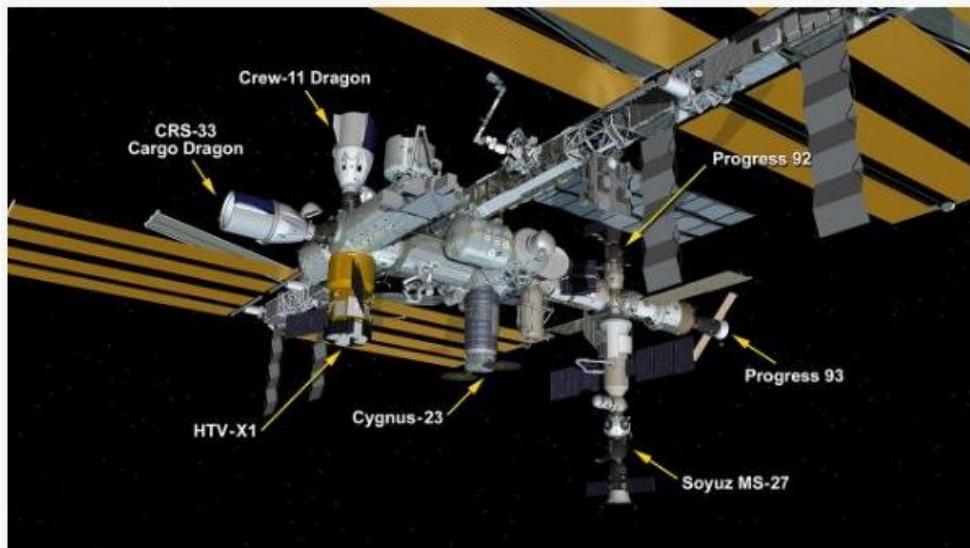


Will ISS Scientific Research become Obsolete?

A German journalist wrote in his newsletter 'Mr. Sternzeit' [1]

"After a quarter of a century [of ISS operations], all those involved should take an honest look at the dreams of the past. The results are sobering. Yes, interesting scientific experiments in materials science, physics, medicine, and biology are taking place in zero gravity. These experiments involve the growth of protein crystals, the formation of bubbles when liquids boil, and the exploration of new alloys (liquids of different densities can be perfectly mixed up there – the pulp in the juice doesn't sink to the bottom). However, most of these experiments could also be carried out much more cost-effectively and automatically on satellites – human presence is not absolutely necessary."



Oct. 29, 2025: International Space Station Configuration. Seven spaceships are parked at the space station including the SpaceX Dragon cargo craft, the SpaceX Crew-11 Dragon spacecraft, JAXA's HTV-X1 cargo craft, Northrop Grumman's Cygnus cargo craft, the Soyuz MS-27 crew ship, and the Progress 92 and 93 resupply ships.

NASA

That raised the theoretical question for me: **Could AI eventually replace human presence for scientific activities on the ISS?** - As the ISS is also a big satellite after all.

Here are some alternatives as proposed by chatGPT:

AI could eventually take over **some** science activities on the ISS, but a full replacement of human researchers is unlikely in the near future. Instead, the future is more realistically a gradual shift where AI handles larger portions of routine or hazardous work while humans focus on oversight, creativity, and mission-level decisions.

1. Autonomous Experiment Management

AI systems could:

- Adjust experimental parameters in real time based on sensor feedback.
- Detect anomalies faster than humans.
- Run long-duration experiments without crew intervention.

Scenario:

A biology experiment grows organoids in microgravity. An onboard AI monitors growth via imaging,

adjusts nutrient flow, and terminates the experiment when optimal conditions are met—all without astronaut input.

2. Robotic Lab Technicians

Robotic systems like NASA's Robonaut or Astrobee could be paired with advanced AI to perform “hands-on” tasks:

- Handling delicate samples
- Performing calibration steps
- Cleaning equipment
- Swapping experiment cartridges

Scenario:

A robotic assistant equipped with dexterous manipulators replaces an entire cycle of astronaut labor needed to manage fluidic experiments, freeing crew time for spacecraft maintenance or EVA preparation.

