



# Digital Solid State Propulsion, Inc.

New Energetics For a New Era

## Electrically Controlled Solid Propellants: The World's First *Smart* Energetic Materials

### Development Programs

#### DARPA:

**Direct Plasma Production from Electric Solid Propellant for High Velocity Launch Systems: AKA, "The Plasma Cannon"**

As an alternative to near-obsolete double-base or triple-base propellants, Digital Solid State Propulsion is developing Electric Solid Propellants (ESP) as a safe, green, high performance, easily manufactured alternative for high velocity electro-thermal-chemical (ETC) gun rounds. These electric energetic materials are inherently safe, with ignition only possible via the sustained supply of electrical current and not by spark, flame, or even bullet impact. We mature our materials technology by the incorporation of novel forms of nanomaterials in ESP formulations in both the propellant and igniters for enhanced medium and large-caliber gun performance, benefiting defense platforms across the Department of Defense. The demonstration-phase activity is scheduled whereby medium caliber rounds will be instrumented and test fired to show increased range, improved accuracy, in a highly energy-dense transportable form factor.

#### Missile Defense Agency (MDA):

**Precision ACS (PACS) for Kinetic Weapons**

Our Precision ACS (PACS) while combined with either a Liquid or Solid DACS delivers high precision Kinetic Weapon (KW) attitude control for long range target discrimination and acquisition. The PACS features multiple pulse Electric Solid Propellant (ESP) thrusters that are either individually pulsed (controlled for very small impulse bits) or controlled in parallel for larger ACS thrust. The PACS takes full advantage of the inherent IM (1901a) and "Green" attributes of the new ESP technology. The result is an extremely lightweight, simple, and low cost ACS subsystem that, when combined with a Liquid or Solid extinguishment DACS, enables the KW to operate for much longer periods.

#### US Army:

**Electrically-Initiated Igniters and Propellants**

Following the Department of Defense's initiative to improve munitions safety, Digital Solid State Propulsion (DSSP) is testing our Electrically Controlled Energetic Materials (ECEMs) as an alternative to the Army's 120mm tank primer material, Benite. Because primer materials, such as Benite and BKNO<sub>3</sub>, are quite sensitive to external stimuli such as impact, friction, and heat, a high performance replacement is desired that is immune to such threats. The inherent safety of the ECEM propellant is due to ignition being caused by electrical stimulus and not pyrotechnic response. ECEMs are ignited with embedded electrodes, with resulting combustion that can be augmented by power input modulation. DSSP's baseline propellant primer, HIPEP, is insensitive to friction, impact, electrostatic shock, and does not burn with flame impingement or .50cal bullet impact.



#### US Air Force:

Our Air Force programs are focused both on propulsion and warhead/bomb development. Propulsion development is directed at more agile missiles using advanced DACS with /without fin guidance. Our explosives development takes advantage of our smart energetics to be throttled for application to scalable effects weapons. Our new scalable effects weapons will provide a tune-able explosive yield that can be programmed in flight. This Air Force program also leverages DSSP's Plasma Cannon development for DARPA, using electro-thermal-chemical (ETC) combustion on an even larger scale for bomb fills.



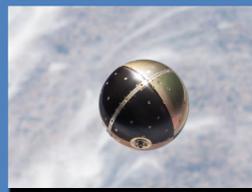
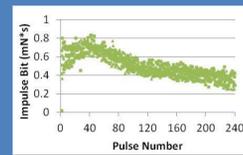
#### US Navy:

**Igniter-less Rocket Motor:**

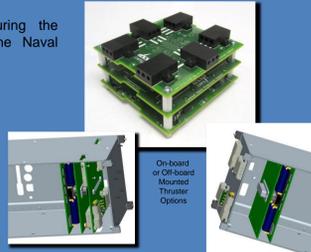
In this work, we developed highly aluminized Electric Solid Propellant (ESP) "igniterless" rocket motors that have been demonstrated at the 4-inch diameter scale. These igniterless rocket motors use inert metal electrodes for direct ignition of the ESP, thereby eliminating the need for pyrotechnic ignition systems. This demonstration included igniterless ignition of static test motors of the 200 lbf thrust class.

### CAPS-3 CubeSat Attitude Propulsion System

CAPS is a flexible and modular CubeSat propulsion system that employs DSSP's electric solid propellant technology. The system can fire up to 12 different micro-thruster elements, each having a lifetime exceeding 250 pulses. Ignition power is delivered via capacitor discharge, which results in an extremely high power, short duration impulse. Pulse frequency is dependent on power input and can reach 0.04 Hz. The CAPS controller is a miniature bi-level PCB stack less than 2.25 inches in height. Thrusters can be board-mounted on a third stacking PCB or be installed in modular housings that wire to the controller. CAPS accepts a 5V to 12V DC supply and has a simple SPI communications interface. Power consumption is dependent on the user-programmable arm rate and varies over the range of 0.1 to 2.3 Watts.



