Smaller is Better

How Small Satellites Have Become a Compelling Option

BY ANNE WAINSCOTT-SARGENT

In this day and age, with so much emphasis on cutting costs and debt reduction, the mantra is to do more with less. The satellite industry is no exception. With technology advances, small satellites suddenly look a whole lot more attractive on a number of levels.

Small satellites — from tiny pico and CubeSats to larger microsatellites — are fast becoming a cost-effective device of choice for low Earth orbit science, research and Earth observation missions. These low-mass (less than 1,000 kilos) spacecraft are significantly less expensive to build and deploy, making them an increasingly attractive option.

In response to shrinking federal budgets, cost overruns on large satellite programs and advances in cell phone technology, small satellites are now coming into their own for both civilian and increasingly military missions, where commanders need faster intelligence on the ground.

This summer, the Operationally Responsive Space (ORS) Office will launch the highly anticipated ORS-1 reconnaissance satellite after several months of delay from imaging payload difficulties. The satellite represents a new approach to building and launching a satellite within 24 months of approval while being military-operated.

In 2012, the Air Force Research Laboratory, which has flown 12 small satellite missions in the past 18 years, will launch the Demonstration and Science Experiments (DSX) satellite. It will carry the "most complete set of space weather instruments ever flown in a highly elliptical orbit," says Col. William Cooley, director of the lab's Space Vehicles Directorate. In addition, NASA issued its draft solicitation for comment on the agency's new Earth Venture II program in February. The program calls for projects with a total mission price between $150,000 and $150 million. Potential missions may focus not only on Earth observation, but also on sun exploration and astrophysics to explore stars and potentially uncover extrasolar (XO) planets.

The emerging small satellite market is giving largely defense-focused companies like ATK, which supplied the bus for the ORS-1 satellite, new opportunities to engage with civil agencies. "We're finding there is tremendous growth potential projected over the next decade for earth imaging satellites on relatively small platforms of 200 to 300 kilograms total mass that can provide not only U.S. but also worldwide coverage," says Robert Meurer, vice president of business development, commercial and international programs for ATK's spacecraft systems and services division. A key advantage, Meurer adds, is the speed by which these assets can be built and deployed. He notes that the goal is for less than a two-year turnaround.

Leveraging Smartphones in Space

The inspiration for the small sat revolution started with another revolution involving mobile devices — namely the processing advances found in today's smart phones. With 2 billion to 3 billion cell phones on the planet, and the investments going into developing these devices, NASA is betting the technology will spill over into the agency's efforts in small spacecraft, leading to more powerful, smaller vehicles.

"The processing power in cell phones is superior to the processing power in most satellites today," says Pete Klupar, director of engineering at NASA's Ames Research Center, the NASA office that builds small satellites for exploration and science missions.

Charles Swenson, PhD, professor of electrical and computer engineering at Utah State University, agrees that cell phones are the basis of the small sat wave. "They're battery powered; they've got sensors in the way of cameras or video cameras; they have magnetometers, accelerometers, memory and lots of computing. They have radios for communicating with cell towers. If you slap on some solar panels they almost have all the functionality of a satellite," he says.

One Answer to Escalating Satellite Costs

For the Air Force, small satellites represent a major departure from large-scale Milsatcom programs such as Advanced EHF. That program and its predecessor Milstar, serves as

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the secure communications backbone for the U.S. military. "We cannot sustain that kind of cost growth — the bottom line is we as a nation have got to find a more cost-effective way to get satellites up," Cooley says.

Small satellites are one answer. Four years after development on TACSAT-3 began, the program, envisioned to give the military more responsive, flexible and affordable surveillance systems, went from an experimental small satellite to an operational capability for the Air Force Space Command in June 2009. The $100 million program serves as an effective surveillance tool for close-in proximity operations, providing real-time data to combatant commanders within 10 minutes of being collected.

As the Air Force seeks ways to reduce manufacturing expense, it is focusing on the merits of plug-and-play components. This engineering approach extends the idea of USB port plugs in IT systems to spacecraft building. According to Cooley, instead of relying on a one-time design, this technique gives satellite planners flexibility to use modular components in assembly to reduce costs.

"Plug and play is a great vision — it has promise, but the challenge we have is it requires industry buy-in to develop and participate in the standards that would allow us to (use this approach) in the way we build satellites," he says, adding that the Air Force is open to industry refining the approach or coming up with alternatives.

Comtech AeroAstro (CAA) is currently working with the Air Force Research Lab on the Advanced Plug-and-Play Technologies (APT) program to reduce risk and increase technology maturation of the Space PnP Architecture (SPA), including SPA hardware and software components.

"We're trying to reduce the design and integration time for these satellites so we can be more responsive and rapid to launch," says Stanley Kennedy, Jr., vice president and general manager of Comtech AeroAstro's newly formed commercial, civil and international programs business.

Army Eyes CubeSat Potential

Both the Air Force and Army are investing in CubeSat technology; with the Air Force planning to launch an experimental CubeSat mission in the next few years to better understand its capability and limitations.

Last December, the Army Space and Missile Defense Command launched a nine-pound CubeSat as a secondary payload on a Falcon-9 mission that represented the first Army-developed satellite to fly since October 1960. They hope to fly an advanced version of the satellite in 2012 in partnership with the Air Force Operationally Responsive Space Office that will feature a software defined radio to enable the military to change frequency on the fly while in orbit.

