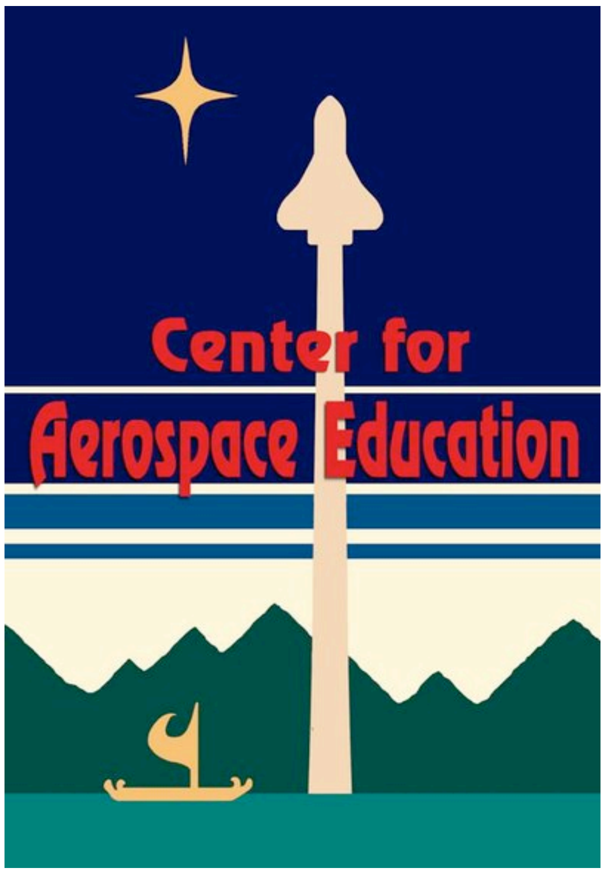
University of Hawai'i
Windward Community College



University Student Launch Initiative
2010-2011

Post-Launch Assessment Review

Team Summary

- University of Hawai'i – Windward Campus
- Hale 'Imiloa
  45-720 Kea'ahala Rd.
  Kane'ohe Hawai'i 96744
- Dr. Joseph Ciotti (Principle Investigator)
  Dr. Jacob Hudson (Team Official)
  Helen Rapozo (IT Specialist)
  Kristi Ross
  Joleen Iwaniec
  Todd Esposito
  Patrick Lancaster
  Jasmine Maru

Launch Vehicle Summary

- Rocket Name: Leo Hano
- The team rocket is 121 inches in length, with a 6" diameter
- The rocket used an **L1300R 98-mm** motor
- Dual deployment recovery system incorporating a 42" drogue deployed at apogee, and a 144" main to be deployed at 1000' altitude was to be deployed.

Brief payload description

The Payload is named Hula-hoop. Its purpose is to determine the rocket's orientation throughout the flight. It will have three perpendicular coils, each with its own parallel resistor. These coils will be wrapped around a sphere. This sphere will be of a material that does not produce or interfere with magnetic fields. As the rocket goes through its flight the payload will travel with the rocket through the Earth's magnetic field. In doing so, an induced voltage will be produced, due to the interaction of the coils as they travel through the Earth's magnetic field. Data will be collected concerning the voltage fluctuations for the three coils. Since the coils will be perpendicular to each other we will have data of voltage fluctuations in three dimensions (X, Y, and Z). This data can be used to determine the rocket's orientation throughout the flight. A more detailed description of the payload is given in later sections.

Rocket mass

Pad weight: 45 pounds

Altitude reached (Feet)

Visual estimation: <50 feet

Vehicle Summary

From our Flight Readiness Review, our Mission Criteria was:

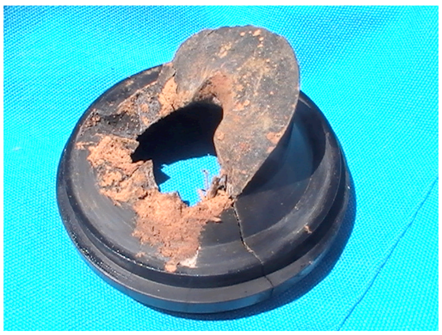
- Payload functions properly
- Successful recovery of the rocket and all its components
- Both parachutes deployed
- The rocket is completely intact
- The data is downloadable via EEPROM
- The payload performed as it was planned to
- The appropriate levels of safety are maintained throughout the entire process of preparation, launch, flight, and recovery of the rocket

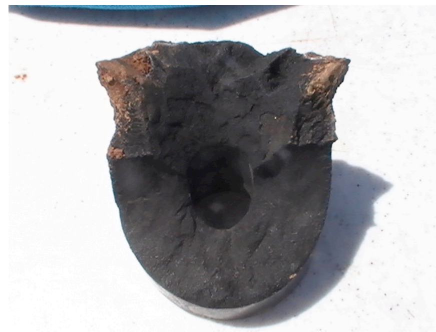
To have achieved any type of success in the mission, the rocket must have deployed a parachute and must have been intact upon recovery, meaning it had the ability to be considered flight ready, meeting all safety requirements without any repairs done to it. Furthermore, if the team did not have a parachute deployment and the rocket was not intact upon recovery, the mission was to be considered a failure. A partially successful mission was defined as meeting four of the criteria, having deployed a parachute, and remaining intact upon recovery.

Our mission did gather data that was downloadable from the EEPROM, indicating that the payload performed as planned, but the flight duration was so small that we are not sure if the payload actually functioned properly. The appropriate levels of safety were maintained throughout the entire process of preparation, and recovery of the rocket. However, having met only three of the above criteria, not deploying a parachute, and not remaining intact, this mission was a failure.

The rocket, and its payload, was prepared following the checklist procedure included in our Flight Readiness Review. After a while, the rocket was carried out to pad #42, inserted onto the rail, and brought to vertical in the usual fashion - all under the supervision of the team mentor and the NAR official at the pad. Previous to motor ignition, the GPSFlight unit was transmitting a good ground trace, and the avionic units were giving audible signals consistent with good continuity to the pyrotechnic charges, as well as having sufficient voltage. At ignition, the Aerotech L1300R motor lit, and the rocket began to lift off the pad. A very short time later, the motor shut down completely. The rocket had enough initial thrust to acquire a speed to clear the pad, reach a very low apogee, and then fall back to ground impacting a few feet away.

Upon investigation, it was found that while the motor was coming up to full pressure, the phenolic nozzle suddenly split horizontally right across the throat, sending the divergent cone about 20 feet away from the pad. The effective nozzle area, that the motor was designed for, was very suddenly increased. Because the motor had not yet come up to full pressure, the sudden, and rapid decrease in pressure extinguished the motor.





This failure of the nozzle occurred during flight, and the piece with the divergence cone was ejected while the rocket was in the air. Evidence to support this statement comes from the recovered nozzle pieces; since the rocket landed tail down in mud (about 5 feet from the pad), it was noted that the larger phenolic nozzle piece, the part that remained with the rocket, had mud on the fractured surface face while the divergent cone was relatively clean.

Because the net acceleration was less then 3 times the acceleration due to gravity, the Raven flight unit did not initiate any flight data recording. Since the change in ambient pressure was too small, the PerfectFlight unit also did not initiate flight data acquisition. Essentially, there was no flight data to retrieve from our avionics. Additionally, the rocket had a Booster Vision GearCam DVR unit attached externally to the booster section. The shock of impact shut the GearCam off. Because the shut down of the GearCam requires an end of data statement (i.e. pushing the 'OK' button once before shut down), the video data was un-extractable. Examination of the NASA live stream video files did not capture the flight of the Leo Hano rocket[1], only its aftermath. In fact, the only visual record of the flight was obtained from a video shot by one of the team members – whose attention was (understandably) diverted after the motor extinguished itself. Based on this video, we estimate that the motor was lit for about 0.3 seconds before the nozzle failed, and the motor was snuffed out. This time estimate is based on video observations of when the signature 'red-line' plume started. The video recorder had a frame rate of 25 frames per second, and the entire powered flight consisted of only 8 frames. It is estimated that this short acceleration time gave the rocket an initial upward velocity of roughly 45 feet per second, and reached an estimated height of 35 feet. The rocket then descended, still maintaining a 'nose-up' vertical attitude, and impacted with the ground with an

[1] This is true of last year's Leo Hano flight as well.

equivalent force of between 200 to 430 pounds (depending on the estimates of collision duration). The force of the impact broke the aft bulkhead, which held the motor retainer, damaged the bottom of the body tube, deformed the drag shoes, and crumpled the motor mount tube. The total flight time is estimated to be roughly 3.5 seconds (the video did not capture the descent phase of the rocket). The damage to the motor mount tube, and aft bulkhead, was extensive, and it was determined that repairs could not be completed at the launch site. Since the aft bulkhead is responsible for fixing the motor to the rocket booster, and maintaining the overall alignment of the motor with the long-axis of the rocket, its placement (and secure attachment) is essential to the over-all stability of the rocket. This, coupled with the motor mount tube not being integral, made the Leo Hano rocket no longer flight-worthy. When the team mentor was asked about a possible second attempt (should another motor become available), it had to be declined. Effectively, this ended this year's USLI attempt.

There are three major causes for the type of nozzle failure we experienced: (1) improper fabrication, (2) improper handling before use, and (3) improper motor preparation. Improper motor preparation (3) can be ruled out. Under the supervision of team mentor Dr. Jacob Hudson (NAR/TRA L3), the motor was prepared by team member Todd Esposito (NAR L2) – together, these two members have over 12 years experience in preparing Aerotech motors of all sizes, including many 98-mm M1419 motors. The motor grains were visually inspected before placement in the motor. The nozzle was also inspected, and there were no defects that could be seen, and certainly nothing that would impede the exhaust flow at the nozzle. Aside from an over-zealous application of Vaseline to the motor casing sleeve, the instructions for the motor preparation were followed to the letter. After flight, when the team pulled the motor out, and took the motor apart (under the observation of two NAR officials), the grains looked good, and the seals were in place and tight. In fact, the grains actually looked so good, that it was opined that if the team had a new nozzle, they might have gotten about 95% of an L1300 out of it.

As to improper handling before use (2); we believe that this can be ruled out as well. Ostensibly, it should be mentioned that we are unaware of the handling that was done by the merchant, or indeed the postal service, previous to the team obtaining the motor. However, that being said, a phone conversation with Aerotech's Karl Bauman gave us the stress over strain (T/S) ratio for the material that the nozzle was fabricated from. For a nozzle of this type of motor, this value is between 10,000 to 12,000 psi. As such, short of running the nozzle over with a truck (which we did not do) this is beyond the range of any improper handling that we could have done. Also, the reputation of Huff Performance Hobbies is such that this team believes that the motor was properly handled prior to the team receiving it. Once procured by the team, the motor remained in its package until shortly before motor preparation.

Although a failure of the phenolic nozzle has a very low probability of occurring, estimated to be less then 0.2%, this team believes that this did occur.

Data analysis & results of payload

Though we have every reason to believe that the payload functioned properly and would have performed all its duties, if given the opportunity, no data has been recovered from our flight in Huntsville. We base the idea that the payload was fully operational due to the fact that preliminary testing with payload unit itself, while in Huntsville, showed that there were no issues with either the hardware or the software of the unit.

No data has been recovered from the payload at the point, though there is data stored on the payload itself. This is due to several different reasons. First off, the logistical problems of having the launch on Sunday and issues at the launch field gave the team some additional and unexpected challenges. With the launch day being on Sunday, we could no longer use Saturday night to pack the rocket for shipping and then have the entire next day to get it to a shipping agent. Instead we would have to quickly pack it after the launch and try to make it to the post office before they closed that night. We determined that arriving early at the field and subsequently getting an early launch would solve this problem. After getting to the field very early and fully prepping the rocket there were additional issues at the launch field with our team being sent to the wrong pad. After about an hour and a half wait we were sent to a pad suitable for our rocket. At this point the payload was reset, as it had been recording data for over an hour, and considering the potential pad-stay time, we wanted to make sure we had enough storage room. Once getting out to the correct pad we discovered that the dome-head bolts holding our rail buttons in were too high. A NAR official told us to wait at the pad as he got bolts for the team that would work. After about a 20-minute wait he returned with only one bolt. So an additional 15-minute wait was required as a second bolt was retrieved. After all of this the rocket did not successfully fly. Because of this, almost all of the data stored (over an hour) is the rocket staying still and about 0.3 seconds of the data showing rocket movement that we were actually interested in.

After the launch, because the team was in a rush to get the rocket shipped, and also because our minds were largely focused on the events of our short flight, little thought was put towards the payload and retrieving the data. Most of us were content with doing the data dump once we received the payload in Hawaii, after it had been shipped. In hindsight, this was not a good decision. Though we were short on time, the amount of time needed to do a data dump on sight probably could have been found. This would have enabled us to overcome any problems that the rocket and payload would have endured during shipping. To date we have not received any of the boxes that we had sent from Huntsville. This is probably due to the natural disasters that have impacted the area.

Though we can safely assume that the payload functioned as intended, it relied on large amounts of movement to make our experiment effective. Due to the short flight time, we do not believe that the data recovered from the payload would provide an adequate relevant data sample for us to make any conclusions on at this point.

Scientific Value

This project is a valuable method for getting hands-on experience in physics, aeronautical engineering, electrical engineering, and project planning. The Center for Aerospace Education (CAE) will continue its efforts at promulgating interests in science, technology, engineering, and mathematics. Several on-going programs that will benefit from the outcomes of our project are discussed below:

- **CanSat:** The WCC CanSat program is a project based learning opportunity to instill an interest in science, technology, engineering, and mathematics in college students that would otherwise not pursue such endeavors. Students are tasked with designing, building, and the subsequent testing of a fully operational device that will emulate a space probe gathering an array of data. There are strict physical limitations to the design volume of the CanSat, usually confined to fitting inside of a standard 350 ml soda can. Students are usually required to interact with experts in the engineering community, or faculty experts on other campuses of the University of Hawaii system. Since the majority of students attending the satellite Community Colleges are pursuing a liberal arts certificate, the CanSat program is ideally suited to for these students. Aside from acting as a resource, the CAE would like to be able to provide a means of *in-situ,* rigorous, testing of the involved electronics previous to departure for the competition.
- **ARLISS:** Among the many variants of CanSat is ARLISS (A Rocket Launch for International Students Satellites). ARLISS is hosted by AeroPAC (a recognized high powered rocketry organization) and Prof. Robert Twiggs (recently retired from Stanford University), and takes place in Black Rock Nevada, primarily to foster relations between universities around the Pacific Rim. Students are tasked with designing, building, and testing, an electronics package that emulates a planetary probe. The goals for ARLISS are well defined - the electronic package must, when deployed from a payload bay, autonomously make its way to a GPS target site, all the while gathering external data and transmitting it to a passive ground station. A low-altitude rocket would provide a marvelous opportunity for the multi-faceted testing required for a successful endeavor.
- **Curriculum Development:** Current efforts to develop a rocketry certificate program, requires curriculum development for two courses; Rocket Principles, and Ground Safety Protocols. A re-usable rocket, launched in conjunction with the above two projects, utilizing students from the two classes, provides a *hands-on* situation that can only be beneficial to the learning environment. By having one to two launches a semester, students

can come away with a greater understanding of the rocketry principles involved, and the safety procedures followed.

- **High School Science Fair:** Preliminary data collected by the CAE indicates that there is a wide interest in student lead research involving rocketry. By soliciting proposals from High Schools that have flight ready projects, the CAE could host launches involving the students in the Rocketry certificate program. Interested High Schools would submit a proposal to the CAE for a flight request. The accepted High Schools would then submit a Preliminary Design Review, a Critical Design Review, followed by a Flight Readiness Review prior to the project being flown. These would be reviewed, and commented upon, by the students in the Safety Protocols class. Any recommendations would be conveyed back to the particular High School. At the time of launch, interested High School classes would be invited to observe the launch, with the on-board payload carrier electronics performing a 'voice-over' of what the rocket is doing at all phases of is flight profile.

As to our payload results; what little data we have obtained has indicated that it is possible to determine the rocket orientation, at any given instant in its flight path, by studying the induced voltage produced by the interaction of the Earth's magnetic field and three mutually perpendicular coils. The Faraday law of Electromagnetic Induction predicted that this should be so, and our experiment was to test this. We believe that there are several applications possible; one of them being that integrating this unit into a proper feedback network, a rocket stability system could be implemented.

Our payload consisted of three mutually perpendicular coils wrapped around a nonmagnetic sphere – a whiffle ball, affectionately called *Walter*. Each coil is in parallel with a resistor. Voltages read across the resistors were then input into an Analog-to-Digital Converter (ADC) and those values were stored to an EEPROM unit. Data from on board accelerometers can be used so that a comparative study can be made- once we get our data, this is what we will do. We expected very small values of the induced voltage, which lead to our choice of ADC. However, one comparison that we have come to consider is whether this effect is so small compared to other methods of inducing voltages. Future studies should compare our results with a payload designed to measure the Hall effect – to determine whether the induced voltages are within the same orders of magnitude. It is possible that this may be an easier way of determining rocket orientation.

Summary of overall experience & Lessons learned

Jasmine Maru:

My overall experience at USLI was good one. I really enjoyed designing, building and launching a reusable rocket with a scientific payload. Being able to interact with the NASA engineers helped provided me with a logical, factual and generally rational explanation of how NASA operates. The project revealed to me, as a student, the actual processes that engineers have to go through to initially work with NASA. For the amount of students that attended the USLI launch, the program was very well structured. It was very beneficial for all the students to be allowed to tour the Marshal Space Flight Center (MSFC). The overall program has helped me to keep focused as I pursue my goal in working in the aerospace field.

Kristi Ross:

I have learned a lot in the past school year. Not only about rockets, but about patience. There have been times during the USLI competition that have been rough but I look at it as a very rewarding experience. As a team we worked okay together. I am looking forward to next year and the progress we can make as a team. There is defiantly room for improvement, as is with most things. I know we can achieve higher efficiency and be more professional. Our mentors have been incredible. They have treated us with respect and patience.

As for our trip to Huntsville, that was fun. The space and rocket museum was awesome. The rocket fair was interesting. I really liked seeing all of the team's projects. The hotel was very nice. The overall experience in Alabama was great. The only bad thing I could note was the cold weather.

Patrick Lancaster:

Working on the USLI project has given me great insight into the real design process that NASA uses. Not only has it been a great learning experience but has also been a lot of fun along the way. Though I was very disappointed that the rocket did not have a successful flight, I still believe the experience to be well worth it. The lessons learned along the way and the skills obtained will prove to be very valuable for me in the future.

The challenge that the USLI project puts on the group has been a team building exercise as well. Over the course of time that we have worked on this project our members have built a better foundation for teamwork. It has also encouraged us to reach out to the community and students, through various educational engagement activities to increase awareness and stimulate interest in the STEM fields.

Joleen Iwaniec:

Allow me to begin by saying how honored I am to be a part of this unique team as this has been an interesting year for me during USLI 2010-2011. As Education Outreach Coordinator I have been responsible for getting our team…"out there". Exposing the simplest of projects to children across the state and encouraging STEM based learning and programs. As mentioned in the education portion of this review we have succeeded in many of our goals. I was even fortunate enough to spend time with children on military installations in Japan creating straw rockets and Alka-seltzer rockets. These children had a blast (no punt intended) creating, decorating, and launching (repeatedly) their new rockets. One of my highlights was watching parents have just as much fun as their children. Then in late April I was invited to the STS-134 Pre-launch education summit were I met with

NASA Administrator Charles Bolden and NASA Associate Administrator of Education Leland Melvin. We discussed how best to reach out to today's isolated, under-deserved, and underrepresented students. Mr. Melvin suggested a possible uplink to the ISS, which would most defiantly be engaging and exciting to all who would participate.

Needless to say this program has assisted me to find were my true passions are in life and how I am going to pursue them. After graduating with my electrical engineering degree I hope to further pursue a career with NASA and develop more programs for children of all ages to become more engaged and inspired to discover the plethora of possibilities involved with STEM. Thank you NASA for these wonderful opportunities!

Todd Esposito:

The USLI 2011 trip for team Hawaii was a great learning experience. The whole process of the National Aeronautics and Space Administration (NASA) criteria for our project was an eye-opening endeavor that helped all of our team to understand the complexity of any mission that NASA has to accomplish. I am both honored and privileged to be a part of the Hawaii team.

We had our difficulties with the rocket, as it CATO-ed off the pad on launch day at Bragg's Farm. I was devastated at what happened, but I was a little consoled after the initial post-mortem found the problem to be with a manufacturing defect of the motor nozzle, something that has an extremely low failure rate, but nonetheless it happened to our rocket. I probably could have constructed the rocket a little more robustly to fly again that day, but it is difficult to plan for something of that magnitude. We had our difficulties with the Full Scale Low Power (FSLP) tests as well. We solved those problems and had a solidly constructed rocket and payload ready to be launched at the competition in Alabama. It was great to visit and then to dine under the Saturn V rocket at the U.S. Space and Rocket Center in Huntsville.

Overall it was a valuable learning experience for our team. We will continue to strive and achieve our goals of a successful launch of Leo Hano, our rocket, and Walter, our payload for the USLI competition. I look forward to being a part of this team and continuing our efforts for Hawaii Space Grant Consortium and NASA.

Educational engagement summary

The USLI team at Windward Community College devoted many successful hours into building stronger community ties, which has now enabled our outreach program to include outer-island advertising, more school projects and a competition that will advance a Hawaii team to SLI.

The state of Hawaii is unique not only because it has 2400 miles of ocean separating it from the Continental United States but also the state itself is divided into eight islands making events on one island difficult for the residents of another island to attend. Therefore, we are confident that once our plan to become televised on the local news and the locally produced and run show O'lelo we will close the inter-island communication gap. Our plans for the local show O'lelo are still underway. We have a plan for a half an hour television program in which will describe our CAE facilities, NASA resources, USLI program, SLI program and other educational endeavors that involve rocketry (such as the Hawaii Space Flight College, the Pacific Missile Range Facility, etc.). This approach will be the catalyst to get our message into households and businesses alike throughout the state. Furthermore, press releases to all local newspapers to include the military periodicals will be instrumental in the continuation of the development and growth of community involvement. This millennium has changed to, and is all about, social networking and as such we need to be a part of this change. Targeting these venues are actively being investigated and pursued.

One outreach project that has been in effect, and will continue to be utilized, is a model rocket launch we hold every month. On the third Saturday of every month we launch model rockets for research purposes. This launch is open to the public and is also used for community engagement. These launches have been very successful in reaching people. We have a few regulars that show up consistently. We have afforded an opportunity for teams to utilize this time to launch in preparation for the Team America Rocket Challenge.

On December 13, 2010 we engaged middle school students, of the Boys and Girls Club of America, in a hands-on educational experience where the students built paper Scimitar rockets. We instructed them on simple principles of rocketry (Newton's Third Law, etc.). This was a way for us to share the world of rocketry and possibly strike an interest in science, technology, engineering, and math (STEM).

Detailed flyers and brochures to include what the WCC CAE (Windward Community College Center for Aerospace Education) has to offer students, and schools, and how they can get involved in TARC, SLI, USLI, and the numerous other NASA learning opportunities encompassing rocketry will also be distributed to schools and organizations throughout the state. It is hoped that this will lead to an open-line communication between WCC CAE and the rest of Hawaii. Students of today will be the leaders, discoverers, and inventors of tomorrow and are entitled to be introduced to the opportunities that exist by being a part of this organization.

Additionally, an inclusion to this year's outreach development plan is to host A Rocket Contest for Hawaiian Skies (ARCHeS) in the spring. The preliminary idea for this competition is to have a parachute payload duration experiment. After conversing with SPRCH (Sky Performance Rocketry Club of Hawaii), the local NAR chapter, we have tentatively decided that the competition that fulfills the conditions for suitable challenge, and our limited field size, is the payload parachute duration. We have obtained grant funding, and are planning to supply the motors for all participating teams. This ensures that all teams will have the same specific impulse, and should keep all rockets within our limited field size. In fact, the fact that the motor is pre-determined will be part of the design criteria. The plan is that the student-designed rockets will eject a payload section with a separate parachute and the time of descent will be measured. We are still contemplating on whether to use a kukui nut, or an egg, as a payload mass. This contest, open to all interested high schools, will enable (we hope) a Hawaii team to compete at SLI in the following year. We look forward to the participation, and the shared learning experiences, that will ensue with this year's outreach plans.

With this multifaceted approach, it is expected that all educational outreach goals will be fulfilled. Windward Community College, a University of Hawaii satellite campus, and the Kaneohe Marine Corps Air Station, will be essential to all of the launches that take place on Oahu. The Pacific Missile Range Facility on Kauai has also been a host to community events in the past, and has expressed a willingness to continue this collaborative effort. They hosted one such event on December 18, 2010, at which we acted as a resource for the involved learning institutions. Support for our educational endeavors are being sought on the islands of Maui and Hawaii (The Big Island).

During the course of this semester we have had a success with Education Outreach as our main goals were to inspire, engage and educate our community about STEM projects and programs. Not only were we able to spark the student's interest in STEM through several hands on workshops, building small rockets and learning rocketry terminology, but we successfully had a segment on OC16 which airs across the state. This type of publicity is crucial for us since our state is comprised of islands with no inexpensive means to reach the outer islands. This segment has bridged gaps we never thought possible. Fortunately it doesn't stop there. We are already planning a segment to incorporate more in depth aspects of what we as a team and as a school have to offer. Windward Community College is fortunate to host one of 42 Aerospace Education Labs (AEL) on the island of Oahu. With more media publicity we hope to have more outer island students participate in our labs.

Also our Educational Outreach Coordinator, Joleen Iwaniec was invited to the STS-134 Pre-launch educational summit in Orlando, Florida. During the summit Joleen was able to meet with NASA Associate Administrator of Education Leland Melvin and NASA Administrator Charles Bolden to discuss the difficulties of both nomadic military families and students in both the public and private sector that are not exposed to NASA STEM programs and projects. The main topic of the STS-134 summit, "Meeting America's Commitment to Military Families: Laying the foundation for a Coordinated Approach to Supporting & Engaging Military Children" has truly been inspirational to our group. Being in such a remote location in the middle of six bases (on our island alone) we fully understand the difficulties facing these underrepresented children. Our goal is to continue to engage these communities and inspire them to work with STEM based projects through online activities and visits to our AEL. With this new knowledge and ideas we look forward to next year's opportunities and increased participation island wide.

Budget Summary:

Rocket Cost

Part:	Price Each	Quantity	Total Cost
Body Tube (FT-6.0)	$45.32	10ft	$453.20
Nosecone (FNC-6.0 30.5" ogive)	$89.95	1	$89.95
Coupler (CT-6.0, 16" length)	$68.00	2	$136.00
Aluminum Fins/Can assembly	$80.00	1	$80.00
Centering Rings (FCR-6.0-3.9)	$16.00	2	$32.00
Bulkheads (CBP-6.0)	$5.93	2	$11.86
Motor Tube (FTEX2-3.91, 36")	$58.92	1	$58.92
Drogue Chute (32")	$35.00	1	$35.00
Main Chute (108")	$95.00	1	$95.00
Shock Cord (1" thick)	$0.50/ft	40ft/2	$20.00
Kevlar Patch (9")	$14.00	1	$14.00
Kevlar Patch (16")	$19.00	1	$19.00
Aero-Pack 98 mm Motor retainer	$64.00	1	$64.00
Aero-Pack 98-75 mm motor adapter	$45.00	1	$45.00
Subtotal			$1,153.93

Avionics/Electronics Cost

Item	Price Each	Quantity	Total Cost
PerfectFlight MiniAlt/WD	$99.95	1	$99.95
Featherweight Raven-2	$155.00	1	$155.00
GPSFlight (ST900e)	$695.00	1	$695.00
GPS-P25 (Patch antenna)	$30.00	1	$30.00
RPSMA900 (trans. antenna)	$18.00	1	$18.00
Li-Po Battery Pack	$150.00	1	$150.00
9V Dry Cell	$2.99	4	$11.96
Subtotal			$1,159.91

Payload Cost

Item	Vendor	Part #	qty	Price
Basic Stamp 2p	Parallax	BS2P24	1	$79.00
8 channel 12-bit A/D Converter with SPI Serial Interface	Parallax	604-00062	1	$5.22
MMA7455 3-Axis Accelerometer Module	Parallax	28626	1	$34.99
LM34 Temperature Sensor	Parallax	604-00011	1	$3.99
3 inch Jumper wires	Parallax	800-00016	1	$1.99
BASIC Stamp Syntax and Reference Manual V2.2	Parallax	27218	1	$25.99
Basic Analog and Digital Text V1.4	Parallax	28129	1	$24.99
StampWorks Manual	Parallax	27220	1	$24.99
Applied Sensors Text v2.0	Parallax	28127	1	$29.99
Smart Sensors and Applications Text	Parallax	122-28029	1	$29.99
Process Control Text	Parallax	122-28176	1	$24.99
IC ADC 24BIT SIGMA-DELTA 24-DIP	Digi-Key	AD7714YNZ-ND	1	$44.13
EEPROM - 64Kbytes	Digi-Key	24LC512-I/P-ND	1	$33.75
Subtotal				$538.16

Budget Total

Rocket Body/Construction		$1,153.93
Rocket Avionics/Electronics		$1,159.91
Payload		$538.16
	Total:	$2,852.00

Travel Costs

Airfare: $ 937 (UAL) X 5 = $ 4685

LV (4/12) HNL 10:00 pm UA42 to DEN
10:40 am UA6570 to HSV @ 2:19 pm
RT (4/18) HSV 6:30 am UA4532 to IAH
IAH 9:35 am UA3927 to HNL @ 12:55 pm

Van Rental: (Full size van for 1 week) = $ 353

Alamo – Huntsville International Airport
Huntsville Alabama

Rooms: $534 ($89/night X 6 nights) X 3 rooms = $ 1602

	Holiday Inn Downtown (USLI Special) 401 Williams Avenue SW Huntsville AL 35801 (256) 533-1400	
Food:	$25/day/student X 7 days X 5 students	= $ 875
	$45/day/mentor X 7 days	= $ 315
		$ 7830