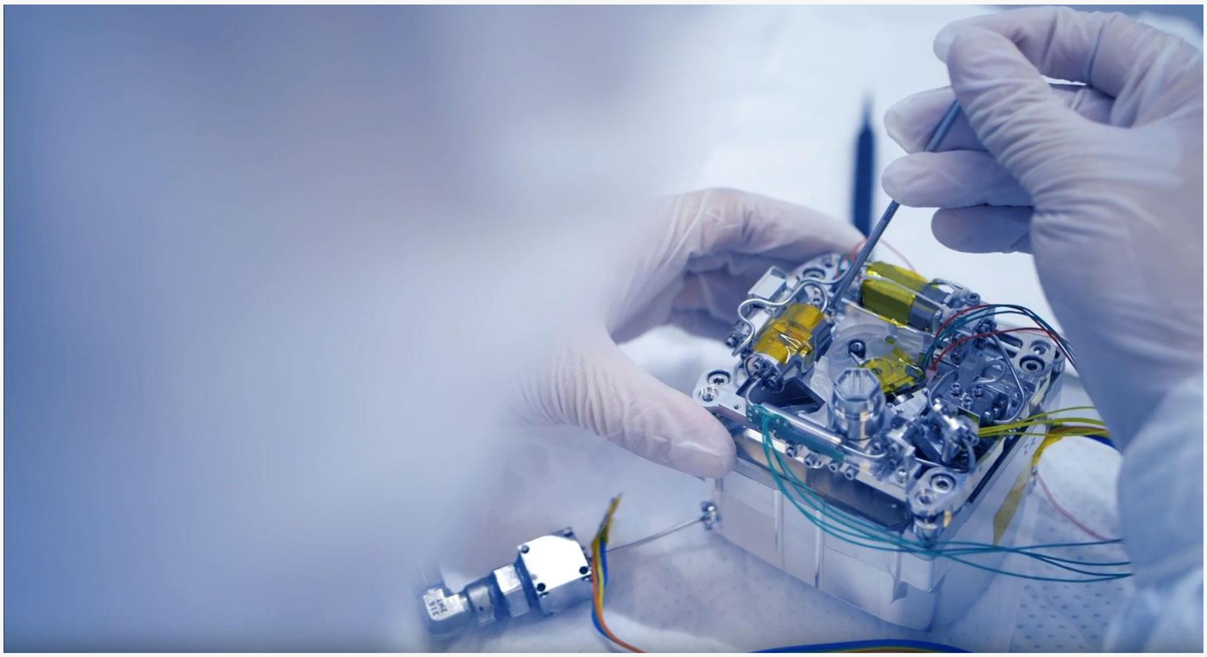

# Propulsion System EPSS C2

Technical Overview / EPSS C2

NA-EPSS-C2-TO-R0

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# Contents

# 1 Enabling Propulsion System for Small Satellites EPSS. Introduction

NanoAvionics is the first aerospace company ready to offer a high-performance and environment-friendly propulsion system for small satellites being compatible with CubeSats. The system has the potential to unlock massive relaunch savings for satellite operators by an estimated 80%.

The Enabling Propulsion System for Small Satellites (EPSS) is a versatile system allowing nano-satellites to perform:

- Constellation deployment and formation flights;
- Drag compensation and orbit maintenance;
- Orbital maneuvering, including Hohmann transfer;
- Synchronization and positioning of communication equipment and payload instruments;
- De-orbiting at the end of the mission and other functions.

The propulsion system is modular in design, permitting integration with multiple present and future small satellite platforms on the market. The system is designed to be easily scaled to optimize for the client mission by adjusting the volume of the tank to accommodate different propellant quantity needs.

The system's operation and functionality were tested and validated during orbital flight on-board the LituanicaSAT-2, 3U CubeSat as part of the QB50 project on 5th of July, 2017 and reached TRL 7. After the successful testing of the system TRL 9 was attained with M6P mission in 2019. Two 2U propulsion systems and one 3U system are currently in production for the missions to be launched in approximately 2 years.

This system is fueled with ADN-based monopropellant which has up to 6% higher specific impulse and 24% higher energy density as compared to the hydrazine employed systems, permitting significant levels of thrust to be stored within a relatively small storage volume. In addition, EPSS allows high thrust-to-volume-to-weight ratio at very low power budget required making it very competitive and practically proven solution, even when compared with the electric (high $I_{sp}$) propulsion.

