PCL-VASI

Tri-Colored VASI

Operations Manual

Section 1: System Overview

The PCL-VASI Tri-Color Visual Approach Slope Indicator (VASI) is a ground-based visual aid designed to assist pilots in maintaining a safe and consistent glide path during the final approach to landing at airports and heliports. This system utilizes a multi-light unit that projects three distinct colors—red, green, and amber—to indicate the pilot's position relative to the desired glide slope. The system is intended for use at small airfields or heliports where simplicity and cost-effectiveness are prioritized over a more precise multi-device system like a multi-light Precision Approach Path Indicator (PAPI).

1.1 Key Components:

- **VASI:** A single optical assembly containing a redundant high-intensity LED light source and a color-filtering mechanism to emit red, green, or amber light based on the viewing angle.
- **Mounting Structure:** A stable, weather-resistant 3” Schedule 40 PVC pipe stand cemented 12” into the ground and standing 10” above ground for the airport version. 4” above ground for the heliport version.
- **Power Supply:** Requires 100-240V AC, 50-60Hz power, consuming approximately 12 watts for the 110v, 24 watts for the 220v.
- **Alignment Mechanism:** Adjustable mount to calibrate the VASI’s vertical angle to match the intended glide slope (typically 5–7° for general aviation and 6–8° for a helipad). Adjustment available is +3° vertically for each mount version. Example: Airport 5° mount version adjusts from 5-8° vertically. Heliport 7° adjusts from 7-10°. Custom mounts of any configuration are available.
- **Dual LED bulbs** for redundancy. A single bulb still allows for an effective view at night.
- **Lenses** - High quality lenses for increased optical clarity and transparency, designed specifically for outdoor use.

1.2 Purpose and Functionality:

The tri-colored VASI provides pilots with immediate visual feedback:

- **Red Light:** Indicates the aircraft is below the glide path.
- **Green Light:** Indicates the aircraft is on the glide path.
- **Amber Light:** Indicates the aircraft is above the glide path.

The system is designed for day or night use, with sufficient light intensity to be more or less visible from a distance of at least 0.5 statute mile under clear conditions under daytime conditions, and quite visible from much further distances at night. It is a passive system from the pilot’s perspective, requiring no onboard equipment beyond human visual observation. It aids pilots with vertical color cues during the final ½ mile of the approach to landing.

While the VASI can be seen at night from miles away, its effectiveness at those distances is very limited. It is not until the last ½ mile of the final approach sequence that the VASI becomes effective and the final ¼ mile is quite effective.

1.3 Limitations:

- Limited to Straight-In Approaches
    - PAPI provides guidance only along the extended runway centerline.

    - It does not give useful guidance for circling approaches, offset approaches, or curved flight paths.
- No Information on Alignment
    - PAPI only shows whether you're high, low, or on the glide slope.
    - It does not help with runway centerline alignment (unlike an ILS localizer or VASI with crossbars).
- Not Visible From All Angles
    - PAPI is designed for use on final approach.
    - From the side, on downwind, or in the traffic pattern, the lights do not provide useful or accurate information.
- Range Limitations
    - Effective viewing range is typically up to about 1 miles by day and up to 10 miles at night.
    - On longer approaches or in hazy conditions, it may not be visible early enough.
- Parallax and Aircraft Height Differences
    - Pilots of very large aircraft (e.g., with high cockpit heights) may see slightly different indications compared to smaller planes.
    - This can lead to a slightly higher threshold crossing height than intended.
- Environmental Factors
    - Fog, heavy rain, snow, or glare from the sun can reduce visibility of the lights.
    - Terrain or obstacles in the PAPI's line of sight can block or distort the signals.
- System Dependence
    - Requires proper installation, calibration, and maintenance. If aiming angles drift due to ground settling or poor maintenance, the guidance can become inaccurate.
- Single-Path Limitation
    - Unlike an ILS glideslope, which can support multiple approach paths (e.g., CAT II/III precision), a PAPI offers only a single nominal descent angle. Pilots cannot select different approach profiles.

1.4 VASI Elements & Views

Image 1 side view

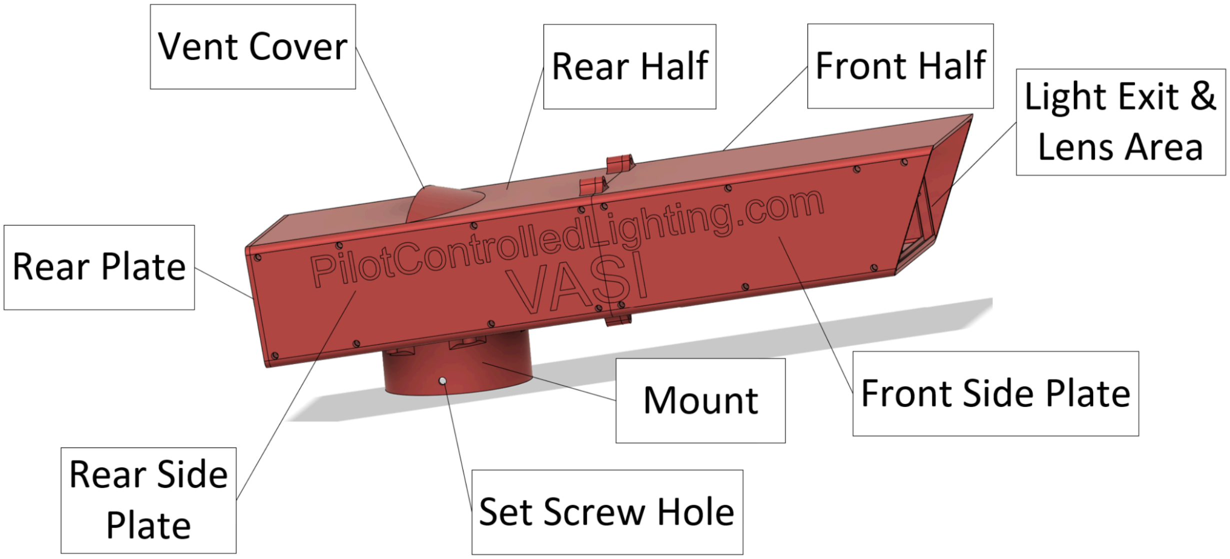
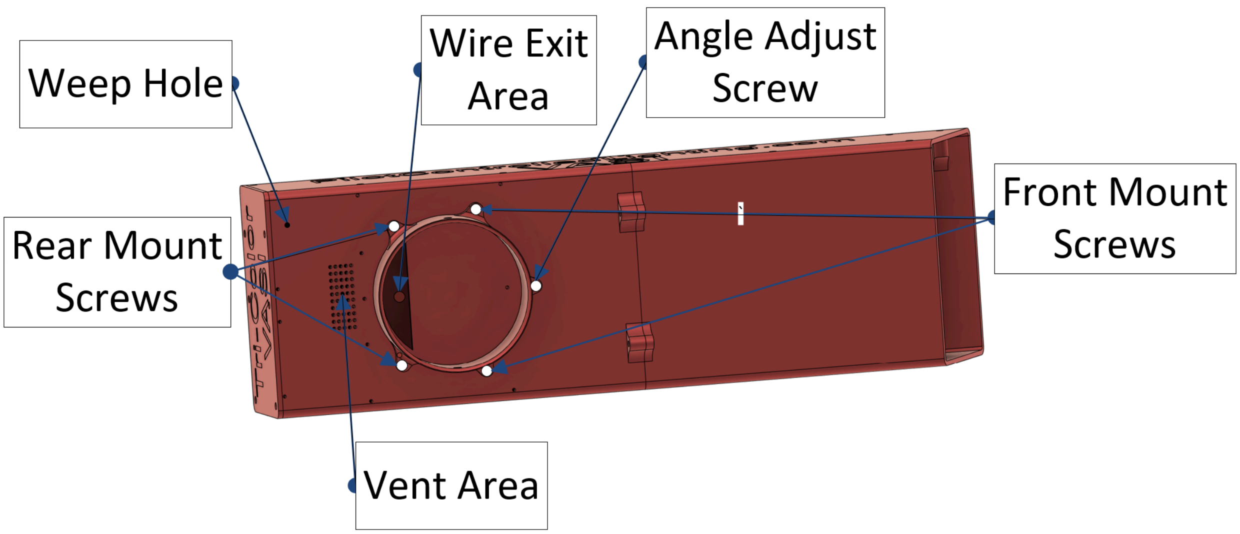


Image 2 Bottom View



n 2: Theory of Operation

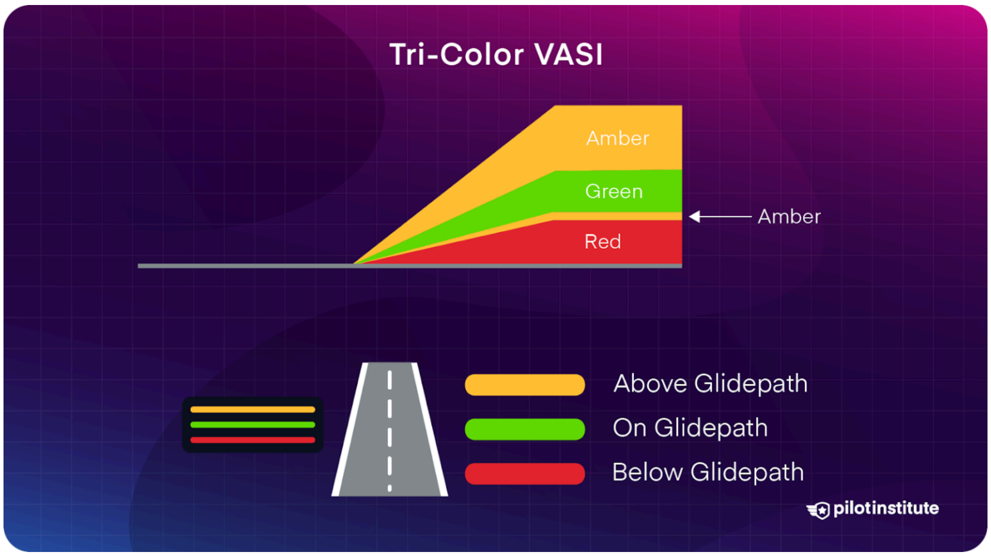
The tri-colored VASI operates on the principle of angular light projection, where the color observed by the pilot depends on their vertical position relative to the VASI's optical axis. This is achieved through a combination of optical design and precise alignment.

2.1 Optical Design:

- The VASI consists of two high-intensity LED lamps paired with a lens and color filter assembly.
- The lens is divided into three angular sectors, each corresponding to a specific color:

- **Lower Sector (Red):** Emits light at angles below the designated glide slope (e.g., <4.5°).
- **Middle Sector (Green):** Emits light along the glide slope (e.g., 5°–7.0°).
- **Upper Sector (Amber):** Emits light at angles above the glide slope (e.g., >8-14°).

- The transition between colors is sharp but not instantaneous, resulting in a narrow overlap zone where a faint "dark amber" may be visible due to color filter blending.



2.2 Glide Path Geometry:

- The system is aligned to project a nominal glide slope, typically set at 4–6° for general aviation and 6–8° for a helipad, though this can be adjusted based on runway length, terrain, or operational needs.
- The VASI is positioned to the left of the runway threshold (standard practice), approximately 200–300 feet from the threshold and 5–30 feet laterally offset, depending on site constraints.
- The vertical spread of the color zones ensures that a pilot at 1,000 feet from the threshold (about 0.2 miles) can distinguish the colors clearly, with the green zone spanning ~3° of vertical angle for a stable on-path indication.

2.3 Pilot Perspective:

- As the aircraft descends, the pilot observes the VASI through the windshield:
  - If too low (e.g., 2.5° approach angle), the red light dominates, signaling a need to increase altitude.
  - If on path (e.g., 5°), the green light is visible, confirming correct alignment.

    - If too high (e.g., 7°), the amber light appears, prompting a descent adjustment.
- The system's effectiveness relies on the pilot's ability to interpret the colors and adjust the aircraft's trajectory accordingly.

2.4 Environmental Considerations:

- The VASI is weatherproof and resistant to dust, moisture, and temperature extremes to maintain consistent output. Weep holes allow airflow to clear moisture and heat generated by the LEDs. All internal components are waterproof, so moisture penetration is not a concern.
- Atmospheric conditions (e.g., fog, rain) may reduce visibility, requiring pilots to rely on alternate cues.

2.5 Operational Sequence:

1. The airport light system is activated by the pilot transmitting on a discrete frequency to activate the runway lights and VASI (e.g., using a PCL-854 or similar pilot-controlled lighting device).
2. The pre-calibrated angle ensures the color zones align with the intended glide path.
3. Pilots approaching the runway use the color visual cue from the VASI to adjust their descent, maintaining the green light for an optimal approach to landing.

2.6 Airports vs Heliports

Helicopter VASI approach angles are typically higher than those for fixed-wing aircraft due to differences in their operational characteristics, safety requirements, and landing environments. Here's a concise explanation of the key reasons:

1. **Steeper Descent Capability**: Helicopters have greater maneuverability and can safely execute steeper descents compared to fixed-wing aircraft. A higher approach angle (e.g., 6°–8° for heliports vs. 4°–6° for runways) leverages this capability, allowing helicopters to descend more quickly into confined landing zones like heliports, reducing exposure to obstacles and minimizing hover time.
2. **Obstacle Clearance in Confined Areas**: Heliports are often located in urban or cluttered environments with tall obstacles (e.g., buildings, trees, power lines) near the landing zone. A steeper glide slope ensures helicopters clear these obstacles during approach, maintaining a safe vertical margin. For example, a 7° glide slope at 300 feet from the threshold places the helicopter ~36.7 ft above the surface (300 × tan(7°)), compared to ~15.7 ft for a 3° slope (300 × tan(3°)).
3. **Reduced Ground Roll and Hover Precision**: Unlike fixed-wing aircraft, which require a runway for rollout, helicopters aim to land precisely on a designated pad with minimal forward movement. A steeper approach reduces the need for extended

hover or forward taxiing, aligning with the helicopter's ability to transition directly to a hover or vertical landing, improving efficiency and safety in tight spaces.

4. **Wind and Turbulence Sensitivity**: Helicopters are more sensitive to low-level turbulence and wind gusts due to their lower approach speeds (typically 40–60 knots vs. 70–120 knots for small fixed-wing aircraft). A higher approach angle keeps the helicopter above turbulent ground layers longer, providing a more stable descent path and reducing the risk of rotor interference with ground obstacles.
5. **Pilot Visibility and Control**: During a steep approach, helicopter pilots maintain better visibility of the landing zone due to the nose-down attitude and slower speed. A higher VASI angle ensures the pilot can visually confirm the landing area earlier, aiding precise control. The VASI's color cues (red, green, amber) are calibrated to guide this steeper path, with a wider green band (e.g., 2°–3°) to accommodate the helicopter's dynamic flight profile.
6. **Regulatory and Design Standards**: Standards like FAA Advisory Circular 150/5390-2D (Heliport Design) and ICAO Annex 14 (Volume II, Heliports) recommend steeper glide slopes for heliports—typically 6°–8° or more—based on these operational needs. For instance, a 7° slope is common for hospital heliports to ensure rapid, safe approaches over urban obstacles.

In contrast, fixed-wing aircraft use shallower angles (e.g., 3°–6°) to maintain stable, fuel-efficient descents suited to longer runways, where obstacle clearance is less critical and glide path precision is supported by systems like PAPI or ILS, or non precision VASI's. For helicopters, the steeper angle aligns with their unique flight dynamics and landing constraints, prioritizing safety and operational efficiency in compact environments.

Section 3: Assembly From Shipping

1. After unboxing, inspect all the components for any shipping damage. Ensure that all the components are in their place.
2. The device arrives in 3 sections, front, rear, and mount sections. The LED bulbs are pre-installed in the rear section and the sockets for the bulbs are lubricated with a rust inhibitor. There is an o-ring pre-installed on each LED bulb that prevents moisture intrusion into the bulb socket. The bulb socket is waterproof.
3. Begin assembly by joining the front and rear sections with the four 4mm allen screws using the 3mm allen wrench provided no washers.
4. Take the mount and install the rear 2 screws and the front 2 screws loosely onto the VASI light assembly no washers. Ensure the angle adjust screw in the mount does not extend beyond the thread so that the VASI can sit flush with the mount for now. Image 2 Bottom View.
5. The VASI assembly is now ready to be installed.

Section 4: Choosing a Location to Install

Selecting the proper location for your PCL-VASI is critical to ensuring its effectiveness, visibility, and safety for pilots during approach and landing. The installation site must balance runway geometry, terrain features, and operational requirements while maintaining clear sightlines and compliance with basic aeronautical principles. While this system is not subject to current FAA certification unless used at a regulated airport, the following guidelines draw from general aviation standards to optimize performance.

4.1 General Placement Guidelines:

- **Runway Side:** Position the VASI unit on the left side of the runway threshold (from the pilot's perspective on approach), as this is the conventional standard for visual aids. If site constraints require placement on the right, ensure pilots are briefed accordingly.
- **Distance from Threshold:** Install the unit approximately 200–300 feet beyond the runway threshold. This distance allows the glide path to intersect the runway at a practical point for touchdown, typically 400–600 feet from the threshold, depending on the runway length and glide slope angle (e.g., 5°).
- **Lateral Offset:** Place the unit 5–10 feet laterally from the runway edge to avoid interference with aircraft wings or ground operations while keeping it within the pilot's peripheral vision.
- **Height Above Ground:** The international standard for runway edge lights is 14" above ground to the top of the light. For a VASI installed close to the runway, a 3" PVC pipe cemented 12" into the ground and extending 10" above ground provides adequate clearance for aircraft.
- **Bollards:** Required to protect the VASI, as described in Section 5: Bollard & VASI Stand Installation.
- **Other Lights:** There should be no other lights within 50'' of the VASI to avoid color wash out, discoloring, or mis-identifying the VASI on approach. While it may be convenient to wire the device to an adjacent runway light, ensure that the runway light is disabled if it is near the VASI.

4.2 Glide Path Alignment:

- The location must support the intended glide slope, (e.g. 5°), determined by the vertical angle of the VASI relative to the runway aiming point. Below are some calculation examples for height and distance to help support your install location.
    - A 5° glide slope starting 300 feet from the threshold requires the VASI to project green at approximately 26.2 feet above the runway threshold at that point. This is calculated as:

        - Height = Distance × tan(Glide Slope Angle) = 300 ft × tan(5°) ≈ 300 ft × 0.0875 ≈ 26.2 ft.
    - To achieve this, the VASI unit, mounted 10 inches (0.83 ft) above ground, must be positioned such that its optical axis aligns with the 5° glide path, intersecting the runway at the desired touchdown point (typically 400–600 feet from the threshold).
    - For a touchdown point 500 feet from the threshold, the glide path height at the threshold is:
        - Height = 500 ft × tan(5°) ≈ 500 ft × 0.0875 ≈ 43.8 ft above runway surface.
    - Adjust placement farther or closer if terrain slopes upward or downward, ensuring the green zone (e.g., 4°–6°) aligns with the desired touchdown zone. For example:
        - If placed 200 feet from the threshold, the green zone would be ~17.5 ft high (200 ft × tan(5°) ≈ 17.5 ft).
        - If placed 400 feet from the threshold, the green zone would be ~35.0 ft high (400 ft × tan(5°) ≈ 35.0 ft).
- Avoid locations where the glide path would intersect obstacles (e.g., trees, buildings) before the runway. For a 5° glide slope, the path rises more steeply than a 3° slope, requiring greater clearance:
    - At 1,000 feet from the VASI, the glide path is ~87.5 ft high (1,000 ft × tan(5°) ≈ 87.5 ft).
    - Ensure no obstacles encroach within a 6° vertical arc (e.g., 2°–8°) to maintain visibility of the red, green, and amber zones.

Practically speaking, installing the VASI ~300’ from the threshold, with a 5° inclination on the VASI is a good starting point and the actual alignment will be adjusted during commissioning.

4.3 Terrain and Obstacle Considerations:

- **Flat or Graded Area:** Choose a site with level or easily gradable terrain to simplify installation and alignment. Uneven ground may require precise angle adjustments.
- **Obstacle Clearance:** Ensure no obstructions (e.g., power lines, fences, vegetation) block the light’s projection within a 5° vertical and 10° horizontal arc from the unit toward the approach path, covering the pilot’s viewing range out to 0.5–3 miles.
- **Approach Path Visibility:** Verify the light remains visible from at least 0.5 statute miles in clear conditions, avoiding sites behind hills, dense tree lines, or structures.

4.4 Environmental Factors:

- **Weather Exposure:** Select a location sheltered from extreme wind gusts or flooding but accessible for maintenance. Avoid low-lying areas prone to standing water that could damage the power supply or VASI.
- **Lighting Interference:** Position the VASI away from any artificial lights (e.g., hangar floodlights, road lamps, runway edge lights) that could wash out the red, green, or amber signals, especially at night. Maintain at least 50’ distance from other lights.
- **Snow or Vegetation:** In regions with heavy snow or tall grass, clear the area seasonally to prevent obscuring the light.

4.5 Accessibility and Power:

- **Maintenance Access:** Choose a site reachable by foot or vehicle for installation, calibration, inspection and repairs. Avoid remote or hazardous locations that complicate upkeep.
- **Power Availability:** Ensure proximity to a power source.

4.6 Site-Specific Adjustments:

- **Short Runways:** For runways under 2,000 feet, position the VASI closer to the threshold (e.g., 150–200 feet) and consider a steeper glide slope (e.g., 6°–7°) to accommodate shorter landing distances, if pilot training supports this.
- **Terrain Slope:** If the runway slopes uphill, move the unit slightly closer to the threshold to keep the glide path within the runway surface. For downhill slopes, extend the distance slightly or adjust the mounting height.
- **Dual-Approach Runways:** If the runway serves approaches from both ends (e.g., Runway 18/36), install a second unit at the opposite end.

Section 5: Bollard & VASI Stand Installation

Protecting the PCL-VASI from accidental impact by vehicles, mowers, or other ground equipment is **critical**, as even slight misalignment can lead to unsafe glide path indications and deadly results. Four bollards are installed around the device to create a protective barrier. These bollards are constructed from 1.5-inch diameter Schedule 40 PVC pipe, anchored 6 inches into the ground and extending 10 inches above the surface, secured with cement. The VASI itself is mounted on a 3” Schedule 40 PVC pipe stand, cemented 12” into the ground and extending 10” above ground. These bollards are not meant to stop a vehicle from hitting the VASI, but intended as a deterrent from doing so. It is assumed that the airport environment is already secured from intruders and closely monitored for vehicles coming and going. Your location may require the device be elevated beyond the reach of a snowmobile perhaps, and surrounded by more effective bollards that can actually stop a vehicle from hitting it.

5.1 Materials Required:

- **Note: All PVC lengths below are warm climate depths. Check your area for your frost line depth requirements to prevent freezing upheaval of the mount.**
- **PVC Pipe Bollards:** Four lengths of 1.5-inch diameter Schedule 40 PVC pipe, each cut to 16 inches (6 inches below ground + 10 inches above ground). Four 1.5-inch sch40 PVC caps for them.
- **PVC VASI Stand:** One 3” Schedule 40 PVC pipe, 22” long (12” below ground + 10” above ground).
- **Cement:** Quick-setting concrete mix (e.g., one 80 lb bag, sufficient for four 6-inch deep, 6-inch diameter holes for bollards and one for the VASI stand; approximately 0.6 cubic feet total).
- **Tools:** Post-hole digger or auger, tape measure, level, hacksaw (if cutting PVC), mixing bucket, shovel or trowel, water source, marker or spray paint, inclinometer or digital level for VASI adjustment.
- **Optional:** Reflective tape or high-visibility paint for enhanced nighttime visibility.

5.2 Layout:

- **Positioning:** Arrange the four bollards in a rectangle or square surrounding the VASI, ensuring the light’s projection path remains unobstructed. See Appendix A: Bollard Layout for a recommended configuration.
- **VASI Position:** Note that the VASI mount is not centered on the bottom of the VASI. Refer to Appendix A for precise placement relative to the bollards.
- **Power:** Consult your electrician for getting power to the device. You will need enough power to run ~11 watts.

5.3 Installation Steps:

1. **Mark Locations:**
   - Use a tape measure and marker or spray paint to mark the four bollard positions and one VASI stand position based on the layout in Appendix A.
   - Verify alignment with a straightedge or string to ensure a neat arrangement.
2. **Dig Holes:**
   - With a post-hole digger or auger, excavate four holes for bollards, each 6 inches deep and approximately 6-8 inches in diameter, and one hole for the VASI stand, 12 inches deep and 8-10 inches in diameter.
   - Clear loose dirt from the bottom of each hole to provide a firm base.
3. **Prepare PVC Pipes:**

- Airports
    i. Cut four 16-inch lengths of 1.5-inch PVC pipe and one 22-inch length of 3” PVC pipe using a hacksaw.
- Heliports
    i. Cut four 10-inch lengths of 1.5-inch PVC pipe and one 16-inch length of 3” PVC pipe using a hacksaw, if not pre-cut.
- Deburr the cut ends with sandpaper or a utility knife for safety and a clean fit.

4. **Electrical power**:
    - Bring power to the device by placing it in the ground and preparing to bring it inside the 3” PVC stand with at least 6” of excess cable run that will allow the connection of the device later.
5. **Mix Cement:**
    - In a bucket, mix the quick-setting concrete with water per the manufacturer’s instructions (typically 1 part water to 4 parts mix) to a thick, workable consistency.
    - Prepare enough to fill all five holes (about 0.6 cubic feet total).
6. **Set Bollards and VASI Stand:**
    - Pour 2–3 inches of wet concrete into the bottom of each hole.
    - Airports
        i. For bollards, insert a 1.5-inch PVC pipe vertically, centering it until 10 inches remain above ground.
        ii. For the VASI stand, insert the 3” PVC pipe while pulling the power wire through the PVC until 10 inches of PVC remain above ground. Leave the excess wire outside the PVC dangling over the top for now.
    - Heliports
        i. For bollards, insert a 1.5-inch PVC pipe vertically, centering it until 4 inches remain above ground.
        ii. For the VASI stand, insert the 3” PVC pipe while pulling the power wire through the PVC until 4 inches of PVC remain above ground. Leave the excess wire outside the PVC dangling over the top for now.
    - Hold each pipe plumb(use a bubble level) and fill the hole with concrete up to ground level, tamping it down with a trowel to remove air pockets.
    - Repeat for all bollards and the VASI stand, checking alignment between them.
7. **Cure and Adjust:**
    - Allow the concrete to cure for at least 4–6 hours (or per mix instructions) before disturbing the pipes. Full strength typically takes 24–48 hours.
    - During and after initial curing, verify each pipe is plumb with a level and adjust if needed before the cement fully hardens.
8. **Paint or Tape:**
    - After curing, paint the bollards and VASI pipe stand with a bright orange color spray paint or reflective tape so that it can be easily seen. Krylon K02718007

Popsicle Orange Fusion All-In-One Paint & Primer Spray Paint has shown to be effective on PVC after a light scuffing with 200 grit sand paper.

