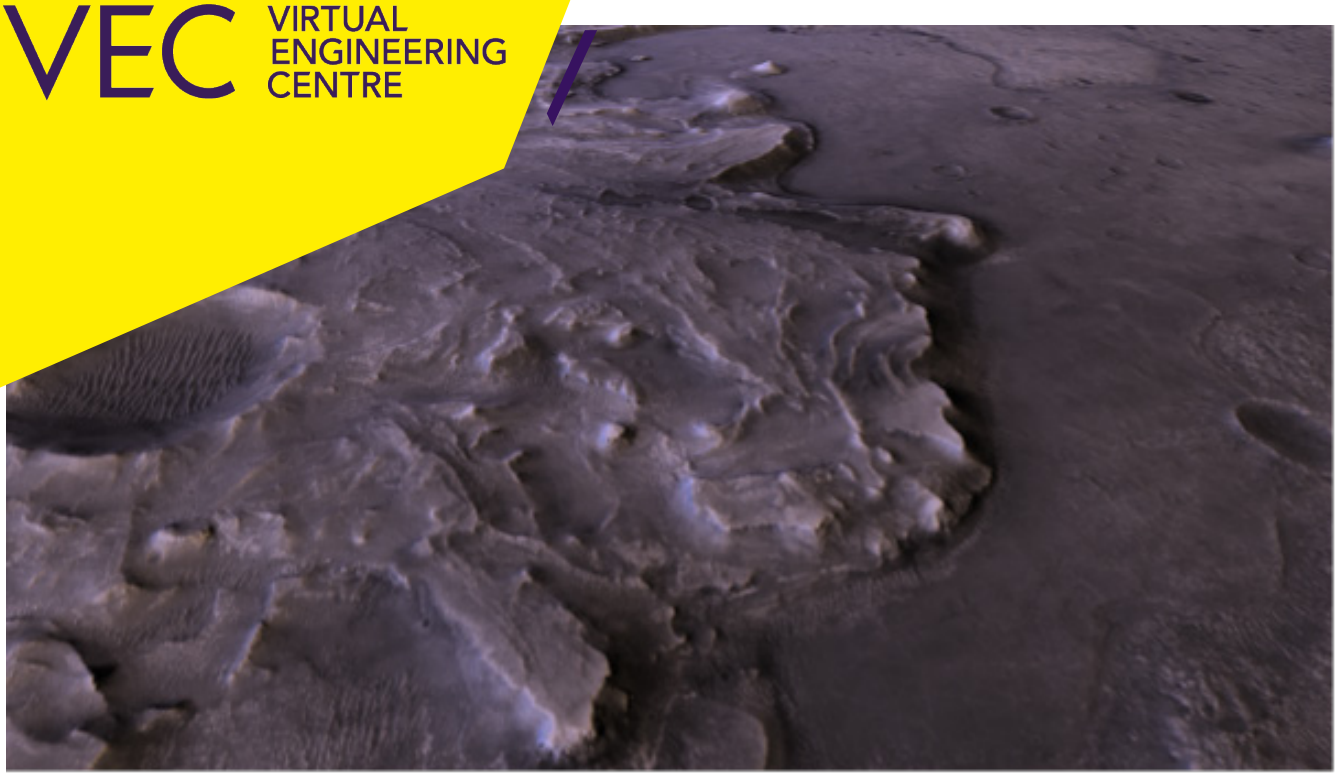
VEC VIRTUAL ENGINEERING CENTRE



Virtual Engineering Centre uses Distributed Simulation for simultaneous and remote testing, using multiple robotics on virtual planet

BACKGROUND

Mars is often linked with space missions and explorations as we search for life beyond Earth, being the closest potentially habitable planet. However, being roughly 225 million km away from Earth provides an array of challenges for research and testing.

NASA's current Mars exploration mission aims to "explore Mars and provide a continuous flow of scientific information and discovery through a carefully selected series of robotic orbiters, landers and mobile laboratories." Combining this with the SpaceX plans for human Mars exploration missions, it is extremely important to deploy simulation capabilities for improved planning and to de-risk such complex missions.

Robots and autonomous systems are often integrated into simulations for testing dangerous and hazardous environments, de-risking such environments before any human interaction. Robots are more robust than humans, requiring fewer resources such as food, withstanding harsher conditions and can work autonomously and independently for longer periods during the testing phase.

Applying expertise in complex system simulations, the Virtual Engineering Centre (VEC) has implemented a high fidelity and realistic virtual Mars environment that would allow to model robotic orbiters and landers already deployed on the planet, plan future missions and provide the ability to make virtual interplanetary trip by students, researchers and engineers through virtual reality technologies.

THE CHALLENGE

Planning interplanetary missions for robotic orbiters, mobile ground laboratories, and human missions is extremely difficult due to the high costs and time spent planning, constructing, and executing these missions.

Collaborative testing amongst researchers is difficult, as many are located all over the world. Creating a digital twin of the physical environment to mimic the Mars environment for robotic testing can also be expensive and time-consuming. The constructed environment may not incorporate physical variables that are difficult to recreate, considering temperature and weather conditions such as dust storms in addition to communication errors due to long ranges between the robot and the home station.

THE SOLUTION

The VEC has built a virtual Mars environment to simulate the surface operation in the mission of Mars 2020, a space mission launched by NASA on 30th July 2020, to explore the Red Planet and search for signs of microbial life, collection of rock and soil samples for

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return to Earth and test new technologies for supporting future Mars missions.