As ADN-based propellant is "green" its usage contributes to ESA's and NASA's clean space initiatives. Components such as valves, fuel tanks, propellant management system, and high-performance thrusters were designed, manufactured and supplied by NanoAvionics' partners - globally trusted aerospace companies.

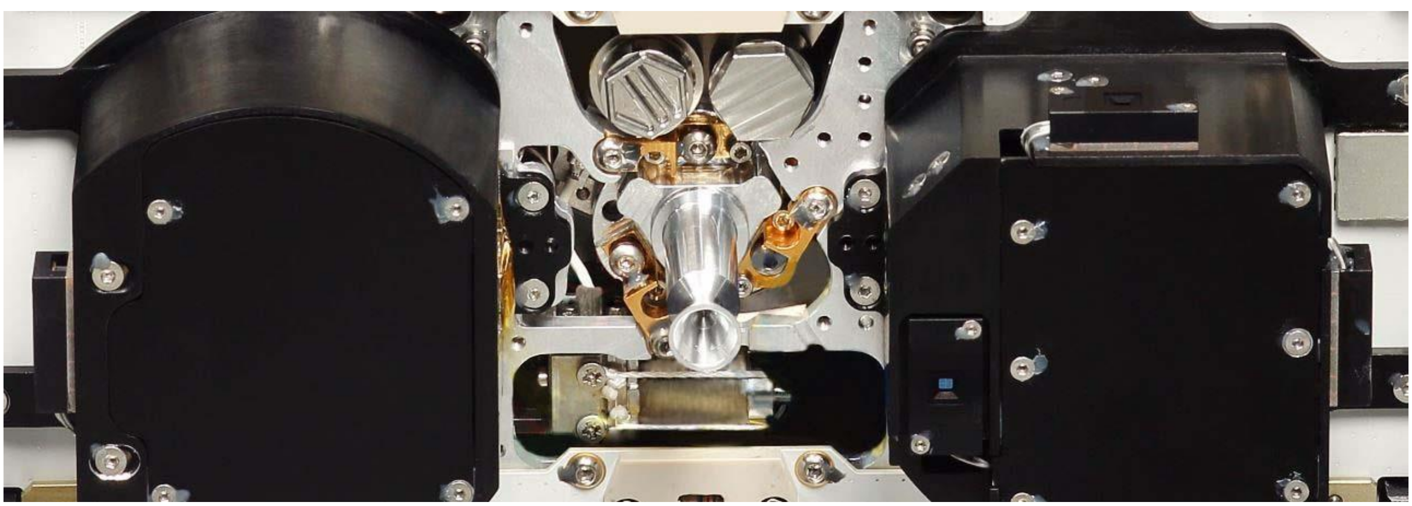

Figure 1. Enabling Propulsion System for Small Satellites

# 2 Specifications

EPSS propulsion system is designed and manufactured by NanoAvionics. EPSS system is already pre-integrated (mechanically, electrically and functionally tested) and pre-qualified to be immediately ready for the integration. Therefore, the final flight acceptance and flight readiness procedures are significantly easier for the customer. Firmware is installed for the customer to be able to run system diagnostics upon delivery.

An integration service can be performed by the NanoAvionics team according to separately agreed terms and conditions. Fueling operations are handled by the experienced NanoAvionics propulsion engineers.

Table 1. EPSS C2 Specification

| Parameter | Value | |
|---|---|---|
| Satellite Type | CubeSat / Nanosatellite | |
| System name | EPSS C2 | |
| Propulsion System Size | 2U | |
| Lead Time | 12-14 months | |
| Propellant Type | Ammonium Dinitramide (ADN) Blend | |
| Thruster Type | Green monopropellant | |
| TRL | 9 | |
| Propulsion System Dry Mass (kg) | 1.7 | |
| Propulsion System Wet Mass (kg) | 2.5 | |
| Sub - System Data Interface (e.g. RS422) | CAN | UART |
| Sub - System Operating Voltage for Heaters and Valves (V) | 12 | |
| System Telemetry Logic Voltage TLM (V) | 3.3 | |
| Tank Pressurization Type | Barrier-separated blow-down | |
| Mission BOL pressure (Bar a) | 23 | |
| Mission EOL pressure (Bar a) | 4.7 | |
| Proof Pressure (Bar a) | 37 | |
| Burst Pressure (Bar a) | 39 | |
| Propellant Mass (kg) | 0.8 | |
| No. of Thrusters | 1 | |
| Thrust BOL | 1 N | |
| Thrust EOL | 0.22 N | |
| Specific Impulse (s) | 214 | |
| Total Impulse (N.s) | 1700 | |
| Mass flow BOL (kg/s) | 4.6 E-04 | |
| Mass flow EOL (kg/s) | 1.1 E-04 | |
| Propulsion System Rad tolerance (rads) | 20k | |
| Propulsion System Vibration (Grms) | 14.1 qualification | |

