# Pleiades 1 Launch Manual


By:
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Monica Choiniere, Thomas Rapp, Gary Fussell

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# 1.0 Pleiades 1 Launch Day Logistics

## 1.1 Important Address

Hotel:

Courtyard by Marriott Victorville Hesperia
9619 Mariposa Road
Hesperia CA 92345

ROC Launch Site:

Granite Rd, Lucerne Valley, CA 92356

## 1.2 Time Line

Friday, June 12th:

- Hotel Check In
- Arrival Times:
  Sarah and Gary - Arrive around 8 PM
  Thomas - Arrive around 11 PM?
  Marvin - Arrive around 10 PM
- Focus On:
  - Rest
  - Basic checks
  - Sign waivers

Saturday Morning, June 13th:

- Wake Up
  - 5:00 AM - 5:30 AM
- Checks and Packing
  - 5:30 AM - 6:00 AM
- Leave
  - 6:00 AM
- Arrive at Launch Site
  - 6:50 AM
- Check In
  - 7:00 AM
    - Waiver
    - Colored card
- Unpack and Organize
  - 7:15 AM - 7:30 AM
- Set Up
  - 7:30 AM - 8:30 AM
    - Inspection
    - CP + CG possible quiz

        - Motor install
        - Pad setup
- Launch
    - 8:30 AM - 2:00 PM

## 1.3 Rocketry Rules and Safety Regulations

**Source:** Rocketry Organization of California (ROC) https://rocstock.org/flying-with-roc-2/

Remember that rocketry is an inherently dangerous activity – objects often fall from the sky, sometimes at a very high speed. Rocketry Organization of California (ROC) imparts rules and procedures to make this activity safe for everyone as possible, but bad things can happen if the rules are not followed. Please ensure that you understand the ROC spectator safety rules in tandem with the safety regulations below. Everyone flying must understand and follow these rules to ensure safety:

- Check in at Registration as soon as you arrive and sign the ROC Agreement and Liability Release Form to indicate understanding and acceptance of the risk and liability. Flyers will be given a wristband to indicate that they have registered.
- In order to fly high power, present your current NAR or TRA membership card indicating your certification level. You will be provided with a red wristband indicating your ability to access the mid and back row high power pads.
- Please fill out the correct flight card for your flight before arriving at the RSO table. We have three card styles: a red card for complex and certification flights, a white card for night flights, a green card for low power (F and below) flights, and a yellow card for all other flights.
    - Flight cards can be found in a black wooden container near the LCO table.
- All motors of impulse class “F” and above must have their ignitors installed at the pad. If you arrive at the RSO with an igniter installed you will be asked to immediately leave the line to correct the problem, and you will have to wait in line again. Note there are only two exceptions to this rule:
    - The ignitor must be built-in to the motor during construction; in this case, all ignitor leads must remain shorted together until the rocket is on the pad.
    - The rocket is a cluster rocket; in this case, ignitors may be loaded in a designated area within the range, as directed by the RSO.
- All rockets must be inspected and approved by the Range Safety Officer (RSO) or a Flight Safety Reviewer (FSR) prior to each flight. Please be prepared to show that your rocket is powered by a motor approved by the Office of the California State Fire Marshall, that it will have a stable flight, and that it will recover safely.
- Roving Flight Safety Reviewers (FSR), the folks in brightly colored vests, can inspect and approve your rocket to help shorten the RSO line at the range head. An available FSR will usually come to your rocket, rather than you having to bring your rocket to the RSO for large projects. If you need a rocket inspection before transporting your rocket, contact Registration.

- Rockets with total impulse of class “M” must have documentation for the RSO showing that the rocket will be stable.
- All electronic recovery devices must be safed, shunted, or powered off when the rocket is brought to the RSO.
- Radio Control (RC) systems used on the range connected to any pyrotechnic devices (ignitors or backup charges) must be commercially available systems that are specifically designed for remote ignition of pyrotechnic devices (such as, but not limited to, the Missile Works WRC or Digifire systems). No car/aircraft/boat systems can be used for ignition or backup charges.
- The Pad Manager will assign your pad after the rocket is inspected. If you have any difficulty with your pad, please ask the PM for assistance.
- Do not enter the range to load or recover a rocket until the Launch Control Officer (LCO) announces “the range is open“.
- No one is allowed on the range unless the LCO has announced that the range is open for loading or recovery. Anyone entering the range will require all launching to stop.
- At some multi-day launches we conduct night launches. All night launch rockets must have a light that is visible throughout the flight – meaning from before liftoff all the way to touchdown. A light only deployed at apogee is not acceptable. Additional lights, LEDs, electroluminescent strips, etc. are recommended.
- The use of drones, R/C aircraft, UAVs, RC Gliders and any similar non rocket powered flying device anywhere at the event at any time is expressly prohibited. This exclusion does not apply to rocket powered RC gliders that are flown from the range in accordance with the NAR Rocket Powered Glider Safety Code.
- ROC is a volunteer organization, so we appreciate help with setting up and taking down the launch equipment.
- ROC supplies launch pads and a centrally-controlled launch system. We have launch rods for 1/8″, 3/16″, and 1/4″ launch lugs, and launch rails for 1010 (1/4″) and 1515 (5/16″) guides. Rails are highly encouraged for rockets G powered and above, with a limited amount of rods available at the mid and away pad banks.
- We fly under the safety codes of the Tripoli Rocketry Association (TRA) and the National Association of Rocketry (NAR). Hobby rocketry is also regulated in California by the Office of the State Fire Marshal (OSFM).
    - All high power flights must be conducted by users certified by TRA or NAR. For information on certification, visit the TRA or NAR websites.
    - All motors must be listed by the OSFM as “model rocket motor” or “high power rocket motor. Evidence of this is an OSFM stamp on the motor, packaging, or accompanying paperwork.
    - High Power Rocket Motors must be used by, or under the guidance of an OSFM Pyrotechnic Operator. For more information, consult the OSFM website.
    - California regulations limit the maximum single motor size to M (10,240 Ns).
    - The size of our launch site limits the maximum complex total impulse to M (10,240 Ns).
    - If you plan on flying a cluster with an impulse over 5120 Ns, please contact us ahead of time so we can have a pad at the appropriate distance.

- It is the flier's responsibility to read and understand the safety codes applicable for their flight, and fly within those codes.

## 1.4 Day Launches

**Source:** Rocketry Organization of California (ROC) https://rocstock.org/first-timers/

Our monthly Day Launch events occur on the second Saturday of every month and typically run from between 7 and 8 AM to between 11 AM and 2 PM. Times may vary depending on weather conditions and event participation. Adverse conditions, including but not limited to heat, rain, wind, and other airspace activities, may cause launches to be abbreviated or cancelled. Note: Conditions are nearly always better early in the day, so everyone is encouraged to arrive early.

