Team Name
- Team Hawai’i

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)
  Premitivo Ames II
  Joleen Iwaniec
  Todd Esposito
  Patrick Lancaster
  Jasmine Maru

Altitude Reached
- 4662 ft.

Launch Vehicle Description
- Rocket Name: Leo Hano
- Leo Hano Length: 86 inches
- Leo Hano Diameter: 4 inches
- Leo Hano Pad Weight: 23.06 lb
- The rocket is designed to have a dual deployment recovery system incorporating a 36-inch drogue chute deployed at apogee, and a 96-inch main chute to be deployed at 500’ altitude.
- Rail Size: 10/10 rail with a length of 10 feet

Brief Payload Description
- The payload consisted of three individual units. Unit 1 (Sparrow 1) sampled air temperature at a rate of 1 sample/second. Unit 2 (Sparrow 10) measured acceleration at 1 sample/second. Unit 3 (Sparrow 12) measured acceleration at 3 samples/second. The dimensions of each unit are 177.8mm in length, 42mm in diameter, and weighed no more than 141.75 grams. All units were housed in the payload carrier, which was housed in the payload bay. All units were independently powered and were able to endure the 1-hour pad stay time without consequence.
Motor Used

- Cesaroni K510

Diameter: 75.0mm
Length: 35.0cm
Total Weight: 2590g
Prop. Weight: 1197g
Average Thrust: 514.0N
Maximum Thrust: 689.8N
Total impulse: 2486.0Ns
Burn Time: 4.8s

Mission Criteria:

- Successful recovery of the rocket and all its components
- Both parachutes deployed as scheduled
- The rocket is completely intact
- The data is downloadable via EEPROM
- The voice-over performs its programmed duties (public would be addressed)
- The subcontracted 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

At the on-set it was believed that to achieve any type of success in the mission, the rocket must have deployed a parachute, as well as being intact upon recovery - it has the ability to be considered flight ready (i.e. meeting all safety requirements without any repairs). If the team did not have a parachute deployment and/or the rocket was not intact upon recovery, the mission would be considered a failure. A partially successful mission was defined as meeting 5 of the 7 criteria, and had to have deployed a parachute resulting in an intact recovery. Our flight was partially successful.

**Evaluated Performance Criteria**

- Motor performed as expected.
- Rocket did follow the expected trajectory.
- Desired altitude of 1 mile was missed by 618’, but not exceeded.
- Drogue chute was deployed at apogee.
- Main chute was deployed prematurely.
- Leo Hano (voice-over) did not perform throughout the entirety of the mission.

**Flight Assessment**

As has been well established, the flight characteristics for the Leo Hano rocket had been determined for use with an Aerotech K560W motor. Shipping a motor from Hawaii was not an option – especially since the motor would have had to be shipped to Hawaii first. The plan was to pre-order the motor, and then pay for it upon arrival to the launch site. As such, contact was made to Huff Performance Rockets and purchase of a K560W was negotiated. It was mildly disturbing for the team to be informed, the afternoon previous to the actual launch date, that the required motor was not available (it having been ‘lost’ by UPS in transit to Huff Performance). A contingency, a Cesseroni K510 was available, and subsequently purchased. Concern about the different mass of the
motor, and how this lowered our rocket’s CG was an issue. However, RocSims performed the evening before launch, showed the rocket to be safe and stable throughout the trajectory.

Loss of the motor was not the only pitfall given to us by UPS! Despite numerous stress tests, planned and un-planned, where the rocket came through without damage, it was discovered that a fin fillet was cracked during transit to Huntsville. Inspection of the rocket in Hawaii, previous to delivery to UPS, showed that rocket to be entirely intact. However, inspection in Huntsville revealed a crack that ran parallel to one of the fins down the center of a fillet. While it was thought that this might not seem significant, it cast doubt on the structural integrity of the fin mount. After some discussion, it was decided to be safe. The team removed, and then rebuilt the fin prior to the Hardware inspection.

