

Reaction Wheel with Embedded MEMS IMU  
[Milli Sensor Systems and Actuators, Inc.](#)

#### Technical Abstract

Reaction wheels are used to stabilize satellites and to slew their orientation from object to object with precision and accuracy by varying the rotational speed of the wheels. Three or four wheels are usually used with three of them aligned along orthogonal axes. The degree to which pointing stability is achieved depends on the stability of the wheels' angular momentum vectors while spinning, which can be affected by static and dynamic unbalance contributions and other wheel construction issues. With the smaller satellites, requiring smaller wheels, the stability of the wheels will be even more challenging as the uncertainty of construction is likely to remain the same. To stabilize the smaller reaction wheels we propose to integrate a Sensor Chip containing MEMS gyroscopes and accelerometers with each reaction wheel. This allows direct measurement of the wheel motions for fine-tuning its operation. The improved wheel then becomes a means for improving IMU sensor stability for precision pointing and slewing from object to object.

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TORC-SP: High Torque, Low Jitter Scissored-Pair  
CMG Technology  
[Honeybee Robotics Ltd.](#)

#### Technical Abstract

NASA sees an increasing role in the near future for small satellites in the 5-100 kg size range. A potentially disruptive technology, small satellites are being eyed as platforms for the rapid demonstration of new technologies and important science missions. Currently, small satellite platforms struggle to balance the three critical tasks of collecting enough power, acquiring data and downlinking that data to ground stations in a way that maximizes mission return. For these small platforms, which usually do not benefit from steer-able solar arrays or gimballed antennas and instruments, optimally balancing these three tasks strongly depends on the satellite's attitude control agility. Spacecraft agility has to do with rapid retargeting, fast transient settling and low jitter pointing control. Dr. Bong Wie, renowned spacecraft attitude control expert and Professor of Aerospace Engineering at Iowa State University, stated that ultimately the "measure of an agile satellite attitude control system is its ability to collect the maximum data from an area on the Earth that is rich in data-collection opportunities". A logical corollary following from this statement would be that to maximize satellite data-collection, system designers should look to increase the satellite's agility. Furthermore, in addition to data-collection, the other two critical tasks of power collection and data downlink are also maximized as agility is increased. Honeybee Robotics proposes to develop a low cost, high torque and low jitter satellite attitude control actuator derived from its Tiny Operationally Responsive CMG (TORC) design. This derivative product would combine two TORC units into a single scissored-pair configuration with SPA compatible interface. The result, a flight-certified TORC-SP, would be an actuator with the simple control interface of a reaction wheel that offers 1-2 orders of magnitude more torque per unit mass at drastically less power than a reaction wheel.

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