HyperStar on the ISS

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An optical system developed for amateur astronomers goes to the International Space Station.

WE ALL KNOW that technology pioneered by professional astronomers has become commonplace in the arsenals of today's amateur astronomers. But did you know that the tables have turned, and that an off-the-shelf product created specifically for amateur astrophotographers is currently assisting with professional research aboard the International Space Station (ISS)?

Called HyperStar, it's an optical component for Schmidt-Cassegrain telescopes that transforms them into high-speed, wide-field imaging telescopes. It was developed by Dean Koenig of Starizona, an Arizona-based astronomy store, and it lies at the heart of the Pathfinder camera system officially known in NASA-speak as ISERV, an acronym for the International Space Station Environmental Research and Visualization System. The project is part of a larger NASA collaboration with the United States Agency for International Development known as SERVIR.

Unlike HyperStar's ground-based counterparts, the orbiting telescope is poised to look back at Earth rather than into space. Its mission is to provide urgently needed images for monitoring the impact of calamitous events such as tsunamis, hurricanes, earthquakes, volcanic eruptions, and great fires, and it's already helping countries respond to these natural disasters. It is also being used to monitor long-term environmental changes on the ground.

HyperStar on Earth

Koenig's idea for HyperStar dates back more than a decade to when he was discussing Celestron's Fastar imaging system with optical designer Richard Buchroeder. Developed in the late 1990s, the Fastar optical assembly was fitted in place of the secondary mirror on selected Celestron Schmidt-Cassegrain telescopes,

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Following page: **Pathfinder's "first light" image was taken February 16, 2013, as the International Space Station passed over wetlands at the mouth of Panama's Rio San Pablo, where the river flows into the Golfo de Montijo.** ***Above right:*** **In the microgravity of ISS's Destiny module, Canadian astronaut Chris Hadfield readies Pathfinder for installation in the Earth-facing Window Observational Research Facility (*right*) in January 2013.**

transforming them into ultra-fast imaging systems. Buchroeder pointed out that the Fastar design was good, but could be improved. By 2003 Starizona introduced its HyperStar optics for several models of Celestron's Fastar-compatible telescopes, and soon after Celestron discontinued its Fastar accessory while continuing to make selected telescopes compatible with HyperStar. The optical system is now also available for several models of Meade Schmidt-Cassegrain telescopes. A review of HyperStar for deep-sky astrophotography appears in the February 2010 issue, page 34.

As an astronomical imaging system, HyperStar has racked up an impressive set of credentials. A HyperStar-equipped Celestron telescope helped celebrate the International Year of Astronomy at the White House in October 2009. American amateur Fred Bruenjes used a 14-inch Meade fitted with a HyperStar to discover Comet C/2012 C2 (Bruenjes) in February 2012. And Australian Terry Lovejoy used an 8-inch Celestron and HyperStar to discover the spectacular sungrazing Comet C/2011 W3 (Lovejoy) at the end of 2011.

HyperStar in Space

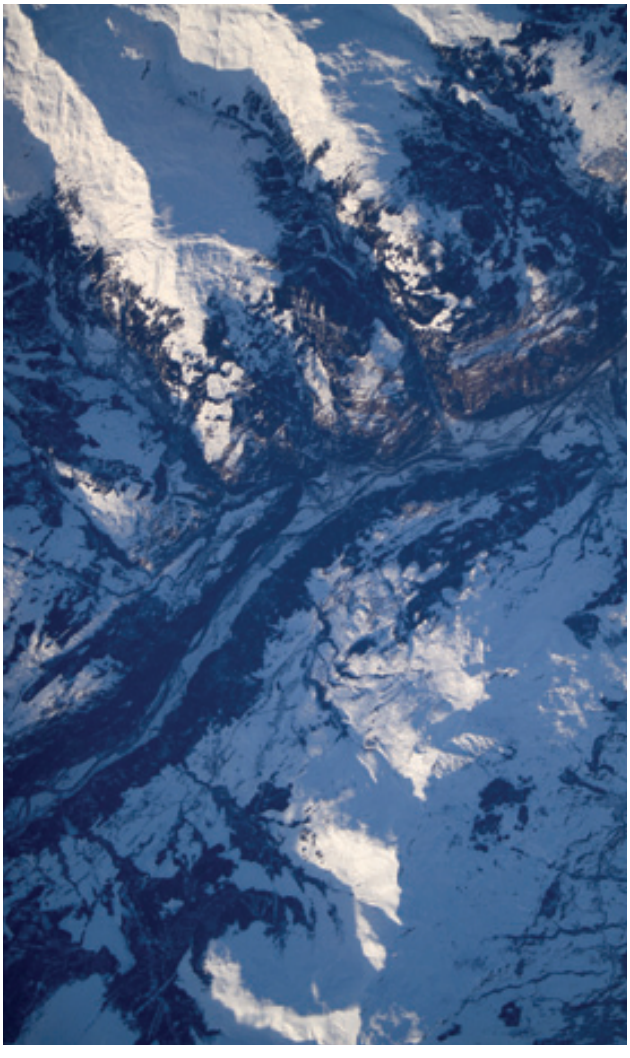
HyperStar's route to the ISS began with Burgess Howell, a scientist at NASA's Marshall Space Flight Center in Huntsville, Alabama. Howell is ISERV's principal investigator and payload developer. The project is a first step in giving scientists operational experience acquiring fully automated Earth-monitoring images from the observation window in the ISS's Destiny module. The experience and expertise gained from this relatively low-cost project will probably lead to the design and construction of a much more capable system that will be externally mounted on the ISS.

