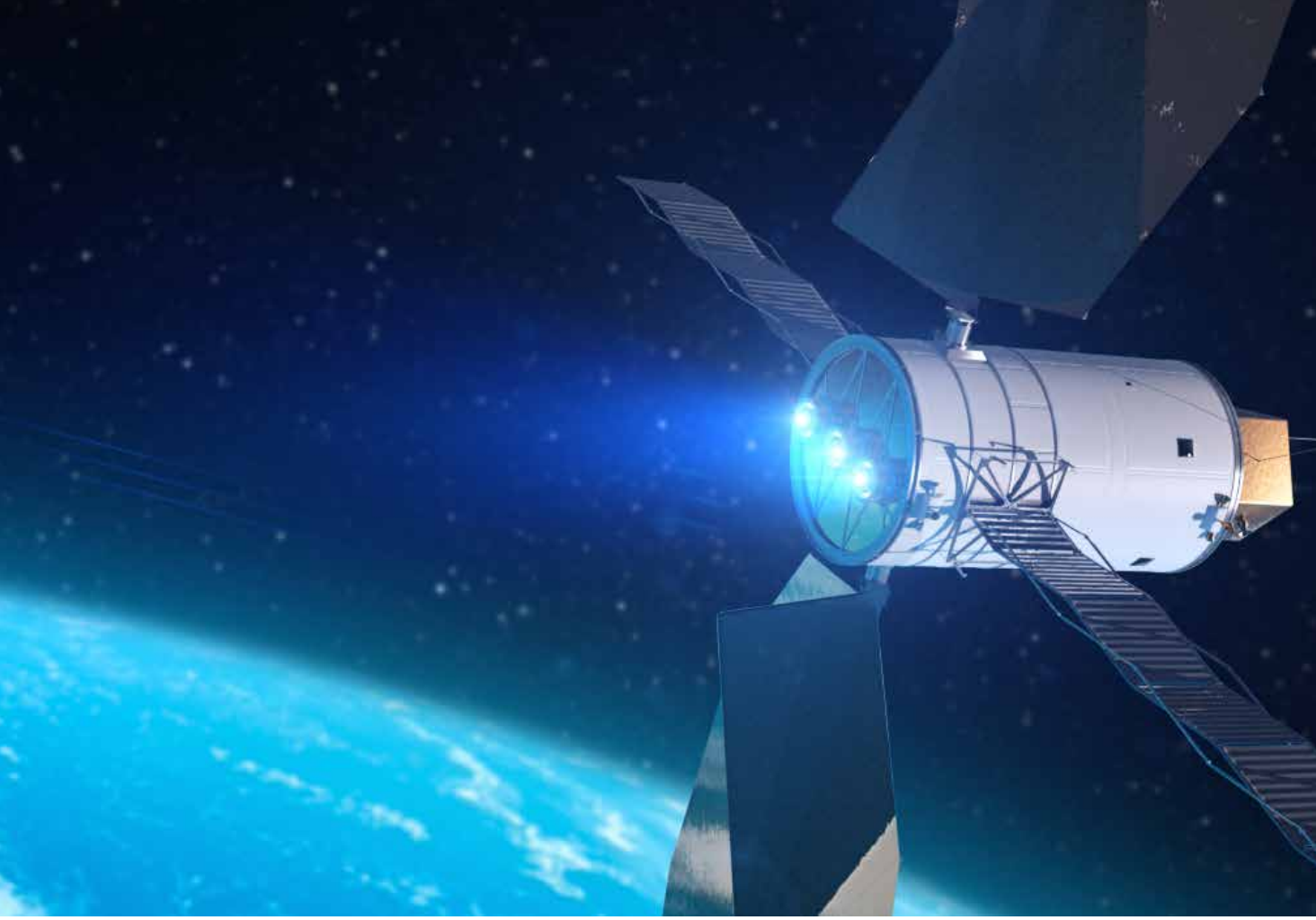

We Need MORE POWER

Optimizing Solar Energy is Key for Unmanned Systems in Both the Airspace and Outer Space

By Nick Adde

When monitoring crops at low altitude or probing the solar system, engineers face a common challenge: propulsion. Systems must be efficient, reliable and able to sustain operation for long durations. More than a few platforms have made significant inroads in powerplant technology, but more necessary improvements are on the way.