At the hardware inspection, the fin assembly was passed, but it was found that one of our tether cords was showing some burn wear, and it was suggested that it be covered with masking tape. After some discussion, it was decided to replace the tether (and its Nomex cloth Shroud) with a new one. Observations of earlier flights had shown that there was a problem with early deployment of the main chute. The question as to whether friction, between the booster section and the avionics section, was strong enough to prevent that from happening to our rocket arose. After discussion, and review of the deployment test footage, it was decided that a layer of duct tape along the booster-avionics seam would suffice. On its way to the assigned pad, the rocket was taken for final inspection. Since the team was not sure what was to be expected at the inspection, they left the rocket in a ‘loose’ state (i.e. the booster was not joined to the avionics section by duct tape). The plan was to apply the duct tape at the pad after the inspection. However, at the pad, the team was strongly advised against this by the NAR official. A compromise was reached, and two small patches of duct tape were applied instead of the entire circumference-encircling band that was planned.
The actual flight of the rocket was straight while under power and coast. Having a Margin of Stability between 1.0 and 2.0 guaranteed that the rocket was steady even through the variable winds. The altitude attained was 4662' (as determined by our PerfectFlight), which is 11.7% (618') short of the desired altitude of 5280’. It should be mentioned that while trying to hear the audible altitude measurement from the PerfectFlight, the G-Wiz HCX was turned off before its altitude determination could be obtained. The drogue chute was successfully deployed at apogee. Inspection of the forward section of the avionics section showed that both pyrotechnic charges had been ignited. Shortly after the drogue had deployed, the dependent rocket began to rotate about an axis that was along the payload-to-avionics tether. Roughly, 5 seconds after complete drogue chute deployment, the rotation rate became great enough that the booster’s rotational inertia (coupled with its weight component) overcame the frictional forces (along with the duct tape adhesive forces) that held the booster to the avionics section. Subsequently, the booster slipped off the avionics section and thereby deployed the main chute prematurely. Inspection of the booster section at recovery showed that one pyrotechnic charge had been ignited, but the second had been pulled off the electronic match (possibly during the main chute deployment), and had not been ignited. It should be mentioned that the naked electronic match had been ignited, which shows that both avionics boards had performed as planned. It is believed that had the full duct taping of the booster-avionics seam had been employed, the rotational inertia of the booster would not have been enough to de-couple the booster from the avionics section, and the main would have deployed according to schedule. For future launches, the plan is to employ two, to four, nylon shear pins to couple the booster to the avionics section.
Leo Hano Payload Summary

Overview

The payloads for the Leo Hano flight on April 17, 2010 consisted of three independent electronic packages summarized in the table below.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Sparrow1</th>
<th>Sparrow10</th>
<th>Sparrow12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Cabin air temperature</td>
<td>Acceleration</td>
<td>Acceleration</td>
</tr>
<tr>
<td>Controller</td>
<td>Basic Stamp 2</td>
<td>Basic Stamp 2pe</td>
<td>Basic Stamp 2p</td>
</tr>
<tr>
<td>Sensor</td>
<td>Dallas DS1620</td>
<td>Freescale MMA7455</td>
<td>Freescale MMA7455</td>
</tr>
<tr>
<td>External EEPROM</td>
<td>24LC256</td>
<td>none</td>
<td>24LC512</td>
</tr>
<tr>
<td>Data Storage</td>
<td>32K bytes (32768)</td>
<td>16K bytes (16384)</td>
<td>64K bytes (65536)</td>
</tr>
<tr>
<td>Bytes per sample</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Sample time in seconds</td>
<td>1.08</td>
<td>1</td>
<td>.333</td>
</tr>
<tr>
<td>Total number of samples</td>
<td>8100</td>
<td>5280</td>
<td>13100</td>
</tr>
<tr>
<td>Total Mission time</td>
<td>2:25:48</td>
<td>1:28:00</td>
<td>1:12:42.3</td>
</tr>
</tbody>
</table>

The reason why Sparrow10 and Sparrow12 used different controllers is that the Basic Stamp 2pe has 16Kbytes of internal EEPROM storage which made for an easier construction and testing of the project, however these controllers were purchased specially for this project at retail cost from the vendor. The Basic Stamp 2p controllers were purchased at earlier times during special sales from the vendor and as such we had a reasonable number of controllers on hand to do this project. With the exception of the Basic Stamp 2pe controller, the Freescale MMA7455 accelerometers and the 64Kbyte EEPROM (24LC512) all of the major semiconductor components for these three projects were built using current inventory of parts.

Both Sparrow10 and Sparrow12 record acceleration in three axes using a range of +8g to -8g. Due to how the MMA7455 is mounted in the project, the X axis detects acceleration along the longitudinal axis of the rocket while the Y axis
detects acceleration in the rocket’s vertical axis and the Z axis detects acceleration in the rocket’s lateral axis.

**Results**

The results of the April 17, 2010 flight are listed in the table below:

<table>
<thead>
<tr>
<th>Project name</th>
<th>Samples taken</th>
<th>Elapsed time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparrow1</td>
<td>4810</td>
<td>86.58 minutes</td>
</tr>
<tr>
<td>Sparrow10</td>
<td>5180</td>
<td>86.3 minutes</td>
</tr>
<tr>
<td>Sparrow12</td>
<td>6264</td>
<td>34.76 minutes</td>
</tr>
</tbody>
</table>

Sparrow10 and Sparrow1 recorded the entire flight while Sparrow12 got restarted during the rocket flight. Below is a plot of Sparrow10’s X-Axis for the entire time it was on.

![sparrow10 - 4/17/10 - X Axis](image)

From this plot a timeline of the mission can be inferred.
Since Sparrow12 recorded only 34 minutes of data it probably got restarted at liftoff or during the ejection of the drogue chute.

The plot below is of the determined flight log of the Leo Hano rocket from the time the unit was powered up to a few minutes after landing.

