2016

Air-Ball: The Free-Flying Satellite Simulator

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Objective

The project objective is to design, build, and fly a multi-rotorcraft that achieves full six degrees of freedom to facilitate research, as well as improve techniques for satellite attitude dynamic and kinematic control.

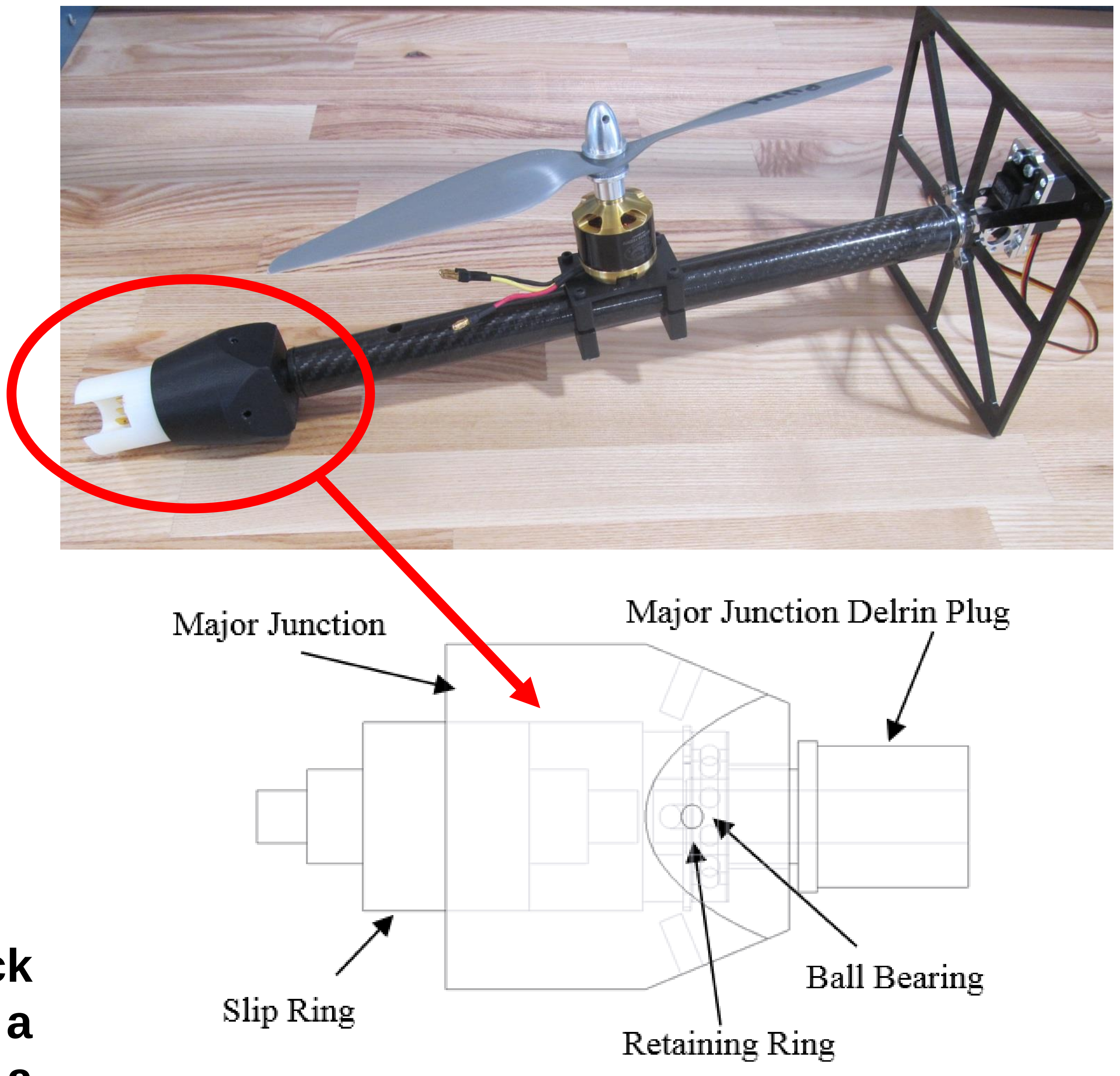
Critical Requirements

Weight	11.9 lbs
Flight Time	4 Minutes
Linear Velocity	1 ft/s
Linear Acceleration	10 ft/s^2
Rotational Velocity	60 degrees/s
Rotational Acceleration	72 degrees/s^2

The rotorcraft will be controlled using OptiTrack motion tracking hardware and software using a PID controller via MATLAB/Simulink from a ground station (desktop computer). Ultimately, the rotorcraft will perform a simulation of a final approach, docking maneuver for an on-orbit servicing mission of a satellite, demonstrating its applicability for space research.

System Design: Propulsion

The propulsion system of the rotorcraft consists of six propellers that are attached to carbon fiber shafts, which can rotate ±360˚ through the use of a servo. Each servo is mounted inside the center console, while on the opposite end, there is a bearing inside a junction to allow the shaft to rotate freely. A slip ring is used to prevent the motor wires from tangling as the shaft rotates.



Each motor produces a maximum thrust of 5.17 lbs, which allows the rotorcraft to perform unrestricted pitching, rolling, and yawing maneuvers.

System Design: Structures

The rotorcraft's propulsion and electrical components are protected from impact by an outer cage and a center console that are comprised of various parts manufactured from carbon fiber, 3D printed ABS plastic, and Delrin plastic.

System Design: Controls

The electronics hardware and software used with the rotorcraft includes: OptiTrack motion tracking system for orientation data, a Wi-Fi transceiver to communicate with the ground station, a Beaglebone Black (microcontroller), a PWM breakout board, an inertial measurement unit, six electronic speed controllers for each motor, and three lithium polymer batteries. Two 11.1 V, 4000 mAh batteries will be used in parallel to power the six motors, while one 7.4 V, 600 mAh battery will be used to power the remaining electronics on board. This successfully provides the necessary power for a flight time of 4 minutes.