



Image courtesy of NASA

NASA's Gold Standard Testing Methods and Software Test Automation

Using automation to meet NASA's challenges of space exploration

eBook

 **KEYSIGHT**

INTRODUCTION

Introduction

From building rockets to landing on Mars, space organizations must consider a host of known and unknown variables before the countdown to launch—whether it's losing contact with Mission Control or a life-threatening equipment failure.

With space technologies becoming increasingly complex and a growing reliance on software, manual testing has become impractical. But how do space organizations anticipate the countless scenarios an astronaut might encounter to ensure mission critical becomes mission accomplished?

According to NASA, the key to achieving this lies in smarter testing of spacecraft and software, leveraging artificial intelligence and machine learning at every step. To help you achieve gold standard testing and automation, this eBook highlights how NASA tests for space, the key insights and challenges on the future of space exploration and testing, and strategies to tackle those challenges and achieve mission success.



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CHAPTER 1

The Evolution of Space Exploration



Image courtesy of NASA

The Evolution of Space Exploration

Whether it's SpaceX designing reusable launch vehicles or NASA launching the Orion spacecraft to orbit the moon, there's no denying the increased interest over the last two decades in furthering space exploration.

The commercialization of space has changed the nature of space missions. Companies like SpaceX, Blue Origin, and Virgin Galactic have developed reusable rockets and spacecraft to make space travel more accessible and affordable. Through lean organizational structure, flat hierarchies, and private funding—a model typically seen in tech startups—private space companies can innovate much faster than government-funded organizations with their traditional approach.

In order to compete, government space agencies are now partnering with private companies to fuel the growth of the commercial space sector and speed up innovation. For example, in 2022, government contractor SpaceX launched a **record-breaking 61 orbital missions**, averaging one launch every six days with a 92% mission completion rate.

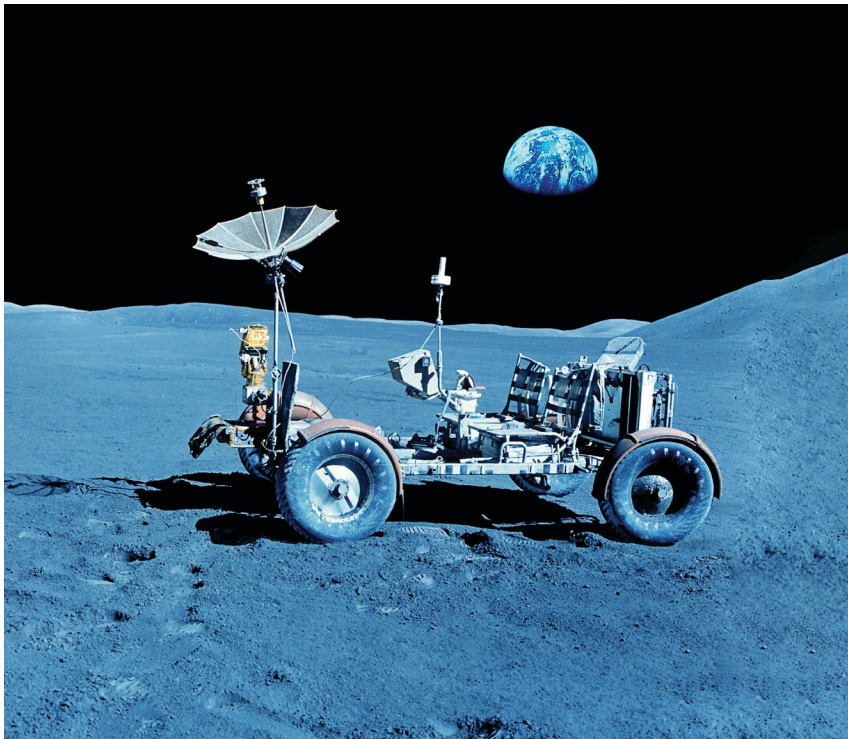
Space is no longer about competition—but cooperation. Each side brings something valuable to the table; commercial companies like SpaceX have more money and resources available to them, whereas NASA brings in its decades of experience and clout. It's allowing both sides to think faster, push further, and take more risk—creating an era of space exploration we've never seen before.



