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Tethers Unlimited: New Thruster to Open up More Doors for CubeSats

By Caleb Henry | January 14, 2014

[Via Satellite 01-14-2014] **Tethers Unlimited** (TUI) is testing a new propulsion method that stands to greatly improve access to, as well as the capability of CubeSats.

Robert Hoyt, CEO of Tethers Unlimited. Photo: TUI

product, and it has already received interest from a variety of markets. Last month the **United States Air Force** signed a contract with TUI for two Hydros thrusters to be used in an undisclosed mission. What makes the Hydros thruster so special is its nontoxic, unpressurized fuel: water. Having recently completed vacuum testing, the thruster is set for an additional battery of tests preceding an in-flight demonstration.

"The Hydros thruster can provide both high thrust levels (up to 1 Newton) and very good specific impulse performance (up to 300 seconds), so it is advantageous for missions that require both orbit agility and large total delta-V," Robert Hoyt, CEO of TUI, told *Via Satellite*. "Compared to the monopropellant thrusters other organizations are developing, our analyses indicate it can provide more delta-V per mass and volume for CubeSat missions requiring more than 100 meters-per-second of delta-V. Compared to the electric propulsion technologies in development, its higher thrust can provide more delta-V per orbit."

The Hydros thruster uses electrolysis to turn water into rocket fuel, greatly reducing the risks frequently associated with fueling and allowing TUI to bring down costs for satellite builders and operators. This combination of clean fuel, lower costs and improved efficiency has attracted attention from customers in the military, the commercial sector and especially academia. According to Hoyt there are multiple reasons for this interest.

A Hydros thruster sized for CubeSats. Photo: TUI

"First, the use of water as propellant eliminates the handling and certification challenges associated with hydrazine and many other propellants, so it is very well suited for programs where students will be handling the hardware," he explained. "Second, its ability to provide both high thrust and fine impulse bit propulsion make it useful for missions requiring orbit agility as well as precise station-keeping. Third, since its water propellant is already 'man-rated', it will be an excellent choice for ISS-launched CubeSats. I hope someday to demonstrate true 'in-space' fueling by having one of our astronauts 'tank up' a HYDROS thruster aboard the ISS!"

Program, so the component has been designed to handle such launches. After release from the ISS, Cubesats equipped with the new thruster will enable missions with longer durations, according to Hoyt. Regarding primary launches, it will also bring costs down by eliminating the risk to primary payloads and associated personnel. Making use of water was seen as the means to address such concerns. TUI has designed the thruster to work in a variety of conditions, including if the fuel freezes before use.

"Ideally, the satellite will be designed with passive thermal control and/or a small heater to keep the Hydros system above the freezing temperature," said Hoyt. "However, we have performed testing in which we have frozen our microgravity electrolysis cell, and demonstrated that it still works, and will actually heat itself back up above freezing. In future work we intend to integrate additional valving and nozzle ports so that the Hydros propulsion module can also provide attitude control functions with a very minimal increase in system mass and volume. This will be particularly interesting for deep space CubeSat missions, where the magnetic torque coils typically used in CubeSat systems do not work."

The Hydros thruster is currently at Technology Readiness Level 4, and still requires more testing prior to reaching higher levels. TUI's recently completed vacuum chamber testing needs to be repeated with flight control software, which is still being evaluated. That will boost Hydros to TLR 5. Environmental testing will mature it to TLR 6 by summer 2014 if all goes according to schedule, and will pave the way for flight-testing. Once complete, the thruster will enable more versatile CubeSat missions around Earth, as well as other celestial bodies.


Test firing of the Hydros thruster in a vacuum chamber. Photo: TUI

"We saw using electrolysis of water to produce hydrogen and oxygen for a thruster as a way to not only provide high thrust and excellent specific impulse with a non-toxic, non-explosive propellant, but also as a step towards enabling a future space transportation infrastructure that can use a resource that is available on Near Earth Objects, the moon's polar craters, and Mars," said Hoyt.