# 3 Safety Features

EPSS system was designed and built under high aerospace requirements following ECSS standard guidelines. It has a number of inbuilt reliable safety features.

Thruster catalyst heater protections:

- Overheat protection (Implemented in software)
- Overcurrent protection (Implemented in software)
- Redundant power switch
- Timeout function
- Single event upset resistant switch circuit
- Latch-up protection
- Heater shutdown function if MCU freezes

Propellant tank temperature control protections:

- Redundant temperature and pressure sensors
- Redundant heaters with independent power channels
- Overheat protection (Implemented in software)
- Overcurrent protection (Implemented in software)
- Overpressure by overheating protection (Implemented in software)
- Single event upset resistant switch circuit
- Latch-up protection
- Heater shutdown function if MCU freezes

Solenoid valve protections:

- Normally closed type solenoids
- Overheat protection (Implemented in software)
- Overcurrent protection (Implemented in software)
- Redundant power switch
- Single event upset resistant switch circuit
- Latch-up protection
- Valves close if MCU freezes
- Demagnetizer function

Firing-state protections:

- Electronic Control Unit (ECU) overheat protection (Implemented in software)
- Chamber overheat protection (Implemented in software)
- Propellant tank overheat protection (Implemented in software)
- Propellant tank overpressure by overheat protection (Implemented in software)
- Continuously monitors CAN interface for commands (such as from ADCS for abort)
- Post-heat if firing stopped due to a fault (non-nominal operation)

# 4 Performance

## 4.1 Thruster Parameters Variation over Lifetime

As the propulsion system features a blow down type propellant pressurization, the tank pressure varies as the propellant is being consumed. Accordingly, the thrust and specific impulse of the thruster firing in steady sate also vary with the tank pressure. The relationships of these parameters at 20 °C tank temperature are given in Figure 2, Figure 3 and Figure 4.

