

## **MODERN WARFARE LOOKS TO THE SKIES**

*How Army researchers developed an eletro-optical microsatellite that will give warfighters a real-time tactical edge*

### **Abstract**

In many remote areas where soldiers operate, communication over large bodies of water or rugged terrain from the field to headquarters is nonexistent, raising uncertainty of a successful operation and increasing risk of loss of life and failure of the mission. U.S. Army researchers at the Huntsville, Alabama-based Space and Missile Defense Technical Center are developing the Kestrel Eye, an electro-optical microsatellite to produce tactically useful 1.5-meter imagery for the ground warfighter.

U.S. Army Space and Missile Defense Technical Center  
Huntsville, Alabama

Public Affairs Contact: Cecil A. Longino | HQ SMDC/ARSTRAT | [cecil.a.longino.civ@mail.mil](mailto:cecil.a.longino.civ@mail.mil);  
phone: 256-955-9977 | cell: 256-777-7100

Prepared for the Department of Defense by  
THE CENTER FOR HOMELAND SECURITY AND RESILIENCE

Submission Date  
August 14, 2017

### **Disclaimer**

This work was produced under the sponsorship of the Department of Defense. However, any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Defense.

## MODERN WARFARE LOOKS TO THE SKIES

*How Army researchers developed an electro-optical microsatellite that will give warfighters a real-time tactical edge*

Day and night, U.S. soldiers at a remote operating base in Afghanistan endure mortar bombardment at the hands of Taliban insurgents. They are constantly under fire. The battalion chief decides to take the fight to the enemy. A small group of soldiers heads toward a hillside—the source of the firing. As one team ascends the slope, another secures the vehicles. The ground unit pulls up a satellite image of the terrain to do a final check on the Taliban's position on the other side of the hill. The commander thinks they're good to go, but there's one tremendously huge risk.

Today, the most updated image could be 30 days old.

In many remote areas where soldiers operate, communication over large bodies of water or rugged terrain from the field to headquarters is nonexistent, raising uncertainty of a successful operation and increasing risk of loss of life and failure of the mission.

“If he had a Kestrel Eye he could request the image and get it down in minutes,” said Mark Ray, lead engineer of an electro-optical microsatellite being developed by U.S. Army researchers at the Huntsville, Alabama-based Space and Missile Defense Technical Center (SMDTC). Named for a small type of keen-eyed hunting falcon, the Kestrel Eye produces tactically useful 1.5-meter imagery for the ground warfighter. It makes it possible to “see if there are cars in the area, if tanks have rolled in, if there are fires or if there is something going on that would very much impact his ability to complete his mission,” Ray said.

The speed of intelligence delivery can be the difference between life and death. A battalion of Marines has just days for their mission: destroy Taliban opium, heroin production and poppy fields; and destroy a local drug baron's highly fortified and heavily armed compound hidden at the base of a mountain range.

When a tactical user, such as a battalion commander, requests an image, he or she might not receive it in a timely manner because there are other users who might have priority, Ray said. There just aren't enough resources for everyone's needs to be met with the level urgency characteristic of a warzone.

Ray, in his early 30s, has been around long enough to remember when satellite imagery was barely available to *anyone* on the battlefield. His career at the Redstone Arsenal lab reaches back over a decade and started as an internship while he was studying electrical engineering at Auburn University. He was the lead engineer on SMDC-ONE (for Orbital Nanosatellite Effect), which was the Army's first satellite to orbit in 50 years, and the first ever nanosatellite developed by Army Space and Missile Defense Command when it flew out of Cape Canaveral in December 2010. <sup>1</sup>

SMDC-ONE represented the lab's first successful foray into what would evolve into the Kestrel Eye program.

---

<sup>1</sup> <http://blog.al.com/huntsville-times-business/2011/01/satellite.html>

## Increasing Access

“The problem Kestrel Eye wants to address is to make more imagery available to lower echelon operations than there is available today,” said Wheeler “Chip” Hardy, Kestrel Eye’s program manager. The assets are extremely expensive and so few that there is high demand on their capability.

