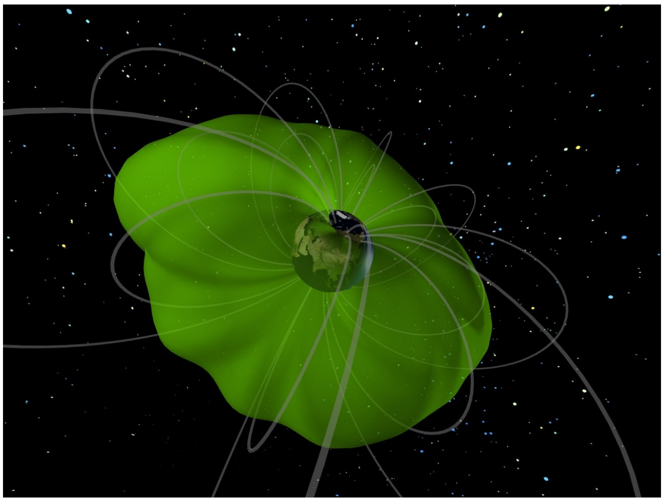
NASA's newly rediscovered IMAGE mission provided key aurora research

2 February 2018, by Miles Hatfield



An oblique view of the plasmasphere, reconstructed from IMAGE data. Credit: NASA's Goddard Space Flight Center Scientific Visualization Studio/Tom Bridgman, lead animator

On Jan. 20, 2018, amateur astronomer Scott Tilley detected an unexpected signal coming from what he later postulated was NASA's long-lost IMAGE satellite, which had not been in contact since 2005. On Jan. 30, NASA—along with help from a community of IMAGE scientists and engineers—confirmed that the signal was indeed from the IMAGE spacecraft. Whatever the next steps for IMAGE may be, the mission's nearly six years in operation provided robust research about the space around Earth that continue to guide science to this day.

On March 25, 2000, NASA launched the Imager for Magnetopause-to-Aurora Global Exploration, or IMAGE, mission. It was the first mission to use neutral atom, photon and radio imaging techniques to produce large-scale, simultaneous measurements of the charged particles that exist in near-Earth space—namely in our magnetosphere, the magnetic fields that surround our planet, and its inner bubble of cold material called the plasmasphere.

"IMAGE was a discovery machine and a seminal mission that gave us a broader perspective on Earth's environment and its ever-changing magnetosphere," said Jim Green, director of planetary science at NASA Headquarters in Washington, who worked as a co-investigator and deputy project scientist for IMAGE. "Much of my career as a magnetospheric physicist was with IMAGE, and the science was transformative."

Originally designed as a two-year mission, IMAGE was approved twice to continue its operations. But when the spacecraft unexpectedly failed to make contact on a routine pass on Dec.18, 2005, its promising tenure seemed to be cut short.

Investigations into possible causes of failure suggested that the transmitter controller power source was tripped, possibly by an incoming high-energy cosmic ray or radiation belt particle. It was hypothesized that passing through a dramatic change in energy—such as what happens when a spacecraft experiences total darkness during an eclipse—could potentially reset the spacecraft. But after a 2007 eclipse failed to induce a reboot, the mission was declared over.

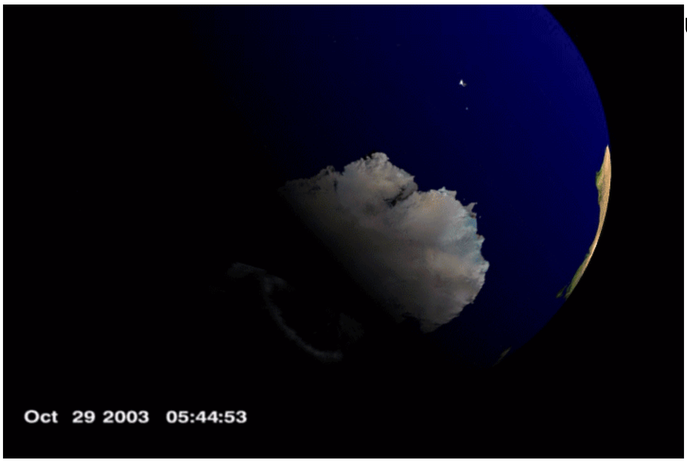


IMAGE captured the South Pole aurora caused by a coronal mass ejection in the fall of 2003. Credit: NASA's Goddard Space Flight Center Scientific Visualization Studio/Tom Bridgman, lead animator

What was the IMAGE mission?

