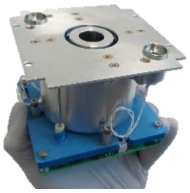
Introduction to the IFM Nano Thruster

For **15 years**, FOTEC has followed a **technology push from ESA** developing a FEEP propulsion technology for a very niche market of scientific satellites in formation flight. This very mature and worldwide unique technology is meeting a **strong need in an emerging market of satellite constellations** (hundreds of small satellites performing a task together). ENPULSION has been founded as a Spin-Out together with FOTEC to meet this market demand by prepraing to **scale the production of this thruster to several hundred units per year**.

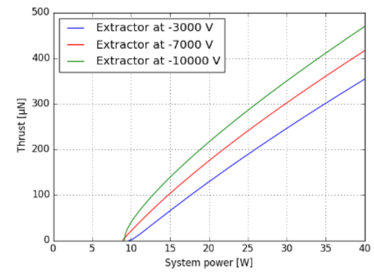
PRODUCT FEATURES

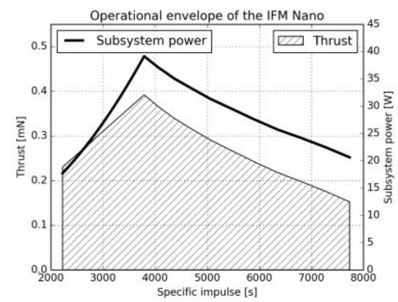
MATURE TECHNOLOGY	The IFM Nano Thruster is a mature technology, developed under ESA contracts for 15 years. In this time more than 100 emitter have been tested and an ongoing lifetime test has demonstrated more than 13.000 h of firing without degradation of the emitter performance.
DYNAMIC PRECISE THRUST CONTROL	The thrust can be controlled through the electrode voltages, providing excellent controllability over the full thrust range and a low thrust noise.
CONTROLLABLE SPECIFIC IMPULSE UP TO 5000 S	Due to the efficient ionization process which allows to ionize up to 60% of the evaporated Indium atoms, the IFM Nano can provide a higher specific impulse than any other ion propulsion system currently on the market.
REDUNDANT NEUTRALIZER CATHODES	As the IFM Nano thruster expels an ion current of up to 3 mA, the module needs means to prevent spacecraft charging. This is achieved by the use of two cold-redundant electron sources acting as neutralizers. Such an electron source consists of a Tantalum disc which is heated up to 2,200 K and biased to -200 V. Once electrons have left the neutralizer, they will be pulled towards the positive potential of the ion plume. The PPU is able to measure and control this charge balancing electron current.
SAFE AND INERT SYSTEM COMPLIANT WITH ALL LAUNCHER REQUIREMENTS	The IFM Nano contains no moving parts and the propellant is in its solid state at room temperature. Avoiding any liquid and reactive propellants as well as pressurized tanks significantly simplifies handling, integration and launch procedures.
COMPACT BUILDING BLOCKS	The IFM Nano thruster module is used as a compact pre-qualified building block in order to provide custom solutions at a commodity price and ultra-short lead times. Although building block is a complete self-contained propulsion system, the whole cluster can be operated as a single plug and play unit.
THRUST VECTORING	Using a cluster of IFM Nano Thruster modules for small satellites provides a significant thrust vectoring capability.

PROPERTIES AND PERFORMANCE



While the required power to operate the IFM starts at around 8 W, at higher thrust levels one can choose between high thrust and high specific impulse operation. The IFM 350 can operate at an Isp range of 2000 to 5000 s. At any given thrust point, higher Isp operation will increase the total impulse while it will also increase the power demand. The thruster can be operated along the full dynamic range throughout the mission. That means, that high Isp and low Isp maneuvers can be included in a mission planning, as well as high thrust orbit maneuver and low thrust precision control maneuvers.

