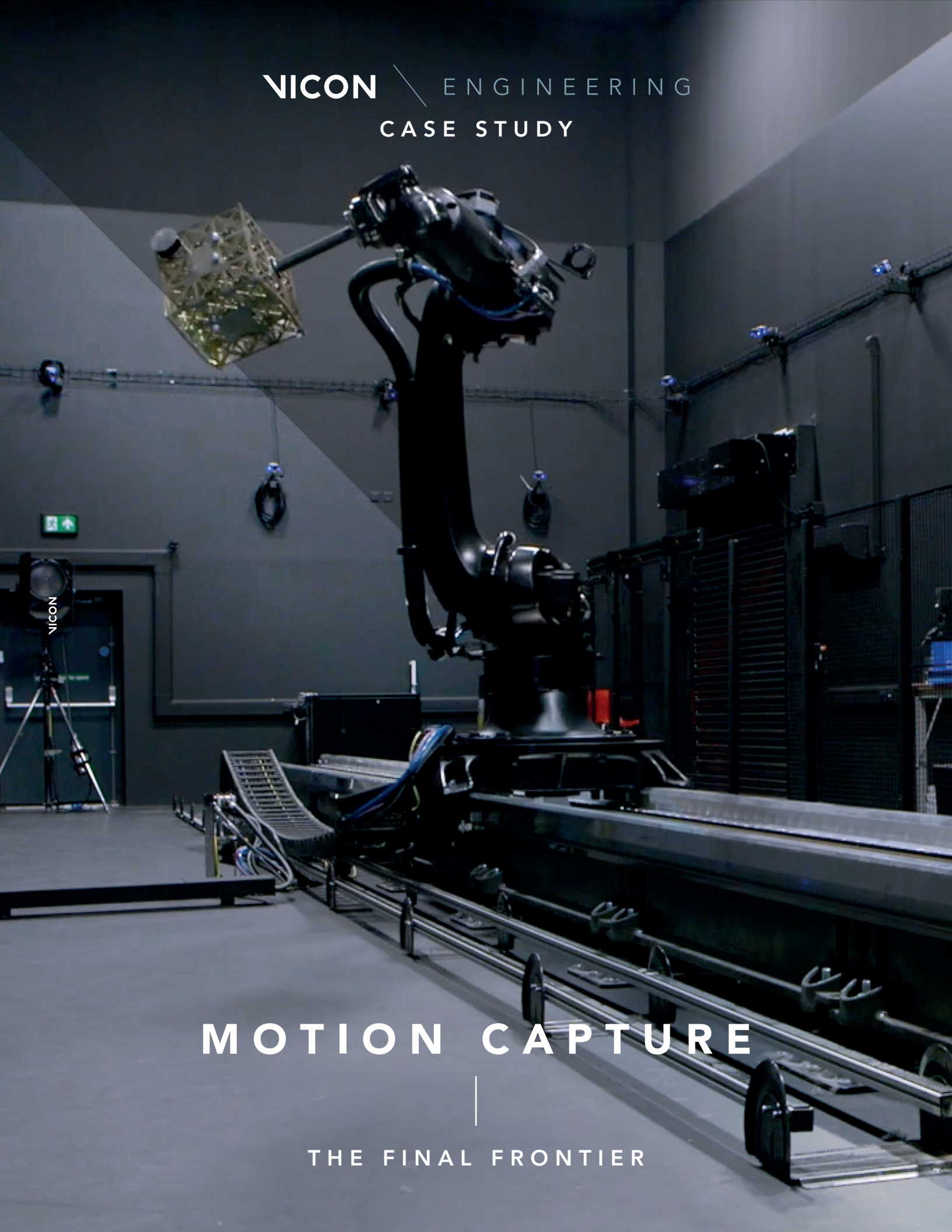
VICON | ENGINEERING

CASE STUDY



MOTION CAPTURE

THE FINAL FRONTIER

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New commercial and state operations are pushing the space industry into uncharted territory, and the UK is poised to become a key player in the growing sector. The British government hopes to have captured 10 percent of the market by 2030, and a facility in Oxfordshire that uses a Vicon system to help it simulate orbital operations is a key part of the strategy.

The Satellite Applications Catapult was established by the UK government to accelerate innovation in the space sector by facilitating collaboration between industry and academia. Jeremy Hadall is Robotics Development Lead at the Catapult, working in the In Orbit Servicing and Manufacturing Yard, a large darkroom facility created to simulate orbital environments. The facility uses robots to simulate how satellites will come together in order to carry out servicing, refueling, assembly and manufacturing operations.

"The operations we're modeling are really important because they mean we can prolong the lives of satellites in orbit and start to build larger structures, like the next generation of space stations; space-based solar power stations; very large antennas and telescopes," Hadall explains.