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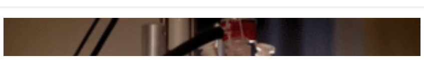
DSSP Soon to Test 'Holy Grail' of Propulsion Systems

By Caleb Henry | August 22, 2014



[Via Satellite 08-22-2014] **Digital Solid State Propulsion**

DSSP propellant in production. Photo: DSSP Screen Capture

controlled Solid Propellants (ESPs) — a new alternative to hydrazine and a potential competitor for electric propulsion. In January 2014 the company proved its thrusters, which are powered using a technique called double-diffusion, successfully reached an efficiency that places them in the regime of electric propulsion, but with a chemical system. The first in-orbit test was originally scheduled for March, but has since been rescheduled for **NASA**'s fourth Commercial Resupply Services (CRS 4) mission aboard a **SpaceX** Falcon 9 in September.

"What we are trying to develop is a true dual-mode thruster where we can operate it at high thrust and relatively low Specific Impulse (Isp*),* which is chemical efficiency, and low thrust and high Isp [which is electric efficiency]," Wayne Sawka, CEO of DSSP, told *Via Satellite*. "The benefit of a dual-mode thruster is you would be able to get through the Van Allen belts very quickly, but then have the electric propulsion high Isp when you've made it into orbit … it falls in between the payload of a fully electric system versus a fully chemical system. I think that's the Holy Grail for a lot of people, and we are making progress towards that on our solid propellants."

DSSP's thrusters will have its inaugural flight on NASA's Special Purpose Inexpensive Satellite (SpinSat), where they will be used to control the spacecraft. Once in space, a laser pointed at the satellite will track its rotation and translation from a Maui, Hawaii-based observatory. Sawka hopes the in-orbit data will build confidence in the system to fly on future missions.

Electrically controlled solid propellants are a spin-off technology that Sawka helped develop while working at **Aerojet Rocketdyne**. In 2005 he created DSSP around the technology, by which a solid rocket motor is able to turn on and off without any moving parts. DSSP now has 14 to 15 different active programs for the technology that are valued from tens of thousands to millions. The other appeal is the propellant's environmentally friendly characteristics. It is not poisonous, and requires no pressurized tanks. According to Sawka, the U.S. postal service will even allow it to travel in the mail.

"In our solid propellants we have a toxicity that is among the lowest out there. We are

Nitrogen and water are our only combustion products. The fuel we use in our solid propellants is polyvinyl-alcohol, which is actually used in a lot of food products," he said.

The unique characteristics of DSSP's electrically controlled solid propellants have captured the attention of customers outside the satellite industry as well. Sawka said oil and gas customers have found electric monopropellants very applicable to their work, and Hollywood is interested in the micro-thrusters for special effects.

Currently the U.S. **Missile Defense Agency** (MDA) is funding a significant amount of DSSP's work for tactical non-satellite purposes. The **Defense Advanced Research Projects Agency** (DARPA) has a plasma cannon test in November that will incorporate the technology, and **Raytheon Missile Systems** plans to use the company's ESPs for anti-vehicle technology and for boost phase propulsion.

Sawka said DSSP is actively working with small satellite companies **Moog** and **Pumpkin**, and has experimental work going on with **Pennsylvania State University** and the **University of Alabama Huntsville**. A company called **Illinois Rockstar** is also working on a theoretical model of the propellants, and the U.S. **Navy** is close to entering a Cooperative Research and Development Agreement (CRADA) with DSSP.

"The next big feat for us will be to do our own satellite test. This will be the test of the larger 1-newton thruster. The thought is to do that demonstration as part of our MDA work, so we're planning that flight for about two years out. What we would be looking at is probably a sounding rocket flight duplicating some of the tactical benefits for the MDA rather than a space mission," said Sawka.

Sawka admitted the next 24 months will largely focus on tactical purposes for MDA instead of satellite, but DSSP has intentions of scaling up its thrusters for use on larger satellites. The company has a second demonstration with an undisclosed customer for a CubeSat mission in 2015. DSSP is currently applying for phase two funding from MDA for a liquid thruster, which will ultimately have both military and satellite applications.

"Pushing it to CubeSats was to show that we could make [our system] fit in a CubeSat, but I really think our sweet spot for this type of propulsion system is probably the 20 to 50 kilogram range for the solids, and then as far as much larger satellites go, if we are certainly be scalable to larger systems," said Sawka. "And when I say larger systems I mean all the way up. There would be no reason it couldn't fly on a very large satellite."

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