Project summaries

Section 011 Human Spacecraft Project

Advisor Colonel (retired) James Voss

Sponsored internally

The current project is to design a human capable lander for NASA exploration missions to the moon. Students work with our industry partner, Lockheed Martin to assist with development of their lunar lander design. Students will build a mockup of the cockpit of the lander they design then will use it to conduct human factors testing.

Section 012 Clock Ensemble Testbed for PNT on Small Spacecraft or UAVs

Advisor Dr. Penina Axelrad

Sponsored by The Air Force Research Laboratory

Spacecraft and UAVs used for communications, imaging, and scientific applications have a wide range of requirements for positioning, navigation, and timing (PNT). Even within a particular mission, the needs can be quite different for real- time knowledge, control, and post-processing. Before the implementation of Global Navigation Satellite Systems (GNSS) ground-based tracking of some type was needed to support all spacecraft missions. Today GNSS greatly simplifies all aspects of positioning, orbit determination, and timing for missions in all near-Earth regimes – including LEO, GEO, and even HEO orbits. However, there is now a critical need to find effective approaches that can insure the integrity of GNSS-based solutions and enable continued spacecraft operational capabilities when GNSS is challenged or compromised. This includes potential advances in GNSS satellite technology that can reduce users' vulnerability to interference and enable longer term autonomous operation. This project focuses on a key element of this challenge – enhancing onboard timing system performance.

Our objective is to design, implement, and operate a clock ensemble testbed to support the assessment of various approaches to create stable, predictable, frequency and time reference signals from multiple, potentially unreliable, clock and oscillator inputs. The testbed will be a resource to inform and support the development of timing systems comprised of components suitable for use on future small GNSS-type satellites. The team will be able to learn from/consult with clock and timing experts at CU Boulder, the National Institute for Standards and Technology (NIST) also in Boulder CO, the Air Force Research Laboratory (AFRL) in Albuquerque, and commercial companies engaged in low-cost clock technology development.

We plan for this to be a multi-year project involving simulation, analysis, hardware and software design, development, and testing. Students with interests and some experience in any of these areas: clocks, GNSS, electronics, software defined radios, software development, testing, timing, small satellites/UAVs are welcome.

Section 013 CubeSats for Space Science

Advisor Dr. Robert Marshall

Sponsored internally; supported by the University Grand Challenge "Our Space. Our Future."

This section will focus on the design, build, and test of two CubeSats that will make important measurements in Low-Earth Orbit. The Compact Space-borne Magnetometer Observatory (COSMO) is a 3U CubeSat designed to make high-resolution, precise measurements of the Earth's magnetic field from space. These measurements are used in the World Magnetic field Model (WMM), which is installed on every iOS and Android phone, and used extensively by the government, military, and industry for navigation. COSMO aims to provide data to the WMM after the SWARM spacecraft mission ends in 2022. The challenges for COSMO are to i) design a CubeSat with low magnetic noise and bias, and to accurately characterize that bias; and ii) integrate a compact, high-resolution magnetometer to provide the needed measurements. This year the Graduate Projects team will continue the detailed of the CubeSat, begin building the spacecraft, and test and characterize components and subsystems for performance and for their magnetic cleanliness. We hope to have the full CubeSat ready to launch in about two years.

The Climatology of Anthropogenic and Natural VLF wave Activity in Space (CANVAS) mission is a 3U CubeSat that will measure the energy injected into space by lightning and VLF (3-30 kHz) transmitters on the ground. These waves have important effects on the Earth’s radiation belts, which in turn are a critical hazard to spacecraft and astronauts. CANVAS will measure electric and magnetic fields using novel, compact antennas. The graduate projects team will be responsible for designing and building the spacecraft bus to accommodate these sensors. Key subsystems include the attitude determination and control system (ADCS), electrical power system (EPS) including deployable solar panels, command and data handling (C&DH) system, and spacecraft structure. The system will also integrate a novel carbon-fiber deployable boom to hold the magnetic sensors. CANVAS and COSMO have many overlapping subsystems, so the two sub-teams will also overlap and collaborate within this graduate projects section.

Section 015 CU-E3 and Maxwell CubeSats

Advisor Dr. Marcin Pilinski

CU-E3 (Earth Escape Explorer)

Sponsored internally; NASA Centennial CubeQuest Challenge participant

The University of Colorado - Earth Escape Explorer (CU-E3) team is a deep-space CubeSat competing for a launch spot on-board the SLS/EM-1 mission. CU-E3 will be competing in the Deep Space Derby portion of the CubeQuest Challenge, which is focused on advancing deep space CubeSat communication techniques. Using the wealth of communication knowledge and technology developed at the University of Colorado – Boulder, such as our reflectarray and X-Band transmitter, CU-E3 believes it has all of the critical components to be successful in this competition.

