Launching an Alert System for the Changing Sky

With the debut of a public alert stream, the Rubin Observatory demonstrates the ability to report transient signals—from supernovae, variable stars, active galactic nuclei and asteroids—in near real time.

By **Matteo Rini**

"Bright star, would I were stedfast as thou art," John Keats wrote in 1820. For centuries, the night sky appeared serene and unchanging—until modern astronomy revealed it to be anything but steadfast. As the NSF–DOE Vera C. Rubin Observatory comes online, our ability to measure that change systematically is about to expand dramatically. With an unprecedented ability to record a time-lapse view of the Southern Sky, Rubin will capture everything that flickers, flares, or moves. Last week, Rubin gave astronomers a first taste of its reach, releasing its first stream of discovery alerts, each flagging a fleeting event that could prompt telescopes around the world to take a closer look.

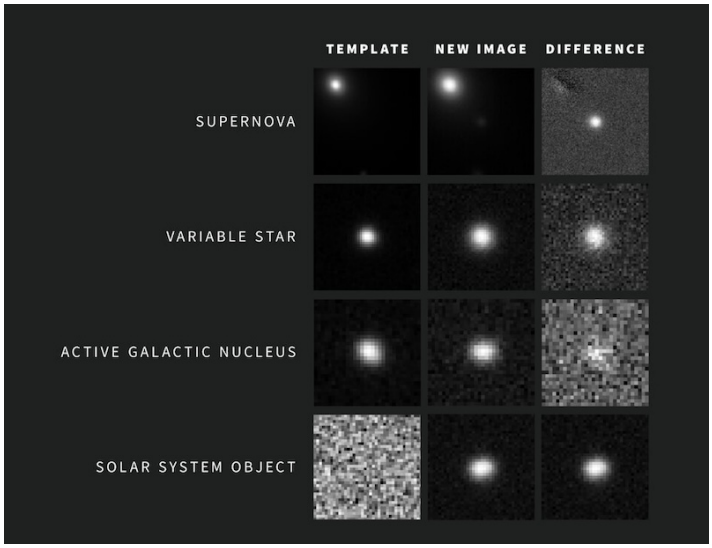
Long-exposure image of the Rubin Observatory on its perch atop Cerro Pachón in Chile.
Credit: RubinObs; NOIRLab; SLAC; NSF; DOE; AURA; P. Horálek/Institute of Physics in Opava

After releasing its "First Look" images in June 2025 (See **Research News: First Takes of the Largest Astronomical Movie Ever**), the observatory in the Chilean Andes has now put its potential for real-time alerts on display. In a single night—February 24—Rubin generated roughly 800,000 alerts. Each is derived from an automated comparison: New images of a patch of sky are measured against a reference, or template, image built from earlier observations of the same region. "The largest spot-the-difference effort ever has begun!" announced the Rubin collaboration on social media.

The initial haul included familiar kinds of transient objects: stellar explosions (or supernovae), variable stars, active galactic nuclei powered by supermassive black holes, and close-by objects such as asteroids zipping around in our Solar System. The volume of detections offers a sense of what lies ahead. Once fully underway, the survey is expected to generate millions of such alerts each night, says Rosaria Bonito, a researcher at the INAF Astronomical Observatory of Palermo in Italy and co-chair of Rubin's Transients and Variable Stars Science Collaboration.

For Phil Marshall, a scientist with SLAC National Accelerator Laboratory in California who serves as Rubin's Deputy Director of Operations, the first flood of alerts represents the culmination of years of construction, testing, and commissioning. The collaboration is now making the final tuning of this precision instrument: reducing heat sources, mitigating scattered light, and optimizing dome ventilation. "We are on the verge of starting the survey," Marshall says.

"What's revolutionary about Rubin is its ability to capture both



"Postage stamp" images shared in Rubin's first alert stream. For each object of interest, the difference is derived by subtracting a previously acquired template from a new image.
Credit: NSF–DOE Vera C. Rubin Observatory; NOIRLab; SLAC; AURA

Artist's rendition of the first alert stream from the Rubin Observatory. The sky is speckled with alert "pings," each indicating a detected change. Different icons indicate the association with various types of astronomical objects.
Credit: NSF–DOE Vera C. Rubin Observatory; NOIRLab; SLAC; AURA; P. Marenfeld; J. Pinto

rapid changes and long-term evolution in the sky," says Bonito. That capability is central to her research on young stellar objects—newborn stars whose brightness can fluctuate on timescales from hours to years as they accrete surrounding material. And Rubin's ability to flag brightness variations associated with eruptive outbursts in these young stars will be crucial for triggering follow-up spectroscopic observations, which could unveil the physical mechanisms behind such outbursts.

The first alert release gives scientists a chance to work with real data before full operations begin, says Marshall. The release is a precursor to the 10-year Legacy Survey of Space and Time (LSST), expected to start this spring. The current alert rate remains relatively low while the observatory builds up the reference images needed to detect changes across the survey area. Once LSST is fully underway, the number of alerts could surge to seven million per night.

Rubin will tackle this data bounty through community-built "brokers." The collaboration has set up nine brokers—involving groups of astronomers, data scientists, and software developers—who use machine-learning algorithms to process the raw alert stream before distributing it to scientific teams and observatories. The alerts will be fully public and include the light-curve history and small "postage stamp" images of the source, the template, and their difference, says Marshall.

The observatory is set to play a key role in the era of multimessenger astronomy. Through a special program, called "target of opportunity," the Rubin collaboration reserves a small fraction of its schedule for rare, time-sensitive events flagged by gravitational-wave detectors such as LIGO, Virgo, and KAGRA. Those instruments can localize signal sources only to broad regions of sky. If a gravitational-wave event has a visible counterpart—as is the case for a neutron-star merger (See **Viewpoint: Neutron Star Merger Seen and Heard**)—Rubin can quickly scan the area and help pinpoint the source, which can then become the target of multiple telescopes that probe different wavelengths of radiation.

The enormous amount of data expected from Rubin will help researchers answer questions on solar system science, on the nature of black holes, and on the origin of structure in our Universe, says Samaya Nissanke, a scientist at DESY Research Center in Germany and member of two LSST science collaborations (Transients and Variable Stars, and Dark Energy). Rubin's alert stream builds on two decades of progress in

time-domain astronomy by smaller-scale projects, such as the Zwicky Transient Facility, by adding unprecedented depth, scale, and cadence, she says. “You can compare these developments to a shift from still images to Technicolor films.

Correction (20 March 2026): *The text was amended to acknowledge previous contributions in time-domain astronomy.*

Matteo Rini is the Editor of ***Physics Magazine***.