October 2013

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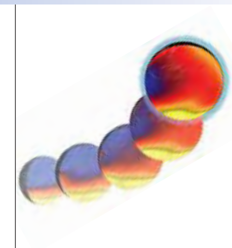
A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS



Space science GOLD: A payload trend?

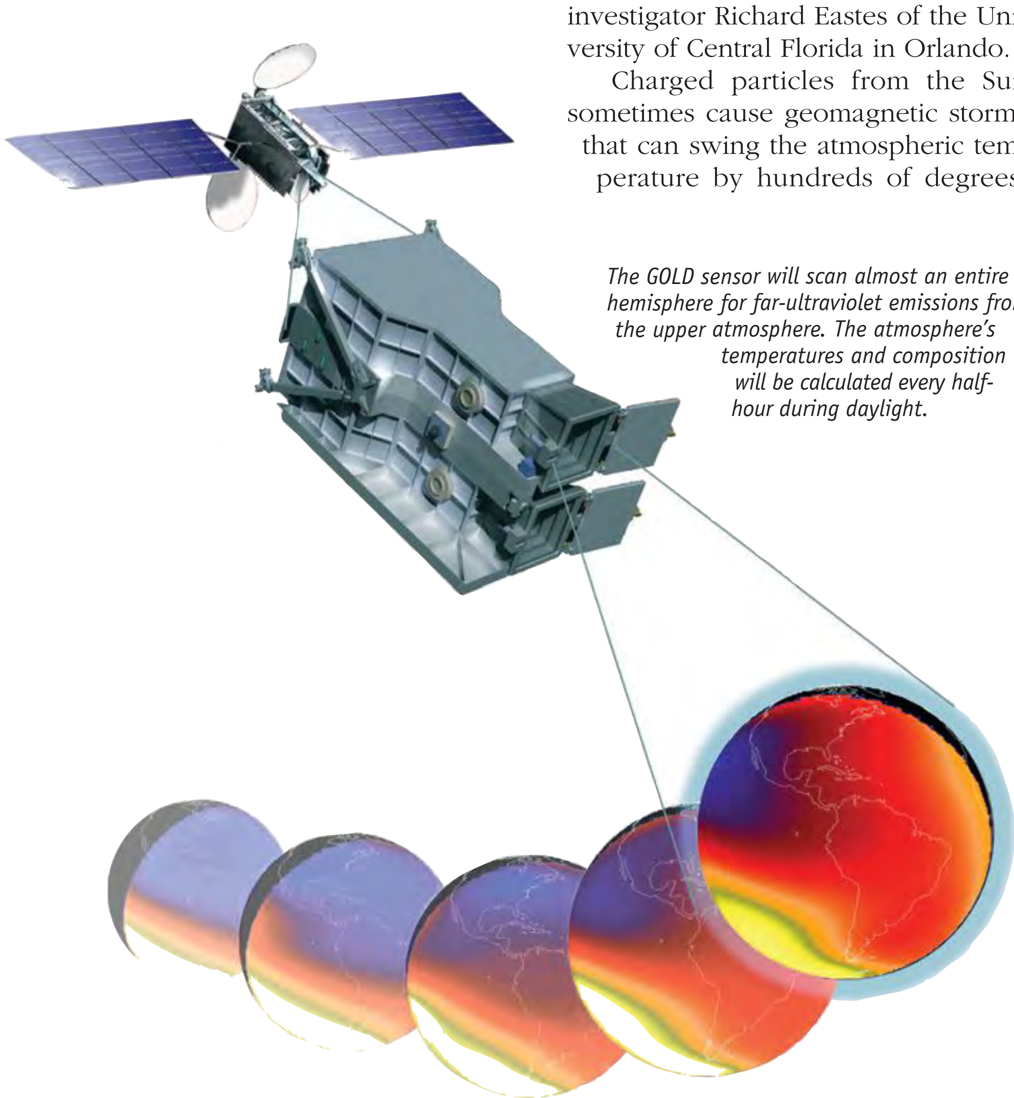
NASA's GOLD (Global-scale Observations of the limb and disk) instrument is a space weather sensor scheduled for launch in 2017 as a hosted payload on a commercial communications satellite.