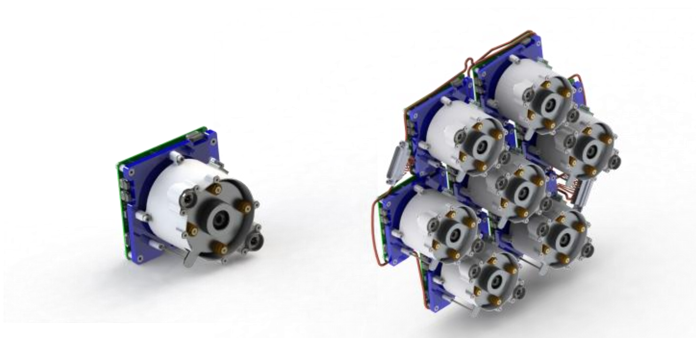


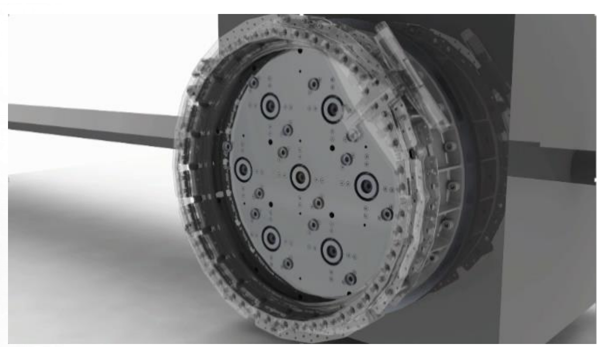


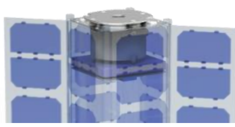
PARAMETER	VALUE
Dynamic thrust range	10 µN to 0.5 mN
Nominal thrust	350 µN
Specific impulse	2,000 to 5000 s
Propellant mass	250 g
Total impulse	more than 5,000 Ns
Power at nominal thrust	35 W incl. neutralizer
Outside dimensions	94 x 90 x 78 mm
Mass (dry / wet)	640 / 870 g
Total system power	8 – 40 W
Hot standby power	3.5 W
Command interface	RS422/RS485
Temperature envelope (non-operational)	-50 to 120°
Temperature envelope (operational)	-20 to 50 °C
Supply voltage	12V, 28 V, other voltages upon request

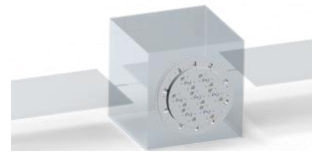
MODULARITY

The IFM Nano thruster can be clustered in order to **meet any specific mission need**. As we are using a number of pre-qualified modules (building blocks), this customization can be done **without increasing the cost or lead times of the thruster**.









Number of Modules	1	2	3	4	5	6	7
Total Impulse	> 5000 Ns	> 10000 Ns	> 15000 Ns	> 20000 Ns	> 25000 Ns	> 30000 Ns	> 35000 Ns
System Mass (wet)	1 kg	2* kg	3* kg	4* kg	5* kg	6* kg	7* kg
System Volume	0.6 dm³	1.2 dm³	1.8 dm³	2.4 dm³	3 dm³	3.6 dm³	4.2 dm³

* Additional mass for brackets or housings might be necessary depending on the accomodation of the thruster modules on the spacecraft.

Δv [m/s]

Spacecraft Mass [kg]	1	2	3	4	5	6	7
2	2879						
3	**2141**	3480					
5	1415	2456	3254	3886			
10	766	1415	1972	2456	2879	3254	3587
15	525	993	1415	1795	2141	2456	2744
20	399	766	1103	1415	1703	1972	2222
30	270	525	766	993	1209	1415	1610
40	204	399	586	766	938	1103	1262
50	164	322	475	623	766	904	**1038**
70	118	232	344	453	560	664	766
100	83	164	244	322	399	475	549
150	55	110	164	217	270	322	374
200	42	83	123	164	204	244	283