AEROKATS

ADVANCING EARTH RESEARCH OBSERVATIONS WITH KITES AND ATMOSPHERIC/TERRESTRIAL SENSORS

FLIGHT OPERATIONS

Beaufort Scale Reference Table

Beaufort Number	Description	Wind Speed	Land Conditions
0	Calm	< 1 mph < 1 km/h	Calm. Smoke rises vertically.
1	Light air	1–3 mph 1.1–5.5 km/h	Smoke drift indicates wind direction, still wind vanes.
2	Light breeze	4–7 mph 5.6–11 km/h	Wind felt on exposed skin. Leaves rustle, vanes begin to move.
3	Gentle breeze	8–12 mph 12–19 km/h	Leaves and small twigs constantly moving, light flags extended.
4	Moderate breeze	13–17 mph 20–28 km/h	Dust and loose paper raised. Small branches begin to move.
5	Fresh breeze	18–24 mph 29–38 km/h	Branches of a moderate size move. Small trees in leaf begin to sway.
6	Strong breeze	25–30 mph 39–49 km/h	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
7	High wind, Moderate gale	31–38 mph 50–63 km/h	Whole trees in motion. Effort needed to walk against the wind.
8	Gale, Fresh gale	39–46 mph 62–74 km/h	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.
9	Strong gale	47–54 mph 75–88 km/h	Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over.
10	Storm, Whole gale	55–63 mph 89–102 km/h	Trees are broken off or uprooted, saplings bent and deformed. Poorly attached asphalt shingles and shingles in poor condition peel off roofs.
11	Violent storm	64–72 mph 103–117 km/h	Widespread damage to vegetation. Many roofing surfaces are damaged; asphalt tiles that have curled up and/or fractured due to age may break away completely.
12	Hurricane force	≥ 73 mph ≥ 118 km/h	Very widespread damage to vegetation. Some windows may break; mobile homes and poorly constructed sheds and barns are damaged. Debris may be hurled about.

AEROKATS Kite Operations Decision Key:

Can't Fly	Difficult	Good	Excellent	Use Caution	Very Risky	Don't Fly	Dangerous!
0	1	2	3	4	5	6	7-12

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INTRODUCTION

AEROKATS, AEROPODS, AND THE AREN PROJECT

Advancing Earth Research Observations with Kites and Atmospheric/Terrestrial Sensors

AEROKATS is the NASA program that designs, creates, deploys, and distributes low-cost, light-weight instrumentation for use in tethered kite and balloon-borne remote sensing and atmospheric sounding. The instrumentation is designed and scaled for use by research scientists, university students, citizen scientists, and K-12 educators and students.

What are Aeropods?

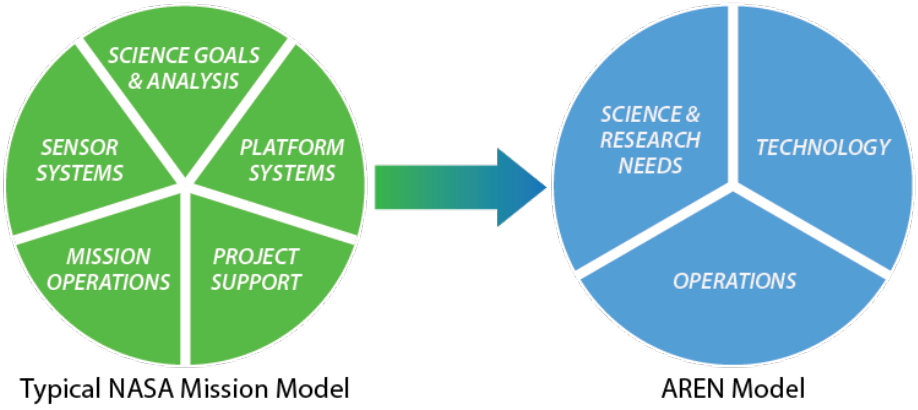
Created by Geoff Bland and Ted Miles of NASA/GSFC Wallops Flight Facility. The Aeropod is an aerodynamically stabilized instrument platform for kites and tethered balloons. Essentially a stick (boom) with directional fins on one end and an instrument on the other that is suspended under a kite. The fins and boom dampen the reaction to the aerodynamic forces acting on the payload, helping to produce a more stable platform for data collection.

The Aeropod is a patented technology, requiring a license (free to educators) to use.

AREN Project Overview

The AEROKATS and ROVER Education Network (AREN) is funded by NASA Cooperative Agreement NNX16AB95A. AREN introduces NASA technologies and practices in authentic, experiential learning environments. Low-cost instrumented systems for in-situ and remotely sensed Earth observations include kite-based “AEROKATS”, and remotely controlled aquatic and land-based “ROVERS”.

AREN technologies and lesson development are NGSS aligned and provide necessary science literacy skills. Data capture and visualization tools, designed to integrate with the GLOBE Program, enable the expansion of GLOBE study sites with transects and vertical profiles. Engineering Design concepts are embedded in student development of platform and instrument systems. Training, safety practices and procedures, and STEM challenges are a focus of the AREN Team, concurrently advancing student research projects investigating Earth science phenomena.



Graphic 1- AREN Mission Model

FLIGHT OPERATIONS SCHEDULE

PREPARING FOR A FIELD MISSION

When preparing for a mission, procedures should be followed prior to the mission deployment in order to maximize the likelihood of success in the field. Failure to adequately prepare can lead to problems in the field, including mission failure, damage or loss of equipment, or worst of all, injury to participants or bystanders. The following sequence will assist in planning and preparation for a successful field deployment.

The steps outlined below refer to sections of this document as noted.

1-2 WEEKS BEFORE DEPLOYMENT:

- ☐ Identify a location for operations (Pgs. 10-11 – Safe Flying Environment / Minimum Flight Area)
- ☐ Secure permissions to use the location (if necessary).
- ☐ Conduct an initial Hazard Inventory (Pg. 12)
- ☐ Begin to monitor weather forecasts (Pgs. 12-13 Weather/Assessing GO/NO-GO Conditions)
- ☐ Begin to gather supplies and PPE for deployment.
- ☐ Inspect equipment to ensure it is functional and no components are missing or broken.
- ☐ *In the classroom, begin to introduce Science and Field Operations concepts to students*.

ONE DAY BEFORE DEPLOYMENT:

Actions:

- ☐ Review the **PRE-MISSION CHECKLIST** (Pg. 27) to ensure all equipment and supplies are ready for the next day. (If you forget to charge your cameras, you probably won't have time to do so on the day of the mission!)
- ☐ Use the **FIELD DEPLOYMENT CHECKLIST** (Pg. 28) to collect equipment and supplies. If appropriate, have the students assist in the inspection and preparation of the equipment and supplies.
- ☐ Conduct a **Pre-Field Day Safety and Operations Briefing** with the class. Make sure they know what to expect and what to wear. If needed, send a note home to ensure parents know the students need proper attire for the field.
- ☐ If going off-site, make sure there is water available and restroom facilities for the students.
- ☐ If going off-site, confirm transportation is available.
- ☐ Check weather- make a preliminary GO/NO-GO decision

DAY OF FIELD DEPLOYMENT

The actions listed below will optimize the chances of a successful field mission. These include steps to take before departing for the field and what to do once you are in the field. There is a checklist later in this document that you can copy to have ready for your reference.

Before Departure to Field Site:

- ☐ Review the **FIELD DEPLOYMENT CHECKLIST** (Pg. 28) to ensure everything is together and ready to go.
- ☐ Conduct a **PRE-DEPLOYMENT REVIEW** with students, including the following:
  - Objectives
  - Rules for conduct in the field
  - Safety (Pgs. 9-14),
  - Personal Protective Equipment (PPE) (Pg. 14)
  - Team assignments (See Pg. 15 for examples of roles.)

On Location at Field Site:

- ☐ Conduct a final **PRE-MISSION BRIEFING** with students, including the following:
  - Conduct a final onsite Safety Review (Pg. 13), including:
    - Mission Focus – Sterile Cockpit and appropriate behavior (no running, etc.)
    - Onsite Hazards Inventory
    - Communications during the mission
    - Ensure all team members are wearing appropriate PPE
    - Establish a safe viewing area outside of the operations area
  - Define Mission Objectives (record in Flight Log)
  - Confirm Team assignments
  - Final GO/NO-GO Assessment*
- ☐ Break into teams and distribute equipment
- ☐ Teams move to the field, leaving adequate distance between teams so that operations do not interfere with each other.
- ☐ Conduct Flight Missions as planned.

* GO/NO-GO Assessment: Once the team has been briefed before a flight, a GO/NO-GO vote should be taken. Every member of the mission has the authority to declare NO-GO if they feel they are unprepared or unsafe. Continue addressing concerns until all members are GO or it is determined that the mission should be postponed.

Conducting the Post-Mission Debriefing:

This can be done on location (ideal) or upon return to the classroom.

Once the flight is complete and the equipment is safely stored, conduct a post-mission debrief. This is a critical component of all NASA missions. It not only builds a sense of participation and ownership in the mission but also often reveals aspects of the mission, including unanticipated successes, hazards, problems, and procedural improvement suggestions for future missions.

Continuous improvement is the goal!

- ☐ Everyone must participate and report out what they observed, including:
  - Successes,
  - Challenges encountered,
  - What could be improved,
  - Remember, all voices are important!
- ☐ The Data Recorder for each mission will capture the notable points in the Field Data log under the Results and Problems fields.
- ☐ Lastly, the equipment is inspected, and any problems are recorded in the Equipment Post-Flight Status field

After the Post-Mission Debriefing, the mission is complete. Congratulations!

Be sure to put away and store all mission hardware in a safe location so it is accessible and ready for your next mission!

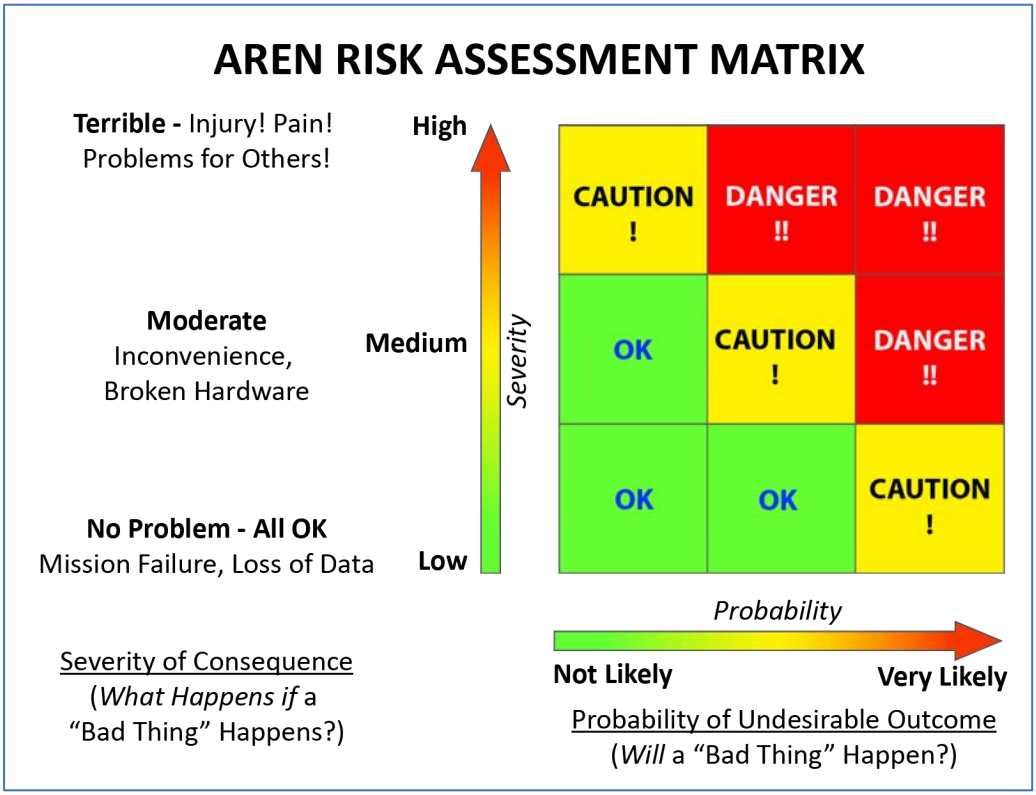
Sharing data about the mission with the AREN Community is strongly encouraged, and this can be done using the AREN Field Data Collector survey tool. (See Field Data Collector Tool – Pg. 17)

Image 1 -Post Mission Debriefing

SAFETY

USING A RISK ASSESSMENT MATRIX

When selecting a location for your missions, conducting a Hazard Inventory, assessing weather for G0/NO-GO decisions, or making other safety-related decisions, we find it helpful to use a risk assessment matrix as a tool to guide decisions. An example matrix is shown below.



