LAJP

Laboratory of
ADVANCED JET PROPULSION
Dnipro

Electric-Rocket microPropulsion System for Nanosatellites like CubeSat

7th NanoSatellite Symposium,
Varna, Bulgaria
October, 2016

Briefly about LAJP Ltd.

The LAJP Brief History

LAJP was established in 2007

LAJP leases land and buildings at **Dnipro National University**

and rents squares in **Institute of Metallurgic Automatic**

LAJP has its own Vacuum Chambers as well it has access to the University’s tool machines and test facilities.

Full-Time Staff – 12 Specialists

Part-Time Staff – 7 Specialists

Organizational Structure

INTER-INDUSTRIAL SCIENTIFIC-TECHICAL CO-OPERATION:
LAJP is a Member of Berlin Space Consortium (Germany)

ST Electronics – SatSys Pty Ltd.
BSS, BST, GAUSS, UoR LS
TUBITAK UZAY
NTUU KPI, DNU
KAIST, CASIC, SSP

TECHNOLOGY & ENERGY COMPANY LLP (UK)

HALL-EFFECT ELECTRIC PROPULSION (STATIONARY PLASMA PROPULSION)

GEL/PASTE/SLURRY MONO-PROPELLANT ROCKET MOTORS

HYDROGEN PEROXIDE+ETHANOL ROCKET MOTORS

© *UAV Engineering*

UAV for Different Tasks

© *LARE*

NON-TRADITIONAL RENEWABLE ENERGY SYSTEMS using 3DOF GYRO

Core Business Areas Description

- **PRIMARY:**

Commercial development, manufacturing and testing of plasma thrusters and propulsion systems for satellites with *milli-Newton* thrust

- **SECONDARY:**

R&D development, manufacturing and testing of chemical “green” rocket motors with high Newton thrust

- **TERTIARY:**

Development, manufacturing and testing of micro and small satellites; light rockets and LVs

The Current Problem

What exactly is a problem we are solving?

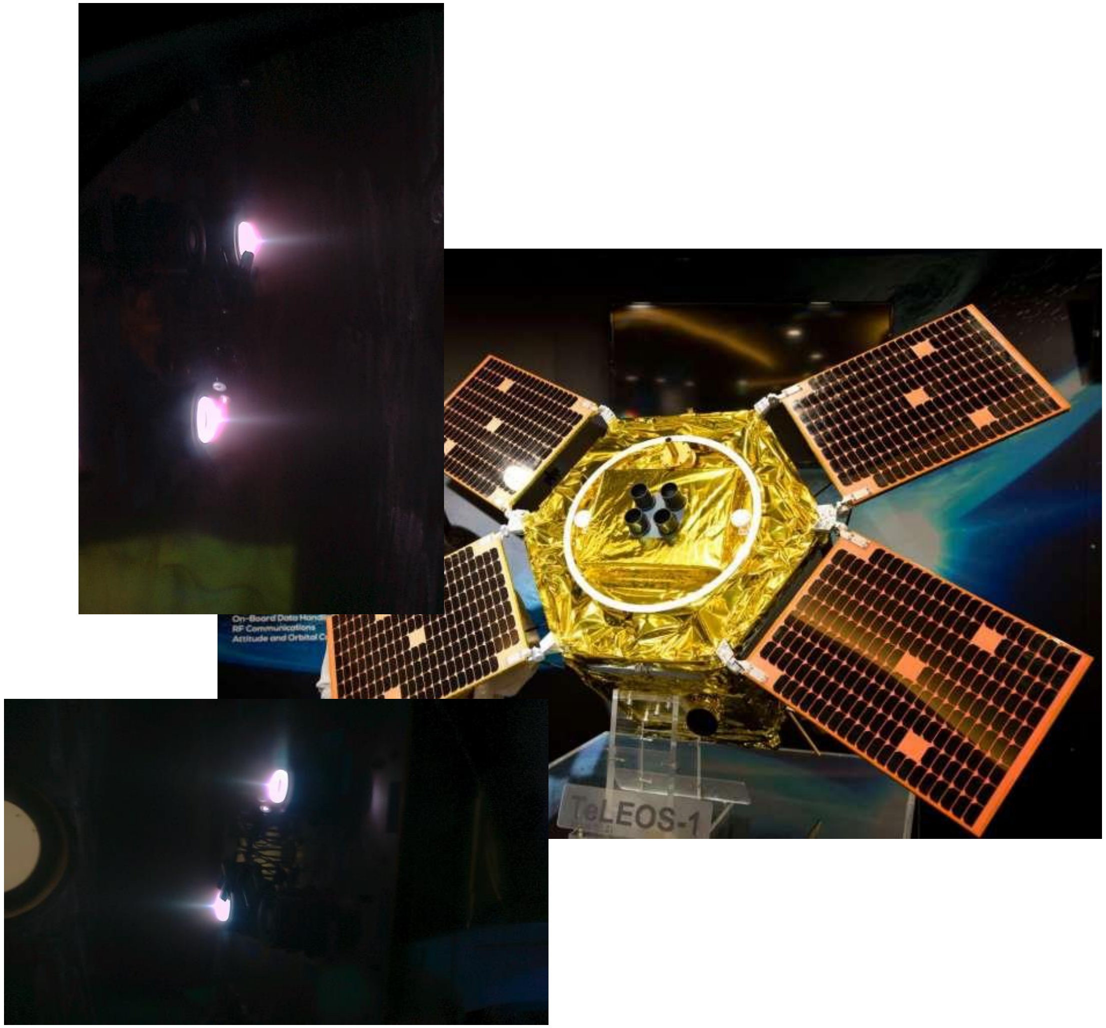
The Space Propulsion Systems are expensive devices.

