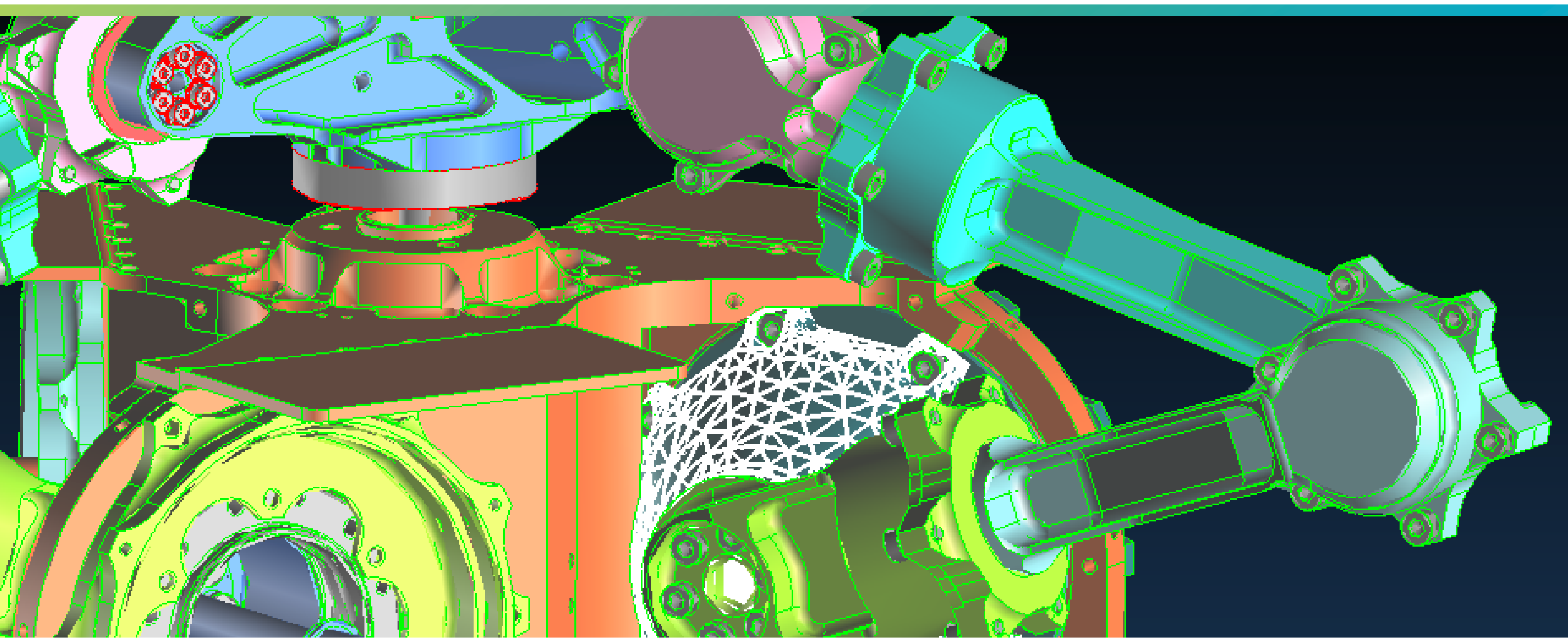
Case study

Comat Aerospace

Developing the 3POD antenna pointing system



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Comat Aerospace is in the process of developing the 3POD Antenna Pointing System (APS) in collaboration with the Centre National d'Etudes Spatiales (CNES), the French national space agency. The role of the 3POD APS is to keep the antenna pointed at ground stations regardless of the satellite's orientation while maintaining low mechanical jitter to ensure line of sight stability.

For its first projected deployment on the OTOS satellite, the 3POD ATS will be required to provide a 74o pointing domain with a worst case pointing precision of +/- 1o at a pointing speed of about 5o per second.

Challenge

The design of the 3POD ATS consists of a parallel architecture robot that uses three fixed rotary actuators at the base joints to control the antenna's orientation and plunge (height on the elevation axis). A fixed base plate on the satellite is linked to the three sets of legs by rotary actuators at the base joints. The lower link of each leg is connected to the upper link via a ball joint. The upper link is in turn connected to the antenna using revolute joints. The linkage allows for three degrees of freedom of the antenna including azimuth, elevation and plunge. A key advantage of this approach is that the actuators are fixed to the satellite so the only mass that needs to be moved by the robot is the antenna and its support platform which are quite light. This makes it possible to move the antenna as often as needed to maintain contact with the ground station without introducing vibration to the satellite.