3. AI-Driven In-Orbit Data Analysis

Instead of sending raw data to Earth:

- AI compresses, filters, and interprets results onboard
- Flags only relevant findings
- Allows for adaptive experimentation in real time

Scenario:

A physics experiment involving cold atoms is run by an onboard AI that models the system, notices an unexpected measurement trend, and automatically adjusts laser configurations to explore the anomaly.

4. Fully Autonomous Free-Flying Lab Modules

Future stations may include “AI-run mini-labs” that:

- Host experiments needing no human presence
- Operate as detachable satellites or extensions of the main station
- Automatically reinstall on the station for sample transfer or power cycles

Scenario:

A free-flying cube-lab conducts crystallization experiments for months, reattaches to the station only when it needs hardware servicing or sample return.

5. Crew Support and Simulation

AI could act as:

- A research advisor
- A planning and scheduling system
- A simulation tool for predicting experiment outcomes

Scenario:

Astronauts propose several experiment configurations. The AI instantly simulates them, predicting which will yield the most valuable results before any real-time resources are used.

6. Completely Autonomous Stations (Long-Term Vision)

Far beyond current capabilities, an AI-operated orbital platform could:

- Run, maintain, and repair its own lab systems

- Launch or retrieve small sample-return capsules
- Conduct continuous research for decades with minimal human oversight

This would look less like “AI replacing humans on the ISS” and more like “a new class of AI-run orbital laboratories.”

[However, the financial impact for design and development of such a project must seriously be traded off – J. Kehr Editor]

Bottom line

AI is poised to increasingly support, augment, and partially automate science on the ISS. Full replacement of human scientists is unlikely soon due to:

- The creativity and improvisation humans provide
- The complexity of ISS systems
- Safety and oversight requirements

But a hybrid future—human astronauts backed by autonomous AI laboratory systems—is not only possible but already beginning.

Follow-up question to ChatGPT

Could the above scenarios and results be achieved *with AI on Earth* also?

Short answer: **Some, yes — but not all.**

Many tasks AI could perform on the ISS *can* be done on Earth, but the **science outcomes** would often be *different* because Earth lacks microgravity, vacuum exposure, cosmic radiation levels, and orbital conditions that create unique research environments. Below is a summary breakdown.

Summary

Scenario from previous answer	Can AI do it on Earth?	Limitation
Autonomous experiment operation	✓ Yes	Environment differences
Robotic lab technicians	✓ Yes	Can't replicate microgravity workflows
Autonomous data analysis	✓ Yes, even better	None (Earth easier)
Free-flying AI-run lab modules	✗ Not fully	Orbital conditions missing
AI as research advisor	✓ Yes	None
Fully autonomous orbital labs	✗ No	Requires orbit

AI can perform all the “intelligence” and “operation” tasks on Earth.

AI cannot reproduce the *microgravity-dependent science* that makes ISS research unique.

The following research disciplines require zero-gravity, i.e., space environment:

Fluid physics, Crystal growth, Combustion physics, Human physiology in zero-g, Radiation exposure studies, Materials processing (alloys, containerless).

However, AI can simulate some *aspects* of orbital microgravity, but it cannot fully replace the physical environment of space. AI and computational physics can model many microgravity-related phenomena mathematically, i.e. AI can simulate **patterns, predictions, and models** of microgravity experiments.

But AI cannot **physically recreate**:

- Continuous weightlessness

- Orbital fluid physics
- Space radiation
- Microgravity-driven biological changes
- Unforeseen emergent behavior

Therefore:

AI can complement orbital research, reduce the number of experiments flown, and optimize experiment design—but it cannot fully replace the need for actual experiments in orbit.

That sums it up pretty good: human tented microgravity research must be continued in orbit – a goal pursued by China unfazed.

References

[1] <https://archive.newsletter2go.com/?n2g=y8byg6h3-bvbk3r8n-2uk>

[2] chatGPT

December 2025, Joachim J. Kehr Editor Journal of SpaceOperations & Communicator
<https://opsjournal.org>