Graphic 2 - AREN Risk Assessment Matrix

In essence, there are two basic considerations:

1. How likely is something to lead to a "Bad Thing" happening (*Probability)*, and
2. What is the severity of the consequence if the "Bad Thing" happens? (*Severity*).

If something is not likely to lead to a bad thing happening, and the consequences are not at all severe, it is safe to do. If, however, something is not likely to lead to a bad thing happening, but the consequences if the bad thing happens are severe, then caution is advised. If something is likely or very likely to lead to a bad thing happening, and the potential consequences are severe, then the situation is dangerous and you should not proceed.

Ideally, your activities should always take place in the green areas of the matrix where the probability is less likely and the severity is lower.

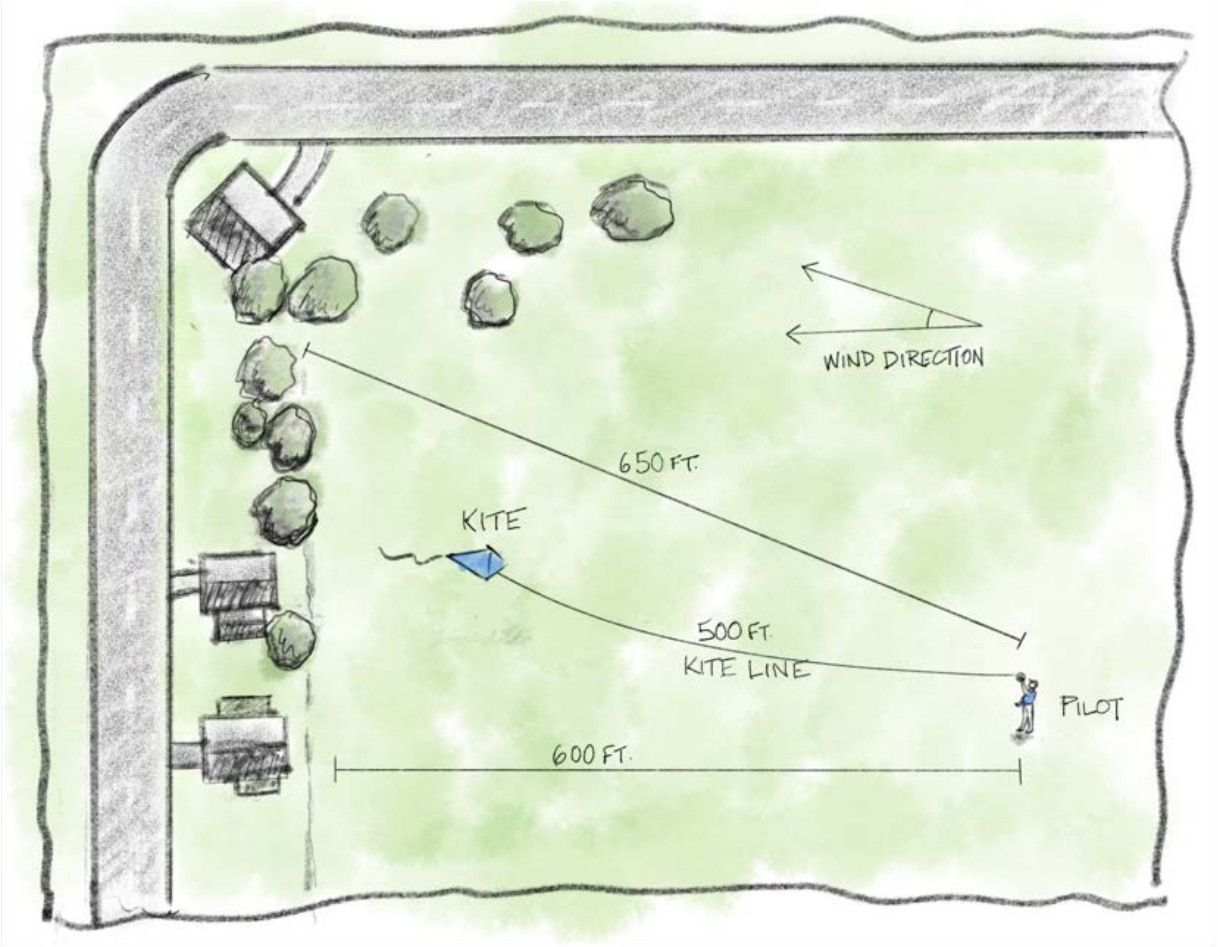
SAFE FLYING ENVIRONMENT

Select a place to fly that has adequate space and a minimum number of hazards. Be aware of your surroundings at all times. Know where your team is and what the potential hazards are while you are in the field. Remember that field work is dynamic – the situation around you is always changing. Continually assessing the conditions in the field will minimize the chances of things going wrong unexpectedly. Here are some general guidelines:

- **Location:** Select a flight location that is large enough to fly safely and presents a minimum of risks. (see Pg. 11 – Minimum Flight Area),
- **Hazards Inventory:** Conduct an onsite Hazards Inventory. (Pg. 12)
- **Non-participants:** Avoid flying over people. Hazards can change – be aware of new people entering the flight area. Create an observation area for those not flying. This should be outside of the flight area – well behind the pilot and upwind of the kite.
- **Weather:** Be aware of changing weather conditions. Abort the deployment if conditions become unfavorable. Do not fly if lightning is indicated. (Pg. 12)

LOCATION SELECTION – MINIMUM SAFE AREA

This is the smallest area where you can safely fly a kite without risk of your kite landing on a power line, road, or other hazard.



Graphic 3 - Calculating Minimum Flight Area

Example: If you have 500ft of line out, you should consider that to be the minimum dimension in the direction of prevailing winds for the field. (i.e., if you are flying in the SW corner of a field and the wind is from the SW, your field should measure at least the length of the line toward the NE. Remember that wind conditions change, and you may have to move your position to maintain a safe minimum flight area. Also know that if you lose control of the kite, it could travel downwind a significant distance before landing.

CONDUCTING A HAZARDS INVENTORY

During the pre-mission briefing, it's important to recognize and address the potential safety hazards during flight, such as dehydration, sunburn, tripping hazards, power lines, strong winds, etc. Students need to participate in this. Make a list and talk about the ways to mitigate the risks. Here is an example list:

- **Trip hazards** – low-lying obstacles or holes in the field
- **Water** – standing water, lakes, streams, ice
- **Trees** – A.k.a. kite keepers
- **People** – other people in the field of operations who are not involved with the mission
- **Structures** – buildings/fences/roads/power lines
- **Weather** – weather can change quickly, be ready to act
- **Airborne** – Planes/helicopters/drones/other kites/birds of prey
- **Other** – Anything else that could potentially cause a mishap or injury

WEATHER – ASSESSING GO/NO-GO CONDITIONS, KITE SELECTION

Note: Every kite has a different wind range; ideal wind conditions for flying are anywhere between 5-12 mph on the ground. Kites should also not be flown in weather where there is a chance of rain or especially lightning.

- **Check Forecast**: Monitor your local weather forecast the day before you are planning to conduct a mission. Recheck on the day of deployment and monitor throughout. (wunderground.com has lots of crowd-sourced data, and you may be able to find a local station very near you.)
- **GO/NO-GO**: Make an initial GO/NO-GO decision based on the weather forecast.
- **Recheck the weather** on the day of the mission, and monitor throughout.
- **Rain/Lightning:** Do not attempt to fly in rain or in weather where there is a chance of lightning.

  Note: A lightning strike indicator is a good tool to carry. It can alert you to lightning when it is still over 25 miles away, giving you a chance to retrieve kites and get to safety. Remember that lightning can travel many miles.
- **GO/NO-GO decision**: Review all criteria on the day of the mission and make a GO/NO-GO determination based on current conditions and preparedness. (See Pre-Mission Briefing)
- **Kite Selection:** Match your kite selection to wind conditions.

- If the winds are too light, your kite may not launch or fly at all. If winds are too strong, your kite or line may break and crash (along with your expensive Aeropod payload). NOTE: You will need more than the minimum winds if you are going to attach an Aeropod. However, the kite can still fail if you exceed maximum recommended winds
- The appropriate wind range for a given kite can be found on the tag that comes with the kite or the manufacturer's website.
- While every kite has a different performance range, ideal wind conditions for flying delta and delta-conyne kites (typical kite styles used to carry payloads) generally fall between 5-12 mph. Check the specifications for your kite(s) before flying.

  IMPORTANT: The wind conditions above ground can be significantly stronger than at ground level. Consider **building in a factor of 2x ground-level wind speed** when making your kite selection!

MISSION FOCUSED BEHAVIOR/SITUATIONAL AWARENESS

- **Sterile Cockpit:** Maintain a *Mission-Focused* environment. All conversations should be based on the mission in the field. No cell phone use except for documentation or data collection as part of the mission. In aviation, this is referred to as a *Sterile Cockpit*.
- **Moving in the field:** Always be aware of where you are walking. When moving with a kite, it is easy to become distracted by watching the kite. It can be helpful to have a team member watch your footing to help prevent accidents.
- **NO RUNNING!** Running is not required to launch or fly a kite and poses a significant safety risk. Do not run!
- **Communication:** When conducting the mission, maintain communication between the Pilot and other team members. Always announce and confirm transfer of control of the kite and other actions. (See Positive Transfer of Control on Pg. 21)
- **PPE:** Personal Protective Equipment must be worn by all participants. (Pg. 14)
- **Kite Line:** Avoid contact with the kite line when flying. Kite lines can quickly cause cuts and burns to unprotected skin.
- **Kite/Equipment Loss:** Do not attempt to climb trees or engage in other high-risk or dangerous activities to retrieve kites. Equipment is replaceable, people are not. In the event a kite or equipment becomes entangled in a tree or other out-of-reach obstacle and cannot be retrieved from the ground by pulling the line, DO NOT ATTEMPT TO CLIMB to free the kite. Cut or break the line and consider the kite a loss. Note the loss in your flight log. Please contact the AREN team for replacement equipment.

- **Regulations:** Be sure to comply with federal and local regulations for tethered kites and balloons. Although kite systems under 5lbs. are exempt from many requirements, they still must be flown in a safe manner that does not endanger people or property. See Federal Code of Regulations (14 CFR Part 101) for Kites and Tethered Balloons. https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-101

PPE (PERSONAL PROTECTIVE EQUIPMENT)

To ensure safety while flying, every member should be equipped with and wear PPE. The following are strongly recommended. You may think of others.

Required PPE:

- **Gloves** Large kites can pull with surprising force, and the line may spool quickly. Kite lines under force can quickly and easily cut, burn, or abrade skin. All persons directly involved with the mission who may come in contact with the kite line MUST WEAR PROTECTIVE GLOVES. This includes (but is not limited to) the Pilot, Launcher, Payload Specialist, and Line Handler.

  Short-finger sailing gloves are often used for kite flying, as they provide protection for most of the hand while leaving the fingertips exposed for dexterity.
- **Closed-toed shoes** (no sandals).

Recommended PPE:

- **Hats with brims** (provide protection from ticks, biting insects, and glare from the sun).
- **Sunglasses** (provide eye protection from harmful UV rays, and to reduce glare when looking up at the kite or Aeropod).
- **Sunscreen** (protects skin from harmful UV rays).
- **Insect repellent** (protection from ticks and biting insects).
- **Long-sleeved shirts and pants** (protection from UV rays, biting insects, and ticks).
- **Lightning Strike Indicator** (highly recommended to provide advanced warning of dangerous weather conditions).

TEAM ASSIGNMENTS

ROLES AND RESPONSIBILITIES

There are many ways to configure teams for AEROKATS Missions. The smallest team for successfully launching and flying a kite is three people: A Pilot, a Launcher, and a Mission Data Recorder. If an Aeropod is added to the mission, the Launcher could act as the Payload Specialist or Line Handler, or another team member could be assigned those roles. Ideally, the team would self-assign based on their interests. Examples of roles and responsibilities are listed below:

Mission Data Recorder:

Responsible for completing the AEROKATS Mission Flight Data Sheet and for taking notes during the Mission Flight Debrief. One log is completed per mission/flight. The Mission Data Recorder ideally will have a clipboard, pen, watch, GPS, and camera.

Pilot:

Responsible for having the wind at their back, initiating launch communications, getting the kite into the air, holding the kite steady while a payload is attached, flying the kite safely over the mission area, and retrieving the kite, assisted by the Line Handler at the end of the flight.

Launcher:

Responsible for holding and launching the kite (releasing it when instructed by the Pilot). The Launcher holds the kite downwind of the pilot at a distance ranging from ~50ft- 100ft or more, and exchanges communication with the pilot (or Launch Assistant). The Launcher will engage in the launch countdown and release the kite when instructed. The Launcher will then walk to the safe viewing area (typically behind the pilot).