Howell says that his group "sought out equipment that was essentially off the shelf" for the Pathfinder system. A breakthrough occurred when he was talking to Starizona's Koenig at a recent Pacific Astronomy and

Below left: **Pathfinder views the rugged terrain on the eastern side of the Argolic Gulf near the Greek village of Kilada, seen at bottom center.** ***Below:*** **The snow-covered Swiss Alps were another target for Pathfinder's remotely controlled camera aboard the ISS.**

NASA / BURGESS HOWELL, ISERVIR

Above: **This pair of images captured the height of the flooding that inundated downtown Calgary, Alberta in June 2013. The pictures were quickly relayed to Canadian officials to improve the response to the natural disaster.**



Telescope Show in Pasadena, California. Howell asked Koenig about the possibility of imaging Earth with a HyperStar-equipped telescope on the ISS. "You have to be kidding!" was Koenig's initial reaction of shock. But when Howell made it clear he was serious, Dean jumped aboard instantly. "Let's do it!" he said, and a partnership was born.

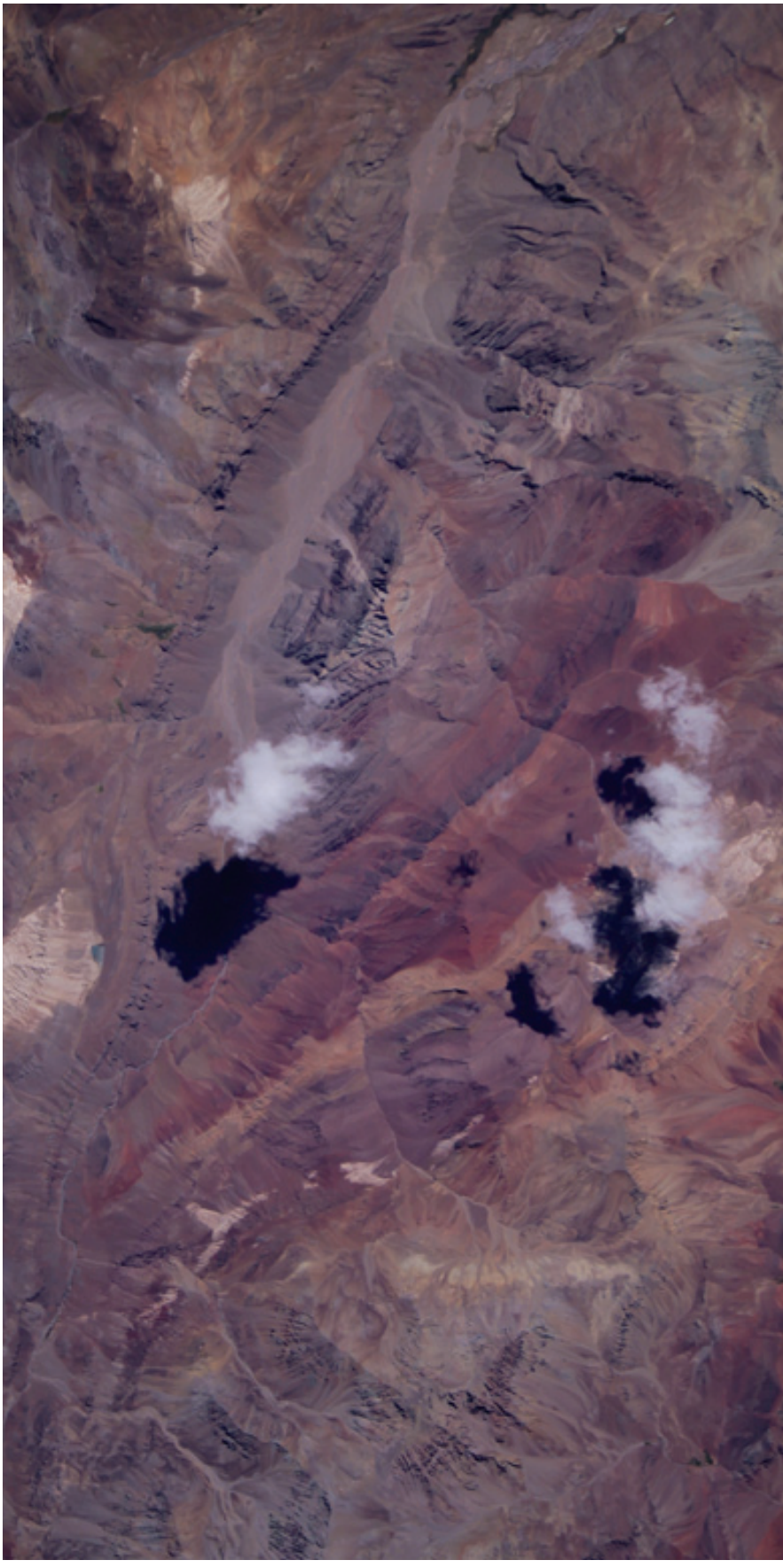
The team had many issues to deal with once the project began. Their first decision was to determine the best telescope assembly that WORF (NASA's acronym for the Window Observational Research Facility) aboard the ISS could support. At first they considered an 8-inch Celestron, but later opted for the increased aperture of Celestron's 9.25-inch Schmidt-Cassegrain telescope. Because of WORF's limited dimensions, however, the larger scope's mount and fork arms were not the right size for aligning the telescope's optical axis with the center of the window. Koenig suggested using smaller fork arms from an 8-inch Celestron as a support for the 9.25-inch telescope tube. Such a hybrid mounting would restrict vertical motion of the telescope for most astronomical applications, but there was still enough motion for the orbiting setup.