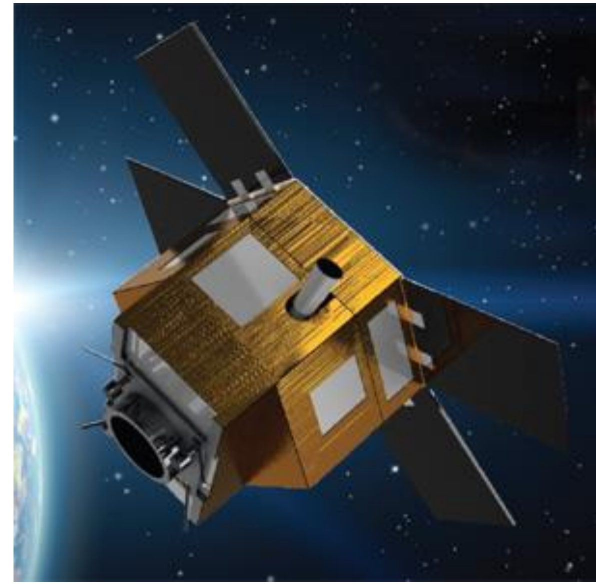
We propose <u>low-cost and technology innovative</u> approach to provide space propulsion for customers who produce **NanoSats/CubeSats** and want they live on orbits essentially more time than several months … or fly to the Moon.

Current Developments and Main Business

Commercial Use of the LAJP Propulsion

It operates in space orbit from 16th December, 2015





Technical Specifications

Satellite Manufacturer	ST Electronics (Satellite Systems) Pte Ltd
Launch Date	Q4 2015
Mission Life	Fully redundant 5 years design life
Orbit	Type/Period - Near Equatorial Orbit/ 96min Inclination – 10 to 15 degrees Altitude - 550 kilometres
Satellite Mass	Approx 400 kilograms (approx 880 pounds)
Satellite Data Storage	64 Gbits solid state recorder
Communications (CCSDS Compliant)	150 Mbps (X-Band)
Attitude Determination and Control	3-axis stabilised
Mission Control	Multiple ground station support

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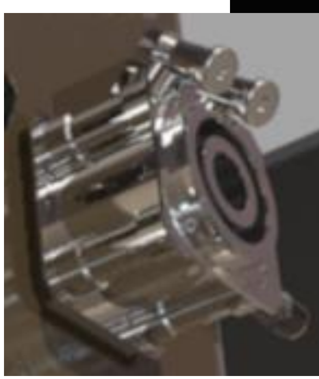
Main Business Activity. Description of Key Products

1 – low power Hall-effect thrusters

HEET-05

SPT-25



HEET-10

SPT-35/50

HEET-05 (SPT-25 type), own design

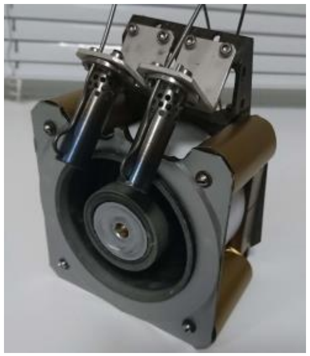
Thrust, mN	*5.2*
Isp, sec	*960*
Power range, W	*100*
Nom. power, W	*110*
Life-time, hours	*2,500 – confirmed*
Efficiency, %	*28*
Start time, min.	*up to 3*
Mass, kg	*0.47 incl. cathodes*
Status	*Flight Model (launched to space*