## 1.5 Cancellation Policy

ROC has established the following weather guidelines for cancelling a launch. If the temperature at the lakebed is expected to be close to 100 degrees by 11 AM, if there is more than a 50% chance of rain with 1/4″ or more in the forecast at the lakebed, or if it has rained recently and the lakebed is soggy, we will most likely cancel a launch. However, since weather forecasts and conditions can change daily, a decision will usually not be made until 3-4 days before a launch.

If we do have to cancel for any reason, an official message will be posted on our main webpage, our Facebook page, and on our e-mail list ROC-chat. IF NO MESSAGE IS POSTED, THEN A LAUNCH IS HAPPENING AS SCHEDULED. If a launch is cancelled, or if you simply want to launch on your own, anyone is welcome to go out on their own at any time. Just be aware that there will be no facilities and you must use motors G impulse and below.

## 1.6 Parking

The center north/south aisle due north of the portable toilets is an emergency access corridor, as is the area 100′ due south of the coned or roped-off flight line. If you park in either area, you will be asked to move your vehicle.

Depending on attendance, a couple of rows of cars usually form in the east/west direction. Once you find a space, please remember that spectators and participants may need more room than in a typical parking lot. We suggest parking about 10 feet away from neighboring vehicles when possible.

## 1.7 Spectator Rules and Safety Regulations

Keep your head up! Rocketry is an inherently dangerous activity. Objects often fall from the sky, sometimes at very high speed. We have rules and procedures to make this activity as safe as possible for everyone, but bad things can happen if the rules are not followed.

- Check in at Registration as soon as you arrive and sign the ROC Agreement and Liability Release Form to indicate understanding and acceptance of the risk and liability. Copies are available onsite.
- Pay attention. Every flight is potentially dangerous to you and your family. If the Launch Control Officer (LCO) yells “Heads up!” they mean it. If you see the incoming rocket, point at it so others can find it as well.
- Please stay behind the coned or roped flight line barrier, and please do not set up your chairs or other items at the barrier.
- The safety zone extends 100′ south of the flight line. No sitting in chairs or on the ground, and no operating wheeled vehicles such as cars, ATVs, bicycles, or tricycles in this area.
- If the LCO announces a flight as a “Heads Up” flight, that means get on your feet and pay attention until the rocket’s recovery device deploys or the rocket is on or in the ground.
- If you are away from the pad area and cannot hear the public address speakers, please tune your FM radio to 90.1 MHz to monitor LCO announcements.
- Do not attempt to catch any rocket as it lands. Even a small rocket can cause injury.
- Do not pick up or move any rocket that is not yours, unless you have the owner’s permission.
- Park your car behind the line marked on the lakebed, and please do not park in any areas designated for vendors or launch administration. If there are no lines marked, as may be the case at some smaller monthly events, ensure you are 100′ south of the flight line and not in the center aisle between the LCO table and the portable toilets.
- RVs and motor homes must park in the second row or farther south.
- Please drive 3 mph as you approach the launch area and within the launch area. A vehicle moving faster can raise a surprising amount of very annoying dust.
- Please use only the provided toilet facilities. Please do not throw trash into the toilets. Human waste, toilet paper, and sanitary products only.
- Please keep control of your trash and carry it off the lakebed when you leave.
- Please keep your children, friends, and family under control and make sure they understand these rules.
- You may pick up or move another flyer’s rocket only under the following conditions:
    - You have the owner’s permission to do so.
    - If you are a long distance away, the rocket is undamaged, and no one appears to be looking for it, you may carefully bring it back to the Registration table.
    - If the rocket is damaged, please note the location and report it to the Registration table.

    - If the rocket is being dragged by the wind, please carefully stop it, place the parachute under its body tube or nose cone, note the location, and report it to the Registration table.
- If you find a reloadable motor casing that has been ejected from a rocket, wait until it has cooled off and bring it back to the Registration table.
- The use of drones, R/C aircraft, UAVs, RC gliders, and any similar non-rocket-powered flying device anywhere at the event at any time is expressly prohibited. This exclusion does not apply to rocket-powered RC gliders flown from the range in accordance with the NAR Rocket Powered Glider Safety Code.

# 2.0 Teams Basic Info

| | **Who** | **What/General Info** |
|---|---|---|
| **Launch Operations** | Tom Perkins | Formulates and executes processes and procedures to ensure successful launch of all vehicles. |
| **Safety** | Sarah Wattenberg | Ensures safety on launch day. |
| **Recovery** | Gary Fussell<br>Thomas Rapp | How to pack parachutes.<br>What parts are involved in recovery.<br>Understanding how the recovery system works in regards to Zephyr rocket kit with H219-14A motor.<br>How to pass Level 1 in regards to recovery. |
| **Propulsion** | Thomas Rapp<br>Monica Choiniere<br>Gary Fussell | Analyze rocket performance<br>Motor selection<br>Simulating motor/rocket<br>How to install motors |
| **Payload** | Thomas Rapp | Electronics and instrumentation<br>Payload housing<br>Lifecycle management<br>Requirements (including certification(s)) |

# 3.0 Safety

## 3.1 Safety Checklist

Launch Site (likely covered by onsite safety officers)

- Launcher is stable and provides rigid guidance until rocket reaches flight speed
- Launcher is pointed within 20 degrees of vertical

- Launcher length is sufficient with increased wind speeds (<5 mph)
- Blast deflector in place to prevent motor exhaust from contacting ground
- Dry grass is cleared from launch pad area as required by minimum distance (additional safety factor of 1.5 for motors using titanium sponge in propellant)
- Launch site is outdoors and in an open area where trees, power lines, occupied buildings, and persons do not present a hazard
- The smallest dimension of the launch site is at least half of the expected maximum rocket altitude or 1500 feet (whichever is greater). For rockets with a total impulse of less than 160 N-sec, total liftoff weight less than 1500 grams and maximum expected altitude of 610 meters, the smallest dimension of launch site is 1000 feet.
- Launcher is 1500 feet from any occupied building or public highway
- Launcher is at least the minimum personnel distance from launch site boundaries

## 3.2 Launch Ops

- 5-second countdown before launch
- Communication pathway is open to warn participants and spectators in the event of a problem
- Ensure no person is closer to the launch pad than required minimum distance
- Ensure no person is at the pad except safety personnel & those required for arming/disarming operations
- Confirm rocket stability
- Confirm launch path does not contain targets, clouds, airplanes
- Confirm launch path is not above any person and does not exceed launch site boundaries or altitude limit
- Ensure wind speeds are below 20 mph
- Rocket will not be recovered from dangerous places (i.e., power lines, tall trees)
- Ensure rocket will not recover in spectator areas or outside launch site
- Rocket will not be caught as it approaches the ground

## 3.3 Rocket Design

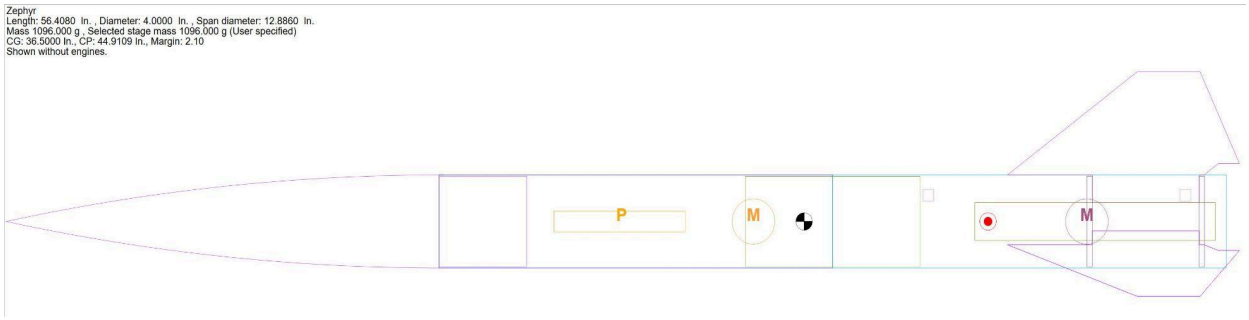
- Rocket motor does not contain total impulse greater than 40,960 N-sec (9208 lb-sec)
- Rocket weighs less than ⅓ of the certified average thrust of the selected motor
- Rocket does not contain flammable or explosive payload
- Rocket contains flame-resistance or fireproof recovery system

# 4.0 Things To Know

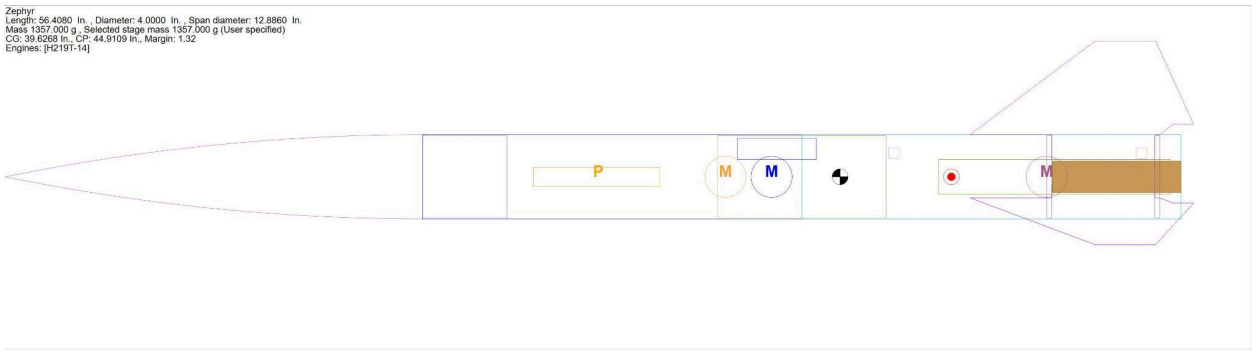
## 4.1 Application info

- Is the model stable? If stability is in doubt, require proof of the CG and CP locations (remember CG should be forward of the CP by approximately 1.0 body tube diameters).
- Ask the modeler to show the CG and CP locations and how they were determined.
- Verify that the modeler shows the CG with the motor(s) intended for flight and not a smaller motor or fewer motors (clusters).
- Ask the modeler to show CG and CP for the complete model and less each stage for a staged model.
- Require evidence of CP calculations if further doubt exists.

Without Motor:




With H219 Motor:




## 4.2 Center of Gravity (CG) and Center of Pressure (CP)

If you have ever dropped something, it may spin and tumble around before crashing into the ground. And if you look closely enough, the object tends to spin around a spot in its body. It's more noticeable if the dropped item has an unequal weight distribution and it is thin and long - such as a baseball bat or an axe.

Those examples will tend to spin around its *center of gravity*, the point in the object considered to be the median or average of all its weight added up and divided in two across all dimensions (length, width, height; or x, y, z).

If you were to mathematically solve the magnitude of gravitational pull at which each little piece of the object and its small portion of mass experiences, you'd find that the math can be simplified down to going to that singular point of the average mass and calculating the total mass of the object and multiplying by the gravitational acceleration of the Earth's pull (~9.81 m/s^2 at sea level). This is what we would consider the "weight" of an object, and it is simply considered to be acted on the object's center of gravity.

Note that center of mass and center of gravity are interchangeable. It differs only in that the center of gravity calculated includes the constant gravitational acceleration across the object's body. Since it is constant, the only difference is in numerical value, not position.

Similar enough to the shape of a baseball bat is a rocket; however, there are more forces acting on a flying object: air resistance. Unlike the (typical) unmoving, still air at the ground, the air high in the atmosphere is moving around quickly, which can push a rocket all around its body. The difference though is that the force of air cannot be simplified down to applying on a singular point of a body. That force is applied across the entire surface area, and we call that type of force "pressure".

We can feel that difference when we stick our arm out the car window - the air is hitting every single part of us somewhat evenly.

"Somewhat" because you can change whether those air particles slam into your hand or glide around it. If you have your palm facing the front towards the air - or towards the front of your car - then the air resistance is strong and can push your hand back if you're not stabilizing your arm enough. But if you face your palm down to the ground, suddenly you don't have to work as hard to keep your arm straight. The slimmer profile of your hand means air isn't slamming into a "wall" and abruptly stopping. Instead, the particles can tumble over or under your thumb and index finger and across your hand, and it keeps on moving.

Newton's third law says for every action is an equal and opposite reaction. So the particles hitting your not-very-aerodynamic palm literally pushes off you, forcing your hand back. With your palm down, it no longer pushes off you as much as the surface area that it could slam into is a much smaller profile.

It was previously stated that the air resistance is a pressure which is not a singular point of force acting on an object but instead along the entire body. One would then assume you could not have a "center of pressure" akin to a "center of gravity". But let us assume that the pressure is applying equal magnitude across the entire length of a rocket. We can assume there will be a singular point of an 'average', and realize the only change in pressure will be due to the profile

of the rocket. The surface area that the air is hitting - similar to our hand out of the window - will affect how many air particles are hitting each area of the rocket body.

Therefore, the *center of pressure* can be simplified to the average of the surface area of the rocket profile. Because of a pointy aerodynamic nose cone in the aft and the inclusion of multiple fins in the rear, one can assume that the average of the surface area is towards the rear of the rocket.

These concepts are important because forces that do not act on the center of gravity induce a spin - or, in physics, a “moment” - around said center of gravity. Because the collective force of pressure is acting on the center of pressure, which is not typically at the center of gravity, pressure will attempt to spin a rocket around. A terrifying concept, only if you do not appropriately place your centers.

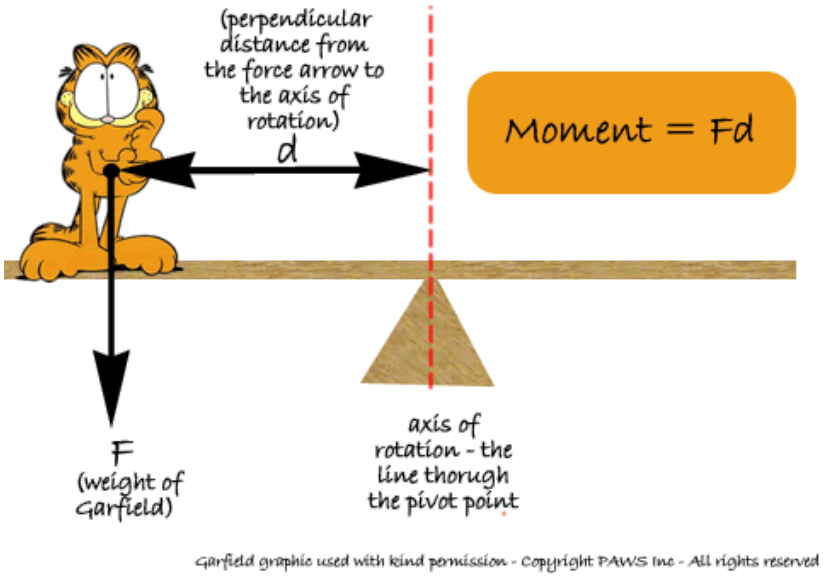



**Figure 4.1 Moments**

*The fulcrum, or pivot point, of the seesaw can represent the center of gravity. The seesaw will rotate/spin around the pivot point, or fulcrum, due to the Garfield applying a force on the bar somewhere other than through the center of gravity. (Source: cyberphysics.co.uk)*

Imagine a rocket that is flying upward through the atmosphere. Regardless of the location of the center of pressure, a wind gust hitting the side of the rocket will tilt the nose downward to the side, rotating around the center of gravity.

Now, put the center of pressure above the center of gravity, towards the nose cone. Besides the sidewards gusts, there are also air particles hitting down on the rocket on the nose cone from drag and gliding across the body towards the fins. The pressure force of the drag will continue to push down and spin the nose cone towards the ground, causing instability. This is not conducive to a good rocket launch.

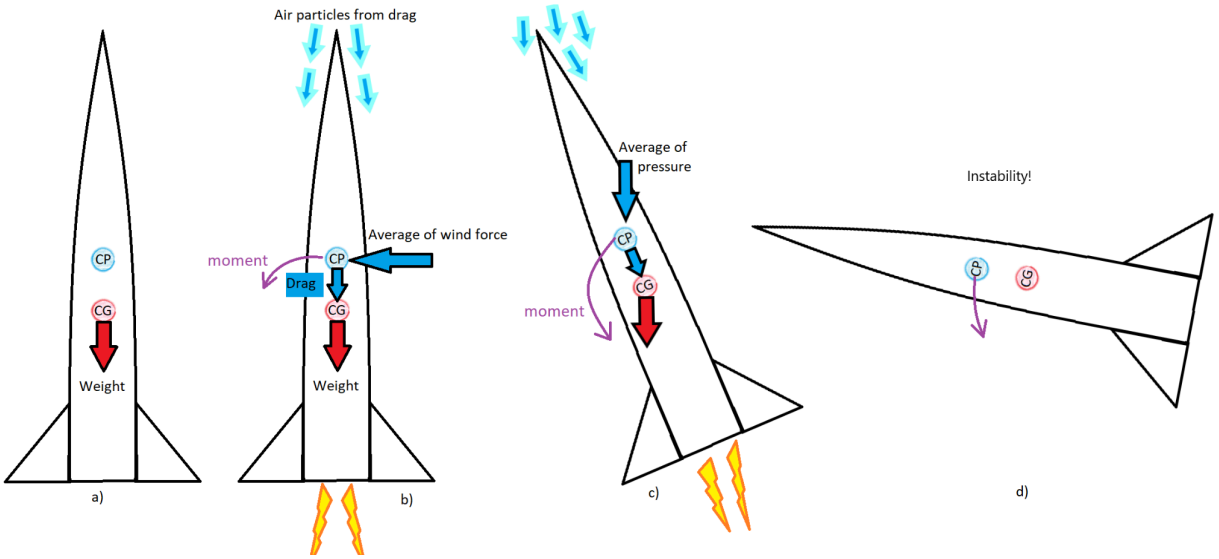



**Figure 4.2 Instability in Rockets**

*The various ways air can apply force on a rocket can induce a spin. If the center of pressure is above the center of gravity, then the rocket is more likely to continue spinning the nose cone downwards. The moment, represented by the purple arrow, is a product of the force from "average of wind force/pressure", not an additional applied force.*

However, if the center of pressure is below the center of gravity, towards the fin, then the average of pressure forces can correct the rocket back to pointing straight up, acting as a stabilizing force.

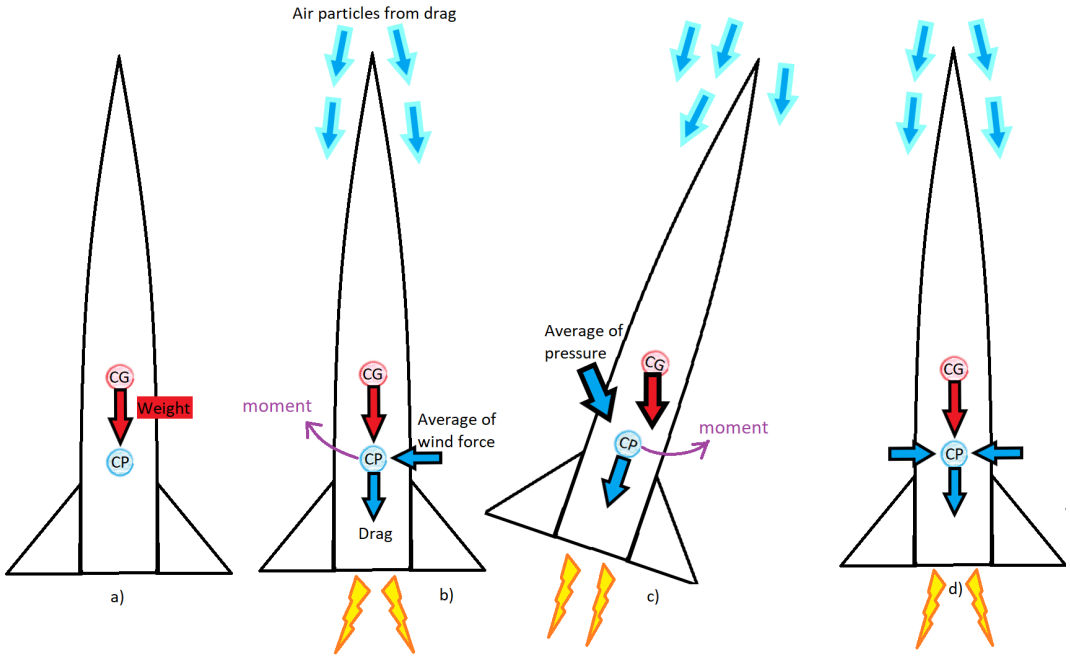



**Figure 4.3 Stability in Rockets**

*If the center of pressure is below the center of gravity, then the spin is self-righting.*

# 5.0 Checklist

## 5.1 Pre-flight

Source: Aerotech
https://www.apogeerockets.com/downloads/PDFs/29-54mm-DMS-Instructions.pdf

**1. Setting the Time Delay**

**Notes:** If you want to use the longest (as-supplied) time delay, do not use the delay drilling tool and instead proceed to step 2.1. **Plugged** motors such as the **H45W** and **I65W** do not have an adjustable time delay and ejection and must use alternative means of recovery system deployment, skip to step 3.1.