CAPS-3 is currently on orbit during the SPINSAT Mission, launched by the Naval Research Laboratory.



THRUST PERFORMANCE	
Average Thrust (mN)	~ 300
Thrust Duration (ms)	2
Minimum Impulse Bit (mN-s)	0.21
Maximum Impulse Bit (mN-s)	0.84
Effective specific impulse (sec)	Up to 900
Thrust Variability (from thrust curve)	+/- 10%
Tested lifetime, # of pulses (per thruster)	>250
Thruster total impulse (mN-s)	0.125

POWER PROCESSING UNIT (PPU)	
Power supply range (VDC)	5 - 12
Arming power (W)	0.1
Standby power (W)	0.01
Minimum Arm time (sec)	20
Maximum shot frequency (Hz)	0.04
Number of Thrusters controlled by a single PPU	12
Mass (g)	475
Height (U)	0.5

THRUSTER DIMENSIONS	
Thrusters per pack	3
Pack Mass (g)	23.3
Pack Height (mm)	9.2
Pack Width (mm)	27.9
Pack Length (mm)	41.6

TEMPERATURE LIMITS	
Operation	-20° to 50°C
On Orbit Survival	-30° to 60°C

PROPELLANT TYPE.....Nonmetalized, Electric Solid Propellant (HIPEP)

PRODUCTION STATUS.....Flown on SPINSAT

SHIPPING CLASSIFICATION.....DOT Class 1.4s

### CDM-1 CubeSat Delta-V Motor

Delivering approximately 50 m/s of delta-v to a 4kg, 3U CubeSat, DSSP's space qualified CDM-1 is designed for either a single delta-V maneuver or a rapid deorbit. The adapter plate is designed for easy mounting of the motor to the standard CubeSat structure. The CDM-1 mounts on the outside of the CubeSat which then fits inside deployment spring of a P-Pod so that the CDM-1 does not intrude into any of the normal CubeSat payload area. The CDM-1 is optimized for smooth plug-and-play integration into the CubeSat standard. The CDM-1 draws less than 5W of power for operation, using an Omnetics Bi-lobe 9-pin connector for arm and fire commands.



MOTOR DIMENSIONS	
Motor diameter (cm)	6.40
Motor length (cm)	4.70

MOTOR PERFORMANCE (STP)	
Burn time/action time (sec)	2.98
Ignition Delay time (sec)	10.8
Total impulse (N-s)	226.4
Effective vacuum specific impulse (sec)	235
Burn time average thrust (N)	76.5
Maximum thrust (N)	186.8

MOTOR WEIGHT, grams	
Total loaded	459.5

TEMPERATURE LIMITS	
Operation	-13° to 50°C
On Orbit Survival	-24° to 61.5°C

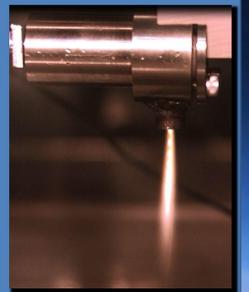
PROPELLANT TYPE.....AP/HTPB

PRODUCTION STATUS.....Qualified for Flight

SHIPPING CLASSIFICATION.....DOT Class 1.4C

### MPM-7 Multi-Pulse Motor

DSSP is currently in development of a multi-pulse motor fueled by the same nonmetalized, Electric Solid Propellant (HIPEP) that was deployed from the International Space Station during the SPINSAT mission. The design goal of this system is to desaturate reaction wheels on 6U or 12U deep space CubeSats. The motor is currently TRL 3, but DSSP is planning on having a flight-ready system by Mid-2017. The MPM performance goals can be seen below.



MOTOR DIMENSIONS GOALS	
Motor diameter (cm)	2.5
Motor length (cm)	4.7

MOTOR PERFORMANCE GOALS (VAC)	
Maximum Pulse Duration (sec)	0.5
Total impulse (N-s)	1.5
Effective vacuum specific impulse (sec)	200
Minimum Impulse Bit (N-s)	0.05
Maximum Impulse Bit (N-s)	0.3
Number of pulses (per motor, using max pulse duration)	5

MOTOR WEIGHT GOALS, grams	
Total loaded	30

POWER PROCESSING UNIT (PPU) GOALS	
Power supply range (VDC)	12-28
Input Power(W)	200
Number of Motors to be controlled by a single PPU	12-24
Mass (g)	<750
Height (U)	<0.75

PROPELLANT TYPE.....Nonmetalized, Electric Solid Propellant (HIPEP)

PRODUCTION STATUS.....In Development, Ready Mid-2017

EXPECTED SHIPPING CLASSIFICATION.....DOT Class 1.4

ASK US ABOUT OTHER PROPULSION  
SYSTEMS IN DEVELOPMENT

FOR MORE INFO, VISIT [DSSPTECH.COM](http://DSSPTECH.COM)