HEET-10 (SPT-35 type), own design

Thrust, mN	*10+*
Isp, sec	*1,070*
Power range, W	*200*
Nom. power, W	*180*
Life-time, hours	*2,500 – confirmed*
Efficiency, %	*32*
Start time, min.	*up to 3*
Mass, kg	*0.52 incl. cathodes*
Status	*pre-FM, TRL9*

Main Business Activity. Description of Key Products

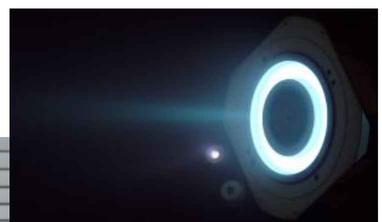
2 – mid power Hall-effect thrusters


HEEET-40

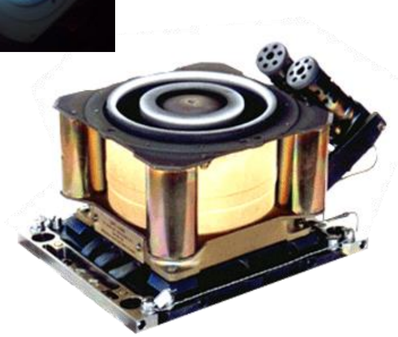

SPT-70

HEEET-40 (SPT-70 type),
own design

Thrust, mN	*40*
Isp, sec	*~ 1,450*
Power range, W	*up to 720*
Nom. power, W	*650*
Life-time, hours	*3,200*
Efficiency, %	*42*
Start time, min.	*up to 3*
Mass, kg	*1.7 incl. cathodes*
Status	*QM, TRL9*




HEEET-85

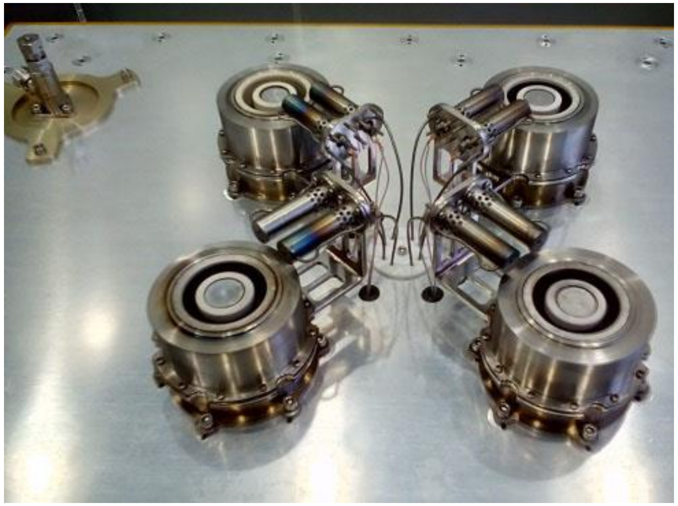

SPT-100

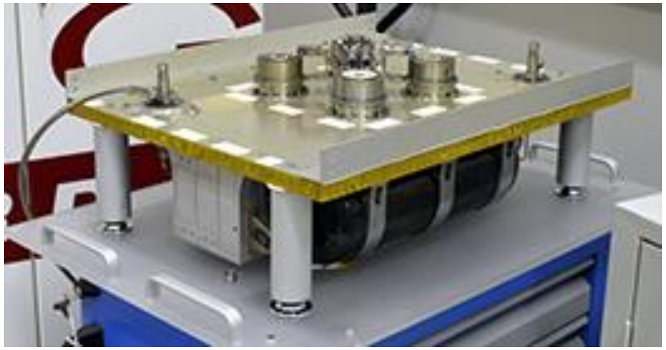
HEEET-85 (SPT-100 type),
own design

Thrust, mN	*85*
Isp, sec	*~ 1,500*
Power range, W	*1,300 – 1,450*
Nom. power, W	*1,350*
Life-time, hours	*6,400*
Efficiency, %	*46*
Start time, min.	*up to 4*
Mass, kg	*3.8 incl. cathodes*
Status	*pre-FM, TRL9*

Main Business Activity. Description of Key Products

3 – cluster PS for small LEO satellites





Propulsion System: made in 2013, test complex completed on Sep’2015, launched to space – Dec’2015.