Another modification was to slide the telescope tube back between the fork arms. This would enable the telescope to pan around a larger field below the spacecraft when the front of the telescope was mounted as close as possible to the WORF window. Koenig noted that such a modification would not work efficiently on Earth because it would be difficult to balance the telescope, but this isn't a problem for the microgravity conditions aboard the ISS. The motorized mount allows the telescope to pan up to about 20° from the point on Earth directly below the ISS. This gives a sweep of about 140 miles (225 km) to either side of the spacecraft's ground track. Overall, the system will be able to image up to 70% of Earth's surface where 95% of the world's people live.

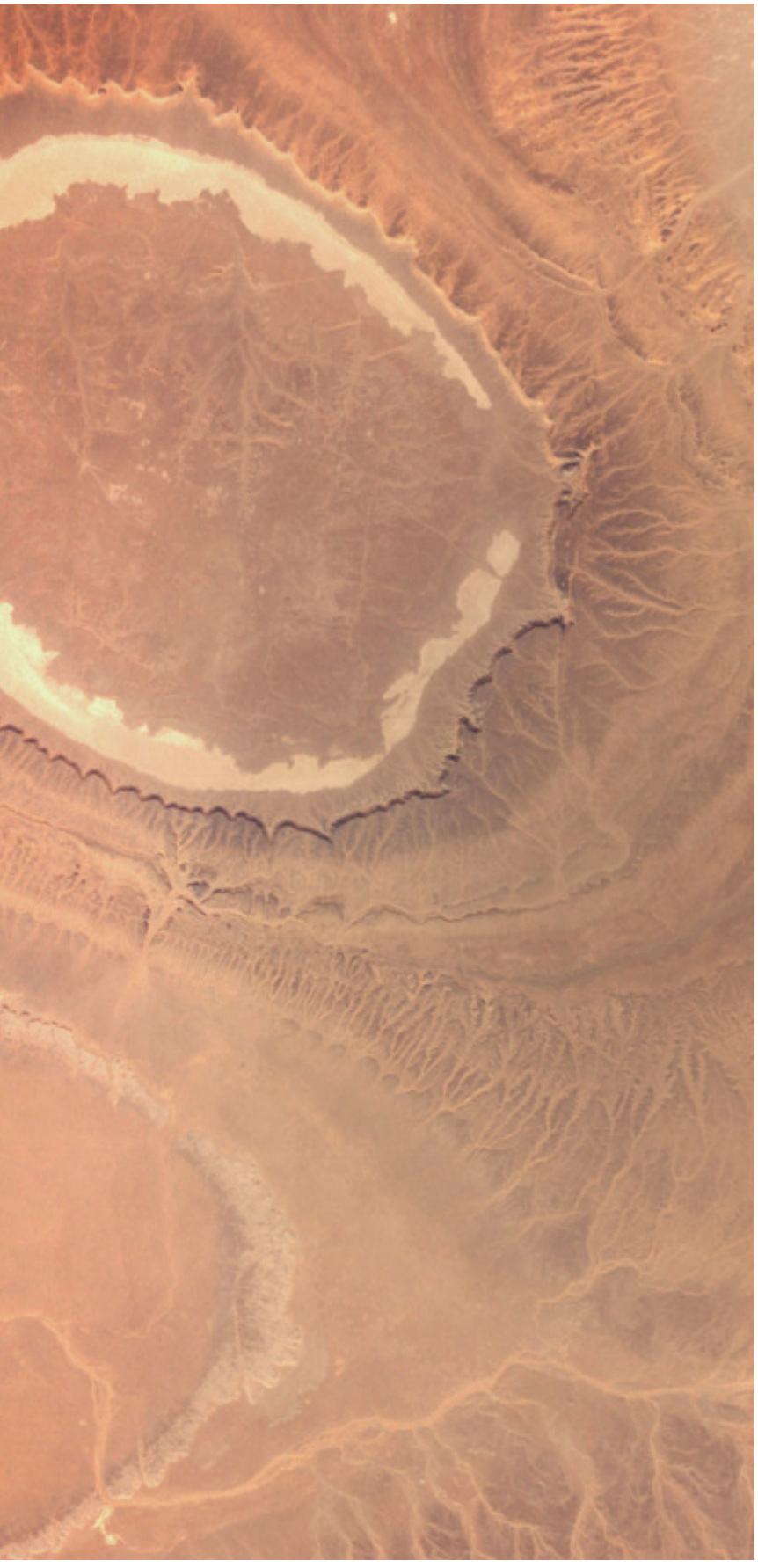
The Pathfinder images are captured with a Canon EOS 7D DSLR camera attached to the HyperStar in the same manor that amateurs use HyperStar for astronomical imaging. The system's extremely fast focal ratio allows exposures of 1/8,000 second, which are necessary for freezing the apparent ground motion as the ISS orbits our planet at 17,000 miles per hour.