1.1 **WARNING**: Do not smoke and ensure that there are no open flames or heat sources nearby when setting the time delay. Assemble the AeroTech Universal delay drilling tool with the desired amount of delay time removal (i.e., the - 4 or - 8 seconds removal marked on the tool label) facing the exposed drill bit and motor bulkhead.

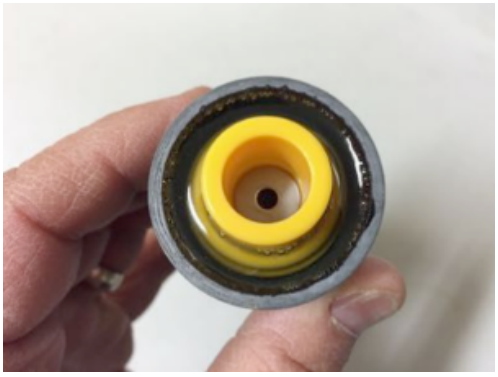

1.2 **Optional:** Place the washer between the drill knob and the tool if you want to remove 2 seconds less than the value printed on the tool (i.e., - 2 or - 6 seconds removal). **CAUTION: Do not** shorten the time delay to a value of less than 6 seconds.

1.3 Place the open end of the tool over the motor bulkhead, hold the tool and motor firmly against each other and turn the drill knob several times clockwise until the drill knob sits flush against the drill tool body.

1.4 Remove the tool and shake out the shavings from the tool and motor bulkhead. Dispose of the shavings by burning with a safe method and in a safe location.

**2. Installing the Ejection Charge and Ejection Cap**

2.1 Open the supplied igniter and ejection charge kit and remove the contents.



2.2 Place the ejection charge baffle washer into the ejection charge well of the motor bulkhead.

2.3 **WARNING:** Do not smoke and ensure that there are no open flames or heat sources nearby when installing the ejection charge. Open the ejection charge vial and dispense the desired amount of black powder ejection charge into the ejection charge well of the motor bulkhead.

Use about 1⁄2 of the contents of the vial for 2.6” diameter rockets and smaller, and the entire vial for 3” and larger rockets. Note:additional ejection charge may be required for rockets exceeding 4” in diameter.

2.4 Insert the rounded end of the ejection charge cap into the ejection charge well of the bulkhead and press in completely with the end of the igniter tube or similar object.

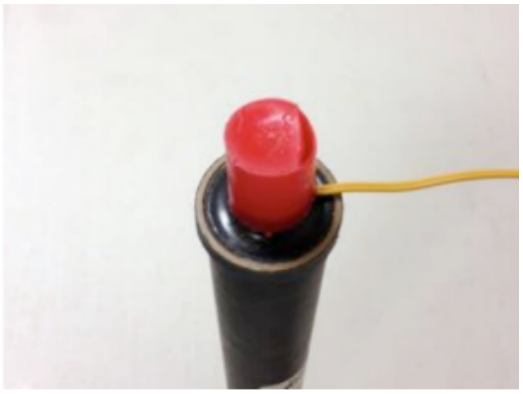
**3. Igniter Installation and Preparation for Flight**

**CAUTION**: Install the igniter in the motor only when the rocket is at the pad and ready for launch.

3.1 Remove the supplied FirstFireTM igniter from the cardboard tube and straighten the leads.

3.2. Strip 1⁄2”-1” of insulation from the ends of the leads.

3.3 Insert the black-coated end of the igniter into the nozzle opening and push it completely into the motor core, until the coated end is touching the time delay element in the motor bulkhead. **IMPORTANT:** On the **H45W** and **I65W** motors that have an offset “moonburning” core, insert the coated end of the igniter through the nozzle and over toward one side of the casing, and rotate the motor until you find the propellant core space. Then continue pushing the igniter into the core space as far as it will go.



3.4 Using a hobby knife or scissors, cut a corner off the end of the nozzle cap (if supplied) to produce a vent hole in the cap about 1/16”-1/8” Wide.

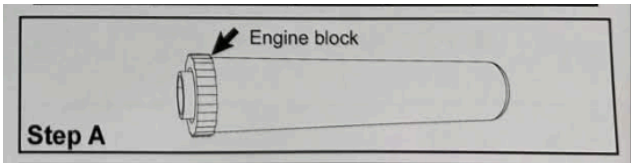
3.5 Press the open end of the nozzle cap over the exposed nozzle extension to hold the igniter firmly in place. Note: If there is no nozzle cap supplied with the motor, use a piece of masking tape to secure the igniter to the motor.

3.6 Install the motor into the rocket's motor mount tube. Ensure that the motor is securely retained in the rocket by using positive mechanical means to prevent it from being ejected during recovery system deployment.

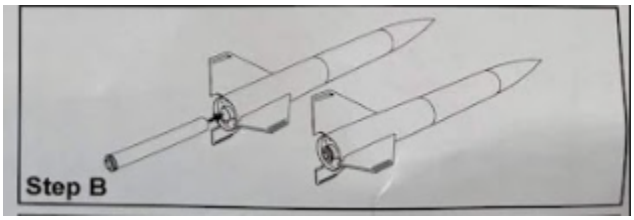
3.7 Prepare the rocket's recovery system and then launch the rocket in accordance with the National Association of Rocketry (NAR) and/or Tripoli Rocketry Association (TRA) safety codes. Note: After use, the rocket motor casing may be disposed of in inert trash.

**4. Motor Installation**

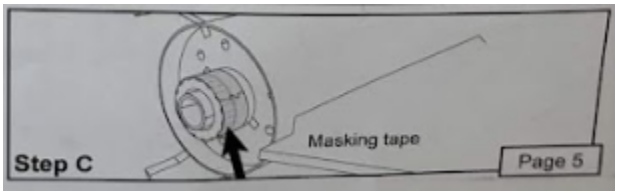
4.1 The high power rocket motors have the engine block built into the back of the engine. You do not need an engine block inside the rocket tube.




4.2 Slide the rocket engine into the rear of the engine mount until it butts against the back edge of the motor tube. If the engine is long, it may project forward out the front of the motor tube, inside the parachute location. Just ensure the parachute is protected from the ejection charge in the rocket motor of the cloth chute protector. You can always add recovery wadding (ie. cellulose house insolation) to the tube for extra parachute protection.