9. **Wiring:**
    - Have your electrician wire the VASI using your local standards and code requirements for water tight connections. Extensions have been pre-wired to the bulb sockets to facilitate ease of connection to your power circuit. The wires with the red stripe (or solid red) are the hot leg, and the wires without the red stripe are the neutral.
    - Watertight silicone filled wire nuts work well in these cases but be sure to consult your electrician for proper code requirements. Ensure the device is disconnected until the unit has been commissioned. It is designed to slip on and off of the PVC stand for ease of maintenance. You may wish to use temporary connections at the VASI during testing to allow for removal of the VASI for installing front mount shim washers

Section 6: Commissioning the Device

Commissioning the PCL-VASI is the final step to verify that the system is fully operational, correctly aligned, and safe for use by pilots during approach and landing. This process confirms that the VASI's LED light unit projects the intended red, green, and amber signals along a glide slope with the center green zone visible (between 5° and 7°for airports, and 7-9 degrees for heliports), integrates with the pilot-controlled lighting (PCL) system, and meets performance expectations for visibility and reliability. Commissioning ensures the system supports safe descents to the runway or heliport, particularly for the final 0.5 mile of approach, as described in Section Glide Path Geometry. Using a drone is a wonderful tool during this process. You can expect this to take 2-3 evenings at sunset to make adjustments, and perform final tests for commissioning.

6.1 Objectives of Commissioning:

- Verify that the VASI projects accurate color signals for your desired glidepath (e.g. red below 4°, green 4°–7°, amber above 7°) aligned with the glide slope centered at ~5°, intersecting the runway at the desired touchdown point (e.g., 400–600 feet from the threshold).
- Confirm that the system activates reliably via the PCL-854 system controller and maintains stable power (100-240V AC, ~11 watts).
- Ensure the installation (3" PVC stand, 1.5" PVC bollards, wiring) is secure, weatherproof, and does not obstruct the light's 10° vertical and 10° horizontal projection arc.
- Validate visibility of the VASI's signals from at least 0.5 statute miles in clear conditions, day and night, under visual meteorological conditions (VMC).
- Document performance for pilot briefings and maintenance records, noting the transitional "dark amber" zone (Limitations) to ensure correct interpretation.

6.2 Pre-Commissioning Checklist: Before testing, ensure the following are complete (refer to Sections 3–4):

- **Site Preparation (Section 4: Choosing a Location to Install):** The VASI is installed 200–300 feet beyond the threshold, 5–30 feet laterally offset, with no obstacles blocking the projection arc.
- **Physical Installation (5.3 Installation Steps:):** The 3” PVC stand (12” below, 10” above ground) and four 1.5” PVC bollards (6” below, 10” above ground) are cemented, level, and stable.
- **Wiring:** A licensed electrician has installed and tested the 100-240V AC circuit, connections, PCL-854 controller, and grounding system per NEC standards.
- **Initial Power-On Test:** The VASI powers on without flickering, and the PCL system activates the unit when triggered by the designated radio frequency (e.g., 3, 5, or 7 clicks).

6.3 Commissioning Procedure: The commissioning process involves systematic testing and alignment, ideally conducted by a team including the installer, an electrician, safety spotter, and a pilot or aviation consultant familiar with VASI operation. Perform tests during both daytime and nighttime to account for varying light conditions. Using a drone is an ideal method but aircraft works too. You can expect this to take 2-3 evenings at sunset to make adjustments, and perform final tests for commissioning.

1. **Verify Physical Installation:**
    - Inspect the VASI stand and bollards for stability, ensuring no movement or settling in the cement bases. Check plumbness of the VASI stand and bollards.
    - Confirm the VASI’s height (<14” above ground) meets with the runway edge light standard (<14” to top of the VASI).
2. **Test Electrical System:**
    - With the electrician present, activate the VASI via the PCL system by transmitting the designated frequency (e.g., 3 clicks for low intensity, 5 for medium, 7 for high).
    - Verify activation occurs within 1–2 seconds and the unit remains on for the programmed duration (typically 15 minutes).
    - Measure voltage at the VASI’s enclosure to ensure it falls within supply voltage requirements (e.g. 120vac), and confirm current draw is ~11 watts using a clamp meter.
    - Check for no flickering or dimming in the LED output, indicating stable wiring and supply voltage.
3. **Prepare the VASI mount for adjustment**
    - Remove the front mount screws see image 2 bottom view
    - Loosen the rear mount screws see image 2 bottom view
    - The VASI should have 3 points of contact now with the mount, the 2 rear screws quite loose, and the front angle adjust screw.

- Adjust the VASI inclination using a digital level or inclinometer to the desired approach angle. ~5° for airport, or 7° for heliport using the angle adjustment screw see image 2 bottom view. Use a digital level or inclinometer, or phone inclinometer app sitting on the top of the VASI as your indication of angle.
- Stand ~20' behind the VASI, looking towards your approach path and align the VASI to a point on the extended runway centerline ~ 1/2 mile final.
- Check that reflective tape or high-visibility paint on bollards (Section 4.4) is intact for ground crew visibility.

4. **Brief the team**
    - Discuss what you are trying to accomplish and how you will communicate
    - **To the pilot** - Your feedback during the process is the key to the adjustments and to the safety of you and the others that follow you on the approach. While the degrees and angles of the math are interesting and important during setup, **nothing can take the place of your experience on what 'feels right'**. Tell the ground crew if at any time it does not feel right.
    - Ensure good communications equipment and communications process has been established
    - Keep other planes, people, vehicles and equipment away from the area so you can focus on the task at hand and not be distracted.
        - Safety Considerations:
            - Conduct tests in coordination with airfield users to avoid disrupting active operations.
            - Ensure no personnel stand in the VASI's projection path during high-intensity tests to avoid eye discomfort.
            - If alignment issues persist, consult an aviation lighting specialist before use to prevent unsafe glide path indications.
            - For public or certified airfields, obtain formal approval from aviation authorities (e.g., FAA), as tri-colored VASIs are non-standard (Section 3.7).
5. **Calibrate and Verify Glide Slope Alignment:**
    - Prepare an aircraft or drone during daytime around sunset is best, to fly the approach and check for glideslope.
    - Have the aircraft initially check for the Amber above glide slope viewing angle. Ensure that the pilot is well above the intended glide slope for altitude and distance from the touchdown zone.
    - Have the aircraft continue to make approaches and go-arounds giving feedback over the radio to the grounds crew on color viewing , height above ground, and distance starting high on the glide path, and slowly working down the glidepath angle until red is seen at the desired approach angle. ⚠️ NOTE: Its very important that even well into the red below glidepath zone, that the aircraft is not in any danger of impacting any obstacle or terrain. A pilot must be able to enter the red zone, begin correcting, and get back into the green