From the ISS's nominal altitude of 220 miles, each Pathfinder image covers a relatively small 8-by-5½-mile footprint with a resolution of about 10 feet. The system can capture as many as three to seven high-resolution frames per second.

According to Howell, a big advantage of the Pathfinder images is that they can be transmitted in near real time, unlike traditional satellite imagery, which takes time to process. The rapid availability of Pathfinder's images



This Pathfinder image captured small clouds drifting lazily above the mountainous region near Valparaiso, Chile.



DEAN KOENIG

Above, left to right: **Starizona's Steve Koenig, Scott Tucker, and Donna and Dean Koenig show off the HyperStar-equipped Celestron telescopes they modified for Pathfinder.** ***Left:*** **The orbiting camera captured this unusual feature in the desert of central Algeria about 85 miles (135 km) south of the town In Salah.**

could make a big difference in determining how officials respond to natural disasters.

The Pathfinder headed to the ISS on July 20, 2012, 43 years to the day after Neil Armstrong first set foot on the Moon. It hitched a ride to the ISS aboard an HTV-3 supply rocket launched from a rain-soaked pad at Japan's Tanegashima Space Center. After a week of lazy travel, the rocket docked with the ISS, and its payload was transferred to the orbiting laboratory.

It wasn't until January 2013, however, that Canadian astronaut Chris Hadfield had the job of installing the telescope on its WORF perch. With everything installed and the camera accurately focused, first-light images from Pathfinder were made the following February 16th as the ISS passed over the mouth of the Rio San Pablo in Panama. A few months later the camera recorded two-dozen images of the flooding that ravaged parts of downtown Calgary, Alberta, forcing the evacuation of more than 100,000 people. Those images were quickly sent to Canadian officials to help them respond to the flooding. You can read more about this and other environmental events that Pathfinder's images are helping to monitor at the SERVIR Global website **www.servirglobal.net**.

According to Corey Lee, Celestron's vice president for product development, the company is "excited and proud that a Celestron telescope is in space assisting NASA's quest for knowledge." Although Celestron and HyperStar's many Earth-based users are happy to see this equipment being used on the ISS, the most animated person of all remains Koenig, who was included in a 2012 NASA Silver Achievement Medal presented to the ISERV team. Whenever the project is brought up in conversation, Koenig's eyes light up. After years developing ideas and equipment to benefit amateur observers and astrophotographers, to see one of his products orbiting in space is a sweet thrill indeed. ✦

Long-time amateur astronomer, comet discoverer, and author ***David Levy*** *lives with his wife, Wendee, on the outskirts of Tucson, Arizona. They maintain the website* ***www.jarnac.org****.*