Captain Chris Cassidy,
Retired Chief Astronaut of NASA
and ISS Commander

Innovations for a New Era of Space Exploration

In a recent Deloitte [article](#), 82% of senior space sector executives said innovation in the space market is a top priority. There are several key innovative trends right now, including autonomous systems (AS), artificial intelligence (AI), lunar exploration 2.0, Mars expeditions, and asteroid sampling. Let's take a closer look at developments in these areas.



Autonomous systems and artificial intelligence

Satellites already use AI-based anomaly detection and algorithms to identify and diagnose potential issues or malfunctions in real time. But it doesn't stop there: missions also heavily rely on AS and AI for navigation, onboard decision-making, communication, data processing, image processing and analysis, and resource management.

Lunar exploration 2.0

Significant investment is being put into lunar exploration 2.0.

[Hakuto-R](#)—developed by Japanese firm [ispace](#)—is on a journey to deploy rovers on the moon's surface. If successful, this will become the first private mission to land on the moon. Two private modules from the US—Peregrine and Nova-C—are also set to reach the moon in late 2023, while the [NASA Artemis mission](#) plans to build a base camp on the moon and a gateway in lunar orbit.



Image courtesy of NASA

Mars expeditions

The US, China, the European Space Agency, Russia, the United Arab Emirates, and India have all deployed spacecraft and rovers to study Mars and learn more about our closest planet. Goals include a search for life, understanding the surface and planet's evolution, and preparing for future human exploration.

Asteroid sampling

NASA's **OSIRIS-REx** mission successfully collected a sample from the asteroid Bennu to advance knowledge on the formation and evolution of our solar system. China also plans to sample a near-Earth asteroid and orbit an active asteroid in the coming decade.

While these developments are exciting and will advance human civilization for the better, they come with many new challenges. Primarily, exploring environments where no one has gone before.



CHAPTER 2

The Challenges Facing Space Organizations



The Challenges Facing Space Organizations

Given the advancing nature of exploration, there are a multitude of challenges facing space organizations, from budget constraints and regulatory requirements, to talent shortages and safety risks. In this section we'll explore these in detail.

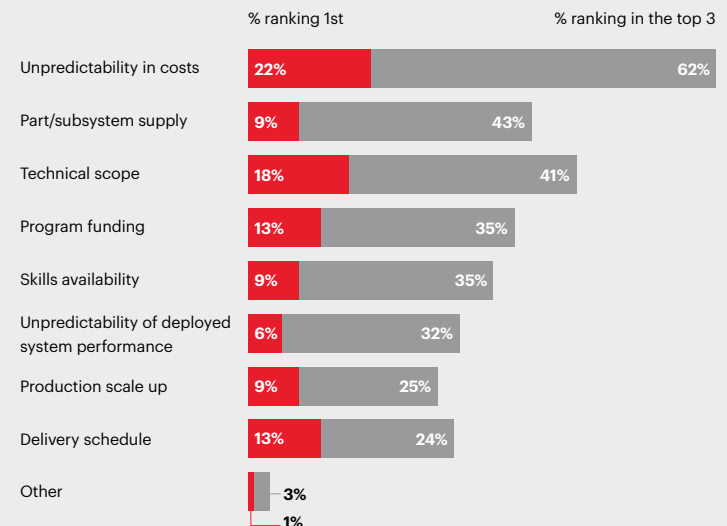
Budget

Going to space is expensive. While budgets are increasing overall, the process of developing, testing, and maintaining space-grade products and components at a competitive cost remains challenging. A recent Keysight [survey](#) of space and satellite companies showed unpredictability in costs as the top risk and concern for space exploration projects.