The parallel architecture robot design is promising, however, it has never flown in space and Comat engineers were not able to find a single application where it has been used to date in the industrial world. So engineers had to carefully study the complex linkage of the robot to gain an understanding of its kinematics to avoid collisions and singularities. Singularities are configurations in which a robot manipulator either loses or gains one or more degrees of freedom instantaneously. For example, if two axes become aligned in space, the rotation of one can be canceled by counter-rotation of the other, leaving the actual joint position unknown. For each proposed design iteration, engineers needed to explore the entire pointing space to identify singularities and collisions and, if they existed, change the design to eliminate them.

Solution/validation

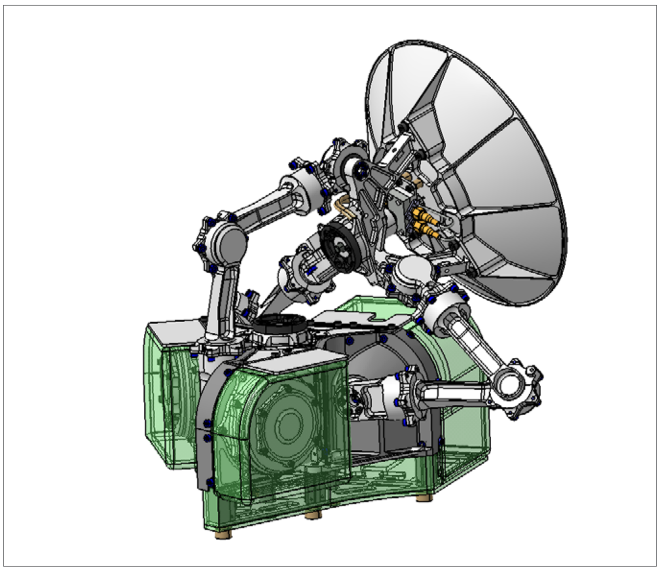
Comat engineers originally used Adams to perform kinematic simulation of the motion and piloting functions of the robot and to complete a parametric study on the various design parameters and their impact on the overall performance. But incorporating flexibility into the Adams model required a long design loop between the CATIA model, Adams model and Nastran/Patran model. By the time this design loop could be completed, the design had often been changed so the results were outdated. Going further in the process, Comat engineers built a prototype of the robot that highlighted the importance of the flexibility of the elements on its overall rigidity in certain positions.

With the goal of accelerating the design cycle, Comat invested in the SimXpert unified computer aided engineering environment. Engineers used the multiple workspaces provided by SimXpert to quickly move from one discipline to another while sharing data models and results. "SimXpert made it easy to add flexible elements to the Adams model," said Lauren Bernabe, Project Engineer for Comat Aerospace. Comat engineers modeled the arms and legs of the robot, the satellite base and antenna platform as flexible elements. They moved the current design iteration through its entire range of motion and looked for singularities in the design.

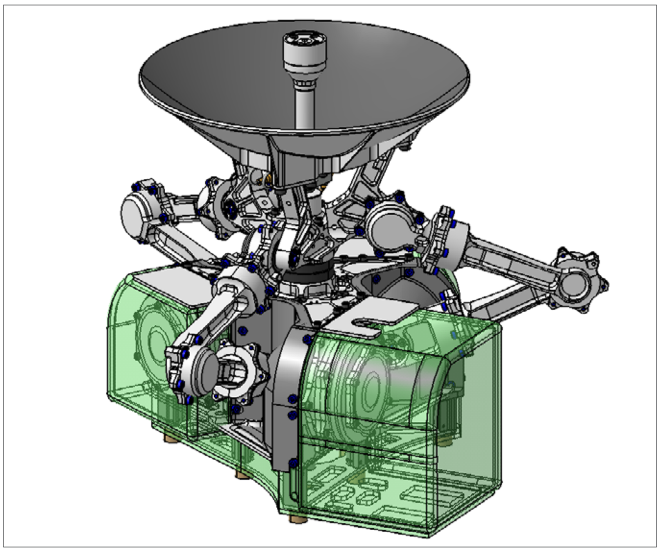
"We discovered a singularity at a position where the platform is moved towards the satellite so that it folds between the arms of the robot," Bernabe said. "At this position, the platform can cave in towards the satellite. We explored the entire range of motion and determined that this was the only risky position. We modified the design to eliminate this weakness. As the design continued to evolve, we evaluated each new design iteration to be sure that no new singularities had been introduced."

