



# CUBESAT HIGH IMPULSE PROPULSION SYSTEM (CHIPS) JULY 2018

The CU Aerospace (CUA) / VACCO CubeSat High Impulse Propulsion System (CHIPS) offers a miniaturized and well-integrated small-satellite propulsion solution, including both a main thruster and three-axis attitude control system (ACS). CHIPS achieves a high total-impulse-to-volume ratio by leveraging CUA's high-efficiency resistojet technology, VACCO Industries' compact frictionless valve technology, and self-pressurizing, non-toxic, and inert propellants. Waste heat from the electronics and resistojet is efficiently and regeneratively recovered to evaporate propellant, resulting in a system temperature rise of only  $\sim 1^{\circ}\text{C}$  per 10 minutes of operation.

The baseline CHIPS is a 1U, fully-throttleable system. System set-points, system status, and firing telemetry are all accessible and configurable through an RS-422 serial interface. CUA offers an optional battery module to simplify integration with existing low-power CubeSat buses. CHIPS may be customized to meet customer-specific mission requirements.

## CHIPS 1U R134a PERFORMANCE:

	WARM AT 25 W	COLD
Specific impulse <sup>†</sup> [s]	76	52
Thrust [mN]	31	31
Max total impulse <sup>‡</sup> [N-s]	478	299
$\Delta v$ 4 kg [m/s]	125	85

## CHIPS 1U R236fa PERFORMANCE:

	WARM AT 25 W	COLD
Specific impulse <sup>†</sup> [s]	60	38
Thrust [mN]	23	23
Max total impulse <sup>‡</sup> [N-s]	433	271
$\Delta v$ 4 kg [m/s]	123	78

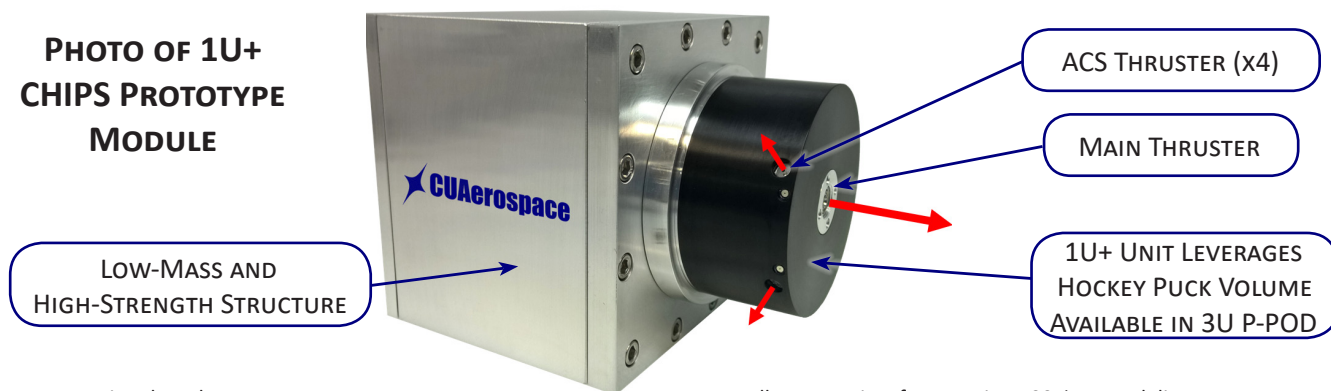
## CHIPS ACS PERFORMANCE:

UNIT SIZE	0.6U	1U*	1.5U
Max specific impulse <sup>†</sup> [s]	47		
Pointing accuracy <sup>†</sup> [°]	1.2		
Min impulse bit <sup>†</sup> [mN-s]	0.2		
Control authority	ROLL, PITCH, YAW, -Z		

\*Baseline 1U CHIPS form factor    <sup>†</sup>Demonstrated    <sup>‡</sup>Estimated

## FEATURES:

### PHOTO OF 1U+ CHIPS PROTOTYPE MODULE



- Two operational modes:
  - Warm gas: high specific impulse
  - Cold gas: minimum or small impulse
- Overall control authority: roll, pitch, yaw, +/- z
- On-orbit update of system parameters, including:
  - Thrust duration
  - Plenum pressure (i.e. thrust)
  - Superheater power level (i.e. specific impulse)
  - Temperature & fault set-points
- Telemetry and status packets for system monitoring
- Dedicated propellant heater for continuous operation below  $0^{\circ}\text{C}$  ambient temperature
- Propellant vaporizer for ensuring 100% vapor delivery
- Voltage and current sensors for closed-loop power regulation, monitoring, troubleshooting, and protection.
- Reliable, frictionless VACCO valve technology:
  - Valves tested to 200,000+ cold gas firings
  - System is two-failure-tolerant against leakage
- Life span: 2+ years from propellant load
- High-density & self-pressurizing propellants (R134a and R236fa):
  - Non-flammable, chemically stable, high critical temperature, low freezing point, & low vapor pressure
  - Commonly used refrigerant / propellant
- Optional battery module