Regulatory requirements

Although stringent regulations are needed, the changing nature of these regulations can be difficult to manage. Regulatory requirements for safety, licensing spectrum allocation, export control, and environmental protection—combined with the cascade of qualification and acceptance tests—only add to the workload.

Greatest sources of risk to projects



Technical complexity

The technology used in space exploration is highly complex and continually advancing to maintain pace. The number of systems involved across the upstream, midstream, and downstream of the space development value chain is ever-increasing and interoperability is a crucial requirement for the majority of these systems.

Talent shortages

In a recent [survey](#), commercial space executives noted a shortage of skilled talent as one of the biggest challenges facing the industry. Government space organizations were already facing a labor shortfall because of challenges in matching pay from commercial organizations, but the skill gap has grown and commercial organizations themselves now face a similar problem.

Timelines

Timetables are shrinking. Space organizations are under pressure to release faster, with the same resources. With competition from commercial and government sectors accelerating production and launch rates, and regulatory approval tightening, these shrinking timelines seem impossible to maintain. In fact, space and satellite communications executives interviewed for the Keysight [Defying Gravity survey](#) said short development cycles are the top challenge facing the industry.

Safety

Space exploration has always held a meaningful place in human history, the imagination, and—crucially—in the media.

Now, with many initiatives in the works, and the world paying close attention, any missteps by a space organization can greatly affect public perception, stock prices and, ultimately, the bottom line.



The good news is AI-driven software test automation can help mitigate each of these challenges, while driving significant business results. [Read on to learn how.](#)