To achieve access, one of the primary goals of a production version of the Kestrel Eye is to create a satellite that’s inexpensive and physically small enough to proliferate as a network into space, creating a constellation. For a tactical user, that would mean there was a satellite frequently overhead to take an image and relay it rapidly, Hardy said.

One Kestrel Eye microsatellite carries an estimated price tag of about \$1.3 million. For space, that’s a trivial amount, as compared to say, a ride to orbit on a private rocket, which may cost anywhere from \$60 to \$90 million<sup>2</sup>. And the Kestrel Eye’s weight of about 100 pounds is eclipsed by that of a commercial satellite used for broadband signals, which can weigh more than 13,000 pounds.<sup>3</sup> For historical comparison, there’s the Saturn V rocket, that transported astronauts to the moon in the 1960s. It was taller than the Statue of Liberty and cost \$185 million to launch, or \$1.4 billion adjusted to 2017 dollars.<sup>4</sup>

In 2012, only 34 satellites 220 pounds or smaller were launched, according to a report by Northern Sky Research, a satellite market research firm. In 2014, the number rose to 172 and by 2017 there should be some 230 launches.<sup>5</sup>

Satellite constellations are poised to inundate outer space. The nanosatellite and microsatellite market is projected to grow to \$3.49 billion by 2022, from \$1.21 billion in 2017, driven by low manufacturing costs and high demand for mini satellites in Earth observation applications.<sup>6</sup>

For the Army, the stealth factor of micro satellites is always a key design consideration. Tiny satellites in low earth orbit can be a deployed in constellation that slowly degrades as it falls towards earth, as individual satellites prove difficult for an adversary to detect and track. These satellites would be designed for short life of about a year, allowing much more frequent design and technology refresh and tailored to specific missions or areas of operation surge requirements.

## Kestrel’s Origins

The Kestrel Eye program started in 2007 as a Defense Advanced Research Projects Agency (DARPA) seedling effort. Toward the end of 2008, the program was transitioned to Space and Missile Defense Command (SMDC). The Kestrel Eye program is just part of the larger Space and Missile Defense

---

<sup>2</sup> <http://www.spacex.com/about/capabilities>

<sup>3</sup> <http://www.webcitation.org/5v19KSD8A?url=http://www.ilslaunch.com/assets/pdf/KA-SAT>

<sup>4</sup> <https://history.nasa.gov/SP-4221/ch6.htm>

<sup>5</sup> <http://www.nsr.com/research-reports/satellite-space-infrastructure/>

<sup>6</sup> <http://www.prnewswire.com/news-releases/nanosatellite-and-microsatellite-market-expected-to-usd-349-billion-by-2022-300479746.html>

Command Nanosatellite Program (SNaP), and is sponsored by the Office of the Secretary of Defense and U.S. Pacific Command.<sup>8</sup>

“SNaP is designed to deliver a more resilient space capability, to explore technologies deployed on nanosatellites in low earth orbit with the goal to ensure warfighters have freedom to communicate, freedom to maneuver and immediate access to actionable situational awareness,” according to the Army’s description of the program. <sup>9</sup>

In a spectacular pre-dawn launch on a crisp October morning in 2015, the Army launched three SNaP nanosatellites from Vandenberg Air Force Base in California. Each SNaP nanosatellite, or CubeSat, consisted of three approximately 10 centimeter cubes stacked for a length a little more than 30 centimeters, about the size of a loaf of bread and weighing nearly 12 pounds. Like the Kestrel Eye satellite, the CubeSat units are economical and cost about \$500,000 per unit.

In March 2017, at the U.S. Army's Global Force Symposium and Exposition, the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) teams demonstrated how the command anticipates the future of integrated air and missile defense and global space operations. Kestrel Eye was among the programs showcased. Also included was the Army Cost Efficient Spaceflight Research Experiments and Demonstrations, or ACES RED, a small spacecraft simulator that will be attached to the exterior of the International Space Station for about a year and aims to help control small satellites.

