Design Manufacturing and Testing of a 3-D Printed Removable Fin Guide for Removable Fins

Team 04 Project Technical Presentation to the 2017 IREC

Rebecca M. Thomas, Nelson L. Ho, Isaac R. Sahagun, Brian M. Weatherspoon, Jeanette Valencia, Donovan I. Harris, Kedar S. Joglekar, Demetria Ma, Jermaine J. Permejo, Sean K. Ton, Michelle A Wyatt, cole R. Edwards, Ismael Garcia, Andres A. Hernandez

California State Polytechnic University, Pomona, California, 91768

As a part of the 2017 Intercollegiate Rocket Engineering Competition, students from the California State Polytechnic University, Pomona designed, manufactured, and tested a 3-D printed fin alignment guide that allows for removable fins. This system was developed because of unmet needs and concerns after the first test flight. First, misaligned fins were common on rockets built by the Undergraduate Missile Ballistic Rocketry Association on campus. This could cause deviations in the rocket's trajectory. Second, it was found that 3-D printed airfoiled fins are frequently damaged on recovery, either through the rocket landing "fin-first" or by being dragged by the wind, as demonstrated by the first test flight. Since the competition requires the rocket to be reusable, this problem needed to be addressed. Finally, the traditional high powered rocket design only allows for one set of fins. A system that permits easy fin replacement would allow the rocket to have a custom set of fins based on the mission.

Mechanically Retractable Pitot Tube

Team 09 Project Technical Presentation to the 2017 IREC

O. Khalimonov

Concordia University, Montreal, Quebec, H3Y 1P1, Canada

One of the innovations in this year's design is the *Retractable Pitot Tube*. During the initial design of the rocket, a pitot tube was added to the rocket's repertoire of sensors. However, while doing research on other rocketmounted pitot tube implementations we learned that pitot tubes regularly bend or break on landing. The development of a design that would prevent damage and allow rapid, reliable reuse of the pitot tube for multiple launches was implemented.

Sounding Rocket Autonomous Recovery System

Team 11 Project Technical Presentation to the 2017 IREC

Pierre-Alexandre Desrochers, Hugo Lemoine Saint-André, Philippe Therrien
RockÉTS, École de technologie supérieure, Montréal, Québec, H3C 1K3, Canada

One recurring challenge the RockÉTS team had to face these past years was alway related to the rocket's recovery process. After reaching apogee, the parachute opens and [the rocket] starts to stray from where it was supposed to land, making the recovery more tedious. Last year was our first attempt at controlling the rocket's descent path with an autonomous system. This year, we decided to concentrate on optimizing the system by reducing its overall volume, reducing its weight, and implementing a new path planning algorithm. This summary outlines the methodology and design results of a high-power rocket recovery control system for the AMAROK II sounding rocket.

Design and Manufacturing of a Deployable Nosecone Carrying Advanced Custom-made Avionics

Team 14 Project Technical Presentation to the 2017 IREC

Michael Pellet
Swiss Federal Institute of Technology, Lausanne, Switzerland

and Team DUSTER
Swiss Federal Institute of Technology, Lausanne, Switzerland;
Swiss Federal Institute of Techology, Zurich, Switzerland;
School of Business and Engineering, Vaud, Switzerland

The team designed and manufactured avionics consisting of a complete set of sensors and telemetry. The avionics is placed in the nosecone of the rocket. The main objective of the avionics is to log data and characterize fully the trajectory and attitude of the rocket. This data will be used for the next year, in order to develop attitude and drag control for the rocket. The nosecone is also deployable, firstly, to let GPS acquire position during the fall-down and landing phase of the rocket, and secondly release a folded glider (the payload).

Modal Analysis of the GUARANI I Experimental Rocket

Team 24 Project Technical Presentation to the 2017 IREC

P. G. C. Martins, K. Máxima
University of Brasília, Brasília, DF, 71020-133, Brazil

This article deals with a modal analysis of GUARANI 1 rocket. In this subject will be performed numerical simulations to get the natural frequencies of vibration of our rocket. The simulations will be realized on the software Modal available on ANSYS, and the other one, will be manipulating in a Engineering vibration toolbox for MATLAB. To do this simulations, it is necessary to have all the project in CAD version and with the material of each component considered, then it is necessary to do a mesh grid over all the rocket, simply support one of the extremities and enter with different vibration frequency to search the phenomena of resonance. For the simulation on MATLAB, the rocket it is divided into 3 modules, propulsion, avionics and payload. In each module it is required 4 properties to perform the simulation, cross section area, moment of area, Young's Modulus and density for unit length. After all the results will be compared and discussed.

Integration of a Fiber Optic Gyroscope in a Rocket

Team 32 Project Technical Presentation to the 2017 IREC

Alex Tourigny-Plante
Laval University, Quebec, QC, G1V 0A6, Canada

The fiber optic is a technology that enables the design of several new sensors who are more precise than the conventional electronic ones. Most of these sensors work by the principle of interference of two laser beam that has been affected by their environment. In our case, the sensor of interest in a Fiber Optic Gyroscope (FOG). A FOG is a Sagnac interferometer, in which two light beams, split from the same source, counter propagate in a path and interfere together. The path in which our laser propagate is approximately 500m of single mode fiber optic. The intensity of the light captured by the photodiode varies with respect to the angular speed. The use of a FOG informs us on the angular speed of the rocket at any moment with a high degree of precision. However, the light intensity will be independent of the direction of rotation. To be able to detect a direction of rotation, a piezoelectric needs to be added to the optical circuit. When the piezoelectric is excited with an alternative signal, its diameter change and the fiber optic is stretched. The piezoelectric is added to one end of the fiber optic coil so that one of the beams sees if at the beginning of its path and the other sees it at the end. With a loop feedback and a demodulation of the signal that excite the piezoelectric and the signal of the photodiode, it is now possible to know the direction of rotation. We duplicate three times this interferometer for our rocket to have one FOG by axis. We use the same laser for the three axes, which is able to output up to 5.3 mW. This laser is stabilized in temperature with a Peltier device and is powered by a constant current source. The laser beam is separate through coupler so that the pitch and the yaw axes have an initial power of 37.5% of the laser power and that the roll axis have an initial power of 25% of the laser power. On each axis, the laser pass through two 50:50 coupler before and after going through the 500 meters of fiber optic. The final light intensity, after the interference between the two beams that have counter propagate, is then read on the photodiode.

Analysis and Testing of Composite Airframes

Team 35 Project Technical Presentation to the 2017 IREC

Amy Vanderhout, Andrew Adams, Matthew Campbell, Carlos Garcia, and Colin Poler
Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139

In house production of composite airframes introduces some variability in the quality of the airframe. For this reason, the properties of the team's composite airframe initially were not well characterized and the team previously chose to design with a high safety factor to ensure that the airframe would meet all structural requirements. The objective of this analysis is primarily to prove that a thinner airframe will meet the requirements of Project Raziel. The secondary objective is to lay the groundwork for a more comprehensive analysis of the structure. An improved analysis will allow the team to improve their processes and material choices. To determine the viability of a thinner airframe, the structures team simulated the rocket's flight to determine the expected loads. The team used this data to calculate the compressive axial and transverse loads on the airframe as well as the expected stresses. Various combinations of materials were tested both to gather material data and to experimentally prove that the tubes can withstand the flight loads. Since only transverse loads were tested experimentally, the team calculated the thickness required to withstand the transverse and axial loads.

Erosive Burning Mitigation in a High Length to Diameter Ratio Solid Propellant Rocket Motor Through Rigorous Verification and Validation Testing

Team 46 Project Technical Presentation to the 2017 IREC

Rachel A. Nelke, Tyler H. Baker, Justice A. Ofosu
Oregon State University, Corvallis, Oregon, 97331

The Spaceport America Cup is an Intercollegiate Rocket Engineering Competition (IREC) that provides a platform for schools around the world to design, build, and launch sounding rockets. The 2017 Oregon State Rocketry (OSR) Team entered into the student researched and designed category with a solid propellant motor in hopes of reaching the target altitude of 30,000 ft. AGL. The altitude target provided a challenge to the propulsion team. Limited by IREC rules regarding motor class, and the OSR Team constraints on diameter and weight of the rocket, the propulsion team had to design a motor capable of reaching 30,000 ft. AGL while ensuring a safe launch and flight. Through months of vigorous research, design, testing, analysis and refinement the OSR Team was able to produce an optimally functioning motor capable of achieving this goal.

Design, Analysis and Testing of Differential Drag Stage – Separation System

Team 47 Project Technical Presentation to the 2017 IREC

Kashish Korotania
PEC University of Technology, Chandigarh, 160012, India

This stage – separation system utilizes the drag separation phenomenon for the separation of booster stage and sustainer stage. The differences created in the acceleration of both the sustainer stage motor and booster stage engine due to the burnout of the booster stage engine and ignition of the sustainer motor will impose forces thus, assisting the stage separation mechanism to separate the stages. The abstract submitted gives a brief overview of the design considerations, problems involved, advantages of the vigyaan drag separation mechanism, material selection process accomplished by the team and the future scope pertaining to the proposed design.

Supersonic Fin Design and Manufacturing

Team 53 Project Technical Presentation to the 2017 IREC

Sadben Khan, Michael Melville
Ryerson University, Toronto, ON, M5B 2K3, Canada

The design of a fin for supersonic flight provides many aerodynamic and manufacturing challenges that must be considered. While the aerodynamics of supersonic flight are well known, the theoretical ideal designs that produce the best performance (i.e. minimize wave drag), often do not consider how the product will be manufactured. The focus of this paper is to present a student researched and designed (SRAD) “Out-of-Autoclave” resin transfer moulding process for a complex fin design. Composite manufacturing processes in industry are highly refined and commonly use pre-impregnated (pre-preg) laminates; these laminates once cut to shape only need to be “cooked” in an Autoclave for the resin to cure and produce a high-quality product, with very minimal defects. The disadvantage with these methods, especially in a university environment, is the significant cost of pre-preg as well as the need for the infrastructure to properly cure the laminates. Thus, a need for a process which can produce products of very similar but with limited resources presented itself.

On the Replacement of Structural Aluminum with WE43 Magnesium in Rocket Components

Team 54 Project Technical Presentation to the 2017 IREC

Xavier McCaig, Aris Simsarian, Charles Hunsaker
Saint Louis University Rocket Propulsion Lab, St. Louis, Missouri, 63103

In the course of designing components for aerospace applications, the necessity of low-weight parts which maintain a high level of strength quickly becomes apparent. From the earliest days of wood and canvas to the days of aluminum and polymers, this has been the case. Today's aerospace industry, however, is poised to make another great leap in lightweight construction. The use of carbon fiber has increased dramatically recently, however the use of perhaps the most useful lightweight material of today, magnesium, has yet to be fully adopted in lieu of aluminum. Although the aerospace industry as a whole has not transitioned to magnesium components, SLU's Rocket Propulsion Lab has undergone an effort to replace all aluminum components in Project Ratatoskr with WE43 magnesium, each component designed and fabricated in-house.

CFD Analysis and Optimization of Flow Deflector Geometry for a Supersonic Free Jet

Team 58 Project Technical Presentation to the 2017 IREC

Ross B. Alexander
Texas A&M University, College Station, Texas, 77840

At the Texas A&M University Riverside Campus, the Dwight Look College of Engineering and the Department of Aerospace Engineering have established a testing environment for use by both current undergraduate students enrolled in capstone courses in the aerospace engineering curriculum and also current students involved in extracurricular organizations affiliated with the Department of Aerospace Engineering. The Texas A&M University Sounding Rocketry Team (SRT) has utilized this facility extensively to test commercial off-the-shelf (COTS) solid rocket engines and student-researched and -developed (SRAD) hybrid rocket engines. Currently, SRT operates their LN-350 Helios and NP-915 Icarus hybrid rocket engines in the Riverside Test Cell (RTC). The RTC is equipped with cameras and data acquisition (DAQ) devices, including pressure transducers, thermocouples, and load cells, which have recorded data for 8 successful engine hot fires in the past year. After several tests, SRT determined that the deflector plate geometry should be optimized in a computational fluid dynamic (CFD) study focused on the efficient deflection of exhaust gases out of the RTC.

Active Drag System for Sounding Rocket Apogee Control

Team 60 Project Technical Presentation to the 2017 IREC

Mark T. Via, Jacob G. Eisen, and Harrison E. Kearby
The Ohio State University, Columbus, Ohio, 43210

To date, all competition rockets designed by the Buckeye Space Launch Initiative (BSLI) have relied on mathematical modeling and prediction to reach the target apogee with no compensation for varying conditions such as wind, deviation from standard atmosphere conditions, and flight angle. While designing last year's 10k rocket, a control system was proposed to mitigate the effect of these uncontrollable variables in the form of an Active Drag System (ADS). This component would fine-tune the apogee of the rocket in-flight. Due to time constraints, the project was not fully realized. However, this preliminary work allowed the creation of a designated subteam for the design and implementation of the Active Drag System on BSLI's 2017 10k Competition Rocket.