<table>
<thead>
<tr>
<th>Starting event</th>
<th>Ending event</th>
<th>number of events</th>
<th>Event Duration in Min:Sec</th>
<th>Integrated Time in Min:Sec</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>205</td>
<td>206</td>
<td>3:26</td>
<td>3:26</td>
<td>Loading the rocket</td>
</tr>
<tr>
<td>206</td>
<td>209</td>
<td>4</td>
<td>0:04</td>
<td>3:30</td>
<td>Tilting the rail</td>
</tr>
<tr>
<td>210</td>
<td>3065</td>
<td>2856</td>
<td>47:36</td>
<td>51:06</td>
<td>On the pad</td>
</tr>
<tr>
<td>3066</td>
<td>3070</td>
<td>5</td>
<td>0:05</td>
<td>51:11</td>
<td>Boost phase</td>
</tr>
<tr>
<td>3071</td>
<td>3239</td>
<td>169</td>
<td>2:49</td>
<td>54:00</td>
<td>Burnout to touchdown</td>
</tr>
<tr>
<td>3240</td>
<td>4395</td>
<td>1156</td>
<td>19:16</td>
<td>73:16</td>
<td>On the ground</td>
</tr>
<tr>
<td>4396</td>
<td>5179</td>
<td>784</td>
<td>13:04</td>
<td>86:20</td>
<td>Recovery and turn off</td>
</tr>
</tbody>
</table>

Sparrow10 - 4/17/10 - Flight profile (180 second interval)
Sparrow1 recorded a range of temperature between 20.5 to 25 degrees Celsius with an average of 21.6 degrees Celsius. During the flight of the Leo Hano rocket Sparrow1 recorded a constant temperature of 21.5 degrees Celsius.

For Sparrow10 and Sparrow12 a summary of what they recorded is in the table below. All of the values in terms of g force:

<table>
<thead>
<tr>
<th></th>
<th>X-axis</th>
<th>Y-axis</th>
<th>Z-axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparrow10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min force</td>
<td>-2.44</td>
<td>-4.00</td>
<td>-1.63</td>
</tr>
<tr>
<td>Max force</td>
<td>5.50</td>
<td>3.31</td>
<td>6.56</td>
</tr>
<tr>
<td>Average force</td>
<td>0.46</td>
<td>-0.56</td>
<td>-0.04</td>
</tr>
<tr>
<td>Sparrow12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min force</td>
<td>-1.75</td>
<td>-3.31</td>
<td>-2.19</td>
</tr>
<tr>
<td>Max force</td>
<td>2.19</td>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>Average force</td>
<td>-0.21</td>
<td>-0.58</td>
<td>-0.24</td>
</tr>
</tbody>
</table>

Conclusion

Having independent projects in the payload worked to our advantage since one project reset itself during the flight. Unfortunately, the one that reset itself was the one that was supposed to sense acceleration at a faster rate. However, from this experience, it is hoped that we can build units with more data storage and dealing with accidental restarts of a project.

The Basic Stamp 2pe controller did prove itself a capable device for small-scale test projects like the Sparrow series. While it barely met the 1 hour mission time, it made programming and construction of the projects faster. As such, these controllers will be added to the list of devices to stock up on, and will be considered for projects that deal with measuring and storing data. The temperature sensor (the Dallas DS1620) used on Sparrow1, while doing a good job as an internal cabin temperature sensor, does suffer from a slow response
time. We found that you cannot acquire data any faster than one sample a second. While we shall continue to use this sensor as a training device, we do need to research other temperature sensors for future use.

The Freescale MMA7455 accelerometers proved to be good sensors to use for acceleration studies of model rockets. We will continue to use this device on future projects that require acceleration sensing.

**Lessons Learned**

Team Hawai’i has learned valuable lessons about the procedural methodology of the design and implementation processes of a NASA launch. Because of the damage that the rocket received during shipping we have determined that a better packing method will be needed for future projects. We are also considering using a removable fin kit to decrease the size of the box and to reduce the chance of damage being done to the fins while they are being shipped. We also need to use shear pins to secure our booster section, so that an early deployment of the main chute does not occur.

**Summary of Overall Experience**

We feel that the overall experience was very valuable to us. We had opportunities to meet other schools that competed in USLI, and to learn more about their projects and experiments. This interaction has helped us to think of new ideas for future projects. We were enthusiastically grateful for the tour of the Marshal Space Flight Center (MSFC) and the U.S. Space and Rocket Center (USSRC). During the entire trip we were able to meet many employees of NASA, which was inspiring and will assist us to further education in Science, Technology, Engineering and Mathematics (STEM).

**Educational Engagement Summary**

Student outreach is extremely important, not only for involvement in USLI, but in today’s growing technological world students need to be involved in
STEM research and programs focused on it. In a rapidly changing environment, the key to success is adaptability. We believe that STEM projects offer the student a level of flexibility in this high tech society of ours. Whatever careers students are contemplating, they can get no better grounding in fundamental, logical and critical thinking than is possible from participating in projects that are STEM based.

By hosting monthly rocket launches, and acting as resources for other launch activities, our team has reached over 120 students on the islands of Oahu and Kauai. As a team, we are very proud to have had the opportunity to work with these up and coming astronauts, engineers, and inventors of tomorrow. By perfecting our Leo Hano rocket, and providing a suitable lifting body for student designed payloads, it is hoped that we can generate much more interest in rockery. We look forward to enriching STEM education in our community, inspiring further discovery, and launching new ideas with more students in the future.