Launch Assistant:

Responsible for communicating between the Pilot and the Launcher in the event the Launcher cannot clearly see or hear the instructions from the Pilot (view blocked by Kite, for example). The Launch Assistant can stand a few steps to the side of the Launcher to be in clear view of the Pilot. After the kite is successfully away, the Launch Assistant will walk to a safe viewing area (typically behind the pilot).

Payload Specialist (AKA Aeropod Handler):

Responsible for assembling Aeropod; connecting the leader to the Aeropod; ensuring sensor is turned on and operational before line attachment; attaching the leader to the kite line; releasing the Aeropod safely; recovering the Aeropod; and turning off the sensors when the operation is complete.

Line Handler:

Responsible for assisting the Pilot with line handling if the line is being pulled in too fast for the Pilot to spool it; assists in holding the line when the Payload Specialist is attaching Aeropod; and uses a carabiner to recover and land the kite, alternating control with the Pilot as the line is retrieved.

MISSION DATA RECORDING

Recording the mission log is a critical component of an AREN field mission. Information about the mission objectives, setting, environmental conditions, conduct of the mission, and post-mission briefing can be key in understanding the data collected by the team, as well as troubleshooting for future missions. Mission logs are a standard NASA practice.

MISSION RECORDING PROCEDURE

The team member assigned will begin a mission log using one of the following methods:

- The AEROKATS Flight Log Booklet,
- The FLIGHT DATA SHEETS in this document (Pgs. 28-29),
- AEROKATS Field Data Collector survey tool (online or field app – see below)
- Mission log of your own design

Prior to Launch – Start Recording the Mission Log During the Pre-Mission Briefing

Data to be logged includes

- Site name,
- Date,
- Mission ID,
- Team Members and Roles,
- Mission Objective,
- Equipment to be Used,
- Atmospheric Conditions,
- Launch Location (GPS)

During Flight – Record Mission Events

This includes:

- Time of Kite Launch and Landing,
- Time of Aeropod Launch and Landing
- Ground Control Points (if used).

After Flight – Post Mission Debriefing

Once the flight is concluded, the team conducts a post mission briefing and results are recorded including any problems and the post-flight status of the equipment.

AEROKATS FIELD DATA COLLECTOR TOOL

Use this QR code, or go to https://arcg.is/1TeDGy to access the Survey123 for ArcGIS app to log your mission data.

The link will let you choose between entering the data directly from a website or using the Survey123 App. If you choose the app and you do not have it on the device you are using, you will be allowed to download it. The App is free and available for iOS, Android, Mac OS, and Windows.

The App has the advantages of both allowing you to capture your location live in the field, and saving what you are working on to finish it later, before submitting the data.

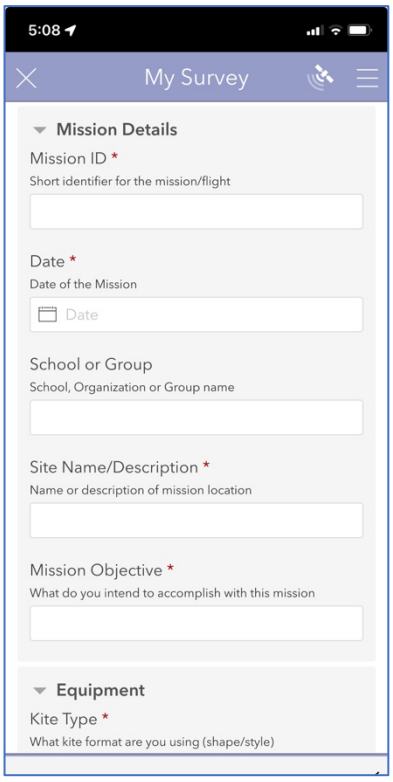


Image 2 - Field Data Collector

AEROKATS MISSION MAPPER

All data submitted through the Survey123 app can be viewed by visiting the AEROKATS Mission Mapper website. https://arcg.is/10Wna4

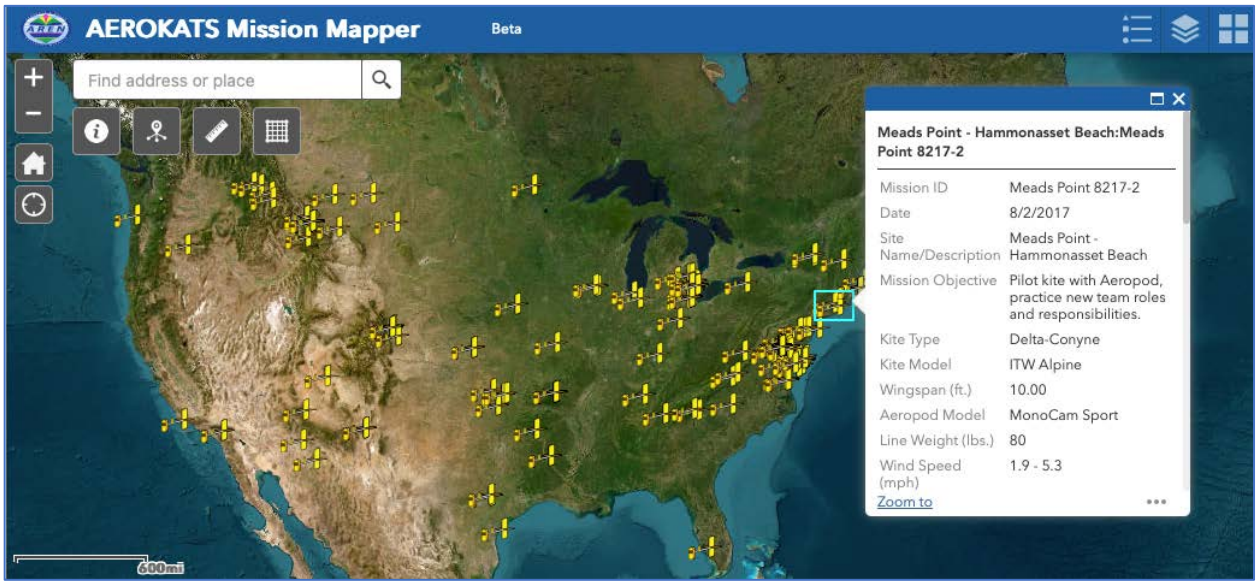


Image 3 - AEROKATS Mission Mapper

STANDARD AEROKATS FLIGHT PROCEDURES

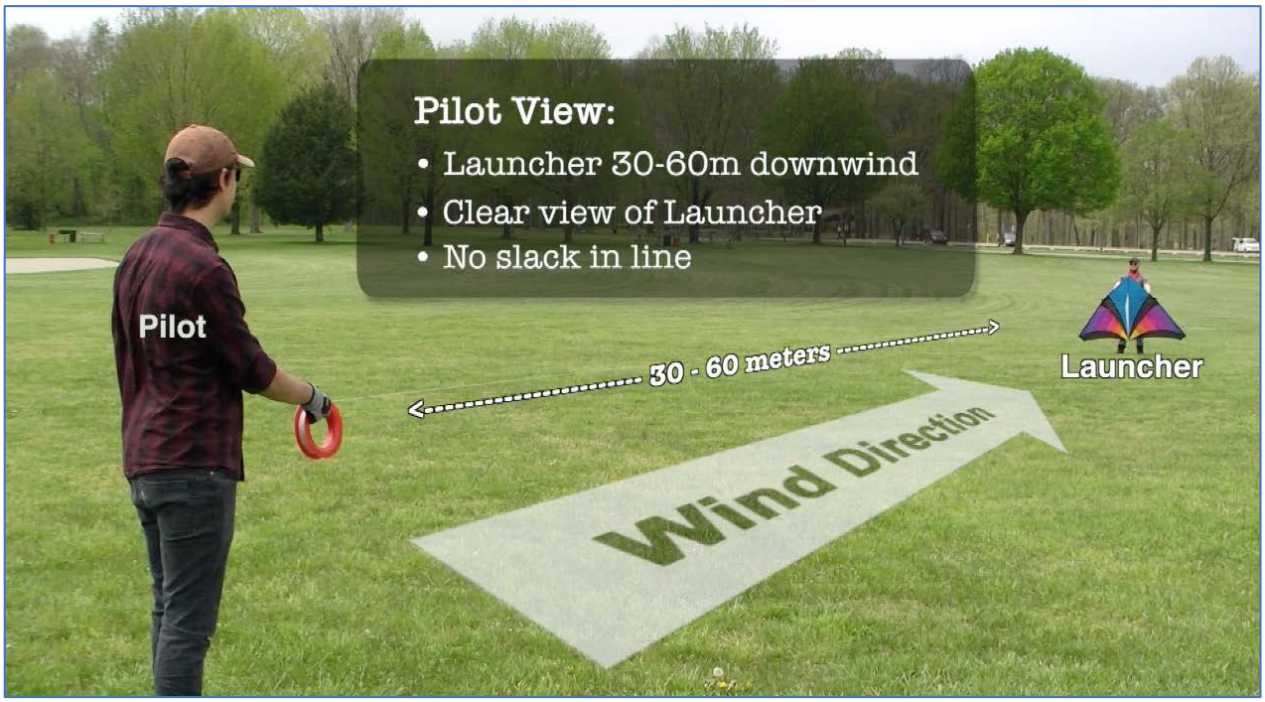


Image 4 - Long Launch Technique

Image 5 – Carabiner Attachment

Image 6 – Carabiner Kite Retrieval

KITE LAUNCH USING THE *LONG LAUNCH* TECHNIQUE

Personnel (Minimum of two required*):

- Pilot (Team member with the spool of line who will fly the kite)
- Launcher (Team member with the kite who will hold and then release the kite on "Zero")

* Launch of kite only. Payload operations require a minimum of three personnel. Optional Flight Team personnel could include a Line Handler or Launcher Assistant. (See descriptions pg. 15)

Procedure:

1. Once the Pilot is in position, the Launcher will walk the kite downwind of the pilot (usually 50ft-100ft) and stand behind the kite.
2. Launcher now holds the kite by the spreader bar with the kite nose pointed up and the bridal facing Pilot, with little or no slack in the line between the Pilot and Launcher.
3. Once the team is in place and wind conditions are good, the Pilot asks the launcher, "**Are you ready**?"
4. Launcher gives verbal confirmation with "**Yes, I'm ready**" or "**No, I'm not ready**"
5. When both pilot and launcher are ready, the pilot announces "**Launch on zero**" and then counts down "**Three, Two, One, Zero**"
6. On "**One,**" the Pilot, holding the spool straight out in front of them, begins to pull the kite line to increase tension and remove all slack
7. On "**Zero,**" the pilot increases the speed of the pull and brings their arm down by their side in an arcing motion to pull the kite towards themselves and create lift
8. Simultaneously, the launcher releases their grip on the kite (Note: they do not need to throw the kite, just let go.)
9. The Mission Data Recorder should record the Time of Launch

Link to video demonstrating correct Long Launch procedure: https://tinyurl.com/3ds6ejhn

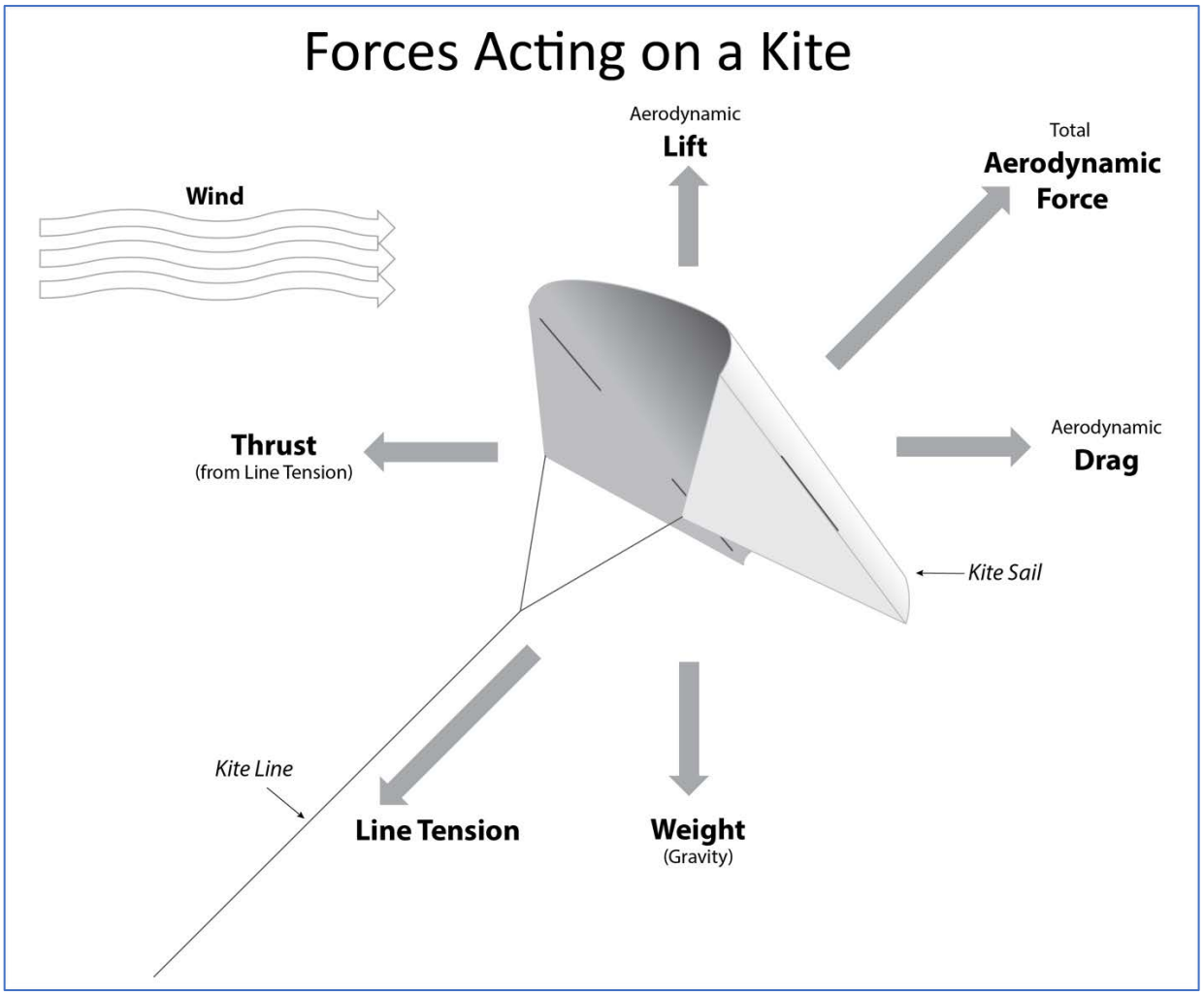
Flying tips:

As the kite rises, the Pilot slowly lets out the string, feeding it line as it continues to rise.

