those time savings really add up. With this added GPU power I can also run SolidWorks and ANSYS simultaneously, and that bi-directionality is incredibly powerful and changes how we approach design and analysis."



Sample analysis image of a component of the wheels for the new rover

Using iray also increased Peterson's lunar surface renders to 20 frames per second on a GPU, up from 1 frame per minute on a CPU. Peterson explains: "To put it in perspective, before we would have to set up the render and literally leave it to run overnight. Now I can sit down and run that same render in ten minutes. It's huge. Flight tests are prohibitively expensive, so we rely on simulations. We need to run a million different lunar surface simulations before launch to make sure that we've tested every possible landing scenario; they need to be very high-fidelity, very accurate, but we also need the ability to iterate quickly, and NVIDIA's Kepler GPUs are enabling the power and speed that we require."

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IMPACT

In the race to the moon, speed and accuracy are key. NVIDIA's Kepler-based Quadro and Tesla GPUs allow Astrobotic's engineers to handle intricate designs and immense analysis with no compromises, which leads to more accurate results.

"Analysis is key because it allows you to make a more informed design," said Calairo. "Now with the capabilities of two GPUs, I'm able to test a far more accurate model and get the results I need faster."

"For us, everything needs to be done yesterday," added Peterson. "Always do it right, but do it quickly. There isn't a lot of time to step back and take pause; we're always making decisions on our feet and moving forward as efficiently as possible. NVIDIA GPUs allow us to have a design cycle that is about 4-6 times faster than our counterparts – for instance, we will spend 6 months building our rover, while comparable industry members or government agencies would probably spend more than two years on a similar effort."

"The bottom line is that we're a small company trying to do things on a tight schedule with limited resources," Peterson concluded. "NVIDIA's GPUs and iray renderer allow us to keep a competitive edge without cutting corners."

Hardware & Software Used:

Workstation	**HP Z800**
Graphics	**Quadro K2000 + 2x Tesla K20**
Applications	**Solidworks, ANSYS**

To learn more about NVIDIA Quadro, go to **www.nvidia.com/quadro**

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