zone without any danger of impacting any obstacle or terrain. It is also important that the pilot's feedback be taken into consideration about what ‘feels good and safe’. While a pilot might clear obstacles while in the red zone, does the pilot feel good about being there? Was the pilot uncomfortable there? Will all pilots feel comfortable there? Did it feel too low? If so, raise the approach glidepath angle to accommodate the pilots feedback. **Ultimately, what feels right to pilots is what the adjustment should be set to. A pilot should be able to fly the upper portion of the red zone the entire approach and not be in any danger of hitting anything, and feel comfortable doing so in the process.** You should also consider that any private pilot should be able to safely execute a VASI approach in the upper portion of the red zone.

    - Make any adjustments necessary using the adjustment angle screw and the digital level or inclinometer.
    - From these points, confirm:
        - **Red** is visible below ~5° (e.g., <26.2 ft at 300 ft, 300 × tan(5°)).
        - **Green** is visible between 5°–7° (e.g., 26.2–36.8 ft at 300 ft).
        - **Amber** is visible above ~7° (e.g., >36.8 ft at 300 ft).
    - Note the “dark amber” transition zone between green and red, ensuring it’s brief and not mistaken for amber (Section 1.3).
    - Adjust the VASI’s alignment screw if colors do not align with the 5°–7° green zone, rechecking until accurate.
    - Gather feedback to ensure the green zone feels stable and the red/amber cues prompt appropriate corrections.
    - Document what you're doing, the pilot's feedback, and adjustments made. Document the final inclination of the VASI now. It will be needed later.
6. **Confirm Visibility and Intensity:**
    - From 0.5 statute miles out, verify all colors are distinguishable in clear conditions at dusk and at night.
    - At night, ensure the LED intensity is sufficient without glare, matching the 0.5-mile visibility requirement (Section 1.2).
7. **Complete VASI installation**
    - Measure the final VASI inclination and document it in the maintenance log
    - Gently pull the VASI and mount off the PVC stand and install shim washers (included) if needed between the mount and the VASI on the front screw holes along with the two 4mm allen screws you removed earlier. Screws to be snug, NOT TIGHT.
    - Complete the wiring if necessary using waterproof connections
    - Install the VASI and mount back onto the PVC stand and verify the inclination matches your final inclination value. Reshim and adjust as necessary.
    - Step back and adjust the VASI onto the approach path pointed to ~.5 mile final as you did before.

- Install the 2 mount set screws provided (#8x5/8 self tapping 316ss) into the PVC stand by pre-drilling a ⅛ in pilot hole into the PVC centered in the mount hole (see [image 1 side view]). Use the provided drill guide and insert the drill guide into the mount and drill the pilot hole.

8. **Final verification flight**
   - Have the pilot fly the complete flight profile using the same process and people as tested and documented earlier starting at sunset and finishing in darkness.
   - Ensure that all the test points are aligned with expectations as tested earlier.
9. **Document Results:**
   - Record test results, including:
     - Glide slope angles (e.g., green zone 5°–7°).
     - Visibility distance (e.g., confirmed at 0.5 miles).
     - Any alignment adjustments made.
     - Pilots perceptions and feedback
   - Update the maintenance log with commissioning date, electrician's certification, and observer names.

6.4 Maintenance Notes:

- Schedule an initial post-commissioning check after 30 days to ensure alignment and wiring remain stable.
- Re-verify glide slope alignment annually or after any ground disturbance (e.g., heavy storms, vehicle impact on bollards).
- Check the LED bulbs monthly to ensure they are working.
- Document all checks in the maintenance log, noting any recalibration or repairs.

Section 6 Maintenance

6.1 Scheduled Maintenance Checks

- Monthly Maintenance Checks
  - Check the bollards and VASI stand for cracks, leaning, or loosening due to soil settling or impact.
  - Reapply reflective tape or paint as it fades from weather exposure.
  - Clear vegetation or debris around the bollards and stand to maintain visibility and access.
  - Inspect the VASI for clearness of the lens's. Ensure no critters have penetrated the VASI and are perhaps impeding the light
  - Check both LED bulbs are functioning
- Annually or after any ground disturbance (e.g., heavy storms, vehicle impact on bollards)

    - Re-verify glide slope alignment with an inclinometer and a flight test

6.2 LED Bulb or Socket Replacement

The VASI is shipped with PAR 20,LED Bulbs. Follow the steps below to replace the bulb

- Disconnect power from the device
- Remove the front half portion of the PAPI by removing the four 4mm screws that hold the halves together using a 3mm allen wrench. Set the front section aside.
- Remove the rear section side plate cover.
- Remove the rear section rear cover plate.
- Remove the slot lens filter.
- Remove the rear vertical divider.
- Remove the 2 bulb retaining screws on the front of the bulb to be removed.
- While holding the bulb socket from the rear with one hand, unscrew the bulb from the socket with the other. Bulbs are snug due to the o-ring seal.
- If replacing the bulb socket:
    - Remove the rear plate
    - Check and document the PAPI inclination with a digital level or inclinometer
    - Remove the PAPI and mount from the stand and disconnect the wiring
    - Pull the wires out of the PAPI through the rear for the socket to be removed
    - Remove the socket by pushing it forward and remove
    - Replace the socket in reverse of this section of steps. The PAPI should be back on the mount when done and the inclination verified to match the original position.
- Replace the bulb
- Reassemble following the steps now in reverse keeping in mind that the screws only need to be snug, NOT tight. About 1/16th of a turn beyond where you feel resistance is just fine.