"It also means we can remove debris or end-of-life satellites from orbit, which is important because we're starting to find that our orbital environment is very cluttered."

The facility offers a critical capability for the UK, allowing other organizations the use of technologies that they wouldn't be able to access otherwise.

"The most important thing this facility is working on at the moment is close proximity operations, which is getting two objects operating close to each other and almost formation-flying in orbit," says Hadall. "It sounds a bit daft—we've been doing that for decades, ever since the Apollo missions. But we're talking about flying things that are much smaller and don't necessarily have all of the capture mechanisms that an Apollo capsule or something going to the International Space Station would have."

To simulate orbital maneuvers, the Catapult uses two robots to mimic propulsion systems and low gravity conditions.

"The robots we use are off-the-shelf industrial robots," says Hadall. "You would never launch one of these robots into space. But the important thing for these robots is they give us a degree of stiffness and a degree of repeatability that we need for some of the operations that we do here in the yard. The best way to think about these robots is not as robots—these are stand-in satellite propulsion systems. What's important is what's on the end of those robots, whether that be a vision-based navigation system, a camera, some sensors, some grappling mechanisms or another robot."

NO SPACE FOR ERROR

But while the robots are extremely useful, they come with limitations. The Catapult's solution for working around those limitations is its Vicon system.

"These robots are very repeatable, but they're not that accurate," says Hadall. "That creates a lot of challenges for us. One of the reasons why we use the Vicon system is to ensure that we know exactly where these robots are because the robots, to be honest, are not that good at telling us exactly where they are in the environment.

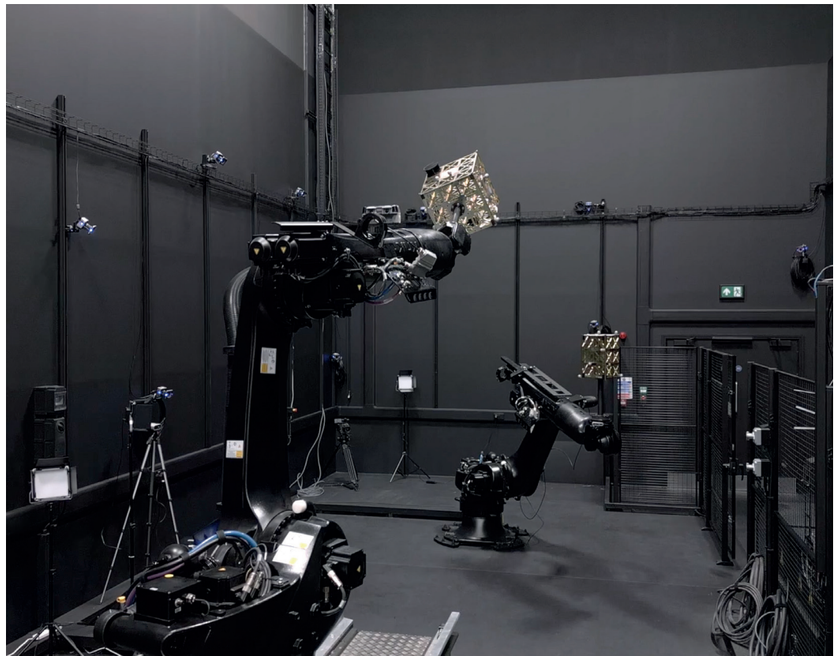
"Motion capture was the right approach for us. We could try to do it with other sensor systems, but they just weren't going to give us the capability that we need across the whole scale of the environment. And that's how we started to use motion capture here at the Catapult."

That environment is 27 meters long, seven meters wide and eight meters high—the largest of its kind in Europe.

"In the yard we have 33 Vicon Vero cameras. That means we've got full coverage of the entire working envelope of both robots, which is important because although we're working on close proximity operations, we also need to do that at quite a long range. Even as large as this facility is, we have to actually scale some of the models to simulate a similar kind of operation to what we would get in space.

"Using the Vicon system allows us to map the entire environment, map where the robots are and where they're traveling to, and give us a degree of reliability in judging how the robots are actually performing the tasks that are being asked of them."

Accuracy in the yard translates to improved performance where it really matters: in space. "Often, clients will come in with their systems and we'll put them on the end of the robots," explains Hadall. "Those systems will be commanding the robots to move into different trajectories and different positions. Those positions are absolute positions that come from the vision system. We need to know that the robots are going exactly where they are being commanded to go. And if they're not going to where they're commanded to go, we need to know where they actually are and then we can do a transformation and figure out whether or not the systems on the end of the robots are actually working properly."



Vicon has been important not only as a technology provider, but as a source of ongoing technical and design support. "Vicon has been a really crucial partner for us in developing the facility," says Hadall. "They've helped us work out how many cameras we need, how to optimize the system, how to set it up and how to operate it.