From its perch in geosynchronous orbit, the 26-kg GOLD sensor will scan almost an entire hemisphere of Earth—175 degrees, to be exact—for far-ultraviolet emissions from the upper atmosphere at an altitude of 160 km. From these spectral readings, the temperatures and composition of the atmosphere will be calculated every half-hour during daylight. At night, GOLD will search the ionosphere for irregularities that can disrupt signals traveling between space and Earth, especially GPS signals.

The ionosphere and thermosphere at 160 km are complicated places that scientists do not fully understand. Hurricanes, weather fronts, and solar energy produce gravity waves and tides that change the composition and temperature. The Sun is the primary source of the tides, because as Earth rotates, heat is deposited along 360 degrees of longitude.

"Beyond that, the pattern becomes more complex," says GOLD principal investigator Richard Eastes of the University of Central Florida in Orlando.

Charged particles from the Sun sometimes cause geomagnetic storms that can swing the atmospheric temperature by hundreds of degrees. GOLD will depict all these fluctuations with color-coded maps.



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The main engineering challenge will be to keep GOLD's optics clean during development, installation, and launch. On top of that, the team has little wiggle room in its development schedule. The instrument must be ready in time to catch a ride on the commercial satellite.

Over time, if all goes as planned, GOLD will chronicle changes more persistently from GEO than it could from low Earth orbit. LEO satellites pass by a particular location on Earth about once a day, but GOLD will stare at the same side of Earth continually from geosynchronous orbit. The sensor could in theory produce images as often as every 15 minutes, but the team plans to operate at a half-hour cadence.

Once GOLD is up, GPS operators are expected to use its data to improve the algorithms that correct for atmospheric signal distortions. The FAA might even be able to reduce false alarms about possible GPS outages during geomagnetic storms.

"This information should, we hope, decrease the chance of having unnecessary [flight] delays, and it would also improve the [GPS] accuracy at other times," says Eastes.

Eight-year effort

Winning a $55.6-million commitment from NASA in April was a big breakthrough for Eastes and his teammates. The sensor will be built at the University of Colorado's Laboratory for Atmospheric and Space Physics, or LASP. Communications satellite operator SES Government Solutions of McLean, Virginia, has reached a "rough order of magnitude" agreement on how much it should cost to host GOLD on one of its upcoming satellites.

Eastes and LASP have been trying to get GOLD funded since 2005 under

NASA's Explorer series but have never gotten beyond phase A research funding until now.

The attraction of a hosted satellite was that building a free-flying spacecraft and launching it to geosynchronous orbit would have been impossibly expensive. The hosted payload option was the only way to keep GOLD under the Explorer cost cap, which is currently $55.6 million.

When Eastes and his partners first broached their idea in 2005, flying a scientific instrument on a commercial satellite was a very new idea.

"There have been ancillary instruments, for instance radiation detectors, on other satellites in the past. However, when we first proposed GOLD there had been no remote sensing science instruments flown as hosted payloads," Eastes says.

The skeptical questions flowed from NASA during site visits and reviews. Could the construction schedule for a scientific instrument be synchronized with that of a commercial satellite? What about contamination on the ground or out in space? A little bit of vaporized goo can wreak havoc on scientific optics.

Not all the questions were from NASA to the physicists. SES Government Solutions had to reassure backers that GOLD would not pose an unacceptable risk to a valuable communications satellite.

"They've got to be able to convince everyone—not just a NASA review panel, but their investors and their insurance company—that this is a reasonable thing to do," Eastes says. Gradually, the concept lost its radical aura. "It became clear that the industry was behind us, that they felt this is something really beneficial for them," he adds.

Even so, the GOLD team needed three attempts to get a 'yes.' "This time, they finally found the money," says Eastes.

Payload pioneers

The selection of GOLD could arguably be considered the start of a payload trend. In November NASA announced selection of another scientific hosted payload, the $90-million TEMPO (tropospheric emissions: monitoring of pollution), scheduled to be built by 2017. That would be in time for launch on a commercial satellite yet to be named.

CHIRP (commercially hosted infrared payload) was installed on the SES-2 commercial satellite. Credit: SES Government Solutions.

Two missions are a good start, but the GOLD team cautions against overconfidence. "We're still in the pioneering phase of doing this," says Mark Lankton of LASP, the project manager.

GOLD scientists may have benefited from the success of an Air Force infrared missile warning instrument called CHIRP (commercially hosted infrared payload). Launched into geosynchronous orbit in September 2011 on an SES communications satellite, it is reportedly performing well. CHIRP is an experimental military instrument, but its challenges are largely similar to those of GOLD. It has a good view of the U.S., so it can watch missile tests at ranges in Arizona and New Mexico.

