SECONDARY SCHOOL
*Gimnazija* Ravne na Koroškem

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# Spacecraft Attitude Control and Stabilization

**Our research project presents two ways to control and stabilize satellites. We developed two models of satellites that are suspended in a magnetic field. In the first model we used a reaction wheel and in the second a pair of gyros (SGCMG). Rotational speed and orientation is measured by a MEMS gyroscope and controlled by a microprocessor.**


## Problem overview

- Every man-made object in space, such as space stations and satellites, needs control systems in order to control and stabilize the attitude.
- **Small satellites are becoming increasingly popular for imaging, remote sensing, disaster management...**
- To do these tasks they need agile attitude control and stabilization.

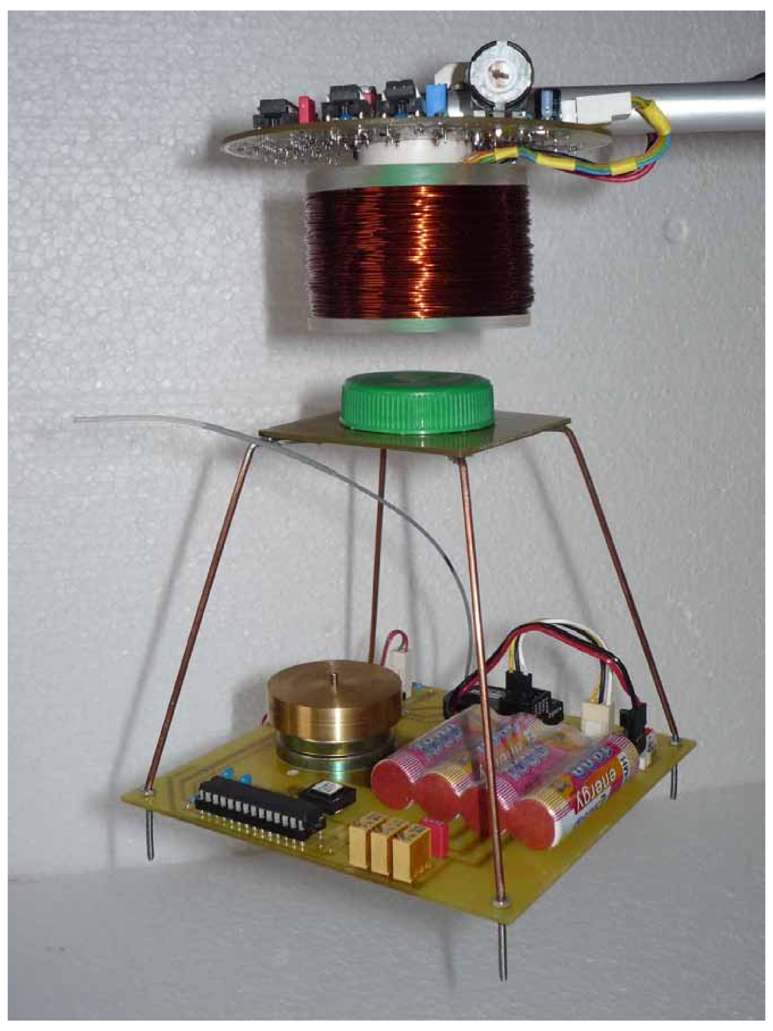

**Fig. 1:** Satellite model with one reaction wheel that can rotate around the vertical axis. Below the green cap is a permanent magnet, which is suspended in mid-air by the magnetic levitation circuit with an electromagnet.