CHAPTER 3

The Promise of Software Test Automation

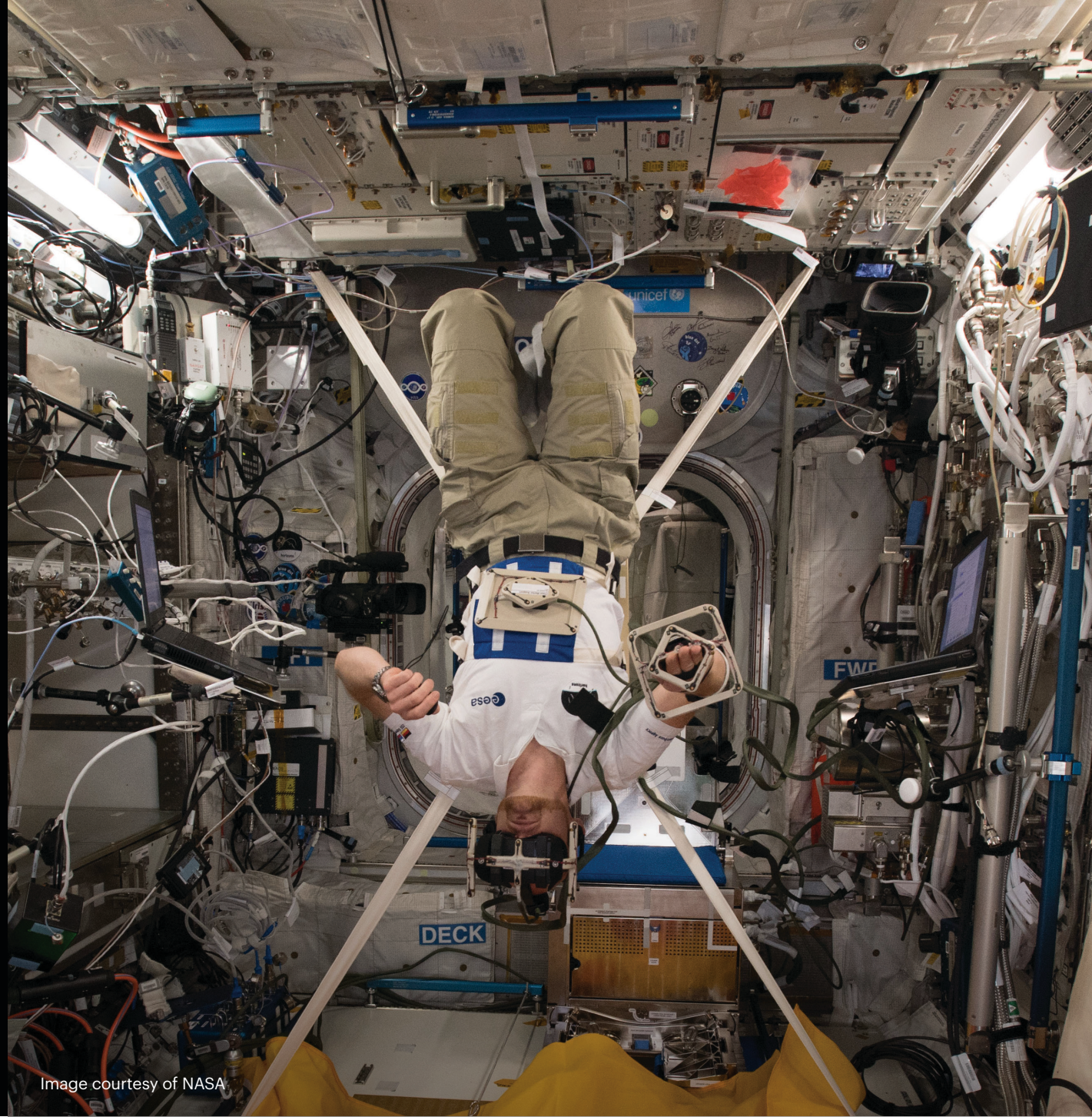


Image courtesy of NASA

The Promise of Software Test Automation

Traditional software testing relies on a person or team manually testing software by typing in thousands of lines of code, and trying to identify every action a user could take to simulate real-world scenarios. The tester creates a test case for each, executes that test, then documents and reports the results. Developers fix the issues, but often their fixes introduce new problems. As a result, testers must go through the whole process again. When the Document Object Mode (DOM) changes—and it will—the tester must rewrite every affected line of code, and the testing must start all over again.

Manual testing requires a significant amount of time and effort. For larger, more complex software projects like those used in the space industry, manual testing can take months. Even then, testing every feature and user function in depth is impossible.



The need for automation

Software testing for space requires a different approach. Organizations like NASA are increasingly turning to automated testing tools and techniques to streamline the process and improve test coverage. While it might sound ambitious to claim software test automation can alleviate all of the challenges cited in Chapter 2, it's certainly possible: here's how.

Budget

Software test automation can save space organizations hundreds of thousands of dollars by cutting time and money spent on testing, and reducing the cost of fixing bugs late in the cycle.

Regulatory requirements

Test automation tools can record the passes and fails of qualification and acceptance tests, including creating artifacts and reports. This level of automation reduces the amount of time required for testing while improving the accuracy and thoroughness of the testing process.

Technical complexity

Manual testing of space systems can be time-consuming and error-prone because of complex interoperability. Automation increases the speed and ease of testing by simulating the challenging conditions of space, and interactions between systems.

With constant modifications in space technology, continuous regression testing and error detection are critical to ensure changes to one part of the system don't break another. Some software test solutions use visual test development, where testers create and design automated test cases using graphical elements. This opens up software testing to practically anyone, allowing organizations to leverage cost-effective resources for the task at hand.

Shortage of skilled talent

Companies that automate testing can save hundreds of hours each week, depending on the size of the team. Morale also improves because automation frees team members from the manual, repetitive drudgery of testing, so they can focus on improving the product in exciting ways.

Timelines

Automation reduces testing from months down to hours. This not only frees up time for more important tasks, but also speeds up production and launch rates, and decreases errors so the development process can be accelerated.

Safety

The space sector operates under an implied zero-failure model because software bugs put lives at risk. Most software testing covers a single user journey called a happy path. But for space organizations, there is no single happy path because so many things can go wrong—whether it's a **thruster failure**, or hitting one of the **27,000 pieces of space debris** when leaving orbit.

That means you must consider and test every contingency well before launch.