GOLD scientists are not sure yet on which satellite their instrument will be hosted, so they do not know where in orbit it will be positioned. Somewhere with a view of the U.S. would be optimal, because it would make downloading the data less complicated, and it would enhance opportunities for public outreach.

"If you say, 'This satellite basically is looking at the thermosphere and ionosphere over your house,' it brings the general interest in," Lankton says.

At the end of the day, the scientists do not really care where GOLD ends up. They can prove its effectiveness anywhere.

No 'goo' please

GOLD will have two separate baffles to let ultraviolet radiation in and keep stray light out. Mirrors and a grating corresponding to each baffle will direct the ultraviolet radiation to detectors. Those optics must be kept clean to keep the UV signal as strong as possible. Covering each baffle will be a spring-loaded hatch that will be commanded to pop open about a month after launch. The optics will produce identical UV channels. The readings will be combined to produce color-coded temperature maps about once every half-hour.

"There are times when we need the two channels to get as much signal-to-noise [ratio] as we want and as we need to satisfy the requirements," Eastes explains.

The GOLD team spends lots of time worrying about contamination from glues or lubricants that might be used in construction of the host satellite and instrument.

"Any sort of goo on your optics—you know, something that evaporates from one part of the spacecraft and lands on your mirrors, for instance—just kills the signal," says Lankton.

Controlling contamination is especially important for instruments like GOLD that must be sensitive to short UV wavelengths. "Basically the shorter the wavelength you're looking at, the cleaner you need to be, just as a rule of thumb," Lankton explains.

One precaution will be to pump pure nitrogen gas into the instrument, from the moment it is assembled at LASP until launch. The nitrogen will flow out of small gaps between the baffles and their protective covers to prevent any contaminants from flowing in.

In space, spring-loaded hatches will be popped open, and this is when a second anticontamination precaution will become apparent. The instrument will be positioned on the satellite's Earth-facing deck so that its mirrors are not in line with any potential contaminant sources, such as the satellite's solar arrays.

"If you've got some lubricant or glue or something that's giving off gas from somewhere on the spacecraft, or somewhere on your own instrument even, it tends to evaporate and just go out," Lankton says. He notes there are "no wind currents up there, so it doesn't turn corners."

Measuring cleanliness

These precautions are not the whole story. The GOLD team has spent time with commercial satellite manufacturers and noticed that they pay more attention to contaminants than some NASA scientists initially assumed.

"Part of the reason is that they have long-term contamination concerns of their own," Lankton says. Thermal control surfaces, for example, need to stay clean over what could be a 15-year communications mission.

The GOLD team visited manufacturers to find out what kinds of materials and practices they typically use. Commercial manufacturers place their spacecraft in thermal vacuum chambers equipped with sensitive scales called thermoelectric quartz crystal microbalances. These devices measure the weight of any contaminants that might outgas and accumulate on a satellite's surfaces.

"We worked with one commercial satellite builder to obtain the data from a representative spacecraft, and found that the overall outgassing numbers were acceptable, given that we plan to protect the cleanliness of the instrument in several different ways prior to launch," Lankton says.

Synchronizing schedules

The GOLD team also faces the challenge of meshing production schedules with a still-unspecified commercial communications satellite. "Typically, the science instruments are on a little bit different schedule—a little longer one, actually—than the commercial communications satellites," Eastes says.

The team does not think this will be a problem. The scientists have had a lot of extra time to refine their design over the years, and they were not starting from scratch. LASP built a similar ultraviolet instrument for the Cassini Saturn probe launched in 1997. The team has a baseline design in hand that will use the RS-232 connection interface. "Now we'll go back and decide the connectors that actually get used, and refine more closely the details of the interface, how that electrically will work," Eastes says.

To be ready to go once they learn which satellite will carry GOLD, the team has been looking at the designs of different candidate satellite frames. Whichever satellite that is, the commands will go up to GOLD via the same route as the commands to the satellite. The scientific data will come down to a ground station via a separate transponder.

If things go well with GOLD, scientists are hopeful the mission will prompt the U.S. to make such space weather readings a regular part of business. "Ideally, you'd have three of these [instruments], and you could see absolutely everything absolutely all the time. But we have one, and it'll be a big step forward," Lankton says.

Ben Iannotta
biannotta@deepdiveintel.com