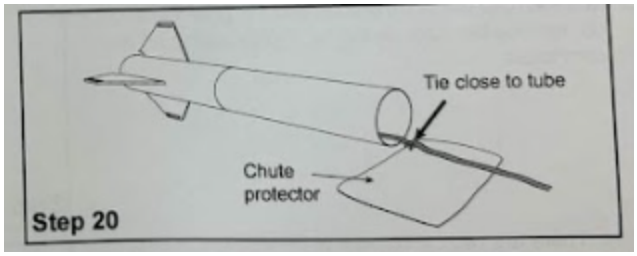



4.3 The engine can be retained by wrapping masking tape around the perimeter of the joint where the motor butts against the engine tube. This is fine for holding the motor in the rocket, even for high power motors. An acceptable alternative is a motor retainer.

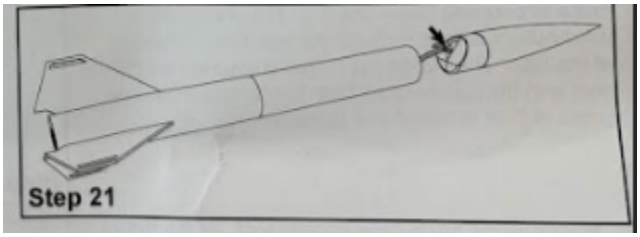



**5. Parachute Preparation and Installation**

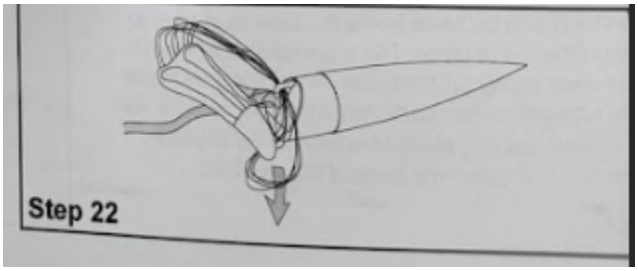
5.1 Pull the nylon shock cord out the front of the tube. Tie the chute protector to it. The cloth should be positioned so that it is just forward of the front end of the body tube when the cord is stretched out. If you wrap it through the hole twice, it shouldn’t slide along the shock cord if tied on.




5.2 Tie the free end of the nylon shock cord to the loop on the base of the node cone.




5.3 Holding the parachute at the center of its top, pull the lines together to even up the ends. Thread the four looped lines through the loop base of the nose cone. Take the top of the parachute and pull it through all three string loops at the same time, and then pull to tighten the knot. This securely attaches the parachute to the rocket.




## 5.2 Post-flight

**Recovery Team:** Recovery team tasked with finding rocket landing site, and assessing condition. Recover Team checklist:

1. Damage checks for:
    a. Parachute
    b. Shock cord
    c. Parachute protector
    d. Nose Cone
    e. Tube body
    f. Fins
    g. Payload housing, if applicable
2. Record damage, work orders
3. Remove and assess rocket motor

**Safety Team:**

1. Dispose of rocket motor

**Payload Team:**

1. Check for damage:
    a. Instrumentation and payload housing
2. Record damage
    a. Assess cost(s), impact to mission timeline
3. Remove/transfer instrumentation as needed
    a. Transfer altimeter(s) to workstation(s)
    b. Transfer camera(s) to workstation(s)
4. Post-flight analysis: take and validate measurements

# 6.0 Risks

| **Risk** | | **Severity** | | | | |
|---|---|---|---|---|---|---|
| **Probability** | | **Catastrophic** | **Hazardous** | **Major** | **Minor** | **Negligible** |
| | | A | B | C | D | E |
| **Frequent** | 5 | 5A | 5B | 5C | 5D | 5E |
| **Occasional** | 4 | 4A | 4B | 4C | 4D | 4E |
| **Remote** | 3 | 3A | 3B | 3C | 3D | 3E |
| **Improbable** | 2 | 2A | 2B | 2C | 2D | 2E |
| **Extremely Improbable** | 1 | 1A | 1B | 1C | 1D | 1E |

Catastrophic – Complete mission loss
Hazardous – Causes the failure of some mission objectives
Major – Impedes mission but does not make it impossible
Minor – Causes small changes in operation
Negligible – Will not change day to day operation
Frequent – Likely to occur often during the mission
Occasional – Expected to occur during the mission
Remote – Likely to occur during the mission
Improbable – Unlikely but possible to occur during the mission
Extremely Improbable – Unlikely to happen over the course of the mission

| **Team** | **Failure Mode** | **Cause** | **Mitigation** | **Risk** |
|---|---|---|---|---|
| Propulsion | Motor fails to ignite | Motor defect | No mitigation. | 2A |

| | | | | |
|---|---|---|---|---|
| | due to motor defect | | | |
| Propulsion | Motor fails to ignite due to igniter defect | Improper igniter installation, ignition system defect | Ensure proper igniter installation, backup igniter. | 1A |
| Propulsion | Motor explodes | Motor defect | No mitigation. | 1A |
| Propulsion | Ignition delay | Improper igniter installation, ignition system defect | Ensure proper igniter installation, backup igniter. | 1A |
| Propulsion | Successful launch with improper burn | Motor defect | No mitigation. | 1B |
| Propulsion | Unsuccessful launch with improper burn | Motor defect | No mitigation. | 1A |
| Propulsion | Fire | Uncontained motor casing causes the rocket body to ignite. | No mitigation. | 1A |
| Propulsion | Motor fall out of rocket before ignition | Improper installation. | Ensure proper installation of masking tape. | 2C |
| Propulsion | Casing failure | Defects in casings allow for excess heat to escape. | Inspect motor for damage prior to flight. | 1B |
| Recovery | Parachute does not deploy | Tangle | Repack parachute and ensure no knots or loops. | 2A |
| Recovery | Parachute rips away from rocket body | Inadequate tie to eye-bolt, shock cord rip, center ring failure. | Ensure proper tie of knot during construction. Ensure no damage to the center ring. | 2A |
| Recovery | Parachute rips away from the nose cone | Damage to shock cord, improper tie down | Ensure proper knot around nose cone tie hold. | 2D |
| Recovery | Late deployment | Internal damage or improper black powder charge detonation. | No mitigation. | 1D |
| Recovery | Black powder fails to detonate | Improper connection to motor, poor | Check charge installment prior to | 1A |

| | | | | |
|---|---|---|---|---|
| | | production of motor. | launch/no mitigation. | |
| Recovery | Internal fire | Poor production of motor. | No mitigation. | 1B |
| Recovery | Hard landing. | Rocket heavier than expected or higher winds than expected. | No mitigation. | 2D |
| Recovery | Parachute becomes tangled | Parachute improperly packed. | Repack parachute before launch and have a 2nd member review packing. | 3B |
| Recovery | Shock cord becomes tangled | Shock cord improperly packed. | Repack parachute before launch and have a 2nd member review packing. | 3B |
| Payload | Payload detached | Improper mounting, mounting failure, excessive forces | Dual validate mounting | 2D |
| Payload | Altimeter unpowered | Inadequate charge | Validate charge | 2E |
| Payload | Camera unpowered | Inadequate charge | Validate charge | 2E |
| Payload | Payload damaged | Ascent/descent outside of desirable parameters | N/A | 3C |
| Payload | Data read/write issues | hardware/firmware/software | N/A | 2D |
| Payload | Payload unrecoverable | Rocket loss | N/A | 3C |
| Launch Operations | Structural fault with rocket identified prior to launch | Such a fault could scrub the launch before the rocket even reaches the pad | Perform routine examinations of vehicle to ensure all pieces are intact and flyable | 3A |
| Launch Operations | Electrical fault prevents ignition of engine | | Follow pre-flight procedures to ensure all electrical connections are properly made | 2B |