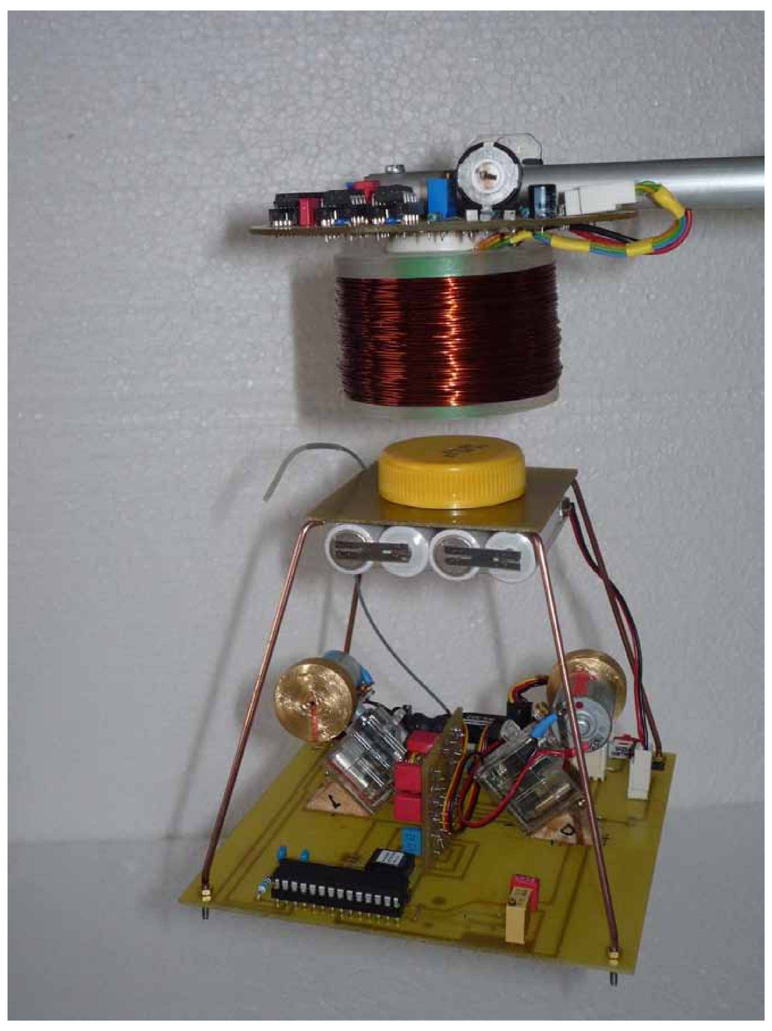

**Fig. 2:** Satellite model, in which two single gimbal control momentum gyroscopes were used. The servo motors are fixed at an angle of 45 degrees. With these gyros, the model can be rotated and stabilized on two axes.

## Data and methods

- Articles about attitude control and stabilization, found on the internet.
- Physics literature about angular momentum and gyroscopes (Janez Strnad, Fizika 1. del).
- Reviewing the various possible methods for attitude control and stabilization.
- Measuring and studying the properties of both attitude control modes.
- Calculating angular momentum: $L = I\omega$, where I is the moment of inertia of the wheel or the satellite and $\omega$ is the angular velocity.