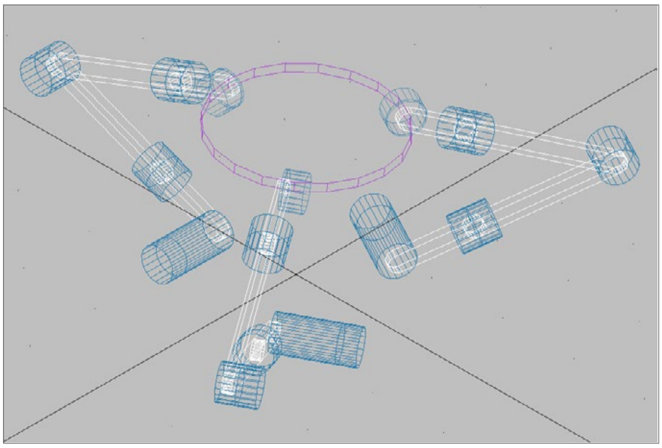
Results

"Without simulation the design phase would have either required many prototypes, which would have been very costly, or it would have required very high safety margins, which would have led to oversizing and reduced the payload that could be accommodated in the mission," Bernabe said. "Simulation with SimXpert made it possible to understand the dynamic performance of the parallel architecture robot both on the ground under gravity and in orbit under microgravity. We were able to identify a rigid



Key highlights:
Product: Adams
Industry: Aerospace
Benefits:
Study various design parameters
Accelerate the design cycle
Modify the design and validate the performance in about 4 hours

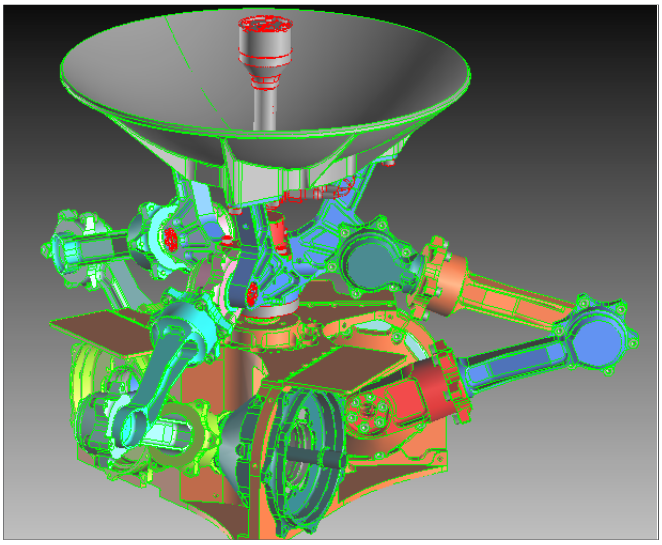




singularity in the initial design, evaluate various alternatives for solving the problem and iterate to an optimized design. The streamlined design loop provided by SimXpert made it possible to modify the design and validate the performance of the new design in about 4 hours. This is about one-fifth of the time required in the past."

"The 3POD ATS was a great first project to demonstrate the viability of this approach," Bernabe concluded. "This project has proven the advantages of an integrated approach to simulation but it's too early to quantify the financial benefits. We have validated our design and are moving forward to detailed design and manufacturing of the 3POD which is planned for 2016. In the future we expect to have many other opportunities to utilize this technology on other projects."

About Comat Aerospace



The company is a prime contractor for scientific equipment used on board manned and unmanned space missions, satellites and ground support equipment. Comat Aerospace provides technology solutions in the field of flight equipment for space programs. It offers space flight products that include on-board scientific equipment for manned/unmanned flights, flight instrumentation equipment, multilayer insulation systems, and satellite integration equipment; and space ground equipment, such as equipment for reflector vibration tests and mechanical and optical test benches. The company also provides aeronautical products, including integration rudder-bars, pod positioning systems, mechanical and thermal test benches, carriages, frames, racks, and airborne equipment; defense products, such as transportation containers and aircraft.

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Lauren Bernabe,
Project Engineer, Comat Aerospace

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