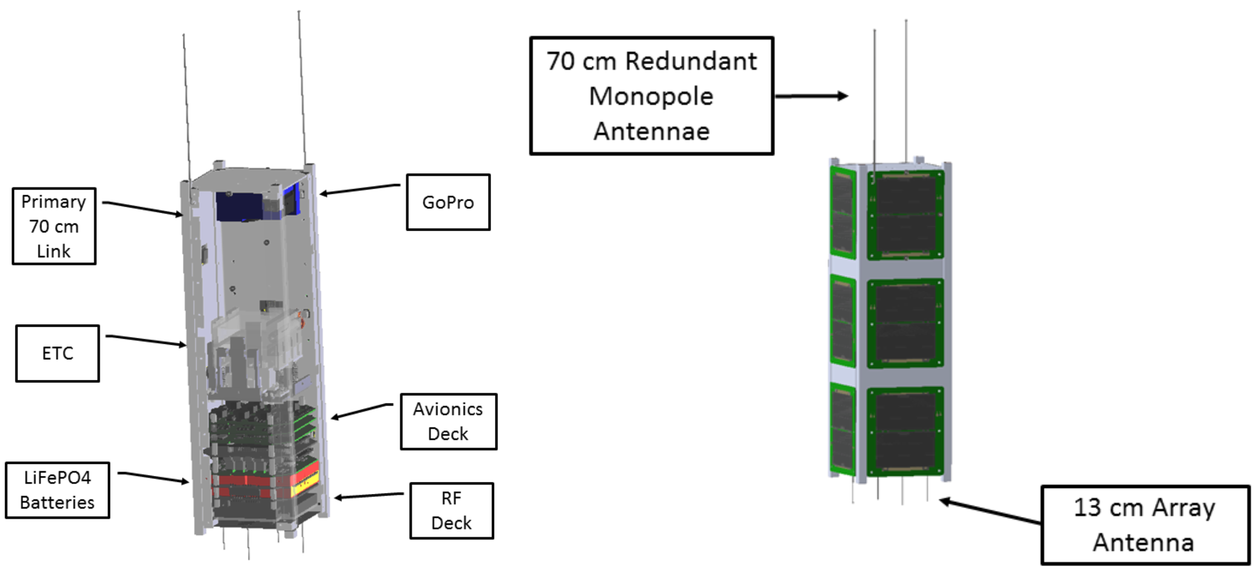
Q-PACE Satellite Technical Description

The overall goal of the Q-PACE mission is to understand protoplanetary growth. Q-PACE is a 3U CubeSat that is scheduled for launch on ELaNa XX June 2, 2018. Q-PACE will perform over 100 collision experiments producing 10's of thousands of collisions simulating the first steps in planet formation. The Q-PACE experiment consists of a particle chamber that is shaken to induce low-velocity collisions between the particles; these types of collision cannot be achieved in Earth's gravity. The collisional evolution of the swarm of particles is captured by a high-speed video camera. The video data is transmitted to the ground station for analysis to measure the outcomes of collisions based on impact speed and particle type.

The satellite will be launched aboard ELaNa XX, on Virgin Galactic Launcher One, from Mojave, California, June 2 2018. It will be inserted into an orbit at 500 km apogee and 500 km perigee, on an inclination from the equator of 90 degrees. Signal transmission will begin when inserted into orbit, and cease May 30, 2020. Atmospheric friction will slow the satellite and reduce the altitude of the orbit, until de-orbiting occurs about 4.5 years after launch. See the Orbital Debris Assessment Report for details.

The spacecraft is a single unit with the dimensions of three stacked 10 cm X 10 cm X 10 cm CubeSat modules (giving an overall dimension of 10 cm X 10 cm X 30 cm.) The total mass is about 2.02 Kg.

Figure 1 Q-PACE Overview



The satellite contains the following systems:

<u>Watchdog Telemetry Controller (WTC) Subsystem:</u> Q-PACE health and operation are primarily controlled with the Watchdog Telemetry Controller (WTC), consisting of a microcontroller and support electronics for the controller, communications, and data acquisition. The WTC monitors the general health of all subsystems, utilizing temperature sensors and analog to digital converters (ADCs). The WTC directly controls the primary UHF link, decodes all incoming commands, and routes commands and data to the CCDR. The WTC also replies to telemetry requests from the ground station.

Attitude Determination and Control (ADAC) Subsystem: Q-PACE utilizes Passive Magnetic Attitude Control to reduce the rate of spin of the spacecraft (about the Z axis) and control tumble rate as the spacecraft orbits Earth. Attitude determination is provided by feedback from solar panel voltages, augmented by a Bosch BMG160 three axes MEMS gyroscopic sensor.

Command, Control, and Data Reduction (CCDR) Subsystem: The CCDR consists of two COTS Raspberry Pi Model B generation 2.1 single board computers (RPi) and a mating / signal switching printed circuit board (PCB). For most operations, only a single RPi is active. The RPi receives command information from the primary UHF link by way of the WTC, or from the backup UHF link on the High Speed RF Deck if the primary UHF link fails. The RPi responds back through the WTC or for high speed data transfer, directly to the high speed S band link.

Power Distribution and Charging Subsystem (PDC): The PDC consists of 13 Solar Panels, Maximum Power Point Tracking regulators (MPPT), Chargers, $LiFePO_4$ batteries, Battery Protection Circuitry, and Rail Regulators. Each battery delivers 3.2V at 1.1 AHr; there are four sets of two cell packs. WTC monitors all voltages and temperatures, and has the ability to disable failed or failing subsystems in the PDC. The WTC can also invoke a passivating protocol to irreversibly discharge the battery packs and sever connection to the rail regulators, RF Deck, and other subsystems.

Communications Subsystem (COMMS): The COMMS Subsystems components consist of the antennae assemblies, primary and backup UHF transceivers designed by UCF and based on Texas Instrument’s CC1101 transceiver integrated circuit, and a UCF designed S band High Speed Data transmitter based on Analog Devices ADF 7242 integrated circuit, along with control and communications interfaces to the WTC and CCDR. There are three antenna assemblies on Q-Pace; two UHF monoplole antennae providing redundant links on one end (-Z axis as deployed), and one steerable S band array of vertical monopoles located on the opposite end of the spacecraft. Only one transmitter will operate at a time, There are redundant transmit power disables for each RF transmitting subassembly.

Experiment Subsystem (Exp): The experiment subsystem is the principal payload for the mission. This subsystem consists of the Experiment Control and Rail Regulators PCB, a COTS video camera (GoPro Hero 3), LEDs, the Experiment Test Cell (ETC), stepper motor for sample selection, and solenoids which execute the shaking profile under the direction of the CCDR.

Thermal Management (TM): Components were selected for operation from -40C to 70C. Additionally, PCB design utilizes adjacent ground planes to sink heat into the Q-Pace structure. The WTC performs temperature monitoring, and over-heating subsystems can be powered off if temperatures climb outside operating range.

Structure Subsystem: The structure is custom fabricated from aluminum with stainless steel fasteners.

Propulsion Subsystem: No propulsion subsystem is included.