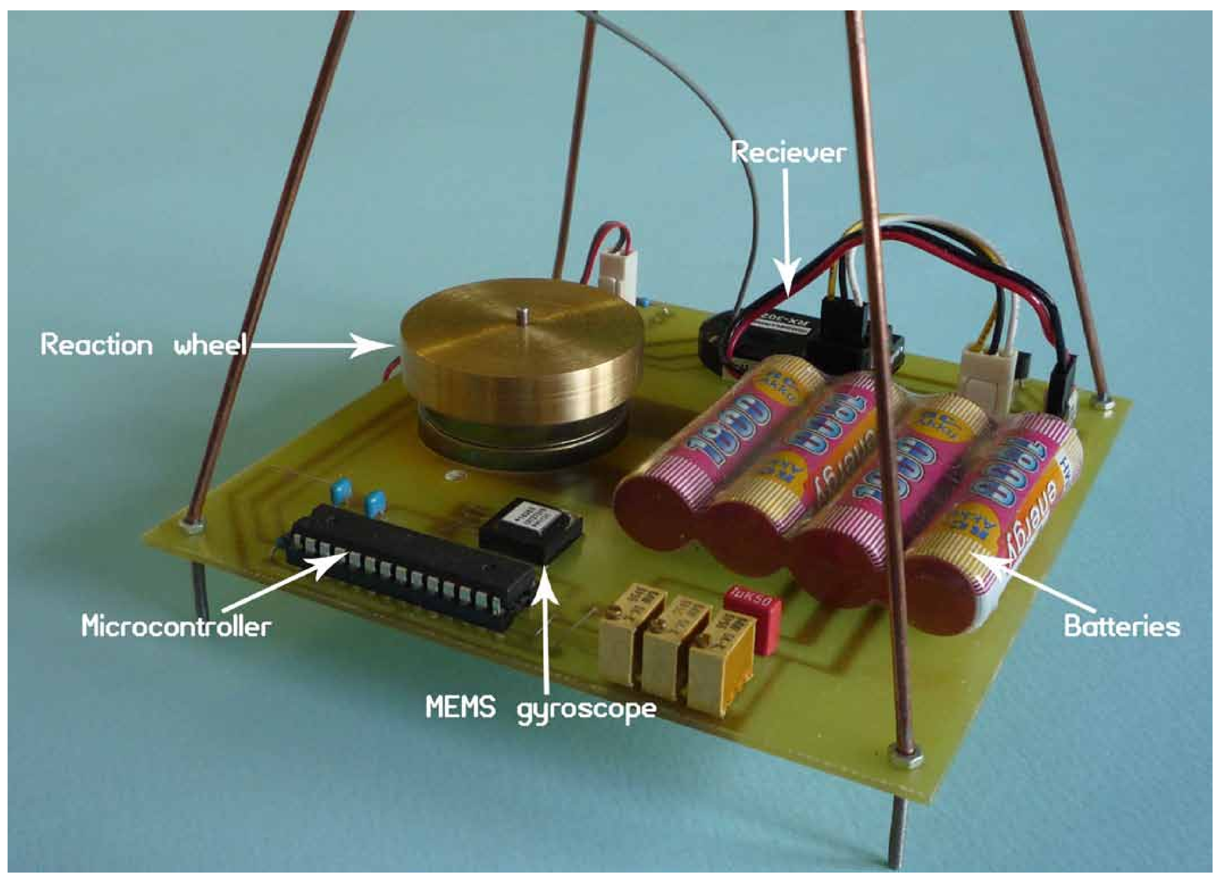


**Fig. 3:** Overview of the circuitry of the reaction wheel model. The reciever is controlled by a radio remote control.

Fig. 6: QR codes of two demonstration videos for two described models. **Left:** A video of a model with the reaction wheel. **Right:** A video of a model with gyroscopes.

