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**Title**

# Design and Testing of a small Water Electrothermal Thruster


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## Abstract

With the rapidly increasing number of satellites in orbit, the growing complexity of their missions and the risk of collisions, there is a clear need to develop low-cost, low volume, reliable and high-thrust onboard propulsion systems. Traditionally, cold gas nitrogen systems have been used as they provide a simple solution, combining high reliability with low cost. However cold gas thrusters exhibit a fairly low specific impulse and poor storage densities. One possible way to enhance their performance is to heat the propellant in order to increase the specific impulse thus extending the mission life. When this is done electrically with resistance heaters the thruster is known as resistojet. Resistojets are the simplest type of electrothermal thrusters. A standard propellant is hydrazine as it presents the best compromise in terms of specific impulse, storage and distribution. Other propellants such as krypton and xenon, commonly used for Hall thrusters and ion engines, can be employed for resistojets, however, they must be stored at high pressure in dedicated tanks and the increase in price observed over the ast few years makes them commercially unattractive.

Finding cheap and easy-to-handle propellants is therefore crucial for space agencies and private entities worldwide. Another propellant that seems interesting for its particular properties is pure water. Water is inexpensive, non-toxic and can be stored in liquid form. It is also an abundant resource in the solar system. Its small molecular mass makes it possible to achieve a high level of specific impulse. There are nevertheless some disadvantages: it must be very pure, it must be kept from freezing and additional power is required for vaporization.

A small electrothermal water-fueled propulsion thruster is currently being developed and tested at the ICARE laboratory in France. The thruster consists of a spherical tank for liquid water, a tank for the pressurizing gas ($N_2$), a printed electronic control circuit based on the raspberry Pi microcontroller, a vaporization chamber, and a convergent-divergent nozzle for expanding the vapor. The input power remains below 50 W with a scalable thrust in the mN range and a specific impulse around 100 s.
In this contribution, we shall present the architecture of the water-fueled resistojet and thrust measurements performed in a vacuum chamber with a calibrated load cell for a broad set of operating conditions. Details about the vaporization chamber will be given as it is a critical component of the propulsion system. Indeed, in the absence of gravity, vaporization must be effective to avoid droplet formation during the expansion process, therefore ensuring high performance.