# 7.0 Sim Data

## 7.1 Launch Conditions

- Altitude: 836.60105 Ft.
- Landing zone altitude: 836.60105 Ft.
- Relative humidity: 50.000 %
- Temperature: 96.000 Deg. F
- Pressure: 29.6777 In.
- Launch guide elevation: 0.000 Degrees from vertical
- Launch guide azimuth: 0.000 Degrees
- Longitude: -116.967 Degrees
- Latitude: 34.517 Degrees
- No wind table data was specified.

## 7.2 Launch Guide Data

- Launch guide length: 120.0000 In.
- Velocity at launch guide departure: 76.9218 MPH
- Thrust to weight ratio at launch guide departure: 21.232
- The launch guide was cleared at : 0.191 Seconds
- User specified minimum velocity for stable flight: 29.9996 MPH
- Minimum velocity for stable flight reached at: 30.0924 In

## 7.3 Weathercocking

With current settings, the rocket stays inside the 40 degree weathercocking cone before apogee which is considered safe.

## 7.4 Max Data Values/ Flight Expectations

- Maximum velocity:Vertical (y): 348.1452 MPH, Horizontal (x): 1.0904 MPH, Magnitude: 348.1469 MPH
- Maximum range from launch site: 6.07290 Ft.
- Maximum altitude: 1939.13369 Ft.

## 7.5 Recovery System Data

- Device Name: P: Parachute
- Deployed at : 14.000 Seconds
- Velocity at deployment: 83.0292 MPH
- Altitude at deployment: 1676.15192 Ft.

- Range at deployment: 5.24937 Ft.

## 7.6 Time Data

- Time to burnout: 1.083 Sec.
- Time to apogee: 9.861 Sec.
- Optimal ejection delay: 8.778 Sec.

## 7.7 Landing data

- Successful landing
- Time to landing: 86.431 Sec.
- Range at landing: 3.75333
- Direction at landing: 179.699 Deg.
- Velocity at landing: X: 5.7647 MPH , Y: 11.3960 MPH , Z: -8.6256 MPH , Magnitude: 15.4111 MPH

# 8.0 Materials

## 8.1 Direct

| ID | Category | Item |
|---|---|---|
| 1.0 | Rocket | Built Rocket x6 |
| 1.1 | Rocket | Motors x5 |
| 2.0 | Payload | USB Cameras x2 |
| 2.1 | Payload | JollyLogic Altimeter One |
| 2.2 | Payload | JollyLogic Altimeter Two |
| 2.3 | Payload | JollyLogic Altimeter One Charger Cable |
| 2.4 | Payload | JollyLogic Altimeter Two Charger Cable |
| 2.5 | Payload | Hood x3 |
| 3.0 | Supplies | Spare Kit |
| 3.1 | Supplies | Epoxy |
| 3.2 | Supplies | Hobby knife x2 |

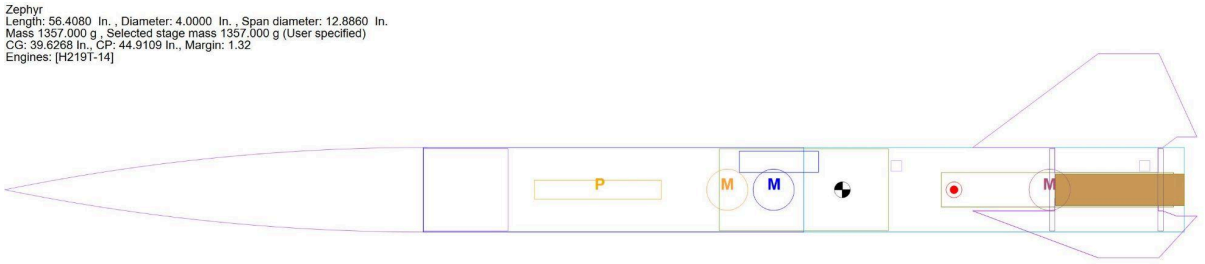
| | | |
|---|---|---|
| 3.3 | Supplies | Ruler |
| 3.4 | Supplies | Pencil |
| 3.5 | Supplies | Wood dowel |
| 3.6 | Supplies | Super glue x6 |
| 3.7 | Supplies | Sandpaper |
| 3.8 | Supplies | Pencil |
| 3.9 | Supplies | Pencil Sharpener |
| 3.10 | Supplies | Screw Drivers x2 |
| 3.11 | Supplies | Masking Tape |
| 3.12 | Supplies | Duct Tape |