Manually, it's nearly impossible to test every path, but with intelligent, AI-driven automated testing you can test every path and scenario extensively. A human can't test 24 hours a day in the same way software automation can.

Solving problems at zero knots and zero altitude is far easier than trying to fix an emergency while hurtling through space.

Space testing teams must consider all scenarios and possible user journeys that could occur during a mission. To make that happen, testing must become smarter.



Jay Epps,
Solution Engineering Manager,
Keysight Technologies

In search of a 'happy path' with AI testing

With almost half (49%) of missions **failing during the ascent phase**, smarter testing and anticipating these moments well ahead of time will save space organizations time, money, and—most importantly—lives.

49%

Failure rate during
ascent phase¹

63%

Failure rate during
payload injection phase¹

So how can you test for the unknown and ensure you have covered all possible user journeys? Or test for the stress and pressure that will affect astronauts' use of the software once they are 240,000 miles from Earth?

Space organizations must onboard technologies that maximize automation and AI testing to better plan for any eventuality—and ultimately drive better outcomes. The success of any mission heavily relies on the harmonious interaction between software and hardware, highlighting the crucial need for these systems to seamlessly integrate and function as one.

¹ Source





CHAPTER 4

Risk Reduction in Testing



Risk Reduction in Testing

By using cutting-edge technologies to optimize automation and AI-based testing in space, you can proactively identify and mitigate errors to avoid potential failures.

Artificial intelligence and machine learning are the foundation of space test automation software like Keysight Eggplant. The tools script any potential scenario to ensure a reliable spacecraft and ultimately keep everyone on board safe.

Test automation software provides visibility into how applications and interfaces can potentially succeed or fail at any moment. Through a combination of testing and monitoring capabilities, teams can explore real end-user journeys and behavior across multiple environments at any time, around the clock.

Working seamlessly across multiple interfaces and systems, the testing platform can understand and control a dashboard just as an astronaut would—following natural pathways and accounting for multiple error possibilities.

And through machine learning, the testing platform only gets smarter.

Once an error is detected, the software proactively looks for similar mistakes throughout the rest of the code and immediately flags them. **The AI thinks like a human**—but at a much faster rate—running 24 hours a day and testing variables across numerous systems without risk.



Greg Patschke,
General Manager of Aerospace, Defense, and
Government Solutions, Keysight Technologies



CHAPTER 5

NASA's Gold Standard Testing



Image courtesy of NASA

NASA's Gold Standard Testing

NASA's goal is to establish a long-term presence on the moon and eventually send astronauts to Mars. But to achieve this, the Orion spacecraft which drives these missions requires testing across all systems first—from rockets to splashdown parachutes—including the three main cockpit display monitors that control the vessel. To ensure these display panels operate without faults and remain safe for all onboard, NASA needed an efficient software testing solution to mimic human behavior.

NASA's Rapid Prototyping Lab (RPL) developed exact replicas of the cockpit interfaces and employed **Keysight Eggplant Test** automation software to address this challenge. By utilizing a cockpit mock-up, the RPL successfully simulates user interactions on the system under test (SUT) without the need for human intervention. Eggplant connects remotely to the SUT, runs scripts that emulate astronaut interactions—from keyboard entries to mouse clicks—and even predicts end-user actions in emergencies.



