2. What is a Reaction Wheel?

Reaction wheels are a class of electrical actuators for satellites that do not require any propellant and are capable of providing torques on satellites. The basic concept of a reaction wheel relies on the concept of conservation of angular momentum (described above). A reaction wheel consists of a spinning mass with a substantial amount of inertia.

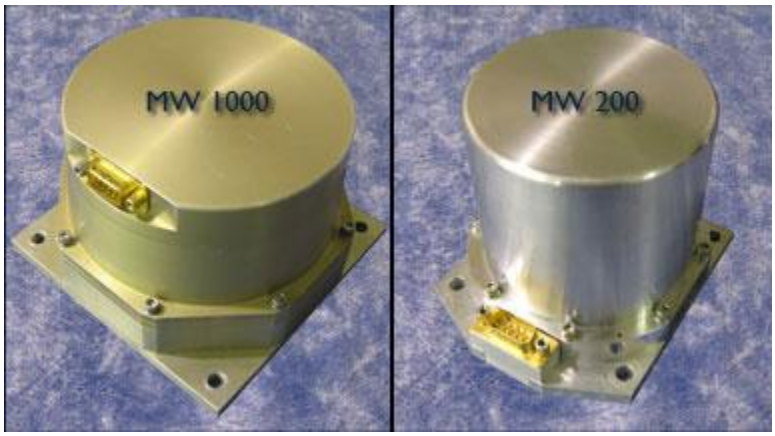
Since a reaction wheel introduces a separate spinning mass to the mass of the satellite (which can also be thought of as a spinning mass), the angular momentum expression must contain terms for the reaction wheels as well as the satellite itself:

$$h_{total} = I_{satellite}\omega_{satellite} + \sum_i I_{wheel\ i}\omega_{wheel\ i}$$

In the above equation, it becomes clear that maintaining a constant total angular momentum (h_{total}), requires a trade between reaction wheel momenta and the momentum of the satellite. One can also see how modifying reaction wheel speeds or axes can modify the spin rate of the satellite.

A. Reaction Wheel

While the term "reaction wheel" technically can encompass all types of spinning mass actuators, it is usually reserved for fixed axis spinning masses such as MSCI's MicroWheels.



Reaction wheels contain an electric motor that controls the speed of a spinning mass with a large inertia. The momentum of a reaction wheel can be changed by changing the speed of the spinning mass but not the axis.

B. Momentum Wheel

A momentum wheel is really just a special case of a reaction wheel. As described above, a large spinning mass will resist small external torques due to its gyric stiffness. By spinning a reaction wheel up to a relatively high rate and leaving the wheel at that speed provides gyric stiffness about that axis that can help an ACS engineer keep the satellite pointing in a given direction. Early satellites were "spin-stabilized", meaning that the entire satellite rotated about a certain axis to provide the same gyric stiffness. While this worked well for communications satellites

that pointed an omnidirectional antenna to the earth, but would not work very well for an imaging satellite. An internal momentum wheel providing high gyric stiffness is an excellent solution for such an application.

C. Control Moment Gyro

Extremely large spacecraft such as the International Space Station use Control Moment Gyros (CMG's) to control their attitude. A CMG is a reaction wheel on a two-axis gimbal. By actuating the gimbal and thus changing the axis of the stored momentum, a torque is applied to the satellite. A typical CMG is shown in the figure below: