Full-Scale Low-Power (FSLP) Test files

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Team Summary
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  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 to be 121 inches in length, with a 6” diameter
• The rocket is designed to accept a K780R with 98-75mm motor adapter
• The rocket is designed to have a dual deployment recovery system incorporating a 42” drogue deployed at apogee, and a 144” main to be deployed at 1000’ altitude.
• 10/10 rail with a launch rail length of 14’
• No payload is to be flown
Leo Hano Rocket
Full-Scale Low-Power Overview

Overall Length: 121.13"
Body Diameter: 6.00"
Span Diameter: 18.00"
Unloaded Mass: 558 oz.
Loaded Mass: 665 oz.
Motor Type: K780R
Center of Pressure: 90.25"
Center of Gravity: 77.09"
Stability Margin: 2.19
Thrust to Weight: 5.2 (max)
Rail Length: 144" – 168"

Nose Cone
Contains the GPS Flight Unit

Payload Section
Contains the Student Experiment Project (Hula Hoop)

Avionics Section
Contains the Perfect Flight unit and Raven unit

Booster Section
Retains the K780R Motor via Aeropack 98-75 mm Adapter and Retainer

Fin /Fin-Can Assembly
Fins (4) are screwed to Aluminum fin-can using 6 8-32 BH screws per fin

VDC Assembly
Consists of two drag shoes. Opened to a pre-determined Angle. Not used for FSLP.
1 FLSP Over-view

Successful completion of the USLI project requires that a Full-Scale Low-Powered flight test (i.e. a Prototype test) be performed. Timing for the test is contingent upon Kaneohe Marine Corps Air Station (KMCAS). The main reason for this is because KMCAS is the only facility with a large enough infrastructure for us to perform a test of this magnitude. This means that the safety of our prelaunch, flight, and recovery are of the highest priority. To have a successful mission the team must ensure that all safety requirements are maintained throughout the mission. The team must also meet all the following criteria below.

Mission Criteria:

- Motor functions properly
- Avionics functions properly
- Successful recovery of the rocket and all its components
- Both parachutes deployed
- The rocket is completely intact
- The appropriate levels of safety are maintained throughout the entire process of preparation, launch, flight, and recovery of the rocket

To achieve any type of success in the mission, the rocket must have deployed a parachute and must be intact upon recovery, meaning it has the ability to be considered flight ready and meets all safety requirements without any repairs done it. If the team does not have a parachute deployment and the rocket is not intact upon recovery, the mission will be considered a failure. For FSLP, there is no partial success.

Proper motor selection requires several considerations, a suitable thrust to weight ratio, and a predicted maximum altitude that is above 1200 feet in order for the dual deployment test to work. Our limited recovery field directs that we cannot go to far over this height. Furthermore, the military cedes control of its air space over to the FAA on the days they open it up to civilian operations. As such, we must keep our flight to below 2500 feet. Motor selection was also dependant on motor availability. All things considered, the choice of motor was an Aerotech K780R. This gives us a maximum height of 1960 feet, which is within our flight constraints. Our only concern is that the thrust to weight ratio is only about 5.2 at maximum, and 4.2 on average, which is marginal.

The flight profile that our rocket will follow is the standard dual deployment routine, and has been simulated (under various launch conditions) on RockSim. The flight will begin with the boost phase. The K780R motor will produce an average thrust of ~175 lbs (giving us a maximum thrust to weight ratio of ~5.2), with a burn time of 2.94 seconds. The maximum estimated acceleration is ~ 10 g’s (344 ft/s/s) for about a 1/10 of a second, with an average of ~4.2 g’s with an estimated
maximum speed of 222 mile/hr (325 ft/s). At motor burnout, the rocket then enters its coast phase. We expect the rocket to reach apogee ~12.3 seconds after launch. At apogee, a 42-inch drogue chute will be deployed, yielding an initial descent speed of ~ 82 ft/s. At an altitude of 1000 ft, a 144-inch main chute will be deployed, slowing the rocket descent rate of 22 ft/s, which we believe to be a safe descent rate. The total flight duration is expected to be ~62 seconds.

2 RocSim Results

USLIROC2011 – Simulation results

Engine selection
[K780R-None]

Simulation control parameters
• Flight resolution: 800.000000 samples/second
• Descent resolution: 1.000000 samples/second
• Method: Explicit Euler
• End the simulation when the rocket reaches the ground.

Launch conditions
• Altitude: 0.00000 Ft.
• Relative humidity: 50.000 %
• Temperature: 80.000 Deg. F
• Pressure: 29.9139 In.

Wind speed model: Light (3-7 MPH)
• Low wind speed: 3.0000 MPH
• High wind speed: 7.9000 MPH

Wind turbulence: Fairly constant speed (0.01)
• Frequency: 0.01000 rad/second
• Wind starts at altitude: 0.00000 Ft.
• Launch guide angle: 0.000 Deg.
• Latitude: 22.000 Degrees

Launch guide data:
• Launch guide length: 144.00000 In.
• Velocity at launch guide departure: 53.5867 ft/s
• The launch guide was cleared at: 0.559 Seconds
• The user specified minimum velocity for stable flight: 43.9993 ft/s
• Minimum velocity for stable flight reached at: 100.4338 In.
Max data values:
  • Maximum acceleration: Vertical (y): 344.468 Ft./s/s Horizontal (x): 0.508 Ft./s/s
    Magnitude: 344.468 Ft./s/s
  • Maximum velocity: Vertical (y): 324.4643 ft/s, Horizontal (x): 6.2505 ft/s, Magnitude: 325.2313 ft/s
  • Maximum range from launch site: 208.87743 Ft.
  • Maximum altitude: 1960.39075 Ft.