"Today's operating environment is among the most challenging we have faced in some time," said Richard P. DeFatta, acting director of SMDC's Future Warfare Center. "This includes changes in the character of war highlighted by increased lethality and potential overmatch and friendly forces being contested in all domains including space. <sup>10</sup>

## **Of Nike II Fame**

SMDC’s legacy of combatting new and emerging threats can be traced back to the Cold War, with the 1955 Nike II study, which determined the feasibility of a surface-to-air defense system against Soviet strategic ballistic missiles. SMDC was established as RAMMSO back then, or the Redstone Anti-Missile Missile System Office, and it was the first Army organization with a ballistic missile defense and space mission.

Sixty years later and SMDC’s mission has evolved in tandem with the “battlefield.” At the Army Symposium, DeFatta explained how space-enabled capabilities affect all warfighting functions.

"Seventy percent of Army systems leverage space, with the Army as the largest user of space in the Department of Defense," DeFatta said. "Army space contributions to the joint fight include globally deployed space forces that plan, coordinate, integrate and synchronize space capabilities for the warfighter."

---

<sup>8</sup> <https://www.smdc.army.mil/FactSheets/KESTRELEYE.pdf>

<sup>9</sup> <https://www.smdc.army.mil/FactSheets/SNAP.pdf>

<sup>10</sup> [https://www.army.mil/article/184348/smdc\\_gets\\_technical\\_at\\_ausa](https://www.army.mil/article/184348/smdc_gets_technical_at_ausa)

## **Preparing to Launch**

SMDC prepared the Kestrel Eye for an August 2017 launch to the International Space Station as a part of a cargo resupply mission.

“Satellites this size are typically a secondary payload, which translated into laymen’s terms means you are a hitchhiker,” said Hardy. “Basically, it is excess launch capacity which is offered to you if you are able to meet certain safety criteria.”

After launch, the Kestrel Eye satellite, which measures about 1 meter in length and 30 inches in diameter, would be unpacked by astronauts, put through the airlock onto the arm outside the space station and released.

“The satellite will be falling back to Earth from that point forward and it’s going to continue to fall and fall and get closer to the earth and burn up in the atmosphere,” Ray said. The duration from release until reentry into the atmosphere is expected to last approximately a year.

Once on-orbit, the satellite would undergo testing in various scenarios by Pacific Command so in order to make a military utility evaluation. If the demonstration is successful, then transition plans will be fully developed.

## **Monitoring From the Ground**

“For the construct of this demonstration we will have one satellite,” Hardy said. “We will have two ground stations. One here at Redstone and one at Pacific Command so they can do the military utility assessment.”

The Kestrel Eye Ground Station (KEGS), built directly by the laboratory team, is a companion to the satellite and is necessary to see what it is capable of doing, Ray said. “They constructed the antennae, integrated the control unit and have made the mission planning software.”

On a sunny morning in early February 2017, the USASMDC/ARSTRAT's Technical Center conducted a demonstration of the fully integrated Kestrel Eye Ground Station in the parking lot of the command headquarters in Alabama. Members of the SMDCTC’s Concepts Analysis Lab (CAL) hunched over their laptop computers next to the large spherical ground station and worked closely with the Kestrel Eye program in supporting the ground station demonstration.

"The Concepts Analysis Laboratory assisted the Kestrel Eye program in reviewing the design of the Kestrel Eye Ground Station, as well as reviewing and assisting with the implementation of those designs," said Christian Reyes, a Concepts Analysis Laboratory computer scientist. "Members of the CAL are constantly providing feedback to the program and to the developers, as well as directly developing components of the ground station that will be used."<sup>12</sup>

The ground station demonstration proved the ability to show rapid integration as it performed a live track of NASA's low earth orbit satellites Aqua, Aura and Terra.

---

<sup>12</sup> [https://www.army.mil/article/162288/KEGS\\_team\\_demonstrates\\_space\\_talk/](https://www.army.mil/article/162288/KEGS_team_demonstrates_space_talk/)

Launch day came on August 14, 2017, as the Kestrel Eye “hitchhiked” its way toward the International Space Station as a payload aboard a SpaceX Falcon 9 rocket. By the end of October, the micro-satellite was deployed into space and activated to begin its two-year testing mission.

"The deployment and subsequent demonstrations are the culmination of a long development process," Hardy said in a press release. "We are all looking forward to those first Kestrel Eye images to show what a satellite of this type can provide for the tactical Army at the leading edge of the fight."

##