Manufacturing of Filament Wound Carbon Fiber Tubes

Team 63 Project Technical Presentation to the 2017 IREC

Britton Reynolds, Colton Muncey, Stephen Tsiu, Daniel Parsons, Alexander Baker
University of Alabama, Tuscaloosa, Alabama, 35405

In the design of the ARES II student-designed rocket, custom filament wound carbon fiber tubes were selected for the main structure. A McClean Anderson Little Hornet filament winding machine was utilized to roll upper and lower body tubes. Parameters were chosen to provide an average thickness of 0.09±0.0015 in. A wind angle pattern of 90°/±45°/±45°/90° was generated by the winding machine to provide optimal structural integrity. West Systems 105/209 resin system, along with a 24-hour curing cycle, was used to harden the sections. After curing, a liquid nitrogen recovery method was enacted to separate the tube from the mandrel. Simple cost analysis was conducted to compare pricing between in-house manufactured tubes and commercial tubes. The completed custom wound body tubes were constructed of 15,000 ft of fiber tow and ⅓ gallon of resin/hardener on an 8 ft aluminum mandrel, giving a total estimated cost of $400. Commercial tubes of comparable quality were estimated at $1000, giving a savings of $600.

Retention Attachment for Fins and Takeoff Assist Motors

Team 73 Project Technical Presentation to the 2017 IREC

Aaron Tiscareno and John Harnsberger
Mechanical and Aerospace Engineering Department, Los Angeles, CA, 90024

This extended abstract will be focused on the the Retention Attachment for Fins and Takeoff Assist Motors (RAFT) internal structure that makes up the backbone of the design for this year's competition rocket, Hydra. The purpose of the RAFT structure is to provide an internal housing for our rocket's takeoff assist motors (TAMs) that acts as a centering ring for the main motor, provide retro-thrust retention for the main motor and the TAMs provide a means of housing mounts for modular fins, act as a thrust bulkhead for the TAMs, and act as centering rings for the TAMs while adding a 5 degree cant towards the center of gravity of the rocket. The RAFT structure allows for the TAMs to be housed within the airframe of the rocket, with fairings covering the protruding TAMs, to ultimately reduce drag and reduce the moment length of the TAMs.

Changes in Injector Oxide Mass Flux Between Flight and Ground Tests Using Self-Pressurized Nitrous Oxide

Team 79 Project Technical Presentation to the 2017 IREC

Tyler Sandberg
University of Michigan, Ann Arbor, Michigan, 48109

There is a strong desire in the amateur rocketry community to directly relate ground test performance of rocket motors to their flight performance. Using test data from the team's Nitrous Oxide and paraffin hybrid rocket motor, we conclude that the mass flux of Nitrous Oxide through the injector varies significantly between flight and static tests. This extended abstract presents this data, suggests possible mechanisms, and provides methodology for scaling injector areas to ensure flight performance of the motor matches ground tests.

Active Control for Rocket Roll

Team 81 Project Technical Presentation to the 2017 IREC

Chad J. Serba, Bryce G. Doerr, Paul R. Gross, Alex R. Pratt, Stephanie R. Wegner, Ryan W. Thomas
University of Minnesota, Minneapolis, Minnesota, 55455

The objective of the active roll control project is to damp out roll motion during a rocket flight. This was done by modeling the rocket dynamics, testing for its mass properties, simulating an aerodynamic model of the flight envelope, and designing a Linear Quadratic Regulator (LQR) Controller to control the roll rate of a 6 inch diameter rocket. Mitigating the roll rate of the launch vehicle stabilizes the rocket along the axis of roll, which in turn stabilizes data collected by attached cameras and onboard devices, improves the rocket trajectory, and prevents high roll rates from damaging sensitive electronics.

Research and Development of a Live Flight Apogee Prediciton Payload

Team 82 Project Technical Presentation to the 2017 IREC

Ben Bevans, Quinn Brandt, Nate Jensen, Nate Mann, Bricen Margritz, Dillon Margritz, Michael Pieper, Alex Rogge, Elizabeth Spaulding, Kenny Thomason, Conner Vokoun, Brandon Warren, and Emily Welchans
University of Nebraska-Lincoln, Lincoln, Nebraska, 68508

For the 10k-COTS-All Propulsion Types competition, University of Nebraska-Lincoln Husker Rocketry has designed a 10.16 cm diameter, 360.6 cm long rocket that will carry its 3.99 kg payload to an apogee of 3390.9 m. The payload is a program named Pythia, whose purpose is to predict the ultimate apogee before it is achieved by the rocket, Oracle. The team chose this particular payload because of the performance of the previous year's rocket, Serenity. It was designed using the open-source software OpenRocket, and its predicted apogee was approximately 1188.72 m. Serenity was launched four times, and its actual apogees ranged from 1432.56 m to 1578.864 m. For Oracle, Husker Rocketry wanted a more accurate software, with fewer assumptions, that could be compared with actual flight data. Thus, the idea for Pythia was born.

