NASA creating a virtual telescope with two small spacecraft

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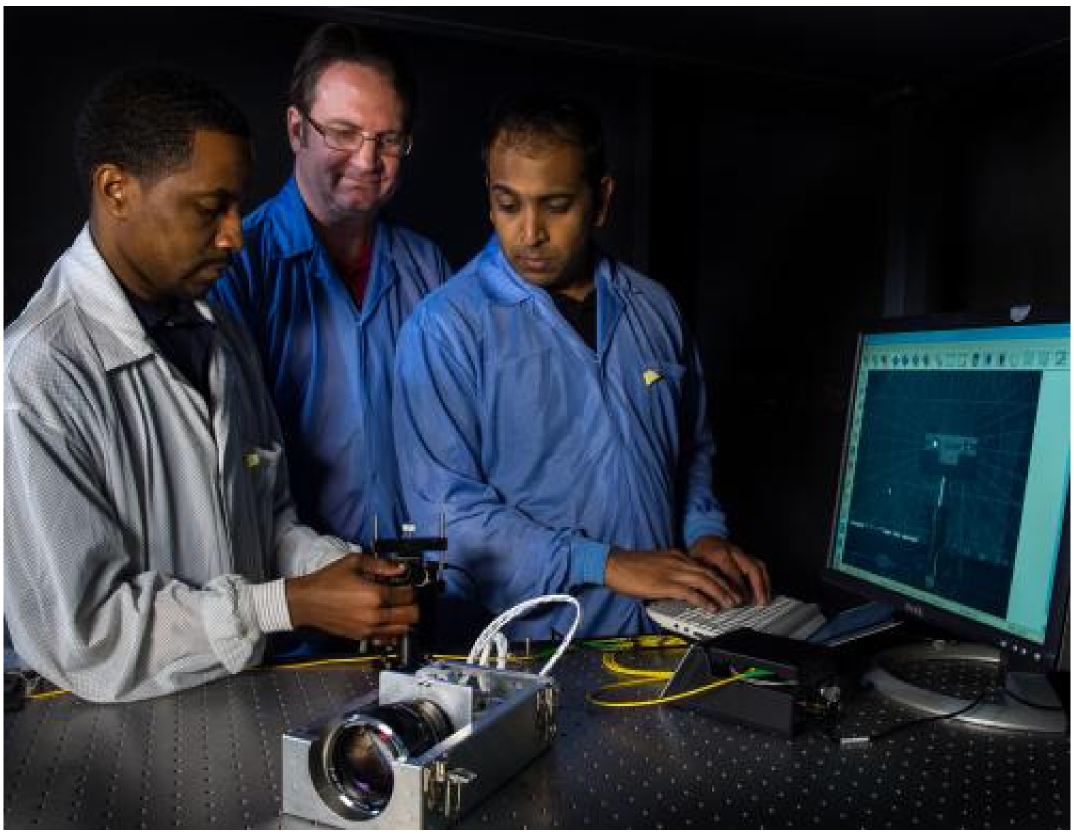

Semper (left), Calhoun, and Shah are advancing the technologies needed to create a virtual telescope that they plan to demonstrate on two CubeSats. Credit: NASA/W. Hrybyk

Although scientists have flown two spacecraft in formation, no one ever has aligned the spacecraft with a specific astronomical target and then held that configuration to make a scientific observation—creating, in effect, a single or "virtual" telescope with two distinctly different satellites.

A NASA team, led by aerospace engineer Neerav Shah of NASA's Goddard Space Flight Center in Greenbelt, Maryland, is not only developing the guidance, navigation, and control (GN&C) technology needed to execute such an exacting orbital configuration, but also is planning to demonstrate the capability on two CubeSats—in itself a NASA first. Working in tandem, the two tiny satellites would create a high-resolution solar coronagraph to examine the sun's outermost plasma layer, the corona, where powerful eruptions called coronal mass ejections take form.

Such a capability would benefit studies of the sun as well as a number of other scientific disciplines—especially those requiring dual spacecraft to detect Earth-like planets in other solar systems or even image the event horizon of a black hole, the point of no return where nothing can escape the black hole's intense gravitational pull, Shah said.

"Many virtual-telescope mission concepts have been conceived and proposed," said Shah. "One of the main reasons they are not selected for funding is because the systems-level capability to align two spacecraft to an inertial source isn't mature enough for projects to take the risk. Now is the time to advance the technology's readiness so that we can confidently propose and win these types of missions, which, I believe, will revolutionize astrophysics and heliophysics."

Partnering with Emergent Space Technologies

Under Shah's technology-development effort, the team is working with the Maryland-based Emergent Space Technologies to advance and test commercial-off-the-shelf navigation and relative-position sensors, actuators, cross-communication links, as well as in-house developed GN&C algorithms. The team also is leveraging an $8.6-million investment from the Defense Advanced Research Project Agency. Together, the system would determine the inertial alignment of the two spacecraft, both aligned with a specific target, and then independently adjust their positions to maintain and control the configuration.

With support from Goddard's Internal Research and Development (IRAD) program, the team plans to develop a prototype system—the so-called Virtual Telescope Alignment System (VTAS)—and subject it to a series of rigorous ground demonstrations.

The team's ultimate goal is to demonstrate VTAS on two CubeSats, relatively low-cost platforms that offer less-risky opportunities to test and demonstrate new technologies. Once demonstrated, Shah and his team believe the technology then could be ripe for infusion into a dual-spacecraft mission.

Developing a formation-flying capability to form a multi-spacecraft observatory is of extreme interest to the worldwide community. A number of technology demonstration missions, including the European Space Agency (ESA) PROBA-3 and the ESA-NASA LISA Pathfinder, currently are under development.

Baseline Mission

Under Shah's baseline mission, the team would launch the satellites into a high low-Earth orbit. One of the tiny spacecraft would be equipped with a communication crosslink, thrusters, GN&C software, and occulter—a small disk used in a telescope to block the view of a bright object so that scientists can observe the fainter one, such as the sun's corona. The other—positioned 20 meters behind its sibling—would carry the coronagraph, a laser beacon, and communications equipment.

Aligned toward the sun, the two-satellite virtual telescope would study in high resolution the sun's corona, and more particularly, the size and scope of solar eruptions that race across the solar system, sometimes crashing into Earth's magnetosphere and causing severe space-weather events.

Shah, along with Joe Davila, senior scientist in Goddard's Heliophysics Science Division and principal investigator on an instrument flying on NASA's Solar Terrestrial Relations Observatory (STEREO), and Phil Calhoun, a Goddard senior aerospace engineer, conceived the solar-coronagraph mission because such a capability is a high-priority science goal.

Furthermore, its architecture is nearly identical to one that an exo-planet mission might use in its hunt for Earth-like planets around other stars. Both rely on an "occulter mask" which blocks starlight. However, the solar coronagraph is less challenging to demonstrate. The angular resolution needed to image the sun's corona is on the order of arcseconds, which is far less demanding than the milli-arcsecond requirement for a planet finder, he said. Another potential, far-reaching application, Shah added, is imaging the event horizon of a black hole.

"Enabling the solar coronagraph paves the way for the more demanding missions," such as X-ray imaging of solar flares and extreme ultraviolet imaging of the sun, Shah said. "Once you fly a virtual telescope with looser formation requirements, you open up the space for others to follow and improve on the accuracy. These investigations will help us understand how the universe works, whether other planets harbor life, and where we came from," he added. "Answers to these questions have perplexed humanity since the beginning of time. We're doing our part."

Provided by NASA

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