If the kite begins to drop, the Pilot should stop letting out the string. If the kite continues to lose loft, the Pilot may need to give small, steady tugs or pull in line, reeling in line as necessary to maintain tension on the line.

If winds drop and the kite loses altitude rapidly, the pilot may need to hand the spool to a third team member (the Line Handler) and pull in line by hand quickly to regain control of the kite. The Line Handler will quickly wind the excess line onto the spool until the pilot is ready to retake the spool.

Conversely, if the winds overpower the kite and it begins diving, the pilot may need to let additional line out until the kite steadies, and then begin retrieving the kite by cautiously reeling in line as the winds permit. Practice to build proficiency!



Graphic 4 - Forces Acting on a Kite

COMMUNICATION

Commands:

All commands should be announced loudly and clearly. A team member may be assigned to stand off to the side of the launcher and relay communications if the Launcher's view of the Pilot is obstructed by the kite or the Launcher has difficulty hearing or seeing the Pilot for any reason.

Positive Transfer of Control:

Any transfer of control of the kite between personnel must be accompanied by verbal confirmations. Standard protocol for this is:

1. Team member to Pilot: "**May I have the kite**?"
2. Pilot response: "**You may have the kite.**"
3. Team member grips the spool while the Pilot continues to hold it.
4. Team member to Pilot: "**I have the kite.**"
5. Pilot responds: "**Your kite,**" and releases the spool to the team member.
6. The team member is now the acting Pilot.

Note – This should be practiced with a spool before actually flying a kite. Proficiency here helps to avoid the very undesirable situation where no one has the kite!

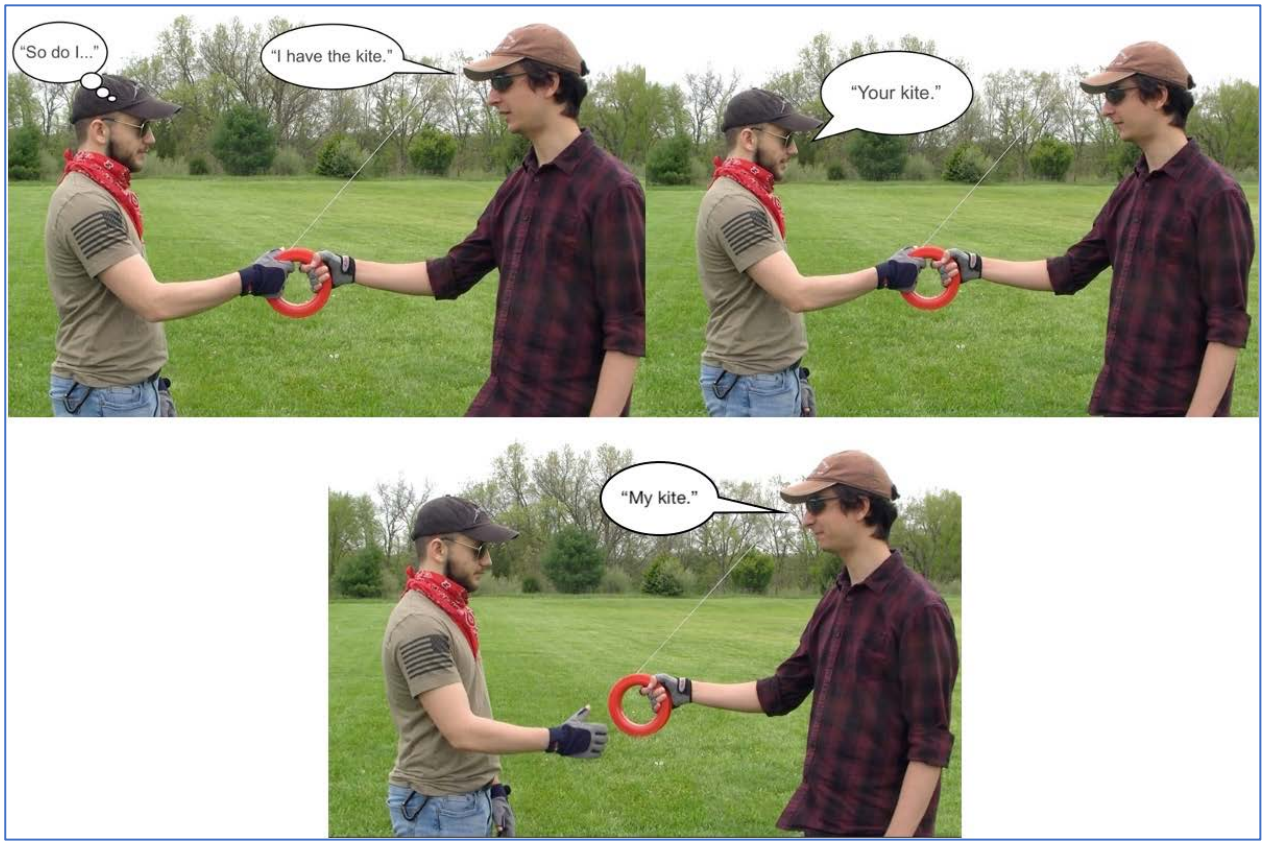


Image 7 - Positive Transfer of Control

KITE RETRIEVAL

Reeling in a large kite can be difficult and take a considerable amount of time, especially in higher winds. The preferred method is for the Line Handler to walk the kite down with a large *carabiner*, allowing the pilot to retrieve the kite in stages.

Carabiner Kite Retrieval Procedure:

1. After conferring with the pilot, the Line Handler clips the carabiner onto the line and grasps the carabiner on the clasp side. Holding the carabiner this way, the Line Handler walks away from the Pilot, pulling the kite line down as they go, while making sure that the line does not contact the hinged portion of the carabiner.
2. The Line Handler walks 25-50 ft down the line, then stops and turns to face the Pilot
3. The Line Handler twists the carabiner 2-3 times to secure the line and grips the line on the twist with their free hand.
4. The Line Handler announces: "**I have the kite.**"
5. The Pilot responds: "**Your kite.**"
6. With the tension now released, the Pilot can now easily reel in the line. Carabiner in hand, the launcher walks back toward where the pilot is reeling in the slack line.
7. Once the slack line has been reeled in, the Pilot prepares to resume control of the kite.
8. The Pilot announces: "**I have the kite.**"
9. The Line Handler responds: "**Your kite.**"
10. The Line Handler now untwists the carabiner to release tension (but doesn't let go of it!), so that the line can pass easily through it again.
11. Repeat the process until all the line has been pulled down and the kite has been safely retrieved and the line disconnected from the kite bridal.
12. The Line Handler announces: "**Kite is down.**"
13. The Pilot responds: "**Kite is down.**"
14. The Mission Data Recorder should record the time.

Link to video demonstrating Carabiner Kite Retrieval: https://tinyurl.com/294u2w6d

NOTE: If the kite needs to be brought down very quickly, and there is room to do so, the Line Handler can walk the kite all the way down to the ground without stopping to let the Pilot reel in the line. While this is faster, it can be difficult to communicate effectively over this distance, and the line ends up on the ground where it can snag and be abraded, or cause a trip hazard.

AEROPOD OPERATION AND ATTACHMENT

These operations should be performed by the Payload Specialist (aka Aeropod Handler).

Aeropod Preparation:

Prior to the kite launch, assemble the Aeropod and make sure it is balanced and the sensors are ready to collect data. (See AEROPOD ASSEMBLY INSTRUCTIONS- Pgs. 33 – 41.) Be sure cameras are on and lens covers removed, weather meter (anemometer) cover is removed, etc. If calibration is necessary, this should be performed now as well.

Aeropod Attachment Procedure:

Note: The Aeropod leader can be attached to the kite running line once the kite is above the ground-level turbulence and flying well in steady air. (Hills, trees, buildings, etc., cause turbulence and disrupt the steady flow of air.) This can range from 50ft- 200ft above ground level, depending on the surrounding environmental topography.

1. Attach a 15 ft leader to both the Aeropod Pylon and Brooxes Hang-Up assembly. (See Aeropod Leader Connections video: https://tinyurl.com/rk94ckys)
2. Once the Pilot determines the kite is flying well and ready for the Aeropod, attach the payload leader to the kite running line using the Brooxes Hang-Up, looping at least 3 times around each end. ** See helpful NOTE below.
3. With the Aeropod leader securely attached to the kite, make one final check that the sensor instrument (camera, weather meter, etc.) is turned on and capturing data.
4. The Pilot can now begin slowly letting out line while the Payload Specialist walks along the line with Aeropod in hand, keeping the Aeropod directly beneath the point on the kite running line where the Aeropod leader is attached
5. Once the Aeropod leader is fully extended, the Payload Specialist can release the Aeropod and let the kite carry it aloft. The Mission Data Recorder should record the time.
6. On descent, the Payload Specialist should walk out to catch the Aeropod as it lands.
7. Continue walking with the Aeropod until the attachment point has been reeled in close enough that the Brooxes Hang-Up can be removed from the kite running line.
8. The Mission Data Recorder should record the time of Aeropod detachment.
9. Take the Aeropod and leader and move to a safe viewing area.
10. The payload can now be turned off.

**NOTE: When attaching and detaching the Aeropod to the kite line, it is often helpful to have the Line Handler take control of the kite line by attaching a carabiner just above the Aeropod

connection point (toward the kite). This will allow them to relieve tension on the line while connecting and disconnecting the Brooxes Hang-Up. The Pilot and Line Handler will be exchanging control of the kite and should verbally engage in Positive Transfer of Control as covered earlier. (Link to video demonstrating Aeropod Attachment and Detachment during flight: https://tinyurl.com/z5y6t5sw)