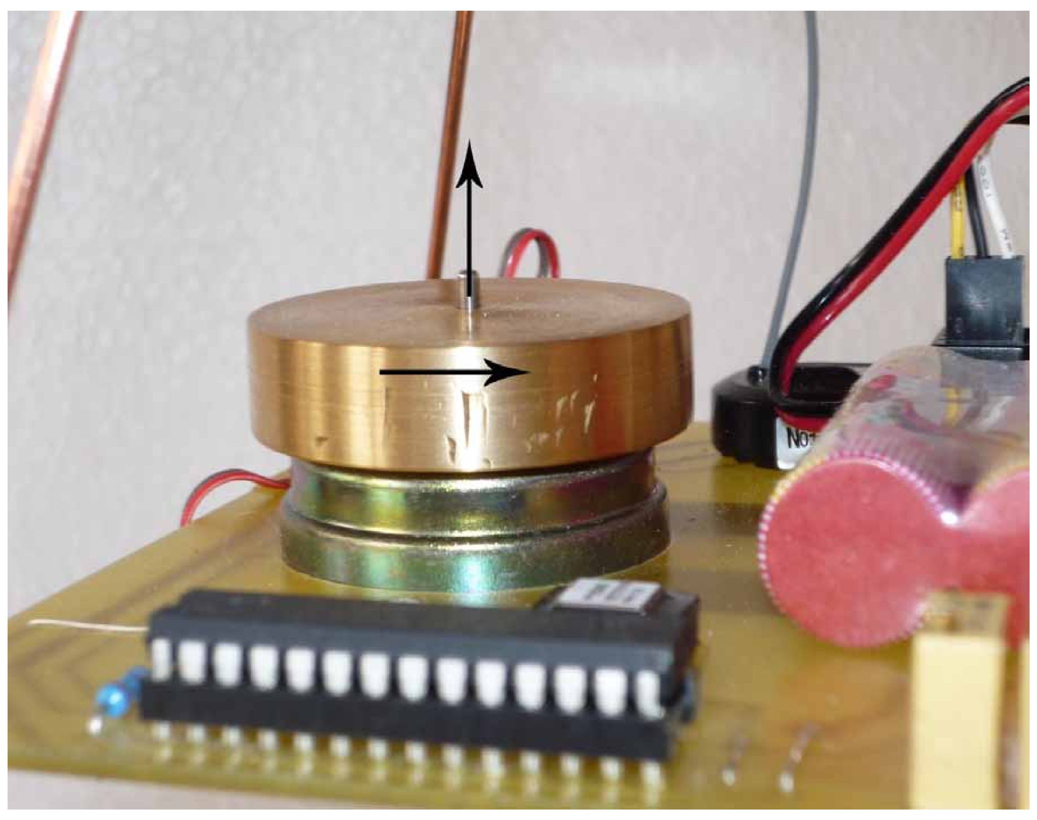

**Fig. 4:** When the reaction wheel is spun counter-clockwise, its angular momentum (L) points up. Because of conservation of angular momentum, the model spins clockwise.

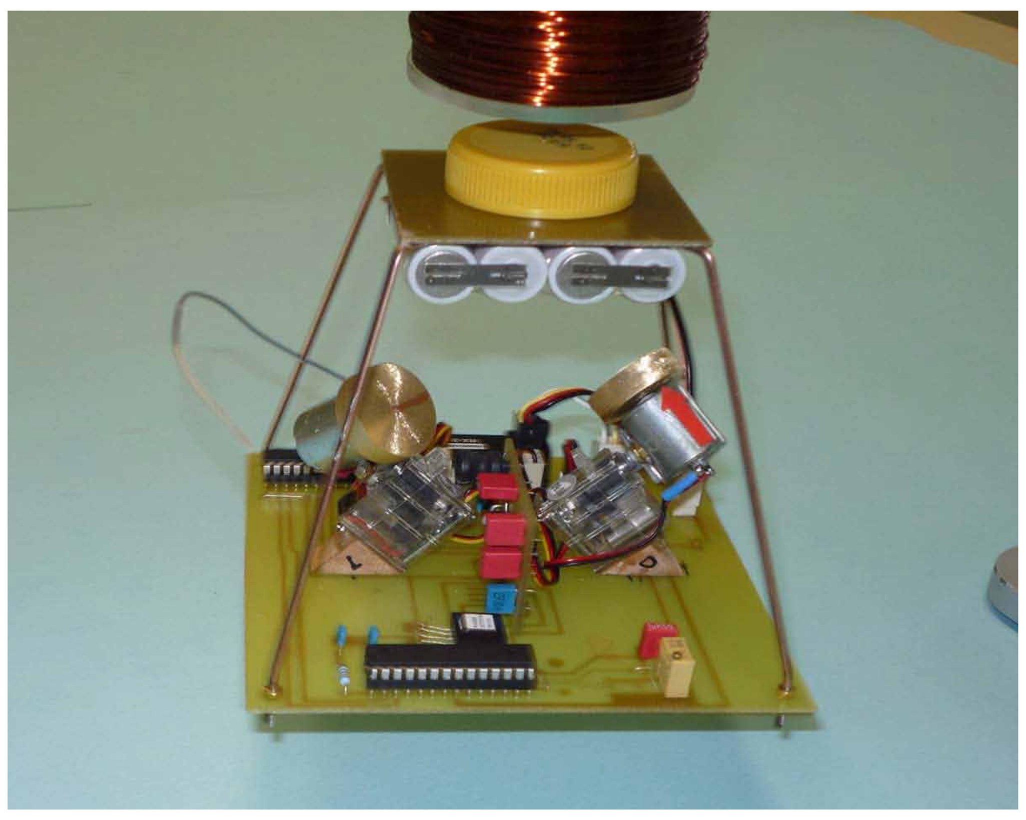

**Fig. 5:** Both gyroscopes are pointing upward, combined angular momentum is vertical and the model spins clockwise.

## Conclusions

- Both attitude control systems are viable for use in spacecraft.
- Reaction wheels are simpler but have technical limitations and need RCS thrusters or some other form of stabilization after some time of operation because of angular momentum buildup. They are heavier than CMGs.
- Control momentum gyroscopes are more complex but offer a more accurate form of attitude control and stabilization. At least 3 gyroscopes are needed to turn around all 3 axes. There are multiple forms of CMGs – Single-gimbal, dual-gimbal and variable-speed gyroscopes.