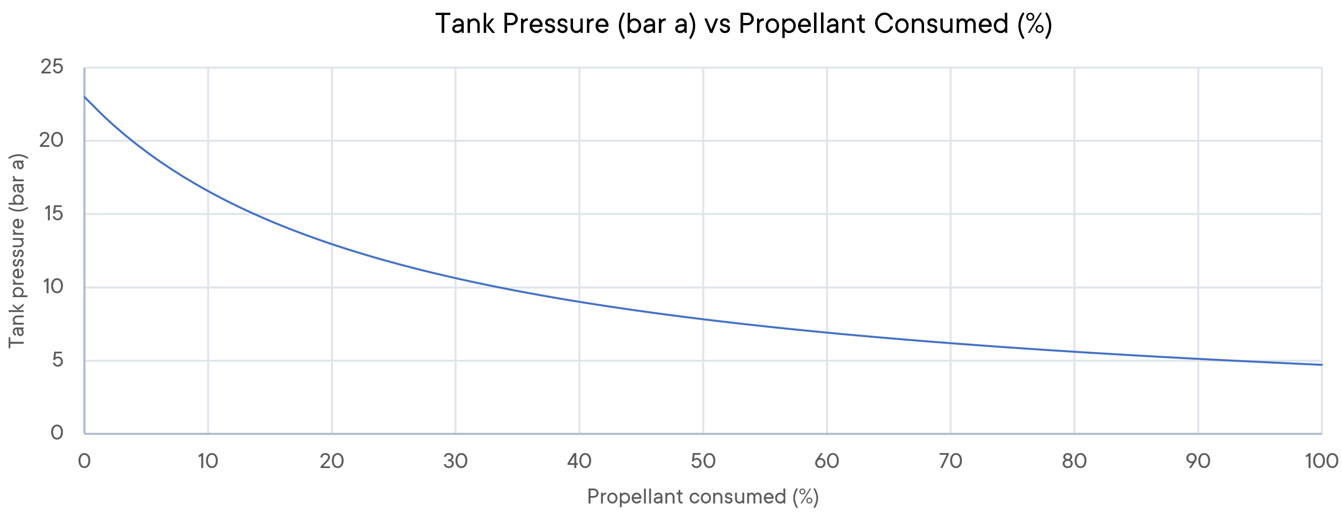


Figure 2. Relationship between the Tank Pressure and Propellant Consumed

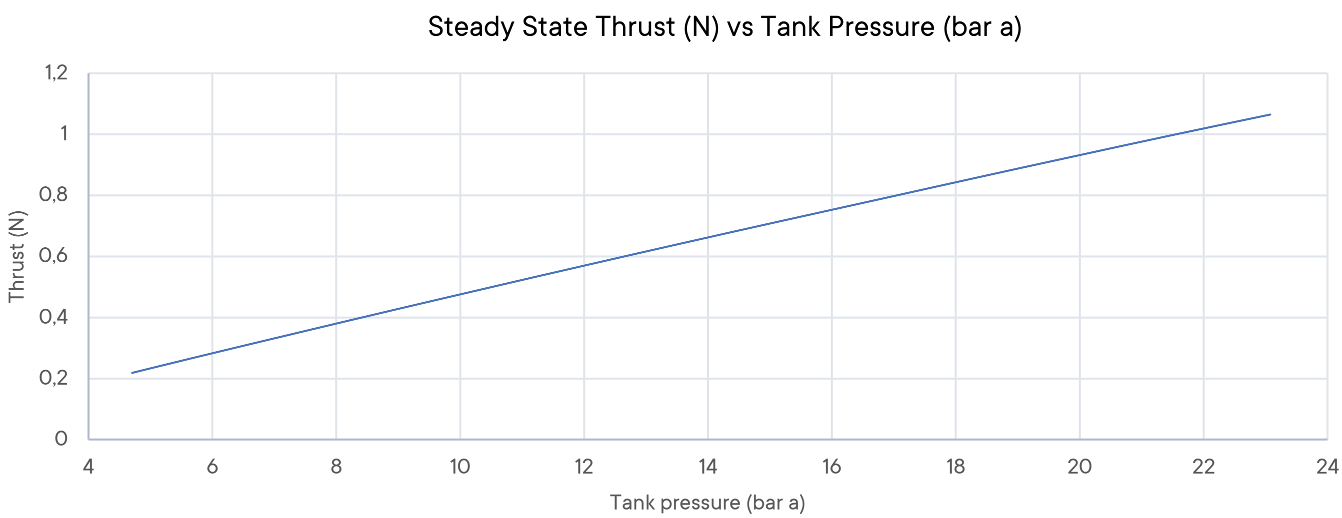


Figure 3. Relationship between the Steady State Thrust and Tank Pressure

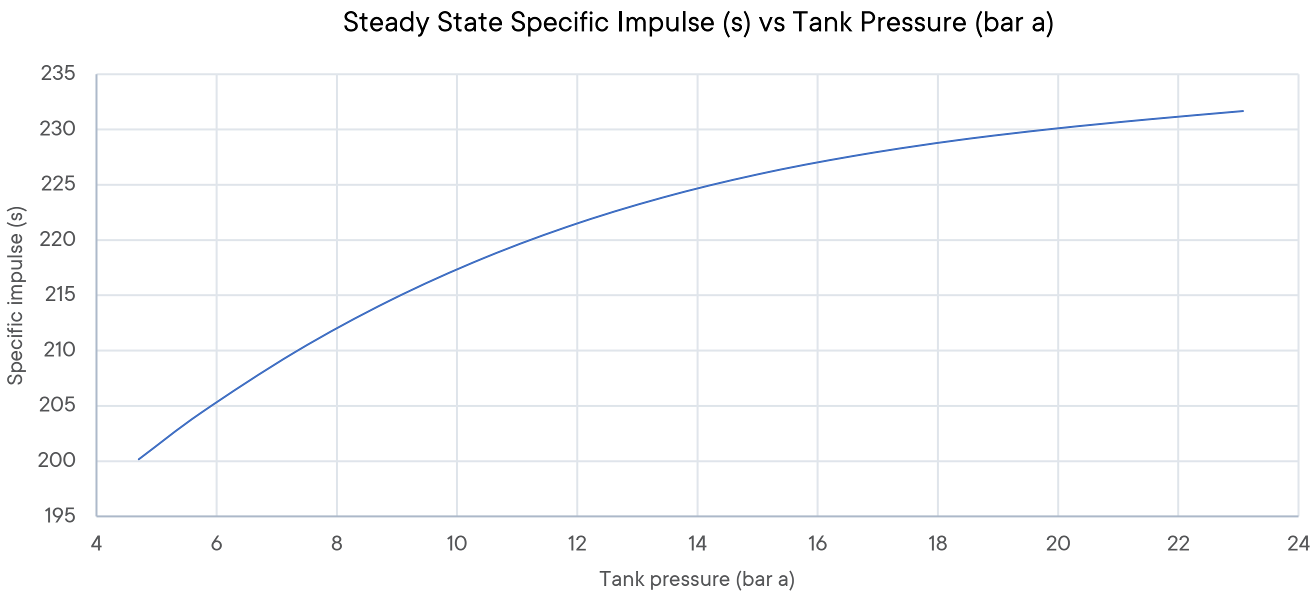


Figure 4. Relationship between the Steady State Specific Impulse and Tank Pressure

## 4.2 Single Pulse Specific Impulse Variation over Pulse Duration

While the propulsion system was designed to minimize the dead volume between the valve and combustion chamber, every time the valves are open for an individual firing, this dead volume must first be filled with propellant. Because of this and also because the thruster has thermal inertia, the specific impulse varies with the duration of