CU-E3 will use a lunar gravity assist to propel itself into heliocentric orbit in order to distance itself from the Earth. As CU-E3 travels further from Earth, it will demonstrate novel communication technology by establishing contact with our ground station network beyond 4 million kilometers until the end of the one year mission lifetime. At that point, CU-E3 is expected to achieve an Earth-Satellite distance of more than 27 million kilometers!

Maxwell

Sponsored Internally, Air Force Research Laboratory's University Nanosat Program Competition Participant

Maxwell is a 6U CubeSat that is part of the Air Force Research Laboratory's University Nanosat Program Competition. The team has won phase A of the competition which will provide the satellite with a flight to orbit. The flight design builds on the heritage of the CSSWE, MinXSS and QB50-Challenger CubeSats which have been developed at the University of Colorado Boulder and all demonstrated mission success on orbit. This project matures hardware designed by the PI, Dr. Scott Palo, as part of the NASA Small Satellite Technology Program to develop a high rate CubeSat communication system that is compatible with the NASA Near-Earth Network.

Section 017 Spacecraft Multi-Layer Insulation Heat Leak Characterization Testing (EAR Restricted)

Advisor Dr. James Nabity

Sponsored by Harris Corporation

This project funded by the Harris Corporation will experimentally assess spacecraft multilayer insulation (MLI) thermal performance. The purpose of this effort is to develop a more thorough understanding of the contribution that different parameters have on blanket performance and generate design curves to allow for more accurate system level modeling of blankets for application to large deployable space structures. The team will develop a Design of Experiments approach to perform MLI Heat Leak testing to characterize thermal transport property characteristics and develop design guidelines associated with each variable studied. Students on this team will utilize Thermal Vacuum (TVAC) test facilities in the Bioastronautics Laboratory (ECAE 1B65). Students will design a new thermal blanket for use on a deployable spacecraft structure such as an antenna boom.

Section 019 Area-of-Effect Softbots

Advisor Dr. Kathryn Wingate

Sponsored internally, using NASA Innovative Advanced Concepts (NIAC) Phase II Award Funding

Area-of-Effect Softbots (AoES) are a promising new concept, developed by Dr. Jay McMahon and Dr. Christopher Keplinger from CU Boulder, that leverage soft-robotics and electro-adhesion forces to move a vehicle over asteroid surfaces. This approach is thought to be more robust than classical robots using multiple hinged limbs. According to NASA, AoES could enable resource extraction from asteroids within 10 to 15 years. The AoES team has been awarded a Phase II NIAC grant by NASA in the Spring 2018 to pursue development and maturation of the AoES key technologies.

The focus of this graduate project course is to deliver a design proposal for the AoES central bus and digging mechanism subsystem. The central bus is the physical core of the AoES, housing critical subsystems such as power generators, navigation sensors and communication payloads, and supports the electro-adhesive appendages. The digging mechanism is another critical part of the AoES, as it is responsible for retrieving the surface material and is more directly exposed to the asteroid surface environment.

Your role in this project will be to deliver an AoES system design proposal that includes detailed power and mass budgets and defines the interfaces between the different segments of the AoES. This design proposal is to be delivered by the end of the first semester of the course, in addition to a realistic CAD assembly of the digging mechanism. The second semester of the course will be dedicated to the fabrication and testing of a small-scale demonstrator of the proposed digging mechanism.

Section 022 Autonomous Cluster Navigation (ITAR Restricted)

Advisor Dr. Daniel Kubitschek

Sponsored by The Aerospace Corporation

The Autonomous Cluster Navigation Graduate Project is a two-semester effort that focuses on the development of key autonomous capabilities for the safe operation of multiple spacecraft operating in the same dynamic environment as a group. The project is sponsored by an industry partner with an interest in solving the technical challenges of on-board, autonomous measurement processing, orbit determination and maneuver computation and will require the students to lead, organize, schedule, develop, test, verify, validate and deliver conceptual approaches, algorithms and hardware solutions to the industry partner at the end of each semester. Weekly status teleconference meetings will be held by the student team to keep the industry partner informed of the progress, with a milestone presentations and product deliverables.

Two focus areas have been defined for this project: 1) Concept of Operations (Design Reference Mission, Mission & System-level Requirements Derivation, Communication & Navigation Architecture, Measurement Model Simulation Development and Navigation Sensor Selection), to be completed during the first semester (Fall 2018); and 2) Navigation System Design (Derivation of Software Requirements for Navigation Design, Derivation of Software Requirements for Cross-link Design, Development of Navigation and Communication Algorithms, COTS Hardware Selection and Procurement, Hardware Prototype Build, Hardware Prototype Demonstration and Test), to be completed during the second semester (Spring 2019).

New for Fall 2019, pending sponsorship:

A Propulsion project to be sponsored by United Launch Alliance and advised by Lakshmi Kantha. Past projects have included characterizing, testing and hot firing an additive manufactured rocket nozzle.

An EVA project advised by Dr. Alison Anderson, still in development.