Two-phase Nitrous Oxide Injector Design and Test for Hbrid Rocket Engine

Team 91 Project Technical Presentation to the 2017 IREC

Emerson Vargas Niño
University of Toronto, ON, M5S 1A1

This paper will cover the complete design, analysis, simulation, and testing for an injector plate for use in a Nitrous Oxide-Paraffin engine. Nitrous Oxide has been of interest as an oxidizer in hybrid rocket engines because it is a self pressurizing propellant. It's high vapor pressure eliminates the need for a complicated pressurizing system. It's high vapor pressure also means the operating pressure of the fluid will easily drop below the vapor pressure, resulting in a two phase mixture, which renders the traditional injector design approach invalid. Two-phase models for mass flow rate were used to identify the critical mass flow rate tha Nitrous Oxide experiences when mass flow rate becomes independent of the downstream pressure. This effect was exploited to simultaneously guarantee the mass flow rate design constraints and attempt to prevent the feeed system coupled instabilities which have plagued the development of hybrid rocket engines.

Improving Performance and Reliability of the SARP Hybrid Rocket Motor

Team 95 Project Technical Presentation to the 2017 IREC

Garrett Allen-Dunn and Alexis Harroun
University of Washington, Seattle, Washington, 98195-2400

The University of Washington's Society for Advanced Rocket Propulsion (SARP) has designed, built, and launched hybrid high-powered sounding rockets since 2012. With this legacy comes the ability to use previous design iterations as stepping stones for future success. In 2017, the Intercollegiate Rocket Engineering Competition (IREC) pushed its high altitude category to 30,000 ft above ground level (AGL), giving the SARP team the chance to re-design much of the launch vehicle to meet the new challenge and fix issues with the legacy design. The primary focus for this year's improvements involves the propulsion system's oxidizer injection and ignition systems as well as its fuel grain composition. Additionally, a more sophisticated simulation software was developed that allows for more accurate prediction of performance.

Improving the Reliability of a Hybrid Rocket Engine

Team 96 Project Technical Presentation to the 2017 IREC

Nicholas Christopher and Miranda Daly
University of Waterloo, Waterloo, ON, N2L 3G1, Canada

The Waterloo Rocketry Team has been developing experimental liquid and hybrid rockets for seven years. All of these rockets have used nitrous oxide (NOS) as the oxidizer. In the past two years, the team has had issues with vapour decomposition of nitrous oxide, and an unreliable ignition system. Therefore, extensive development has been done in the past year on making modifications to the oxidizer feed system and the ignition system of Vidar III, the team's submission in the 2017 IREC. Measurements of the combustion chamber pressure have been taken. The NOS injector has been redesigned to create a larger pressure drop across the injector, decreasing the chance of vapour decomposition. In addition, the injector has been designed to choke the flow of NOS, which in turn has mitigated feed system coupled combustion instabilities.

Refining the Accuracy of a Rocket Trajectory Model

Team 98 Project Technical Presentation to the 2017 IREC

William Oudomsouk and Patrick Pomerleau-Perron
University of Windsor, Windsor, Ontario, N9B 3P4, Canada

The motive behind a precise model came from the fact that software such as OpenRocket and RockSIM overshoot the predicted apogee as a result of neglecting some of the factors that reduce apogee. Additionally, these software options did not allow for the user to input all the conditions of the launch site. Factors such as launch elevation, variable densities and lapse rates needed to be as close to the conditions at the Spaceport America launch site. The goal of the developed trajectory prediction MATLAB program is to create an apogee prediction model that is accurate, and at the same time easy to understand, configure and modify based on different launch conditions at different sites.