The centrepiece of the mission is the perseverance rover, which landed on Mars on 18th February 2021 in a region called Jezero Crater. The region is believed to be home to a lake that could provide a habitable environment for microbial organisms. The perseverance rover is equipped with a SuperCam and a sample-catching system for its exploration. In addition to the rover, the mission also includes a helicopter called Ingenuity, which made history by becoming the first aircraft to make a powered, controlled flight on another planet. Its purpose is to demonstrate the feasibility of using helicopters for future Mars missions.

To ensure the landscape was an accurate representation of the real location and scale, the digital terrain was georeferenced to its real coordinates. To simulate the Martian environment, gravity and atmosphere are considered. Mars has about one-third the gravity of Earth and a very thin atmosphere, with a surface pressure of only about 1%. As a result, the Mars atmosphere contains more dust and fine particles from the ground. Therefore the planet's sky becomes reddish during the daytime and blue during sunset. The VEC also introduced different sounds captured on Mars by the Perseverance rover and dust storms, a common weather condition on Mars for a more immersive experience.

The VEC was able to access multiple 3D models of perseverance and ingenuity, downloaded from NASA 3D resources and launch these into the 3D world, including a habitat demonstration unit, a space exploration vehicle and a third-person astronaut player.

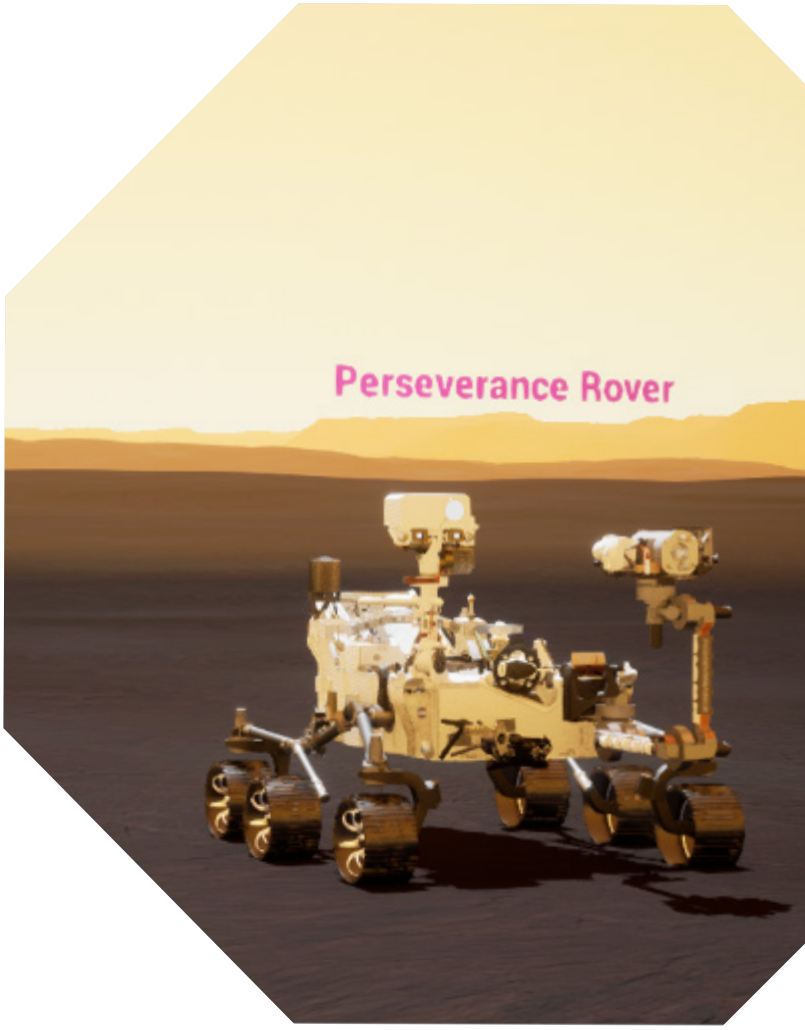
The VEC has continued to develop this distributed simulation, connecting the virtual simulations with a physical Jaguar robot within the autonomous systems laboratory. Using the High-level Architecture (HLA) the VEC experts have enabled the rover to autonomously avoid hazards and support in the collection of samples. This enables the VEC to test the physical functions of the robot under the simulated and controlled environment, evaluate algorithms for autonomous navigation, and assess the varying weather and surface conditions whilst exploring the landing site. This simulation could offer space agencies the opportunity for close collaboration, making well-informed decisions during the planning and execution phase for future space missions.

THE IMPACT

The High-level Architecture (HLA) standard for distributed simulation empowers a 'digital backbone', bringing multiple simulators and physical entities together. The developed architecture provides a standardised set of services through different programming languages that can be distributed across long distances whilst not being restricted to different physical locations, IP addresses and programming languages.

Organisations from all over the world are able to access the Mars simulation for remote testing and communication including accessing large real-time data and information exchange, synchronisation and federation management.

This simulation reconstructs the extreme environment in the virtual world with known knowledge, simulating different conditions, collecting data and piecing information together which can be useful for identifying areas of concern and obstacles for testing, helping users to become better informed and better prepared. Using a distributed simulation as a way of testing before a physical space mission can prove to be not only safer but cost-effective, ensuring organisations are as well prepared as possible and are less wasteful of their resources whilst potentially speeding up the path to success.



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