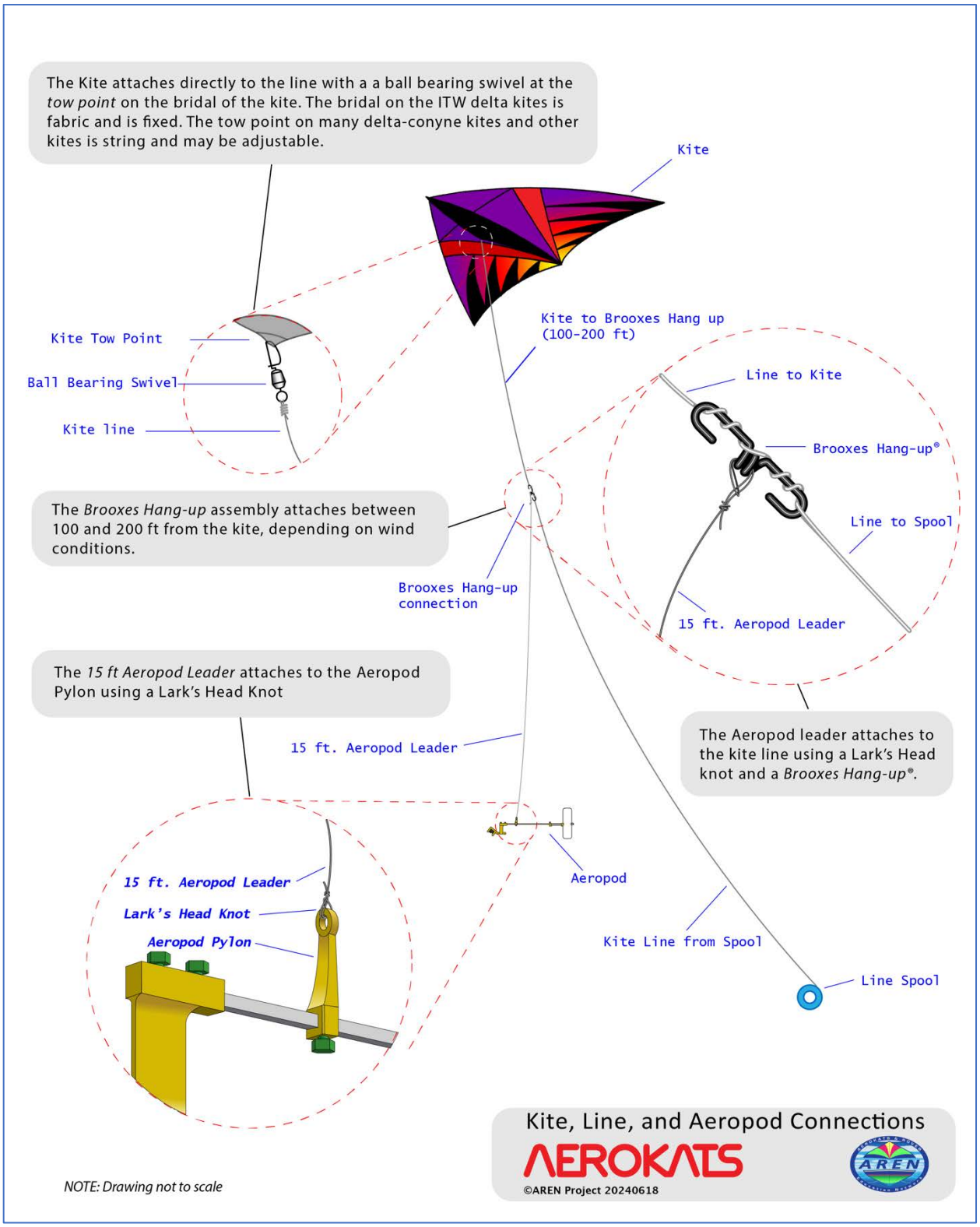
Image 8 - Attaching Leader to Pylon

Image 10 - Attaching Brooxes Hangup to Kite line

Image 11 - Aeropod Launch

Image 9 - Detaching Brooxes Hangup with Aeropod from Kite Line

DIAGRAM: KITE, LINE, AND AEROPOD CONNECTIONS



Graphic 5 - Kite, Line, and Aeropod Connections Diagram

PRE-MISSION CHECKLIST

PRINT AND COMPLETE ONE DAY BEFORE FIELD WORK

- ☐ Check the weather forecast for the mission date. Make preliminary decision- Go/No Go based on available information.
- ☐ Check camera settings and make any necessary adjustments.
- ☐ Fully charge all cameras.
- ☐ Make sure SD Cards are inserted in cameras and work properly. (Take a test picture/video.)
- ☐ Inspect Aeropods for missing parts/signs of damage. Repair or replace parts if necessary. Notify an AREN team member if replacements are needed.
- ☐ Inspect kites for signs of damage/missing spars. Repair tears or replace spars if necessary. Notify an AREN team member if replacements are needed.
- ☐ Inspect kite lines for signs of wear or damage to spools. Replace line if necessary. Notify an AREN team member if replacements are needed.
- ☐ Inspect gloves for wear or damage- make sure you have enough.
- ☐ Check battery(s) in weather meter.
- ☐ Confirm transportation.
- ☐ Perform a safety review with students before going to the field.
  - √ Situational awareness (hazards inventory).
  - √ Review teamwork and communications protocols.
  - √ Review appropriate clothing guidelines (hats with brims, no open toe shoes, etc.).
  - √ NO RUNNING!!
- ☐ Have an on-site mission plan for water, bathroom, and emergency.
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

FIELD DEPLOYMENT CHECKLIST

Take these Items to Site on Day of Field Operations

PPE	Equipment
☐ Gloves*	☐ Kite(s)
☐ Hats	☐ Hoop(s) or handles with line
☐ Sunscreen	☐ Aeropod(s)*
☐ Sunglasses	☐ Aeropod leader(s)*
☐ Insect Repellent	☐ Brooxes Hang-ups (or similar)*
☐ Water	☐ Large Carabiner(s)*
☐ First aid kit	☐ Flight Log books/Data Sheets
* Required when using large kites and Aeropods! Not required for Frustrationless Flyers only.	☐ Clipboards/pens/pencils
	☐ Weather meter (Anemometer)
	☐ Lightning detector (if available)
	☐ GPS (or phone with GPS)
Other items not listed above:	☐ Camera (or phone with camera)
☐ _____	☐ Extra batteries (if applicable)*
☐ _____	☐ Multipurpose Tool w/ screwdriver
☐ _____	* Required when using large kites and Aeropods! Not required for Frustrationless Flyers only.
☐ _____	☐ _____
☐ _____	☐ _____
☐ _____	☐ _____
☐ _____	☐ _____
☐ _____	☐ _____
☐ _____	☐ _____
☐ _____	☐ _____

This list is designed to make sure you enter the field with the supplies necessary for a successful deployment. Note that fewer items are necessary if you are only doing a training flight with lightweight Frustrationless Flyer Kites (or similar). You may find there are other tools that you wish to have on hand. Feel free to add them to the list!

You can print or copy this and use it as a checklist when preparing for a field deployment.

FLIGHT DATA SHEET

Mission Details Mission ID#: _____ Date: _____

Site Name/Description: _____

_____

Pilot: _____ Data Recorder: _____

Other Personnel: _____

_____

Equipment

Kite Type/Model: _____

Aeropod Model:_____ Line Weight (lbs.): _____

Atmospheric Conditions (at ground level)

Wind Speed (mph): _____ Wind Direction: _____ Beaufort Number: _____

Cloud Cover (%): _____ Temperature(F): _____ Rel. Humidity (%) _____

Barometric Pressure (mb) _____

Launch Site Location

Latitude (dd): _____ Longitude (dd): _____

Flight Details

Time of Kite Launch- Kite: _____

Time of Kite Landing- Kite: _____

Max Altitude- Aeropod (ft): _____

Ground Control Points (if used)

DESCRIPTION	LATITUDE (dd)	LONGITUDE (dd)
GCP 1: _____	_____	_____
GCP 2: _____	_____	_____
GCP 3: _____	_____	_____
GCP 4: _____	_____	_____

Mission Objective
Results
Problems
Equipment Post-flight Status

KEY TO FIELDS IN FLIGHT DATA SHEET

Mission Details

Mission ID#: Short identifier for the mission/flight. For example, 20170522_03, where the first part is the date and the last part is the flight number. (Could also use team name, location, etc.)

Date: Date of the mission.

Site Name/Description: Name or description of mission location.

Pilot: Person actively in control of the kite during flight (the person with the spool of line).

Data Recorder: Person recording the mission log

Other Personnel: Anyone assisting with the mission in another role.

Equipment

Kite Type/Model: The name or style of the kite used for the mission

Aeropod Model (if used): Examples: MonoCam Sport, MiniCam, Profiler, etc.

Line Weight: Strength rating of the kite line (e.g., 80lb, 110lb, etc.)

Atmospheric Conditions (measured at 5 ft above ground level)

Wind Speed: Miles per hour (mph)

Wind Direction: Prevailing direction the wind is coming from (N, NE, E, SE, SW, W, NW, Variable).

Beaufort Number: (Estimate- see chart on inside front cover of booklet)

Temperature: Degrees F

Humidity: Relative Humidity (%)

Barometric Pressure: Measured in Millibars (mb)

Cloud Cover %: Estimate based on GLOBE Cloud Protocol https://observer.globe.gov/about/get-the-app

Launch Site Location

Latitude (dd): Latitude in decimal degrees (5 decimal places: xx.xxxxx)

Longitude (dd): Longitude in decimal degrees (5 decimal places: xxx.xxxxx)

Flight Details:

Time of Launch: Record the time the kite was launched

Time of Landing: Record the time the kite was recovered

Max Altitude: (Optional) Estimate the highest altitude attained. (See method on Pg. 31.)

Ground Control Points (GCPs) – *If used*.

GCP 1 – 4: (Optional- up to four). These are points or objects you identify on the ground that you can use to georeference (map) your images.

Description: Describe the point feature (e.g., NE corner of field, bench at south of the park, etc.)

Latitude (dd): Latitude of the GCP in decimal degrees (5 decimal places: xx.xxxxx)

Longitude (dd): Longitude of the GCP in decimal degrees (5 decimal places: xxx.xxxxx)

Mission Results (Pg 2)

Mission Objective: What you plan to achieve (e.g., safety, fly kites to 400 ft, capture images with Aeropod, teamwork exercise, etc.)

Results: Did you achieve your objectives? Were there any surprises? What did you see/learn?

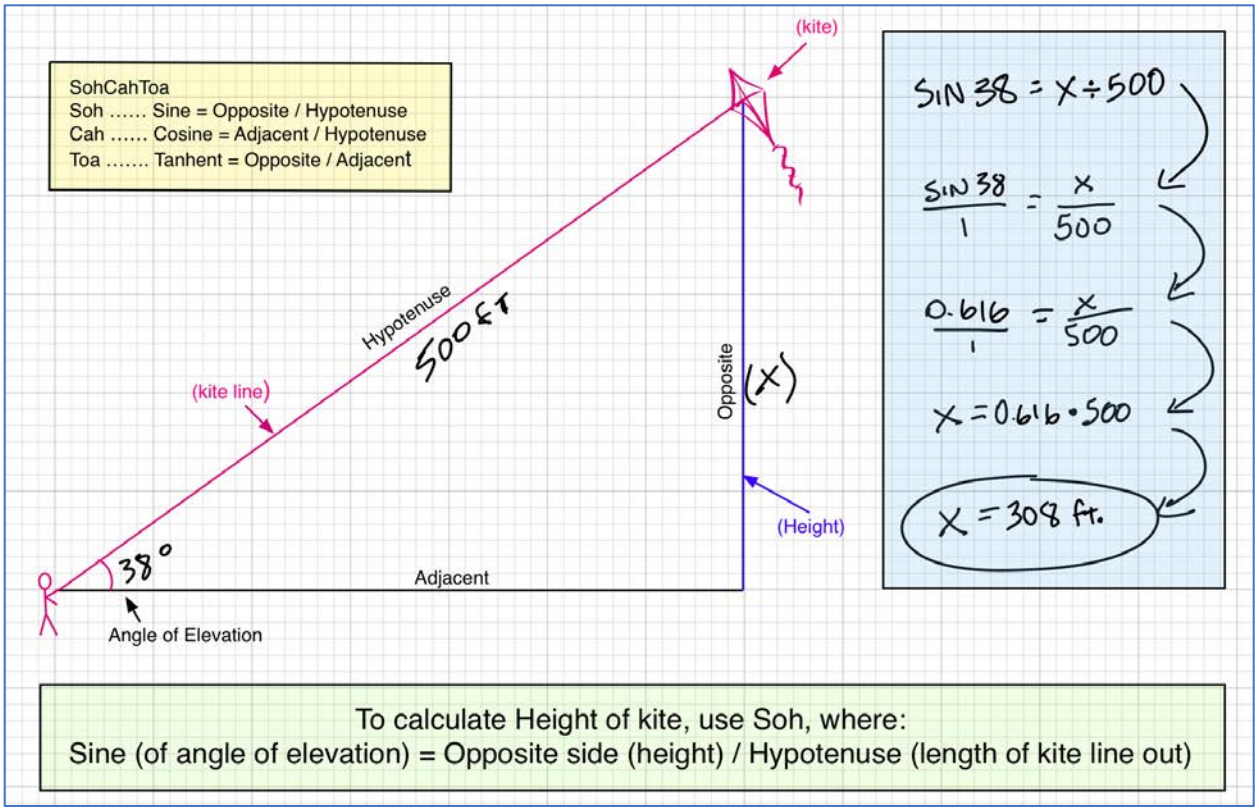
Problems: IMPORTANT! Did anything go wrong? What could be done to prevent it in the future?

Equipment Post-Flight Status: Did any of the equipment get damaged? Does anything need to be repaired or replaced?

NOTE: HOW TO CALCULATE THE HEIGHT OF YOUR KITE

Use a clinometer to measure the elevation angle that the kite line forms with the ground. There are clinometer apps for phones, or you can make a simple one by following the instructions here: https://observer.globe.gov/documents/19589576/dda6ecec-2bdf-57b7-d7bd-0d483b2ed115

Once you know the elevation angle, you can use the following formula to calculate the elevation of the kite. (You can use a calculator or an online calculator to find the Sine of a given angle.)



Graphic 6 - Calculate the Height of a Kite

Links to AREN Operations Videos

Knots and Connections:

- Overhand on a Bight: https://tinyurl.com/eadt3jsw
- Attaching the Swivel to the Line: https://tinyurl.com/t9hvu6fz
- Aeropod Leader connections: https://tinyurl.com/rk94ckys
- Attach Brooxes HangUps to Kite line: https://tinyurl.com/fhtubxd9

Kite Building:

- 7ft Levitation Lite: https://tinyurl.com/58exzz7s
- Frustrationless Flyers: https://tinyurl.com/dk97c24n

Field Operations:

- Assess Flying Site- Hazard Inventory: https://tinyurl.com/fwvf6k8n
- Long Launch Technique: https://tinyurl.com/3ds6ejhn
- Aeropod Attachment: https://tinyurl.com/z5y6t5sw
- Kite Retrieval with Carabiner: https://tinyurl.com/294u2w6d

Aeropod Assembly:

- Aeropod Assembly: https://tinyurl.com/zz4jt4sp

GitUp Camera:

- Configure GitUp2: https://tinyurl.com/a8aj6ha9
- GitUp Camera Data Retrieval: https://tinyurl.com/676ajfc4

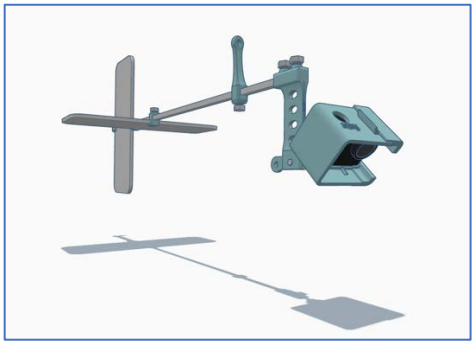
Kestrel:

- Configure Kestrel: https://tinyurl.com/4u68fhr8
- Kestrel Data Retrieval: https://tinyurl.com/4przfsr8

Mission Mapper:

- AREN Mission Mapper Data Upload: https://tinyurl.com/2kz4dh2v

AEROPOD ASSEMBLY – MONOCAM SPORT 2023 VERSION



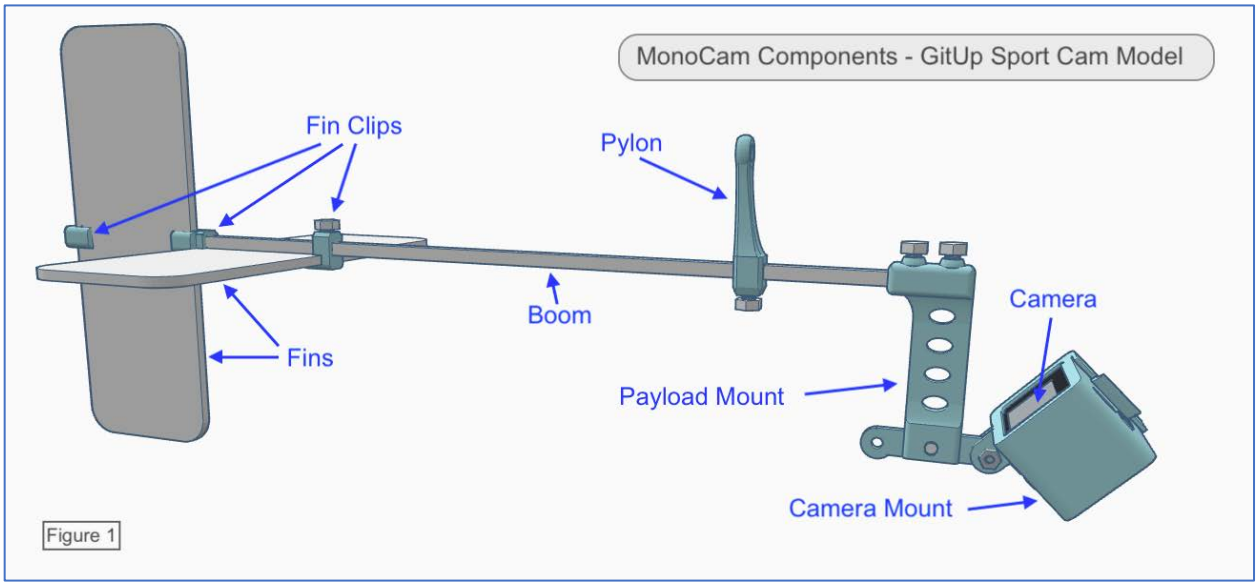


Figure 1: Aeropod Components

MonoCam Aeropod Components

- **Fins:** provide stability and directional dampening
- **Fin Clips:** secure the fins to the boom
- **Boom:** backbone of the Aeropod (aircraft spruce)
- **Pylon:** connects to the leader and balances the Aeropod
- **Payload Mount:** attaches the payload (Camera and Camera Mount)
- **Camera Mount:** holds the camera and attaches to the Payload Mount
- **Camera:** payload sensor

Aeropod Assembly

Part 1 – Attach the Fins and Fin Clips (Figures 2-4)

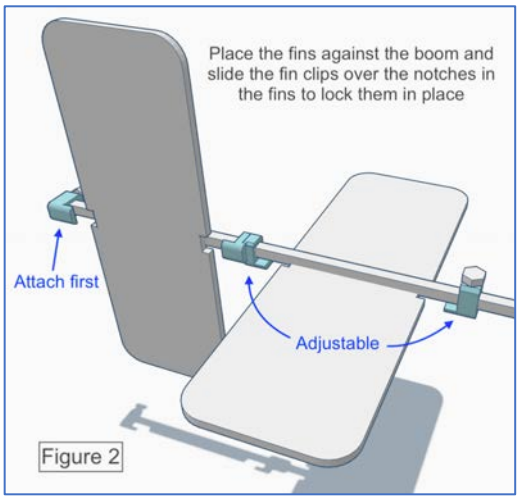


Figure 2: Attach Fin Clips - Pt. 1

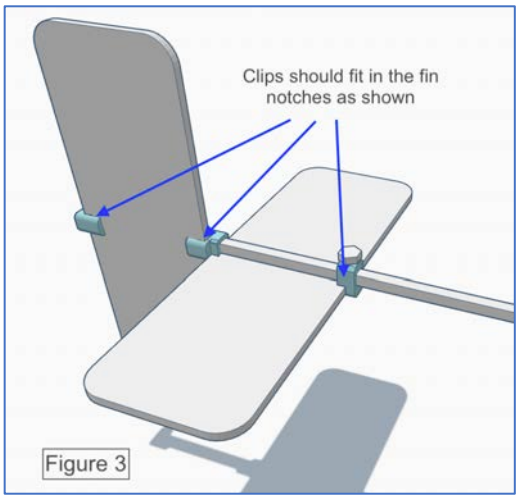


Figure 3: Attach Fin Clips - Pt. 2

1. Slide the fin-clips onto the boom and tighten the rear fin-clip bolt until it is just snug.
2. Place the rear fin against the side of the boom as shown in Figure 2, and slide it back until the notch fits into the rear fin-clip.
3. Slide the center fin-clip over the forward notch in the fin to hold it in place.
4. Place the forward fin against the bottom of the boom and slide it back until the notch fits into the center fin-clip.
5. Slide the forward fin-clip backward until it fits in the notch of the fin.
6. Make sure the fin-clips fit snugly in the notches. (Figure 3)
7. Tighten the forward bolt against the boom until it is just snug and will not slide. (Figure 4)

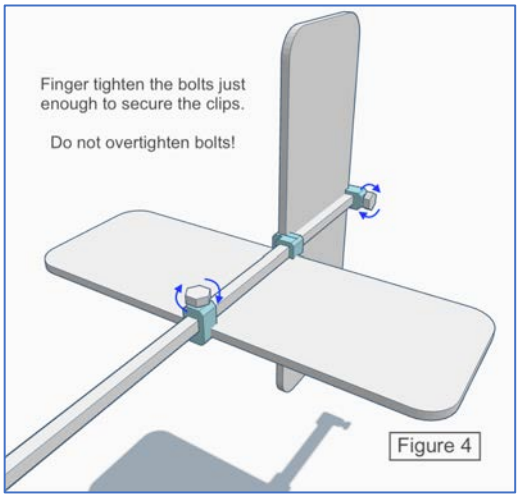


Figure 4: Attach Fin Clips - Pt. 3

Part 2 – Attach the Pylon and the Payload Mount (Figure 5)

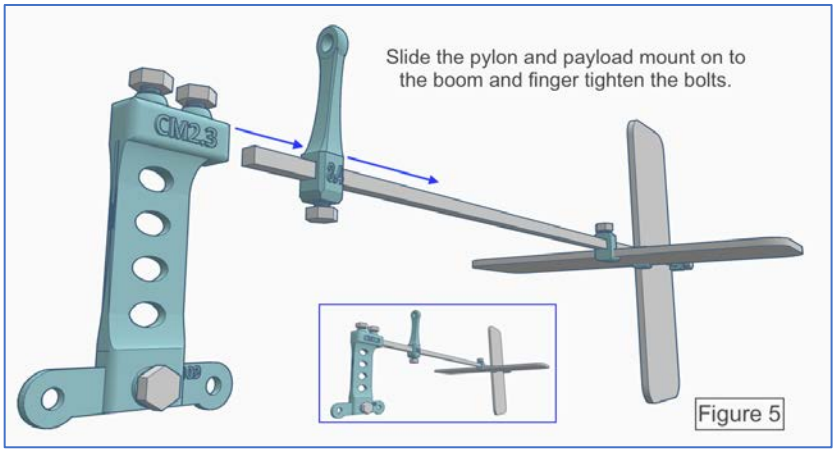


Figure 5: Attach Pylon and Payload Mount

1. Loosen the attaching bolts on the pylon and the top of the payload mount.
2. Slide the pylon onto the boom, then slide the payload mount onto the boom.
3. Make sure the payload mount is seated all the way onto the boom, then tighten the locking bolts just until they are snug and the camera mount doesn't move. Do not overtighten.

Part 3 – Install the Camera in the Camera Mount (Figures 6 – 9)

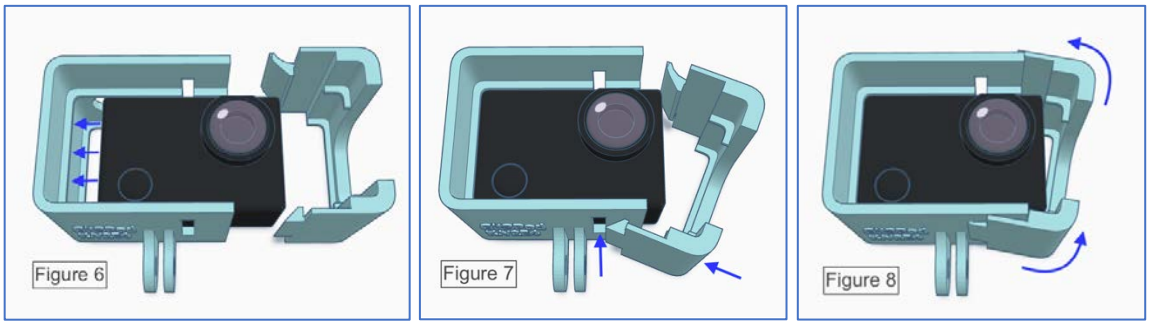


Figure 6 - Install Camera pt. 1 Figure 7 - Install Camera pt. 2 Figure 8 - Install Camera pt. 3

1. Slide the camera into the body of the mount (as shown). The shutter button on top of the camera should align with the round hole in the top of the mount (not visible in image) (Figure 6).
2. Insert the bottom tab of the holder section into the bottom slot of the mount (Figure 7).
3. Rotate the tab into place. The tab should ‘click’ into position (Figure 8).
4. Properly assembled mount and camera (Figure 9).

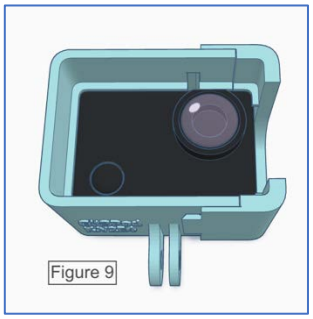


Figure 9 - Camera Installed

Part 4 – Attach the Camera Mount to the Payload Mount (Figures 10 – 11)

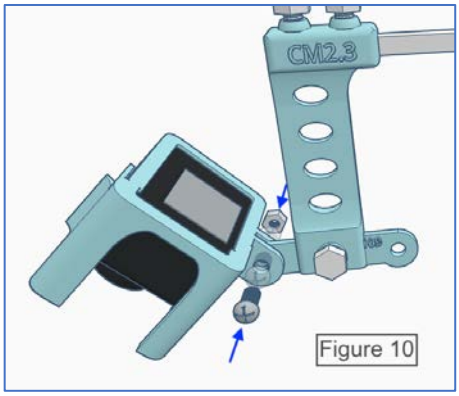


Figure 10: Attach the Camera Mount

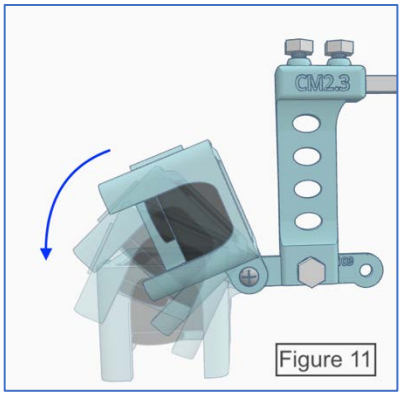


Figure 11: Adjust Camera Position

1. Slide the camera mount tabs onto the forward-facing bracket on the payload mount. Insert the mounting bolt through the hole and thread the retaining nut onto it. (Figure 10)
2. Tighten the mounting bolt until it is snug and the camera doesn't move.
3. Adjust the angle of the camera by loosening the bolt until the camera moves. Retighten the bolt when the camera is in the desired orientation. (Figure 11)

Part 5 – Adjust the Balance and Pitch of the Aeropod (Figure 12)

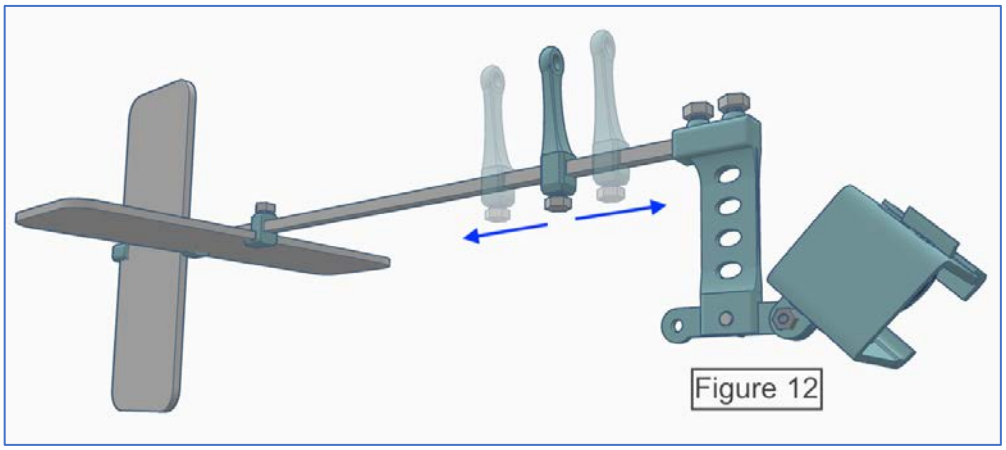


Figure 12: Adjust Aeropod Balance and Pitch

1. Loosen the retaining bolt on the pylon and adjust the position by sliding it along the boom. (Figure 12)
2. The pylon is correctly positioned when the Aeropod is balanced on the pylon with the forward end tilted slightly upward (around 3- 5 degrees). Retighten the bolt when finished.

Part 6 – Optional: Attach the PocketLab Mount to the Payload Mount (Figures 13 – 15)

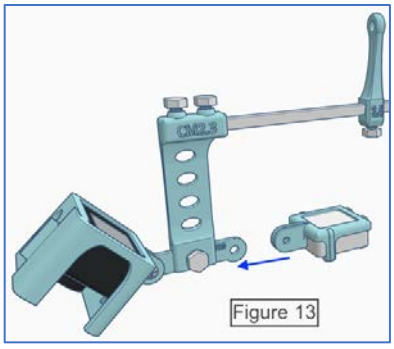


Figure 13 - Attach Pocket Lab Pt. 1

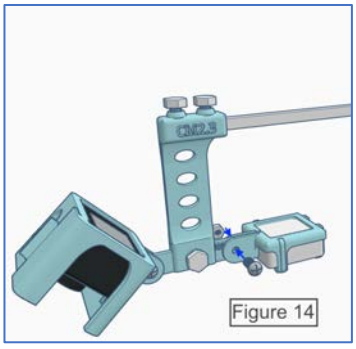


Figure 14 - Attach Pocket Lab Pt. 2

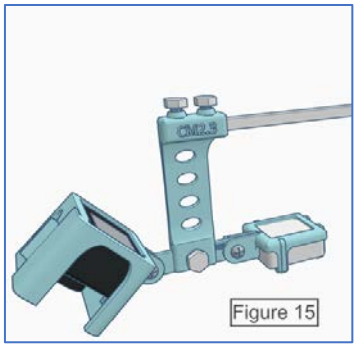


Figure 15 - Attach Pocket Lab Pt. 3

1. Follow the same procedure as described in Part 4 to attach the PocketLab Weather instrument mount to the Payload Mount. (Figures 13 – 15)
2. The instrument should be oriented with the sensor side facing down.
3. Once attached, you may need to rebalance the Aeropod (see Part 5).

AEROPOD ASSEMBLY – MINICAM 2024 VERSION

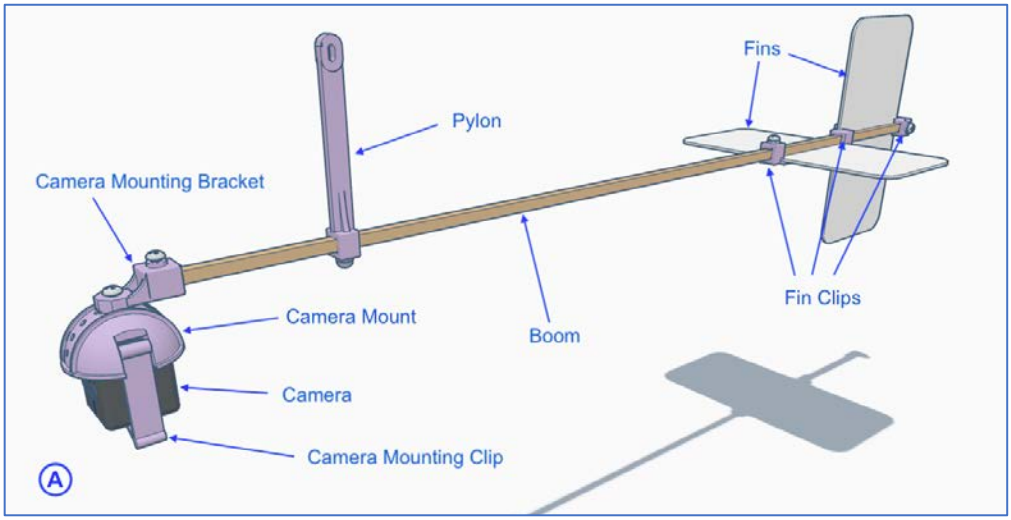


Figure 16 - (A) MiniCam Components Diagram

MiniCam Components

The MiniCam Aeropod system (Figure A) consists of the following components:

- Camera (Figure B)
- Camera Mount
- Camera Mounting Clip
- Camera Mounting Bracket
- Boom
- Pylon
- Fins (2)
- Fin Clips
- MicroSD Card (inserted in Camera – not pictured here

MiniCam Camera Detail (Sir Gawain G007 Model)

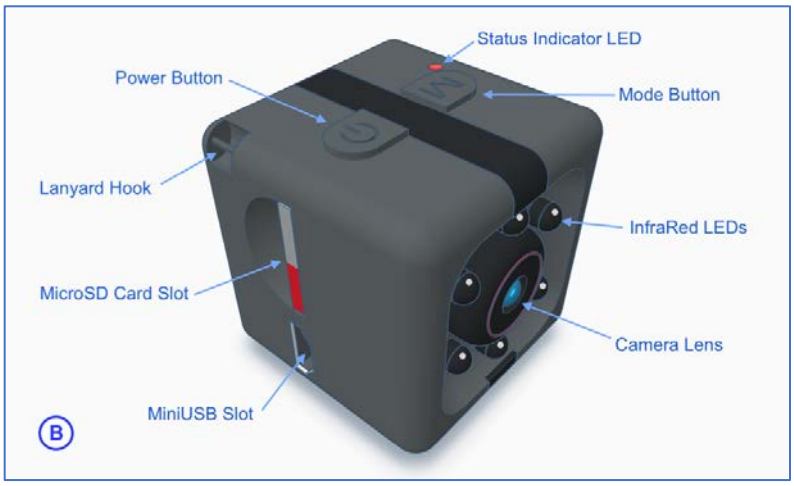


Figure 17 - (B) Sir Gawain G007 Camera Detail

Procedure for Installing the Camera into the Mount

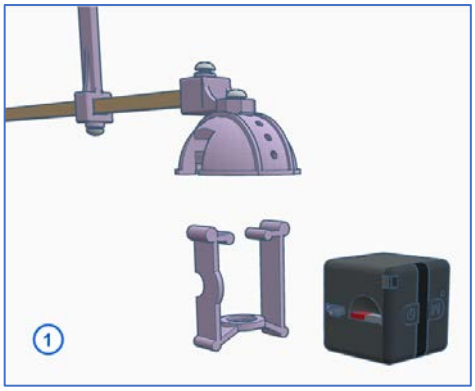


Figure 18 - Install Camera: Step 1

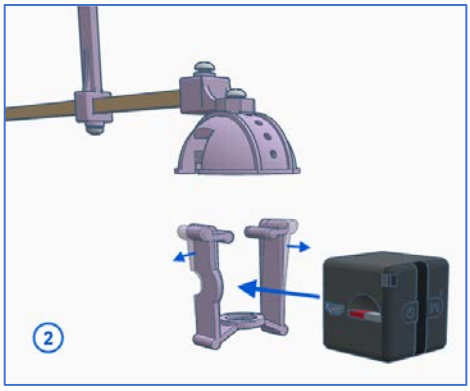


Figure 19 - Install Camera: Step 2

1. Insert the camera into the mounting clip (spread arms slightly if necessary). (Steps 1 and 2)
2. The camera lens should face the circular opening in the clip, and the MiniUSB slot should align with the clip arm cutout. (Step 3)

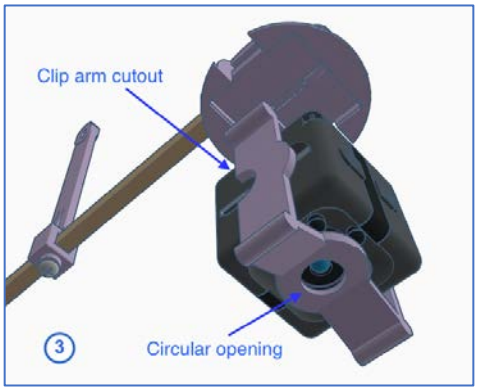


Figure 20 - Install Camera: Step 3

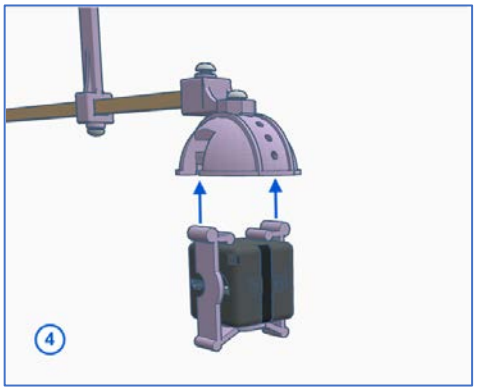


Figure 21 - Install Camera: Step 4

3. Slide the mounting clip and camera up into the mount until the clips lock in place. (Steps 4-5)
4. It may be necessary to spread the arms slightly (as in Figure 2) to get the clips into place.
   Note: Always check that there is no debris between the camera and the mounting clip filter.