Development of a Coast-Phase Active Drag System for Closed-Loop Apogee Control of a Sounding Rocket

Team 101 Project Technical Presentation to the 2017 IREC

Fareez O. Chowdhury, Jonathan E. Jaffee, William M. Lindsey, Peter B. Smith
Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 24060

From prior experiences on multiple sounding rocket projects participated in by members of the team, it has been shown that variable weather and differences in manufacturing of rocket motors - factors outside of the control of the designers of a rocket that is using a COTS solid rocket motor - cause trajectory analyses to be somewhat inadequate in predicting the apogee of a rocket. This is of importance to Rocketry At Virginia Tech, as rockets built for the IREC are scored on many metrics, including accuracy of apogee. Given these facts, it was evident early during the 2017 development cycle that a closed-loop method of reducing the sensitivity of the rocket's apogee to changing flight parameters that cannot be accounted for prior to flight, therefore increasing the probability of achieving a target apogee of 10,000 feet, was desirable. One method to achieve this is the installation and deployment of an active drag system. An active drag system (also referred to as an ADS) centers on the concept that, as the team will be operating in the COTS propulsion category and is therefore unable to control the burn time and thrust of its motors, control surfaces can be used to affect the flight without introducing additional propulsive elements. This method involves purposefully designing the host rocket to overshoot its target apogee when in free flight (i.e. no ADS deployed), and "bleeding off" kinetic energy by inducing additional drag in a controlled manner. Consequently, over the past year, a fully adaptable and dynamic active drag system has been developed for use by Rocketry at Virginia Tech. This system will work in real time on board the rocket to ensure that the rocket drag characteristics match those necessary to achieve an apogee of 10,000 feet based on real-time atmospheric data and flight conditions.

Alternative Lightweight Structures in Airframe Design

Team 108 Project Technical Presentation to the 2017 IREC

Martin M. Aucoin, Shaziana Kaderali, William Zoratto
Carleton University, Ottawa, Ontario, K1S5B6, Canada

One of the most common considerations during the design process of any rocket, aircraft or aerospace vehicle is the weight of the supporting airframe or structure. The ideal airframe would be light and strong while also being economical. This would allow for improved flight performance, flight dynamics and reliability without an extensive budget. Unfortunately, this is not always possible in the real world and the designer is forced to sacrifice one of these options in exchange for the other two. The alternative is often to try and achieve a balance between the three, such that all relevant requirements are satisfied even though acceptable compromises are made in some areas. This abstract will outline the design choices made by CU InSpace, Carleton University's rocketry team, when creating an airframe for their rocket to be flown in the 2017 IREC at Spaceport America. The chosen airframe is a result from attempting to achieve a balance in weight, strength and cost.

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Non-competing, Collegiate Rocket Engineering
Research, Development, Test, & Evaluation
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Innovative, Reliable Designs for High Altitude Rockets

Team 200 Project Technical Presentation to the 2017 IREC

Joshua Allen, Alexander Bruzda, Robert White, Dane Erickson, Eric Kamke, Austin Rose, Jonathan Guzman, Wilson Hansen, Cameron Olmstead, Devyn Uyeki, Bernard Viray, Kawika Wellington, Jake Gilbert, Scott Merrill, Tyler Nelson, Natasha Anisimova, Terrance Lee, Albert Morgan
Oregon State University, College of Engineering, Corvallis, OR, 97330

With the participation of Oregon State University (OSU) High Altitude Rocket Team (HART) in the 2017 Spaceport America Cup, this project aimed to push the boundaries of current undergraduate rocketry capabilities. The project focused the efforts of 12 mechanical engineering, 3 electrical engineering and 3 computer science undergraduates in launching a student-designed rocket to a minimum altitude of 100,000 ft above ground level (AGL). The rocket was designed to meet the requirements of an FAA Class II waiver (mandating less than a 40,960 N-s total impulse), which required efficient, innovative designs from every subteam. The collective innovation and integration solutions generated to meet the altitude challenge are the focus of this presentation. With creative thought, diligent testing and constant design optimization, OSU HART has built a rocket simulated to over 100,000 ft and flight tested to 20,000 ft. The rocket incorporates a two-stage, solid motor design with two custom student researched and developed N and M class motors, delivering a total impulse of 23,690 N-s. The airframes were constructed with carbon fiber and featured a transition to fiberglass to allow for live telemetry data collection. Both fin sets were a sandwiched composite structure comprised of G10 fiberglass, Nomex honeycomb, and carbon fiber. The recovery system utilized a dual front-deploy drogue and main parachute for each stage, each equipped with multiple redundant black powder charges to guarantee deployment. The ground station provides real-time telemetry and GPS of each stage, and the rocket itself will be launched from a student-built, high-durability launch rail. Subsystem testing was performed continuously to increase system reliability culminating with a successful full-stack launch without sustainer motor reignition due to altitude restrictions. Ultimately this project focused on reliability and performance, serving to launch current OSU students into the aerospace industry and serve as a backbone for future OSU innovation and development of high-altitude, staged rockets.