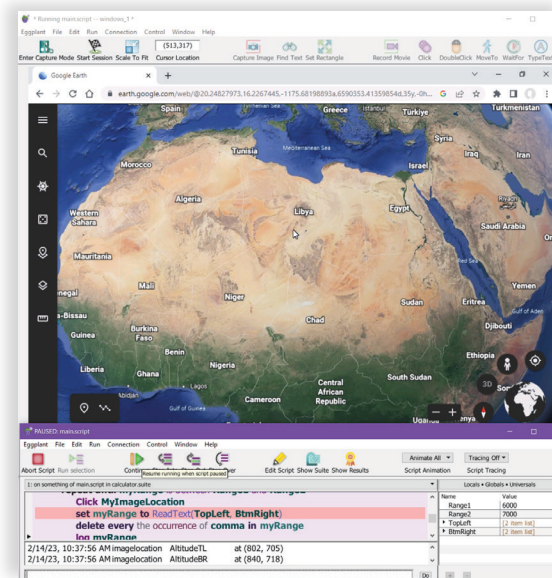
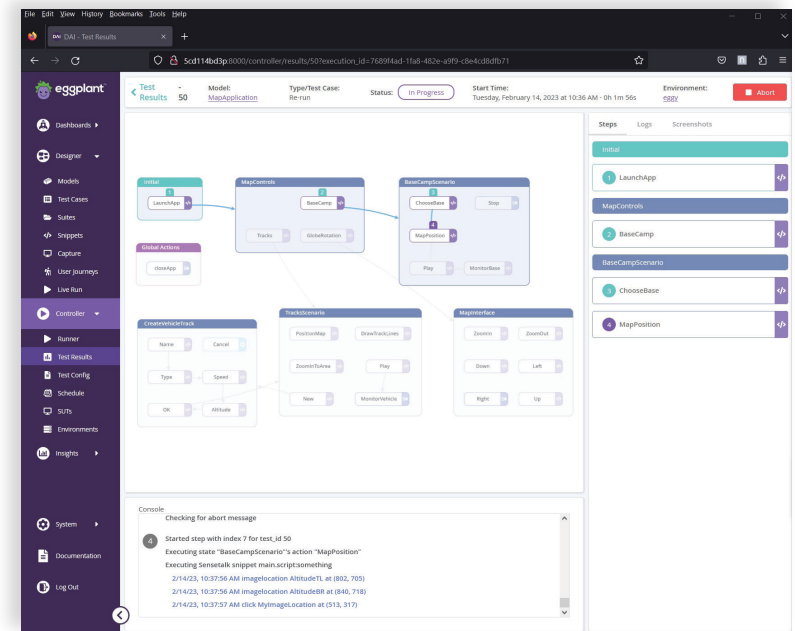
Image courtesy of NASA

One of the key advantages of Eggplant is its ability to dynamically test the software's user experience, even under highly stressful simulated conditions. Given the sheer amount of code involved, manually testing the programs would take a significant amount of time and resources. Eggplant enables Orion's testers to reduce testing time and increase efficiency while easily accounting for the entire testing life cycle. Test automation results in a quicker turnaround time for the RPL, giving testers more time to stress-test software systems and ensure functionality in the event of a change or update to the underlying software. Read the full story about Orion software testing [here](#).

These days ... so much more of the capability is embedded in the software and in the touch panels, and **that's really where Keysight and the Eggplant capabilities come in**, because how in the world do you test every single aspect of that software with people? You really can't. You've got to be able to run it through its paces in a way that is more robust than we can do as 10 astronauts sitting there trying to break it.



Chris Cassidy,
Retired Chief Astronaut of NASA
and ISS Commander



Eggplant seen here utilizing Google Earth. Eggplant zooms in on a location until it reaches a specific point. Then it switches to monitoring the screen for changes. When Eggplant sees certain triggers, it sends an alert. An example would be a group of warfighters entering a restricted zone, or detecting a threat within a set distance.

Conclusion

With so many unpredictable scenarios an astronaut might encounter, testing for every scenario is critical to ensure a successful mission. An incredible amount of forethought is involved to ensure that all controls, interfaces, and systems work as they should.

AI and machine learning in your software test automation tool helps you anticipate and predict those issues long before they arise—preventing errors in critical moments. **Contact us** to learn how Keysight Eggplant can dramatically enhance the quality, responsiveness, and performance of your software application. Or see for yourself by **taking a tour** of Eggplant software.

Want to learn more?

- Watch our webinar **Mach-Speed Software Testing for Safe Space Travel** on-demand today to hear more about NASA's software testing program and Chris's experiences on the International Space Station (ISS).



Image courtesy of NASA



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.

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