No. of thrusters – 4 heads with average resource ~2,500h each

Operation – by thruster’s pair upon diagonal

Pair thrust, mN	*10…11*
Isp, sec	*1,070*
Power range, W	*4 x 100*
Nom. pair power, W	*200*
Start time, min.	*up to 3*
Mass (incl. Xe), kg	*29*
Functional period, years	*up to 7*
Status	*FM*

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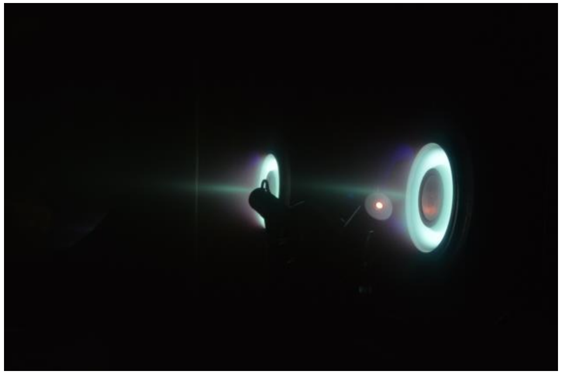
Main Business Activity. Description of Key Products

4 – HOLLOW CATHODES for Hall-effect and Plasma Ion thrusters

	Parameters	HCC-3	HCC-5
1	Discharge current, Amp	0.5 - 3	0.5 - 5
2	Operating voltage, V	12 … 5	15 … 5
3	Fuel consumption, mg/sec	0.07 – 0.25	0.12 – 0.28
4	Fuel type	Xe, Kr, Xe+Kr, Ne, Ar, He, N_2, H_2, I and even O_2	Xe, Kr, Xe+Kr, Ne, Ar, He, N_2, H_2, I and even O_2
5	Fuel cleanness, %	Xe 5.0 … 2.0	Xe 5.0 … 2.0
6	Heater start voltage, V	12	12
7	Heater operation time, s	< 240	< 240
8	Start power consumption, W	36	58
9	Operation power consumption, W	15	25
10	Number of ignitions, times	> 1,800	> 1,000
11	Life-cycle, hours	~ 3,000	~ 3,000
12	Size (Diameter x Length), mm (without flank)	12.5*42	13*56
13	Mass, gr	48	62
14	Reliability	0.99	0.98
15	Development Status	FM	TRL9

Main Business Activity. Description of Key Products

4 – HOLLOW CATHODES for Hall-effect and Plasma Ion thrusters



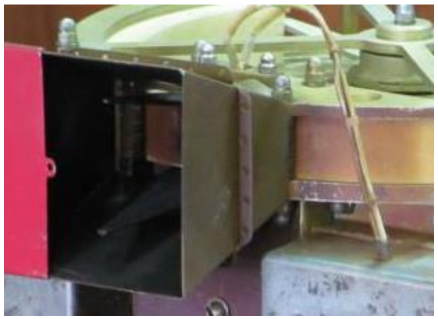
Both electric Hall-effect and Plasma Ion thrusters use additional external electron sources called Cathodes. LAJP develops and manufactures its own cathodes types HCC-3 and HCC-5 from high-grade materials such as Cesium, which brings along a multitude of advantages.
The Cesium Cathodes are highly tolerant for air, water and steam. They do not need high-purity operating gases, nor special protection for storing and handling. Moreover, the Cesium Cathodes need less power for electrons output, while they also do not need special casings.

For redundancy reasons, the cathodes for space applications are usually positioned as pair or double pair around the thruster. HCC-3 cathodes are being successfully operated on small satellites, while HCC-5 cathodes are more robust and suitable for laboratory applications.

Propulsion Proposal for NanoSats/CubeSats

NanoSat/CubeSat Propulsion Systems

There are different types of propulsion systems for NanoSats/CubeSats:

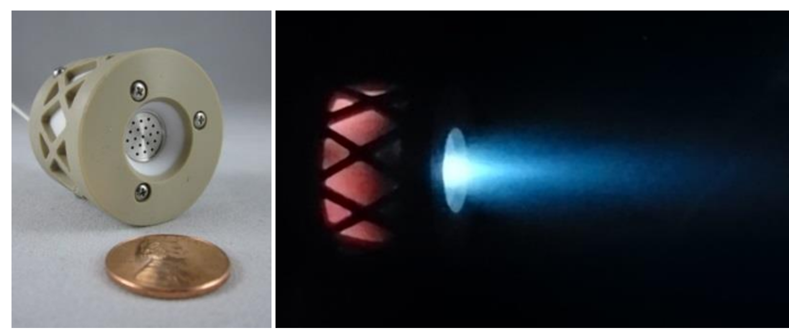


µicro PULSE PLASMA PROPULSION

CATHODE's PLASMA PROPULSION

ELECTRIC-HEATING LIQUID MONOPROPELLANT PROPULSION

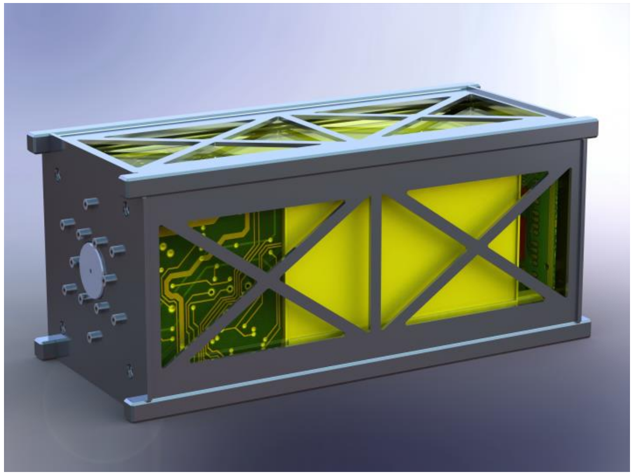
µicro ION PLASMA PROPULSION

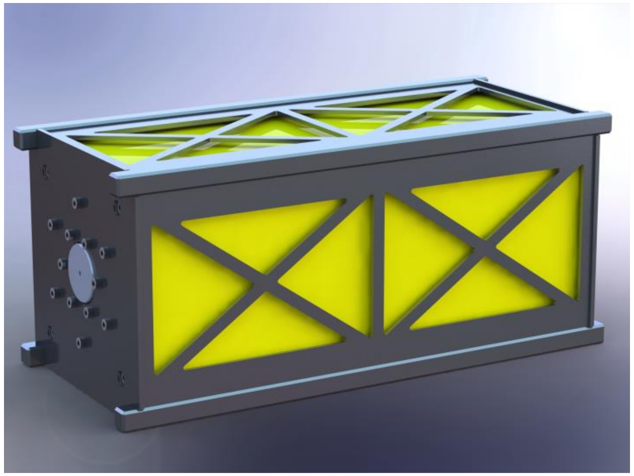


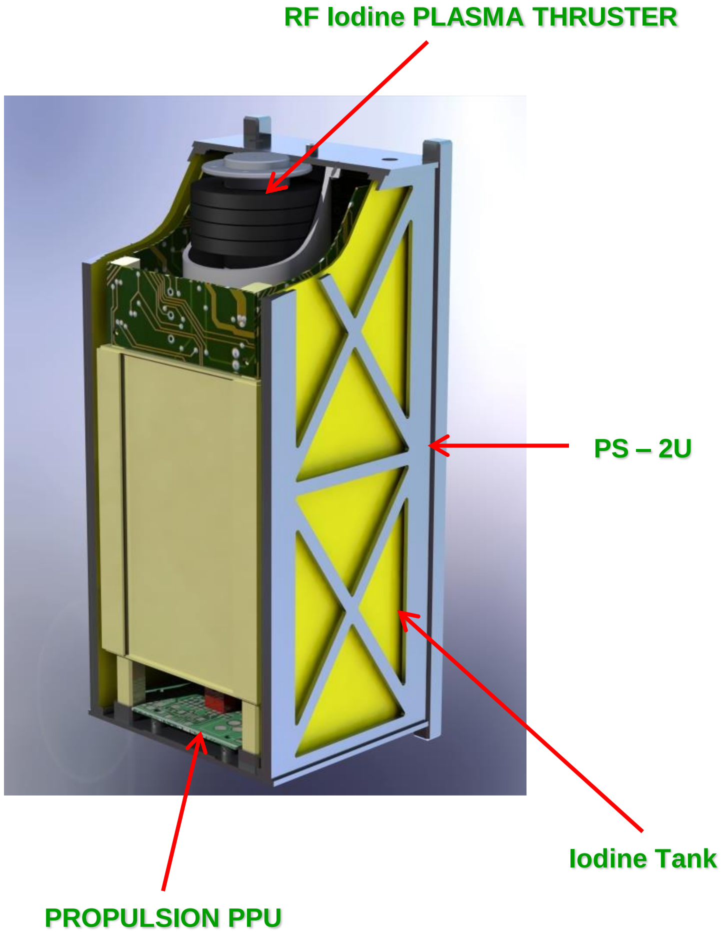
RF ION PLASMA PROPULSION

LAJP NanoSat/CubeSat Propulsion Development

The propulsion system operates as innovative RF Plasma Motor using Iodine as a Working Body:

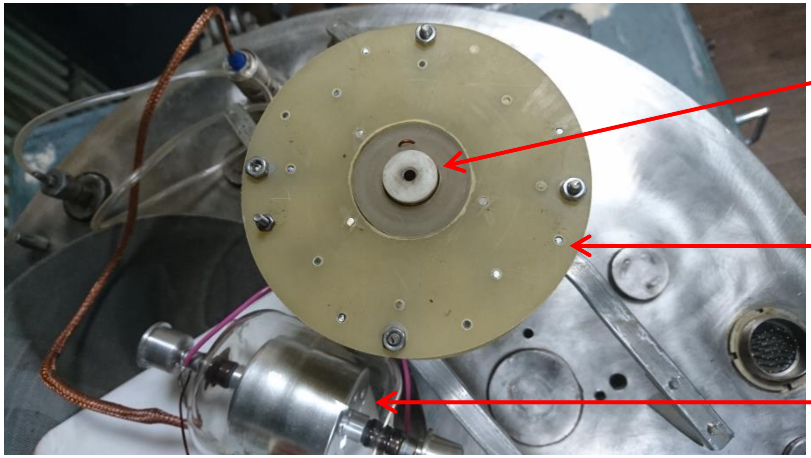






LAJP NanoSat/CubeSat Propulsion Development

The tests into vacuum chamber:



Tube of Gas-Iodine Ionization

Electro-Magnetic Coils

Vacuum Capacitor

Firing Tests

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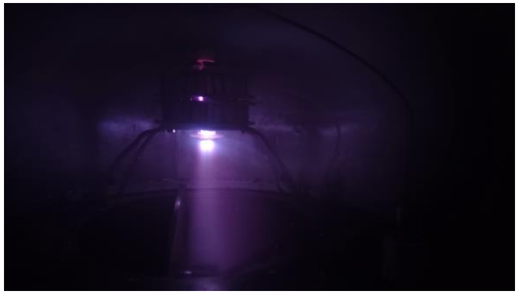
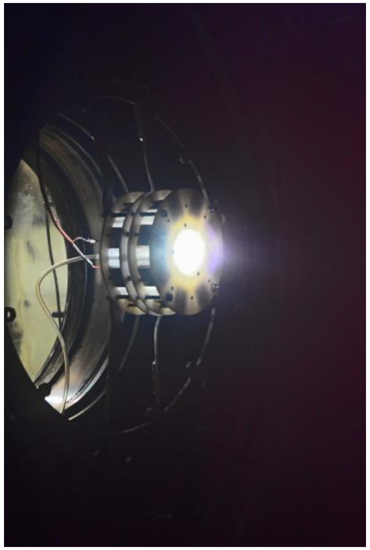
LAJP NanoSat/CubeSat Propulsion Development

Received technical parameters:



8W of Power Consumption,
0.04 mg/s of Gas Consumption



12W of Power Consumption,
0.05 mg/s of Gas Consumption

Dry Propulsion System Mass*, kg	1.3
Dimension (without fuel tank), mm	1U
Fuel	Inert and Halogen gases
Fuel consumption, mg/s	0.04…0.1
Neutralizer (cathode)	No
Thrust, microN	300…1,000
Specific impulse, s	500…800
Power consumption, W	8…30
Efficiency, %	~30
Status, (TRL, model)	TRL6, EM
Product delivery, months	5…7
Product price	Low-cost

* Propulsion System includes: thruster, feeding&flow control sub-system, power processing unit, telemetry unit

LAJP microPropulsion for CubeSats

CubeSats in Ukraine:

National Technical University
'KPI'

CubeSat PolyTAN-1,
launched 2015

PolyTAN-2 currently is in the
ISS and soon will be launched
by astronaut

PolyTAN-3 is in devepoment
and will have 3U design to use
RF Iodine propulsion system

Possible design of the Moon 9U Sat

Propulsion System – RF Iodine,
only 5 kg of crystal Iodine to reach
the Moon

Thank You!
Will be glad your questions.