Large projects, such as QinetiQ's Zephyr, AeroVironment's Global Observer and Boeing's Phantom Eye, have been proven to be able to remain aloft at high altitudes for as long as several weeks. Although they have set the bar high, they are expensive.

Two much smaller companies are aiming to extend flight time well beyond that, for a much lower cost. Meanwhile, NASA is working on a system that would extend the envelope exponentially — in anticipation of the agency's most ambitious future projects.

NASA plans to use solar propulsion technology on its 2020 deep space mission to look at asteroids Ceres and Vesta.

The smaller companies would bring both the price tag and mission capabilities to a level appealing to municipal governments and small-business operators. The NASA project would result in delivering the largest piece of extraterrestrial rock to earth-bound scientists.

At Falls Church, Virginia-based Vanilla Aircraft LLC, engineers are working on a propulsion system that would increase the overall performance of aircraft by a factor of 10, says Jeremy Novara, a company officer.

Novara and his partners are mum about specifics, wanting to protect their idea until it is ready for the marketplace.

"I can only refer to it as a highly efficient, reliable commercial off-the-shelf [hydrogen propulsion system that uses] JP-8 fuel," Novara says.

The company began the project six years ago, with the first designs of its VA-001 unmanned aircraft. Its creators were looking to build a platform that would stay aloft 10 days at a time, while achieving speeds as high as 70 knots, with extended range capabilities as well.

"We saw a space in the market for the same endurance and range on the smaller end [as Zephyr, Global Observer and Phantom Eye]. A lot of the small-market unmanned aerial systems have endurance of less than a day. Most is less than 12 hours. We identified a highly reliable, fuel-efficient engine and designed a plane around it," Novara says.

Today, with the VA-001 aircraft nearly ready to offer to potential buyers, the company has completed multiple-week, ground-based endurance tests. They are working toward the goal of having the plane with its 36-foot wingspan carry a 30-pound payload, burning two-thirds of the fuel other such vehicles would require at a very slow rate.

Vanilla Aircraft aims to have its VA-001, shown here, fly for up to 10 days at a time.

Solar power alone would not suffice, Novara says, because they require batteries that would degrade over time as they recharge and discharge. Batteries with higher performance would not provide the solution. Increased capability only enhances the degrading problem, he says.

To date, the 10-year-old company has designed, built and tested the aircraft on the ground in its Falls Church facility and conducted an initial flight at the New Mexico State University flight test center. By year's end, designers hope to have accomplished five-day duration flights, which would be a world record in its class. In roughly a year, they intend to have the plane ready for the marketplace.

"Initial flight tests showed we were meeting all of the expected fuel-consumption [and] climb-rate performances," Novara says.

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As a long-time client of the Naval Research Laboratory and other government entities, Packet Digital LLC of Fargo, North Dakota, has worked for years to produce long-life batteries. While focusing on power management of electronics, the company developed computer chips and embedded software aimed at optimizing systems for size, weight and power.

When the company was able to extend battery life for their radios by 40 percent, the NRL met with them and asked if they could apply the improved power electronics toward unmanned aircraft.

Coincidentally, North Dakota — with its vast acreage of farmlands — finds itself in a relative boom regarding the use of unmanned aircraft for crop management. To that end, Packet Digital entered a contract agreement with the state's commerce department to incubate new technologies in renewable energy.

Packet Digital does not build its own UAS. Rather, its products are geared toward enhancing customers' existing platforms.

The key to such improved performance lies in photovoltaics — solar power — CEO Terri Zimmerman and advanced-technology director Andrew Paulsen say.

