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ULTRA-SAFE PROPULSION SOLUTIONS FOR CLUSTER CUBESATS

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Overview

A new design of satellite propulsion system is being developed by Benchmark Space Systems (BSS) with properties that make it an ideal choice for typical microsatellite and CubeSat missions.

First, this poster describes what this propulsion system is, what fuel it uses, details its operation and why it is ideal for microsatellite missions.

Second, an example mission will be provided along with how the unique properties of this propulsion system can improve the safety and lifespan of microsatellites.

Finally, results from orbital simulations will be provided showing the thruster performance aboard a proposed mission using the expected performance parameters given by BSS.

Starling Ardent

Benchmark Space System's Starling Ardent, is an Azodicarbonamide (AZO) based, ultra-safe, non-toxic propulsion system; to be flown aboard an Ames Research Center (ARC) TechEdSat launching early 2022. The Starling Ardent is an evolution of the Starling thruster (flying on the inaugural Firefly Alpha launch)* that aims to improve ISP using a resistive heating element, currently being developed through a phase II NASA SBIR.

Starling stores solid AZO powder in a tank that remains unpressurized during manufacturing, shipping, integration, launch, and deployment. Once in orbit, a pressurization command initiates an exothermic reaction that produces a gas composed primarily of Nitrogen to be stored in an expansion tank for on demand use. Highly attractive for systems with rigorous safety requirements.

Product	Propellant	Thrust	ISP	Power	TRL	Missions
Starling Ardent (Electrothermal)	AZO	0.01 - 1N	110 - 140	50 (Max)	5	TES14
Starling (Cold/warm gas)	AZO	0.01 - 1N	70	< 3	8*	BSS1

Azodicarbonamide

AZO is a DOT approved, non-toxic, inert powdered chemical that is widely used in many applications; baking dough conditioner, general use blowing agent for manufacturing and as a burning rate suppressant in other rocket propellant systems. AZO also needs a high temperature (170 - 225℃) for combustion and decomposition which significantly reduces the risks of spontaneous combustion or rapid decomposition when handled. Decomposition initiates a 300:1 gas to solid expansion ratio process resulting in a very high yield of propellant. For these reasons AZO is the perfect candidate for an ultra safe propulsion system for CubeSats.

Sample Mission

This last year, San Jose State University and Benchmark Space Systems partnered together to develop a module to be flown on NASA Ames' TechEdSat 14. This propulsion module includes BSS' Starling Ardent warm-gas thruster joined with SJSU's in-orbit experiment and control module. With the initial conditions of the mission and propulsion system characteristics known, a simulation was run to ascertain the orbit perturbation capability of the Starling Ardent. The table below represents the difference in orbit ephemera of the cubesat after burning all fuel with and without resistojet at the same starting conditions pointed in the anti-velocity direction.

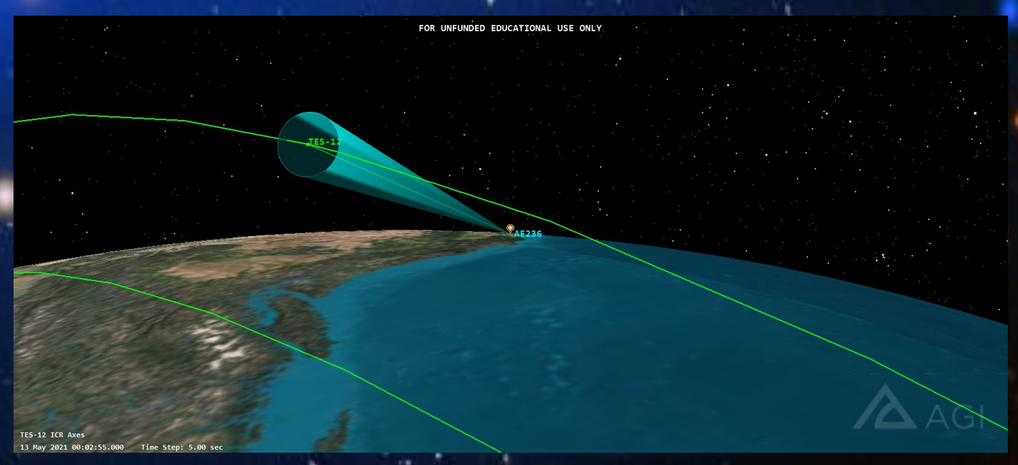
This upcoming mission will demonstrate the real in-flight capabilities as a benchmark for future missions using this technology.

Spacecraft Specifications	
Parameters	**Values**
Spacecraft Dry Mass	3.5 kg
S/C Drag Area	0.03 m^2
S/C Drag Coefficient	1.4
Fuel Mass	.09
Thrust R-on	0.05 N
Thrust R-off	0.05 N
ISP R-on	110 s
ISP R-off	70 s

Maneuver Initial Conditions	
Parameters	**Values**
Inclination	51.6°
Eccentricity	2.62E-4
Perigee Altitude	407.33 km
Apogee Altitude	404.87 km

Resistojet Off Maneuver Properties	
Parameters	**Values**
Perigee Altitude	326.62 km
Apogee Altitude	400.81 km
ΔV (Velocity)	17.43 m/s
Fuel Used	0.09 kg
Total Burn Time	1235 s
Power Used	0.08 Wh

Resistojet On Maneuver Properties	
Parameters	**Values**
Perigee Altitude	309.73 km
Apogee Altitude	391.45 km
ΔV (Velocity)	27.38 m/s
Fuel Used	0.09 kg
Total Burn Time	1941 s
Power Used	26.95 Wh



Proposed Mission

The Starling Ardent system would be an ideal propulsion system to be implemented on cluster satellites in future missions. Given the nature of cluster satellites, they would require a cost-effective, modular, safe propulsion system for station keeping and deorbiting. The Starling Ardent system is expected to extend the lifetime of nanosatellite missions, as in the TechEdSat mission. For cluster satellites, this would lead to less cost per mission and the ability to carry on longer missions and even further distances for imaging and discovery missions.

Furthermore, the integration and testing technology developed to interface the Starling Ardent system on the TechEdSat missions enables the ability of being used as a propulsion testbed for future new propulsion technologies or experimental systems.