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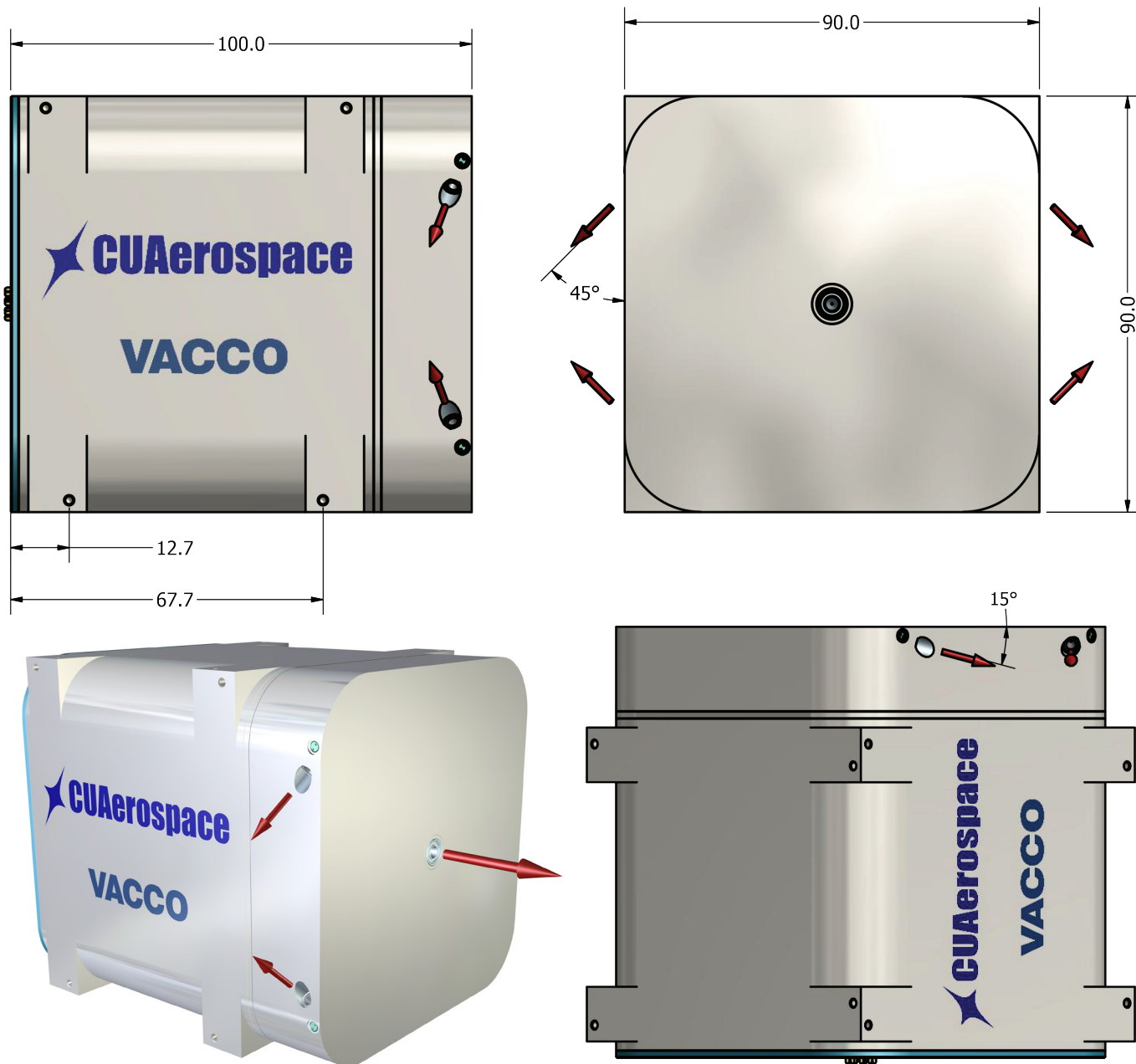
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## BASELINE DESIGN FOR 1U CHIPS



**0.6U System:** Subtract 40 mm from length  
**1.5U System:** Add 50 mm to length

Dimensions of the baseline 1U CHIPS unit are for illustrative purposes only. CHIPS is highly adaptable to a wide range of customer-specific geometries. Inquire to see how CUA can adapt CHIPS to meet your mission requirements.

CHIPS is engineered and manufactured through a partnership between CUA and VACCO Industries.