a single firing. It is advised to fire the propulsion system in long firings (>30 s) in order to achieve maximum propellant usage efficiency. The relationship between the specific impulse of a single pulse as a function of a pulse duration is given in a Figure 5. Please note that this is a specific impulse as integrated over the whole single pulse duration for a maximum tank absolute pressure of 23 bar.

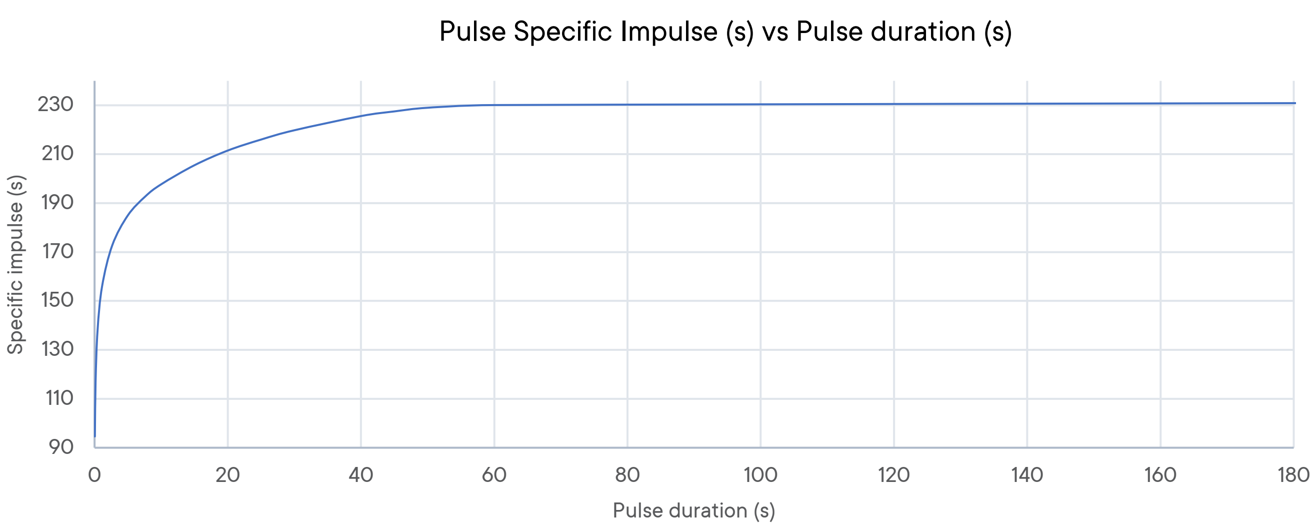


Figure 5. Relationship between the Pulse Specific Impulse and Pulse Duration

# 5 Disclaimer

The information in this document is subject to change without notice and should not be construed as a commitment by NanoAvionics, Corp. NanoAvionics assumes no responsibility for any errors that may appear in this document.