"We believe we are developing a solution that will have the longest endurance — a maximum power point

Image: NASA. Photo: Vanilla Aircraft LLC.

The VA-001 uses a proprietary blend of solar power and fuel to maintain its endurance.

tracker, with smart batteries, speed and torque, motor control, and soaring algorithms," Zimmerman says. Simply put, power point tracking enables the most efficient integration of solar panels and the batteries they are charging.

Packet Digital's success will depend upon addressing the challenges of balancing size and weight, Paulsen says. Power electronics are needed to link the solar cells and battery systems in order to convert solar power into a useful form. Solar-powered unmanned aircraft do not entail many moving parts.

"The speed at which they operate is generally slow," Zimmerman says.

They use solar and thermal energy — both supplied by the sun but quite different — to remain aloft and in motion while powering the payloads. Because they are in motion, factors that affect all of these, motion itself and angle to the sun, are changing constantly. The algorithms Packet Digital develops would enable UAS to "stay within the curve of power to get the most out of the solar technology, to get more uplift [and] extend flying times," Paulsen says.

"We are providing a customized solar solution for customers, to enable solar technology to be attached to the wings of their aircraft," Zimmerman says.

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While Vanilla Aircraft and Packet Digital direct their respective energies to lower altitudes, a research team at NASA's Jet Propulsion Laboratory in Pasadena, California, as one would expect, has its sights set on an exponentially loftier goal.

By 2020, the NASA Asteroid Redirect Robotic Mission Activity at JPL intends to launch a spacecraft toward the asteroid belt, with the intent of conducting close-up probes of two of the heaviest objects there — Ceres and Vesta. Nothing new, in that the lab already had launched a spacecraft called Dawn in 2007. Dawn took four years to get to Vesta, and then spent four years exploring the object.

What is different is that the new mission would entail the spacecraft touching down in Ceres and by 2025 bringing back to earth a piece of the asteroid weighing at least 20 metric tons.

Astronauts aboard NASA's Orion spacecraft would rendezvous with a robotic craft, which would do the actual mining of the asteroid.

"The high-powered solar electric propulsion system [will need to be] roughly 20 times better than the high-end propulsion system that's on the Dawn spacecraft," says John Brophy, the project activity's chief engineer.

The additional performance capabilities are required because of the amount of fuel required to achieve what rocket scientists call Delta V — the amount of acceleration required to perform a given maneuver. In this case, it would apply to increases in the velocity of the craft from a starting point at rest.

"The higher the Delta V, the harder it is to do. You need more fuel. It's a sensitive, exponential relationship," Brophy says.

The Dawn mission required

Scan this QR code with your smartphone for more information on NASA's asteroid redirect mission.

Vanilla Aircraft's goal is to have the system aloft for five days in flight tests by the year's end.

Photo: Vanilla Aircraft LLC.

a Delta V of 11 kilometers per second — impossible to achieve by chemical propulsion alone. To power Dawn, and the future mission to the asteroids, requires the use of large solar arrays that collect sunlight and convert it into power. They would be linked to ion thrusters, which ionize propellants. The positive ions are accelerated into very high exhaust velocity, 10 times better than the best chemical propellant.

For the asteroid mission, the robotic spacecraft would take four days to reach a speed of 60 mph, Brophy says.

"But if you continue to thrust like that after two years and use up all the propellant, the craft would be going 25,000 miles per hour with 60 gallons of fuel. It's acceleration with patience," Brophy says.

To achieve that, the laboratory is working on development of an ion thruster that would last long enough to be useful. Shrinking such systems down to practical size is one of many hurdles that must be overcome, for instance.

While difficult from a technological standpoint, Brophy and his NASA colleagues say it is the future of interstellar travel — for both manned and unmanned missions.

"The bottom line is solar electric propulsion now is not good for everything," Brophy says, "but it's dominating the aerospace industry." ■