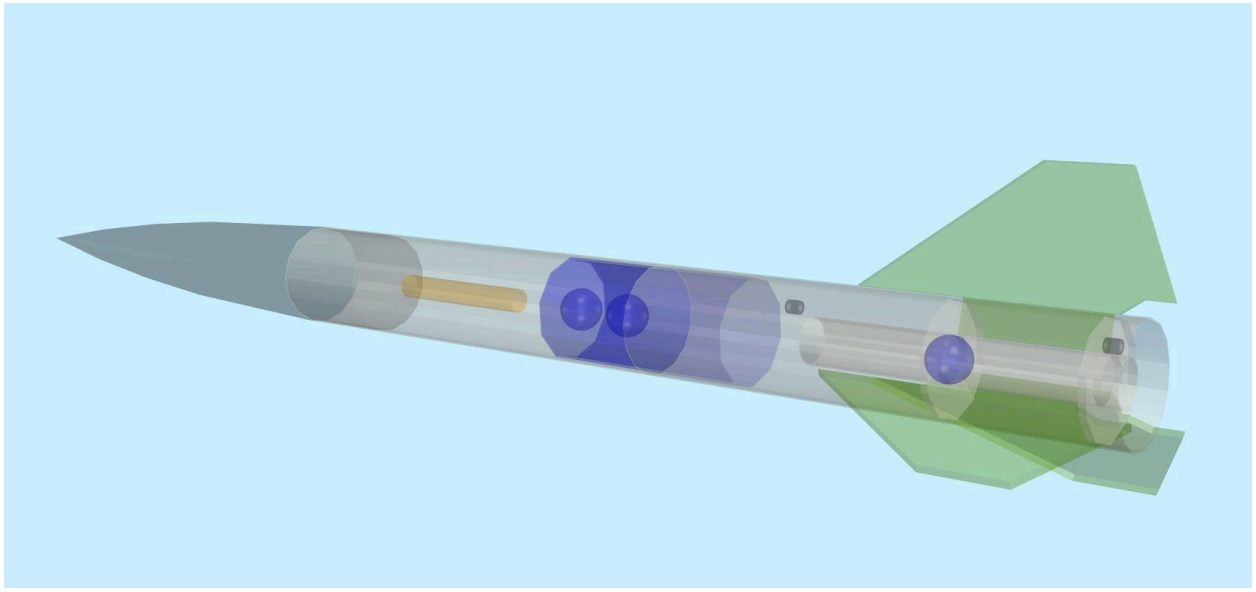
## 9.2 Supporting

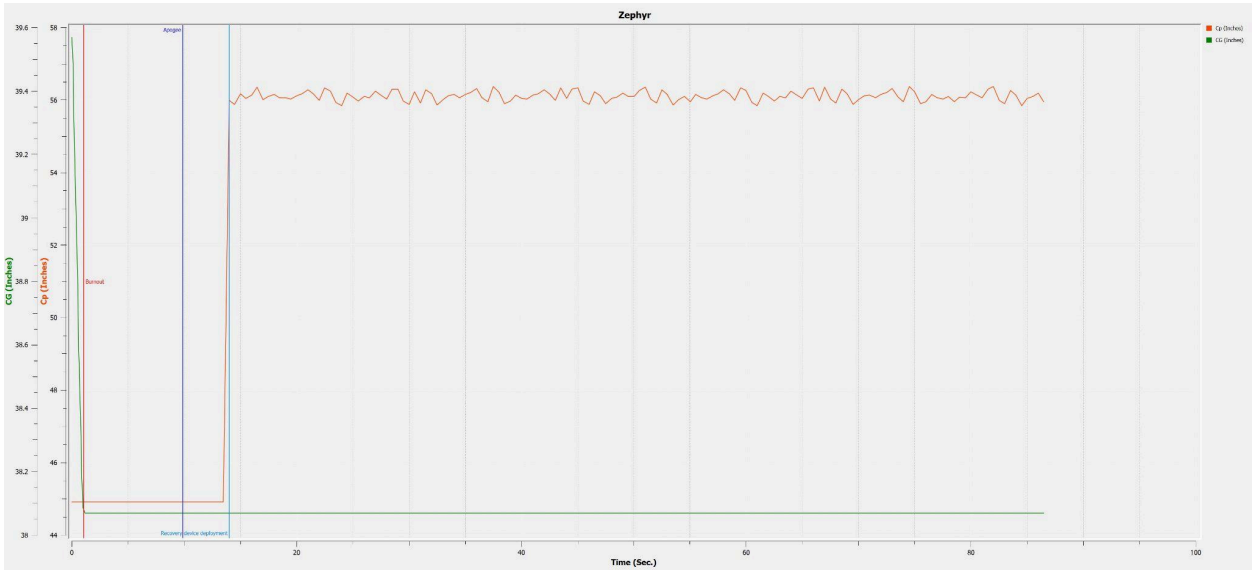
| **ID** | **Category** | **Item** |
|---|---|---|
| 1.0 | Supplies | Hats |
| 1.1 | Supplies | Sunblock |
| 1.2 | Supplies | Large Cooler |
| 1.3 | Supplies | Foldable Table |
| 1.4 | Supplies | Chairs x2 |
| 1.5 | Supplies | Binoculars |
| 1.6 | Supplies | Food |
| 1.7 | Supplies | Laptop |
| 1.8 | Supplies | Large Battery Pack x2 |
| 1.9 | Supplies | Laptop Charger |
| 1.10 | Supplies | Paper Towels |
| 1.11 | Supplies | Notebooks |

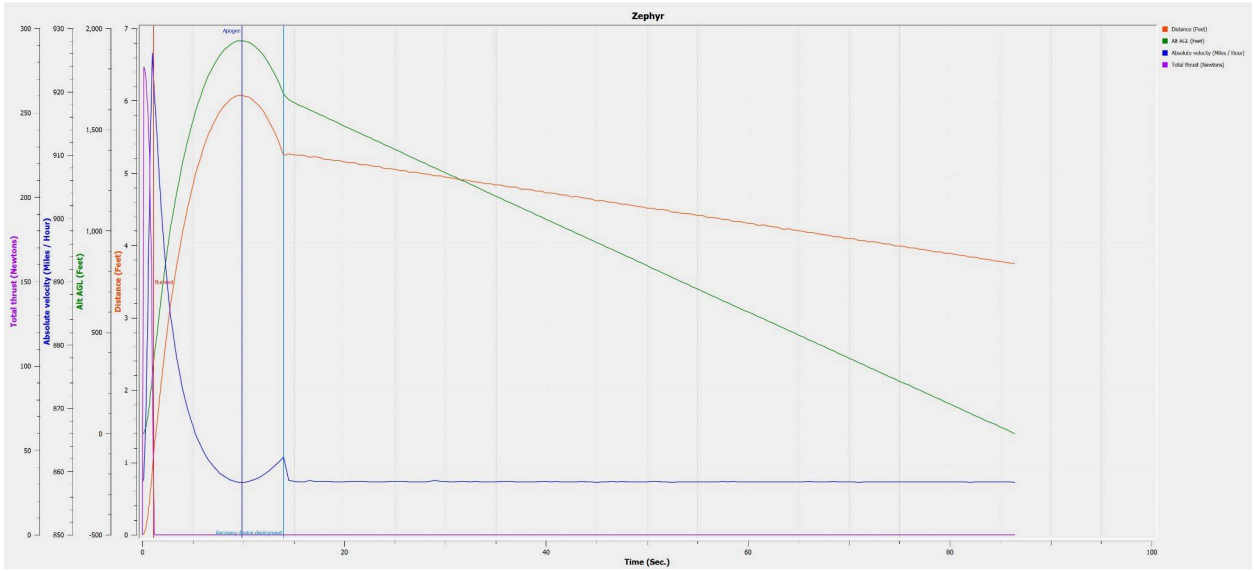
| | | |
|---|---|---|
| 2.0 | Paperwork | NAR Membership Card x4 |
| 2.1 | Paperwork | Level 1 High Powered Rocketry Application |
| 2.2 | Paperwork | Rocket Club of California (ROC) Waiver |

# 10.0 Supporting Imagery




Zephyr
CG (Inches)
Cp (Inches)
Apogee
Burnout
Recovery device deployment
Time (Sec.)


Zephyr
Total thrust (Newtons)
Absolute velocity (Miles / Hour)
Alt AGL (Feet)
Distance (Feet)
Apogee
Burnout
Time (Sec.)