"When we originally set the system up we only had 24 cameras. It worked, and we got some good results out of it, but we quickly recognized there were areas where we were getting some blind spots. With Vicon, we worked out how we would improve that. Vicon has been critical in supporting the development of the facility, not just on the physical camera setup and how many we've got, but also on how we use the software and how we take data from the Vicon Tracker software and apply it to satellite guidance and navigation systems.

"Using Vicon's technology has enabled us to understand how these robots are reacting, and how that affects the work we're trying to do with satellites for servicing and repair. For us, investing in the Vicon system was definitely worthwhile. We couldn't do what we do here without it.

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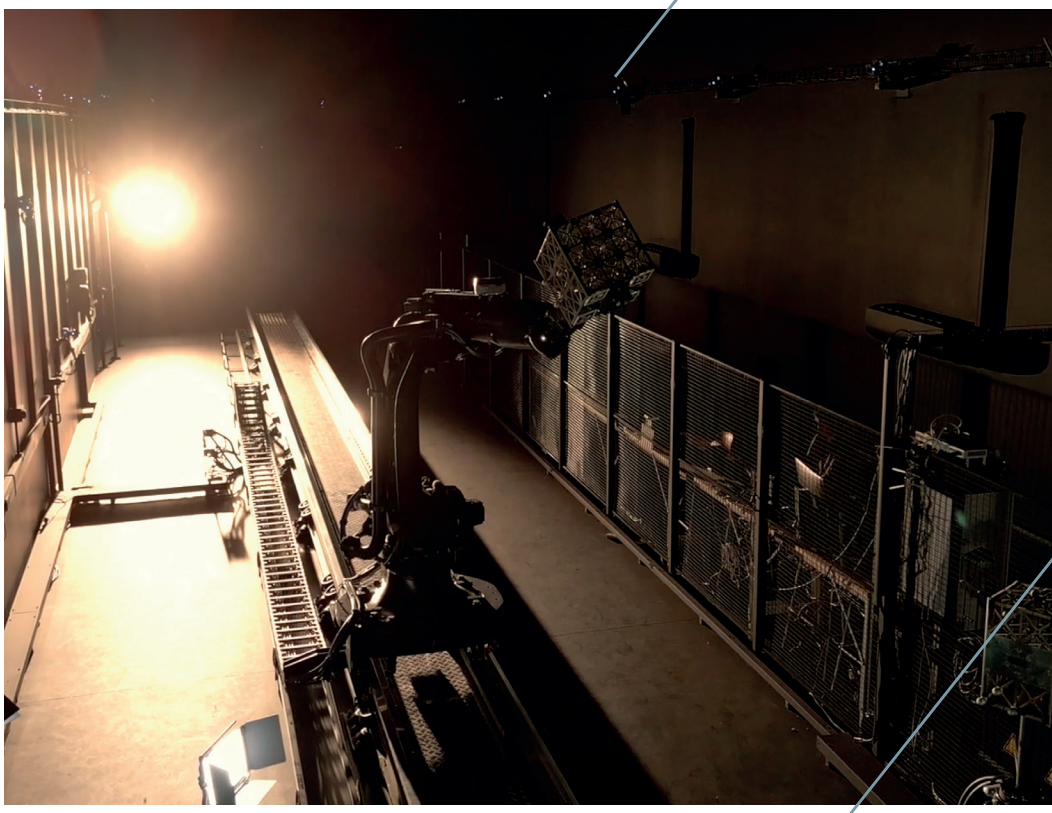
BEYOND EARTH

The Yard is an evolving facility, and its Vicon system evolves alongside it. "We are developing this facility all the time, alongside Vicon and other partners," says Hadall. "I think we find out new things in this orbit servicing and manufacturing field all the time, because it's so nascent. It's often been equated to the Apollo missions. We're trying to do things that nobody's ever done before. And we need to do them at a relatively high pace. So we're always finding out new things, and some of those come out of the Vicon system. With some of those learnings we see how the systems are reacting and it gives us a new insight into the whole process. This facility never has a single operating state. We're always evolving it. We're always finding out new things. We're continuously improving it."

Hadall expects motion capture to become even more integral to the In Orbit Servicing and Manufacturing Yard in the future. "I think, for us, the way we use motion capture is going to evolve by linking the outputs and motion capture into the robots directly. So, feeding back into the robots, changing the robots' behavior based on what the motion capture system said. The next evolution of the manufacturing field is going to be rapid.

"Once we crack close proximity operations and we get those processes working at a very high cadence, we open up a whole range of new commercial opportunities in space. And then, outside Earth orbit and out towards Mars and beyond."

For more on Satellite Applications Catapult see our video case study **https://eu1.hubs.ly/H08wsWJ0**



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