Recovery system data
  • P: Drogue Deployed at: 12.295 Seconds
  • Velocity at deployment: 20.0897 ft/s
  • Altitude at deployment: 1960.39071 Ft.
  • Range at deployment: -208.87743 Ft.
  • P: Main Parachute Deployed at: 25.906 Seconds
  • Velocity at deployment: 81.3824 ft/s
  • Altitude at deployment: 999.92078 Ft.
  • Range at deployment: -126.63283 Ft.

Time data
  • Time to burnout: 3.064 Sec.
  • Time to apogee: 12.295 Sec.
  • Optimal ejection delay: 9.231 Sec.

Landing data
  • Successful landing
  • Time to landing: 61.296 Sec.
  • Range at landing: 63.80652 Ft.
  • Velocity at landing: Vertical: -28.1473 ft/s, Horizontal: 4.9767 ft/s, Magnitude: 28.5839 ft/s

Competition settings

Competition conditions are not in use for this simulation.
USLR0C2011
Length: 121.1250 In., Diameter: 6.0000 In., Span diameter: 18.1250 In.
Mass 663.5068 Oz., Selected stage mass 663.5068 Oz. (User specified)
CG: 17.6077 In., CP: 90.2507 In., Margin: 12.11 Overstable
Engines: [K780R-None, ]
Estimate of the CG, Stability Margin, and Thrust to Weight Ratio

<table>
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<tr>
<th>Component</th>
<th>Wt (oz)</th>
<th>Est. CG (in)</th>
<th>(Wt.)r</th>
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<tr>
<td>Nose Cone</td>
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<td>GPS Flight</td>
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<td>98-75 mm Adapter</td>
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</table>

\[ \sum (Wt.) = 665 \text{ oz.} \quad \sum (Wt.)r = 51,267 \text{ oz-in} \]

Therefore: \[ CG = \frac{\sum (Wt.)r}{\sum (Wt.)} = \frac{51268}{665} = 77.09 \text{ inches from the nose cone tip.} \]

Since the Center of Pressure has been calculated to be 90.25 inches, our stability margin is...

\[ \text{Margin} = \frac{|90.25 - 77.09|}{6.00} = \frac{13.13}{6.00} = 2.19 \]

This indicates that our rocket will be slightly over-stable, with an average thrust to weight ratio of 4.2, and a maximum of 5.2.
4 Motor Specifics

AeroTech K780
(Data from ThrustCurve.org)

Manufacturer: AeroTech
Entered: May 25, 2006
Last Updated: May 4, 2009
Mfr. Designation: K780R
Brand Name: K780R
Common Name: K780
Motor Type: Reload
Diameter: 75.0 mm
Length: 39.5 mm
Total weight: 2934 g
Prop. Weight: 1268 g
Cert. Org.: Tripoli Rocketry Association, Inc.
Cert. designation: K794 (85%)
Cert. date:
Average Thrust: 780.0 N
Maximum Thrust: 965.0 N
Total Impulse: 2371.0 Ns
Burn Time: 3.0 s
Case Info: 75/2560
Propellant Info: Redline
As can be seen, the predicted acceleration is fairly typical; there is a rapid increase in the rocket velocity for the first second. Thereafter, the acceleration begins to decrease until near burnout. After that, drag forces dominate, reducing the rocket speed rapidly. Gravity finally reduces the rocket’s vertical velocity to zero at apogee.
5 b  Plot of Velocity versus time for FSLP

As can be seen, the expected rocket velocity is also fairly typical. The rocket is expected to reach a maximum speed of mach 0.28 (nowhere near sonic) shortly before motor burnout. This is expected because the motor thrust curve shows the burn to be regressive at that time.
The predicted plot of the altitude versus time for the FSLP lies well within our operational constraints, with burnout corresponding to a point of inflection of the curve.
7 Launch Pad

As it stands right now, the cost to send the necessary launch equipment to the USLI launch site is prohibitive to say the least. The plan for the USLI launch is that WCC USLI team will be using the UA Huntsville launch pad equipment (they have agreed to let us use it). Nevertheless, in order to perform a FSLP test, WCC needs to fabricate a launch pad and its associated electronics. For this endeavor, the AeroPAC group has been a great help. One of their members has donated a single channel launch controller, which has been based off of their multiple launch controller (schematics follow).

The RocSim simulation for our rocket, using the K780R, showed that the bottom of the rocket reached a safe velocity at 100.4” (~8 feet 4 inches). This suggests a launch rail length of 10 feet (assuming a rail button separation of 18 inches). However, due to a marginal thrust to weight ratio, we believe that a longer launch rail should be used. Rail lengths of 12 to 14 feet are being discussed. The rail is to be made of medium extruded metal uni-strut capable of accepting standard 10-10 rail buttons. Currently, construction of a launch pad, based on the AeroPAC launch pad design (plans follow), is underway. Upon completion, and before use, every effort will be made to ensure that the center of gravity for the loaded launch pad falls within the area defined by the base of support.
Rocket Launcher Base

John Coker
(650) 685-1890

Folding Legs (2)

Center Leg (1)

Mast (1)

Mast Brackets (2)

Notes
1. Sections are 3" square aluminum tubing.
2. Leg plates are ¼" aluminum plate.
3. Holes are all ½" diameter and centered on circle of radiused ends.
4. Leg plates are welded to tubing where shown to overlap.
5. Radiused ends are 1.5" radius (3" diameter circles to match 3" tubing).
6. 4-hole pattern is ¼" holes on a 2" square (leg and mast brackets).
7. Folding legs pivot on bolts through plates on center leg.
8. Rest for mast (when lowered) is also 3" square aluminum tubing.
9. Mast brackets are ¼" stainless steel plate.
10. Slot in mast bracket is 0.55" wide by 1.5" long on a 12" circle.