"Tremendous advancements in computing and electronics capability allow you to put a lot more power in a much smaller package. You can put militarily relevant capabilities in a very small and lower cost package," notes John London, Nanosat technology manager in the Army Space and Missile Command.

London expects that once the technology is proven in flight, the Army will be able to leverage small satellites to fill gaps in capabilities — from communications to intelligence, surveillance and reconnaissance (ISR) imagery ground troops need to perform their mission.

"Our vision is for the soldier in the most far-flung region of the world to have access to information whether it is communications or imagery within seconds of when they need it," London says.

The Army also is developing a medium-resolution imaging satellite, the Kestrel Eye, weighing about 33 pounds and offering 1.5 meters of resolution. The resolution isn't as high as the larger imaging satellites in orbit today, but London emphasizes fine resolution isn't a necessity for many applications required of ground troops.

And, with a recurring price tag of $1 million, "We can put a larger number up where we would have a satellite over head all the time. It's all about responsiveness for the warfighter as opposed to resolution," says London. "We want to break the tyranny of the aperture." He envisions that several of these small satellites could be launched, so a warfighter at any level organizationally can task that satellite. "Our goal is from task to receipt of image is less than a minute," he says.

NASA JPL's Long-time Reliance on Small Sats for Earth Science

On the civilian agency front, NASA's Jet Propulsion

Laboratory (JPL) has relied on small sats for many years for various science missions such as ACRIMSAT, originally launched as a secondary payload in 1999 to measure the sun's energy and its contribution to climate change. GRACE, a gravity mission originally launched in 2005 with a follow-on mission planned for 2015, uses a pair of small sats to pinpoint changes in the Earth's gravitational field caused by the movement of liquid and ice water due to melting ice sheets.

"It turns out most of our planetary missions take small instruments of the kind we would be able to fly on a small sat in low Earth orbit," says Tony Freeman, Earth systems science formulation program manager at NASA's Jet Propulsion Laboratory (JPL).

Commercial satellite players are also responding to the government's growing interest in small satellite technology as an opportunity to grow market share.

CAA is looking at a number of U.S. and International opportunities in the civil and defense mission areas, as well as commercial opportunities with programs such as FORMOSAT-7, says Kennedy. That mission will collect atmospheric data for weather prediction and for ionosphere, climate and gravity research. Other opportunities for small satellites involve the next generation of satellite constellations for communications, and a program to track surface vessels using the Automatic Identification System (AIS) used by Vessel Traffic Services (VTS) for shipping and commerce activities.

"Most of these systems are all very small satellites — 200 kilograms or less in most instances. All of these will continue to help establish a robust business not only for bus providers but also the second and third-tier component providers," says Kennedy.

Universities Enter the Fray

For academic institutions, the revolution in small sats provides new opportunities for space-based research activities. Utah State's DICE (Dynamic Ionosphere CubeSat Experiment), a National Science Foundation (NSF)-funded program, explores the causes and impact of magnetic storms on GPS and other systems on Earth. The project involves developing very miniaturized space weather instruments to better understand how variations in the ionosphere affect the performance of communications, surveillance, and navigation systems on Earth and in space.

"The ability to get lots of data off a very small satellite like DICE if it's proven, enables the commercial industry to think, 'Well, if they can actually get that off a science satellite, maybe there are some commercial applications that we can develop in science monitoring or Earth resource monitoring,'" Swenson says.

The Air Force Research Laboratory Space Vehicles Directorate looks to universities for future innovations in the small satellite arena. It runs the University Nanosat program, handpicking 11 university teams from around the country to design and build a small sat applicable to national security.

According to Marco Caceres, senior analyst with The Teal Group, the affordability of small satellites is such that virtually any college with a science department will have the ability to build small satellites of some type.

"It gives small institutes and universities the hope that they are going to become players in space in the next 10 years," Caceres says.

Making Launch Services Affordable

Industry players in government and in the commercial sector are working collaboratively to make launch services affordable. Caceres says, "Until launch prices come down by a factor of five or 10 the small sat market is going to be limited."

AeroAstro, according to Kennedy, has successfully collaborated with academic and other industry players to develop common interfaces and standards for small sats that will make it easier for launch companies to add small satellite missions to their manifest.

The last small satellite the company flew in November — the DoD Space Test Program Standard Interface Vehicle Program — included seven different spacecraft on the mission, he says. "That is a sign of the new way of doing business where there will be more collections of small satellites to go out to procure launch vehicles and launch services."

Looking ahead, industry watchers and government decision-makers remain upbeat for the prospects of this evolving market.

"What really excites me is it opens up the possibility for more access to space to a larger group of people," says Swenson.

NASA's Klupar sees the idea of clusters and constellations of these satellites taking off in the future. NASA and the Defense Advanced Research Projects Agency (DARPA) have studied ways to use small satellites to refuel GEO spacecraft to extend the life of those assets in space.

"I think this is one piece of the puzzle. It's a way to lower costs dramatically. The challenge," he adds, "is to get the science return out of these devices."

Cooley concludes, "We are going to continue to push the envelope with respect to the types of missions we can satisfy with small satellites."

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