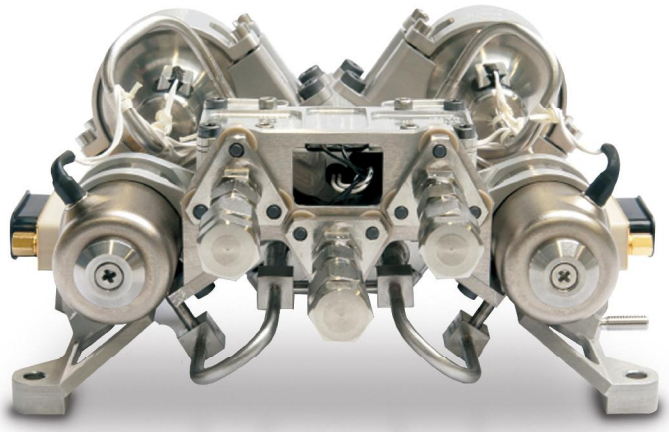
FLOW CONTROL UNIT



Bradford's Flow Control Unit (FCU) technology provides precise control of the xenon propellant flow rates to ion thrusters. The FCU makes use of proportional flow control valves to precisely control the flow rate of xenon by controlling the pressure differential over a fixed hydraulic resistance (i.e. thermally controlled flow restrictor). In principle one of two control logics can be applied:

- **FCU with Closed Loop Control**

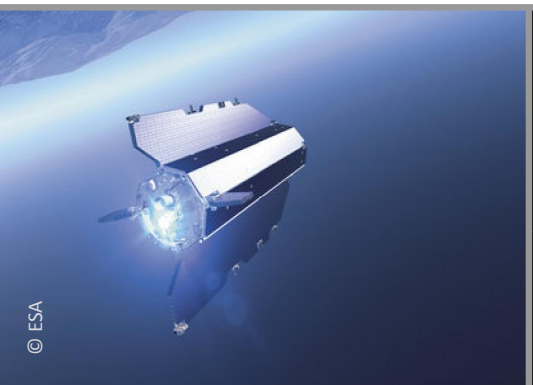
Using the downstream temperature-corrected pressure measurement as a signal for closed-loop feedback, variable current is applied to the proportional flow control valve to control the effective flow restrictor inlet pressure and thereby control the mass flow rate to the thrusters.

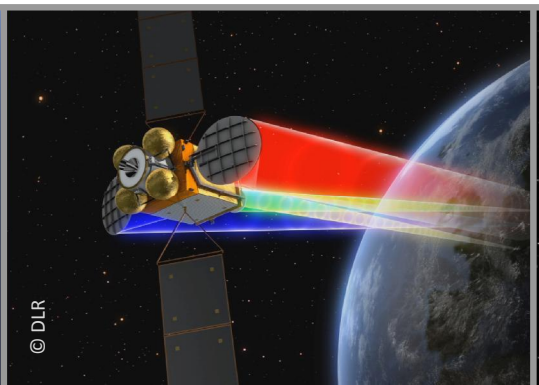
- **FCU with Open Loop Control**

In this architecture, the flow rate control is performed using a feedback device outside the FCU, e.g. the thruster current. Based on the thruster current, variable current is applied to the proportional valve inside the FCU to control the flow rate.

This open loop control strategy allows for a simplified and more cost-effective FCU, while sharing the same component heritage and qualification status as the closed-loop FCU.

The neutralizer mass flow rate is set to a fixed value, which is set by using a defined hydraulic resistance only. Solenoid isolation valves are employed in the FCU, to provide xenon isolation and branch selection.





Flow Control Unit

Characteristic	Performance / Interfaces Budget
Operating media	GXe
Test media	GN_2, GHe, GAr
Inlet filter rating	2 µm absolute filtration
Inlet pressure range	2.50 to 2.85 barA
Maximum expected pressure	10 barA
Proof pressure	15 barA
Burst pressure	25 barA
Main line flow	0.8 to 3.0 mg/s ± 1.0 %
Cathode line flow	0.6 to 0.8 mg/s ± 1.0 %
Neutralizer line flow	0.10 mg/s ± 10 %
Outlet pressure main line	0 to 300 mbarA
Outlet pressure cathode line	0 to 200 mbarA
Outlet pressure neutralizer line	0 to 100 mbarA
Flow rate initialization time	≤ 1 min
Response time	≤ 1 min
Temperature feedback accuracy	< 0.2 °C
Pressure feedback accuracy	< 0.3 %
External leakage	$< 3 \cdot 10^{-8}$ scc/s GHe
Internal leakage	$< 3 \cdot 10^{-5}$ scc/s GHe (≥ -20 °C)
Mass	≤ 1160 g
Overall size	184 x 144 x 76 mm
Operational temperature range	-30 to +65 °C
Non-operational temperature range	-40 to +75 °C

Design Heritage

The FCU with closed loop control, is employed inside BepiColombo's Solar Electric Propulsion System in conjuction with QinetiQ's T6 Thruster. The FCU and T6 are also considered for the derived High Power Electric Propulsion System for commercial communications satellite applications.

The FCU with open loop control, is baselined for the HEMP thruster application for the SmallGEO platform under the ARTES 11 programme.

Components

Proportional Flow Control Valve:	Moog Inc. (USA)
Low Pressure Transducer:	Bradford (NL)
Flow restrictor:	Bradford (NL)
Absolute Filter:	Bradford (NL)
Gas Purifier:	Bradford (NL)
Isolation Valve:	Moog ISP (UK)

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ABOUT

Bradford is a high-tech European developer and manufacturer of satellite control sub-systems and components.

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