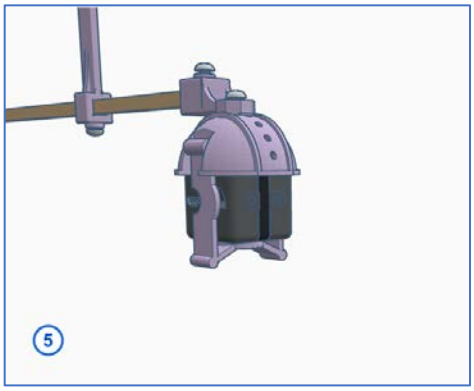


Figure 22 – Install Camera: Step 5

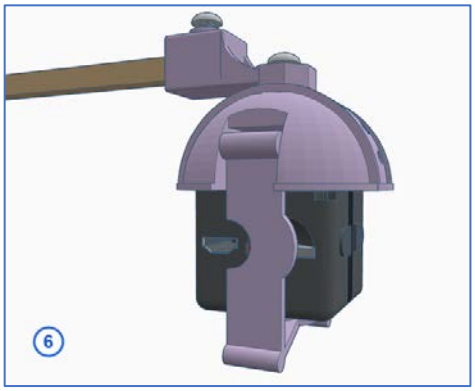


Figure 23 – Camera Installed

Changing the Camera Angle

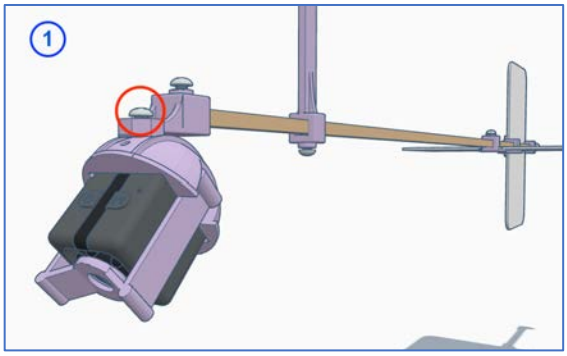


Figure 24 – Change Angle: Step 1

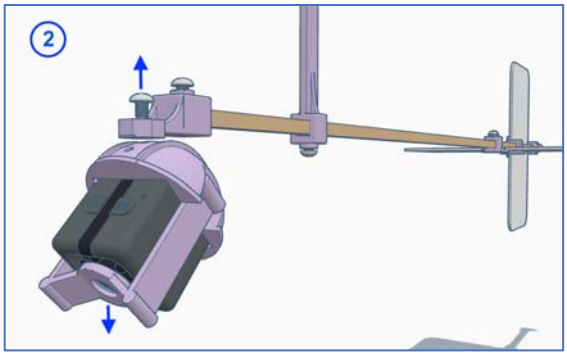


Figure 25 – Change Angle: Step 2

1. Unscrew the forward-most bolt on the camera mounting bracket until the camera mount releases. (Steps 1 and 2)

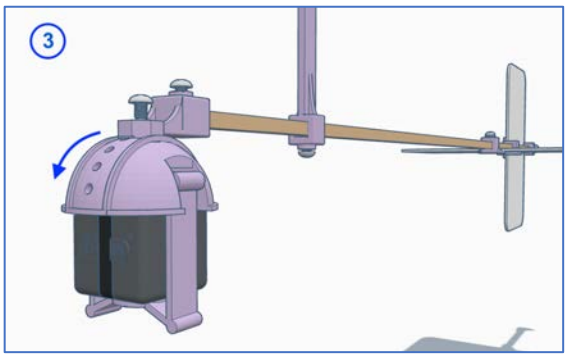


Figure 26 – Change Angle: Step 3

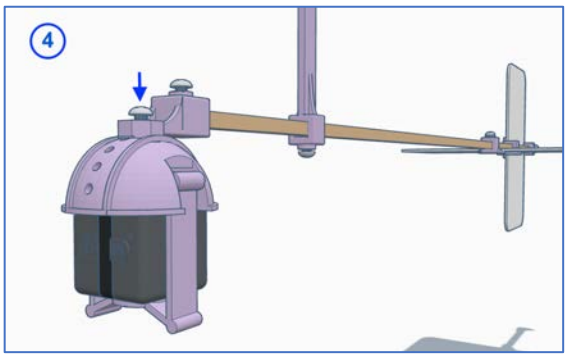


Figure 27 – Change Angle: Step 4

2. Adjust the mount angle, aligning the mounting bolt with one of the pre-set holes. (Step 3)
3. Re-attach the camera mount to the mounting bracket using the mounting bolt. (Step 4)
   IMPORTANT: Bolts should be just snug – do not overtighten!

Adjusting the Pylon to Balance the Aeropod

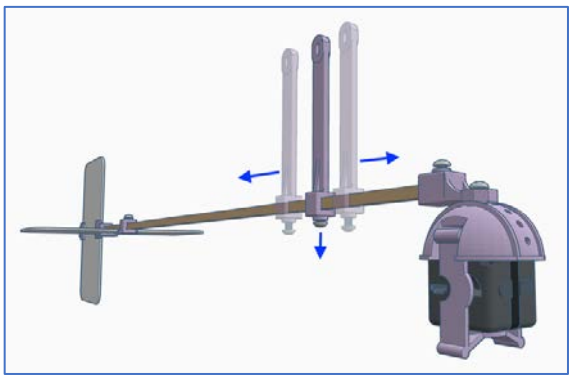


Figure 28 – Adjusting the Pylon

1. Unscrew the pylon mounting bolt until the pylon slides easily on the boom.
2. Move the pylon fore or aft along the boom until the Aeropod is balanced with a slight upward tilt to the nose (~5 degrees). Retighten the mounting bolt.

Installing the Fins and Fin Clips

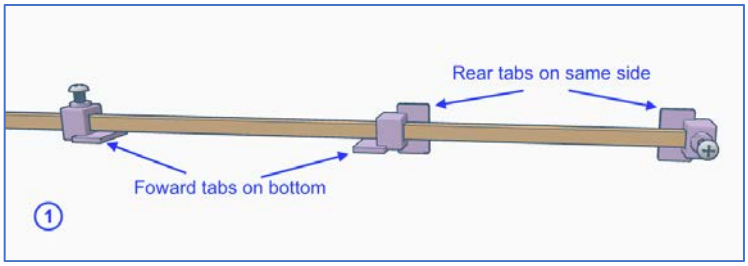


Figure 29 - Installing Fins - Step 1

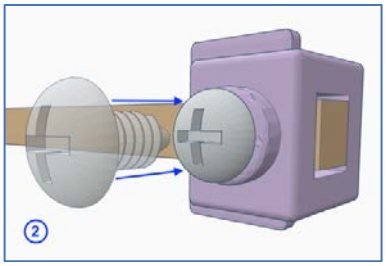


Figure 30 - Installing Fins - Step 2

1. Slide the FinClips onto the boom as shown in Step 1, with the forward clips' tabs on the bottom of the boom and the rear clips' tabs on the same side of the boom.
2. Tighten the rear clip holding screw at the end of the boom until it is snug. Do not overtighten. (Step2)

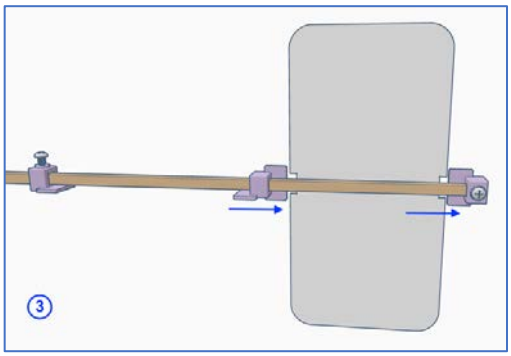


Figure 31 - Installing Fins - Step 3

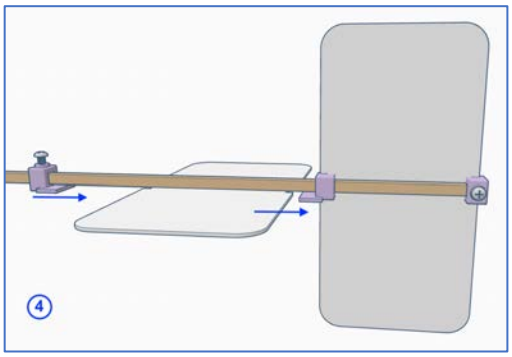


Figure 32 - Installing Fins - Step 4

3. Place the rear fin against the boom on the side with the tabs. Slide the fin and center clip toward the rear of the boom until the fin is locked in place. (Step 3).
4. Place the forward fin against the bottom of the boom and slide both it and the forward clip toward the rear until the fin is held in place. (Step 4)

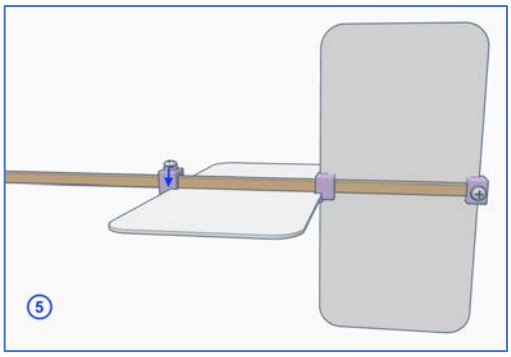


Figure 33 - Installing Fins - Step 5

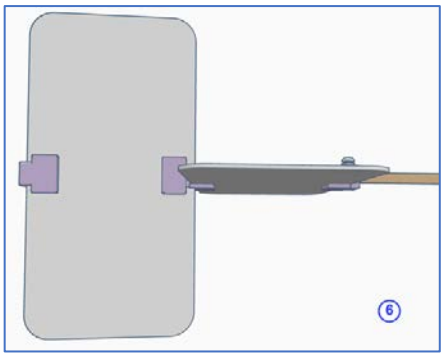
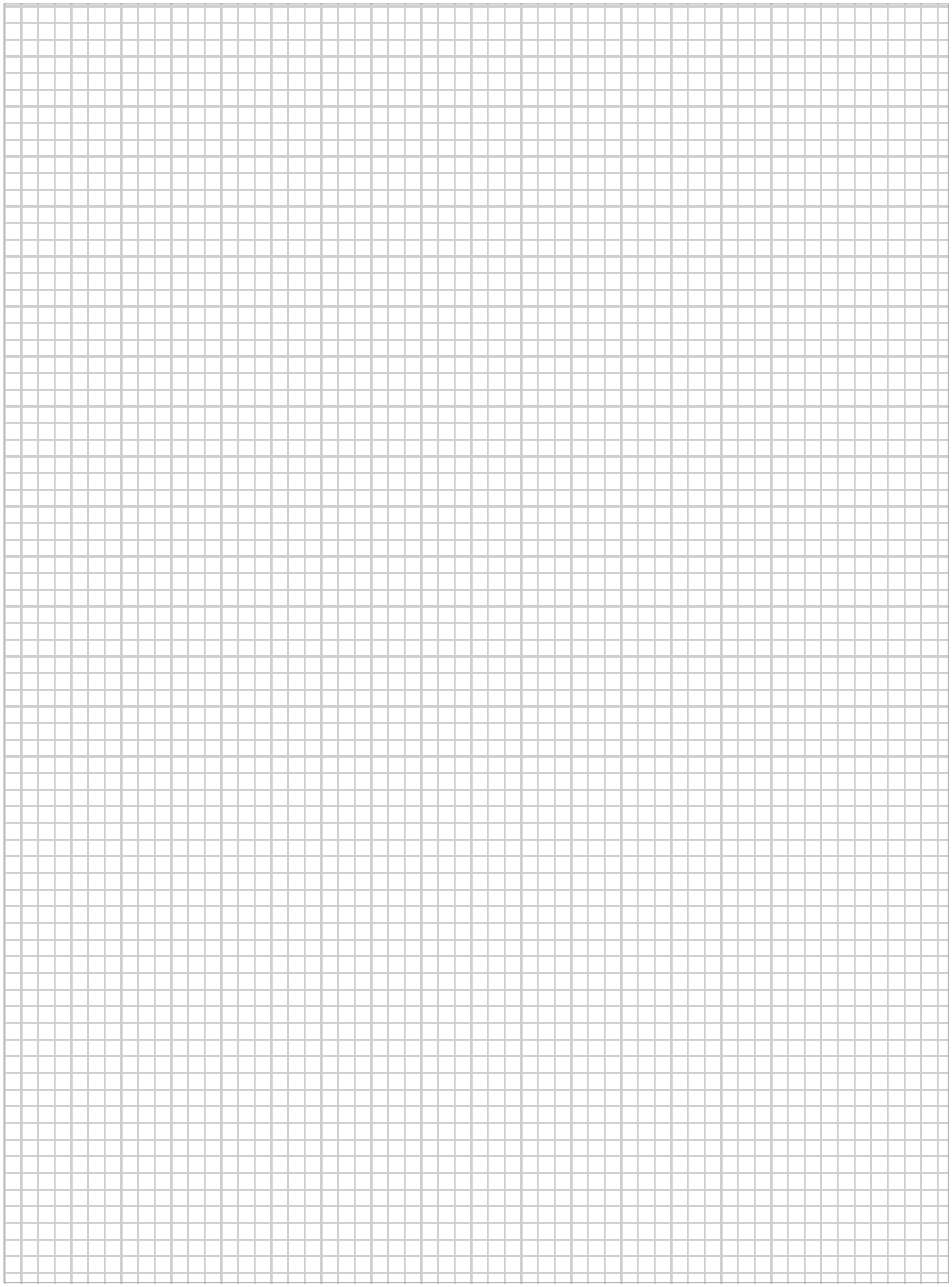


Figure 34 - Installing Fins - Step 6

5. With the fins and clips in place, tighten the forward clip holding bolt until it is snug (Step 5). The fins should be locked in place and appear as shown in Steps 5 and 6 (reverse view).

NOTES



AEROKATS

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To learn more about the AREN project, please visit:

https://www.globe.gov/web/aren-project/overview

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