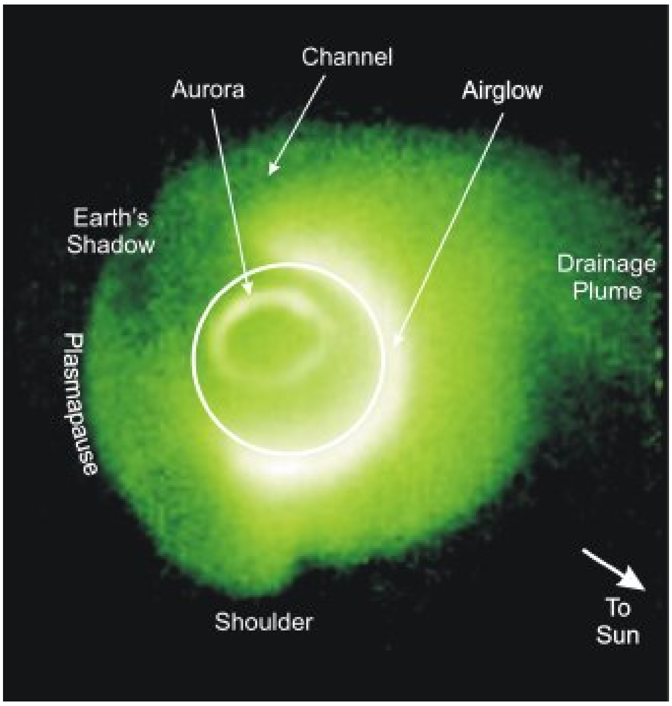
Before that, however, IMAGE was a powerhouse. The data collected during its nearly five years of operation led to some 40 new discoveries about Earth's magnetosphere and plasmasphere. Many of these discoveries had their basis in energetic neutral atom, or ENA, imaging, a novel technique pioneered by IMAGE to render the invisible visible.

The technique makes use of some fundamental space physics. Particles with an electric charge—like the ions that make up much of the plasma in the magnetosphere—are bound to Earth's magnetic field lines, spinning around them like a yo-yo on a string. But when they crash into neutral particles, the charged particles can steal the neutral's electrons in a process called charge exchange, becoming neutral themselves.

No longer magnetically bound, these energetic neutral atoms barrel off into space in whatever direction they were heading when the collision occurred. ENA instruments capture these neutral atoms and use them to build up large scale images of the surrounding plasma, similar to how ordinary cameras capture light rays to create pictures.

In combination with ENA instruments, IMAGE also used ultraviolet and radio imaging techniques that together led to many of IMAGE's most notable accomplishments. Among them is the confirmation of the plasmaspheric plume, a region of plasma particles that flow backwards toward the Sun on Earth's dayside. Such a backflow had been predicted by models, but never directly observed by spacecraft.

"It's as if you're driving in a convertible," said Thomas Moore, the mission scientist for IMAGE, as well as the lead for the spacecraft's Low Energy Neutral Atom (LENA) Imager at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "The air is rushing against the car in one direction, but your hair will blow towards the windshield."



Earth's plasmasphere and plume as measured by IMAGE’s Extreme Ultraviolet Imager. Credit: Sandel, B. R., et al., *Space Sci. Rev.*, 109, 25, 2003

IMAGE produced large-scale images every two minutes. The rapid cadence of imaging allowed scientists to knit the images together to create frame-by-frame movies that could show the vast scale of charged particle interactions in near-Earth space, including those that cause the aurora.

The missions that had flown before IMAGE had only been able to gather measurements at a single point in time and space—catching the particles the spacecraft happened to fly through at the time, rather than capturing a wide panoramic view. But such point measurements are challenging to interpret.

"The trouble with a single point measurement is you're always moving around and you're never quite sure if the variation that you see is because you've moved to a different place or because something has changed globally in the system," Moore said. "I used to liken space physics before IMAGE to trying to study severe storms by driving around with a rain gauge out your window."

IMAGE drastically changed the playing field. "We suddenly had a camera that could see the whole system," Moore added.

But IMAGE didn't just make pretty pictures: It was also the first space science mission to formally include an education and public outreach program (POETRY) as part of its proposal to NASA, specifically setting aside a budget for such activities. Partnering with elementary, middle and high school teachers, IMAGE's science findings were incorporated into lessons and classroom activities.

While IMAGE's future continues to unfold, its legacy has already proven its worth: The information it gleaned with its wide-range view provides an important complement to missions looking at smaller scales of the magnetosphere, including the highly successful Magnetospheric Multiscale mission, or MMS, launched in March 2015 and currently in orbit.

Provided by NASA's Goddard Space Flight Center
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