6.3 Lens Cleaning

The clear lens, positioned in front of the colored lenses, acts as a protective barrier to shield them from damage. Generally just a wipe of a soft cloth with some glass cleaner is all that is required to keep the lens area clean. If the colored lens's need cleaning the following procedure can be used to remove and clean them

- Disconnect power from the unit
- Remove the front side plate (Image 1 side view)
- Slide out the clear lens, and then each colored lens
- Clean and install in reverse
- Ensure that the colored lens panels are fully seated and are sitting just proud of the body before putting the side panel back on. Do not force the side panel. Everything should fit back together nicely.

6.4 VASI Disassembly & Assembly

If for some reason you find it necessary to completely disassemble the unit, it is a very straightforward process. Take some pictures along the way

- Disconnect power from the device
- Check and document the VASI inclination with a digital level or inclinometer
- Remove the VASI from the stand and take it to a workbench for disassembly
- Remove the mount from the VASI and document any shim washer locations
- Split the VASI body into the front and rear halves by removing the four 4mm screws (3mm allen)
- From here, work on each half separately
  - Front half:
    - Remove the front side plate Image 1 side view
    - Remove the clear and colored lens Image 4 Rear Half Front View
    - Remove the light dividers Image 4 Rear Half Front View
  - Rear half
    - Remove the rear side plate cover. Image 1 side view
    - Remove the slot lens filter Image 4 Rear Half Front View
    - Remove the rear vertical divider. Image 4 Rear Half Front View
    - Remove the 2 retaining allen screws on the front of the bulb to be removed and remove the bulb.
    - Remove the bulb sockets by pushing them out of their mount from the rear to the front

Section 7 Specifications

1. **Physical Device** Acrylonitrile Styrene Acrylate (ASA) plastic
   a. **Excellent Weather Resistance**: ASA is highly resistant to UV radiation, moisture, and weathering, maintaining color, gloss, and mechanical properties in outdoor conditions for extended periods.
   b. **UV Stability**: Unlike ABS, ASA resists yellowing and degradation when exposed to sunlight, making it ideal for outdoor applications.
   c. **High Impact Resistance**: It offers toughness and durability, capable of withstanding impacts without cracking.
   d. **Good Chemical Resistance**: ASA resists many chemicals, including alcohols, weak acids, oils, and some cleaning agents, though it may be vulnerable to certain concentrated chemicals.
   e. **Heat Resistance**: It performs well at temperatures up to ~85–100°C, with better long-term heat stability than ABS.
   f. **Mechanical Strength**: ASA is rigid, stiff, and strong, with properties similar to ABS but enhanced for outdoor use.
   g. **Low-Temperature Performance**: With a lower glass transition temperature (~100°C vs. ABS’s 105°C), it maintains flexibility in colder conditions.

    h. **Scratch Resistance**: Its surface is less prone to visible scratches, preserving aesthetic appeal.
    i. **High Gloss and Color Stability**: ASA provides a smooth, glossy finish and retains vibrant colors over time, even under harsh conditions.
    j. **Good Processability**: It can be easily processed via injection molding, extrusion, thermoforming, 3D printing (FDM), and blow molding, allowing for complex shapes.
    k. **Antistatic Properties**: ASA reduces static buildup, useful in certain applications.
    l. **Compatibility with Other Plastics**: It blends well with materials like PVC and polycarbonate, forming compounds like ASA-PVC or ASA/PC.
    m. **Weldability and Adhesion**: ASA can be welded (ultrasonic or solvent-based) to itself, ABS, PVC, or SAN, and is compatible with certain adhesives (e.g., epoxies, acrylic-based).
    n. **Recyclability**: While not biodegradable, ASA can be recycled, and some manufacturers offer recyclable or bio-based grades.

2. **Dimensions**
    a. VASI 455mm x 143mm x 78mm
    b. Mount 114mm dia. x 42mm height
    c. Height above ground with mount for heliport 161mm (6.34in)
3. **Weight** 860g
4. **Electrical**
    a. Comes in both 120vac 60hz and 240vac 50-60hz
    b. ~11 watts of power draw
5. **LED Bulbs**
    a. 120vac or 240vac versions 50hz&60hz
    b. PAR20 form factor
    c. E26/E27 medium screw base (standard household socket).
    d. 5.5 watts each for 110v, and 12 watts each for the 220v model
    e. ~500 lumens each
    f. Narrow beam 24 degree
    g. 5k color temperature
    h. Color Rendering Index of 90 for vivid colors
    i. Lifespan 25k hours rated which I do not believe!
    j. IP65 wet rated
    k. Energy Star rated, ul_listed
    l. O-ring installed to seal the bulb and socket from moisture
6. **Viewing Angles**
    a. Vertical angle viewing available: Amber ~5°, Green ~4°, Red ~10°
    b. Horizontal viewing angle: All ~10°
7. **Hardware**
    a. All hardware is made in the USA 316 Marine Grade Stainless Steel.

b. 4x12mm allen screws for plates and halves

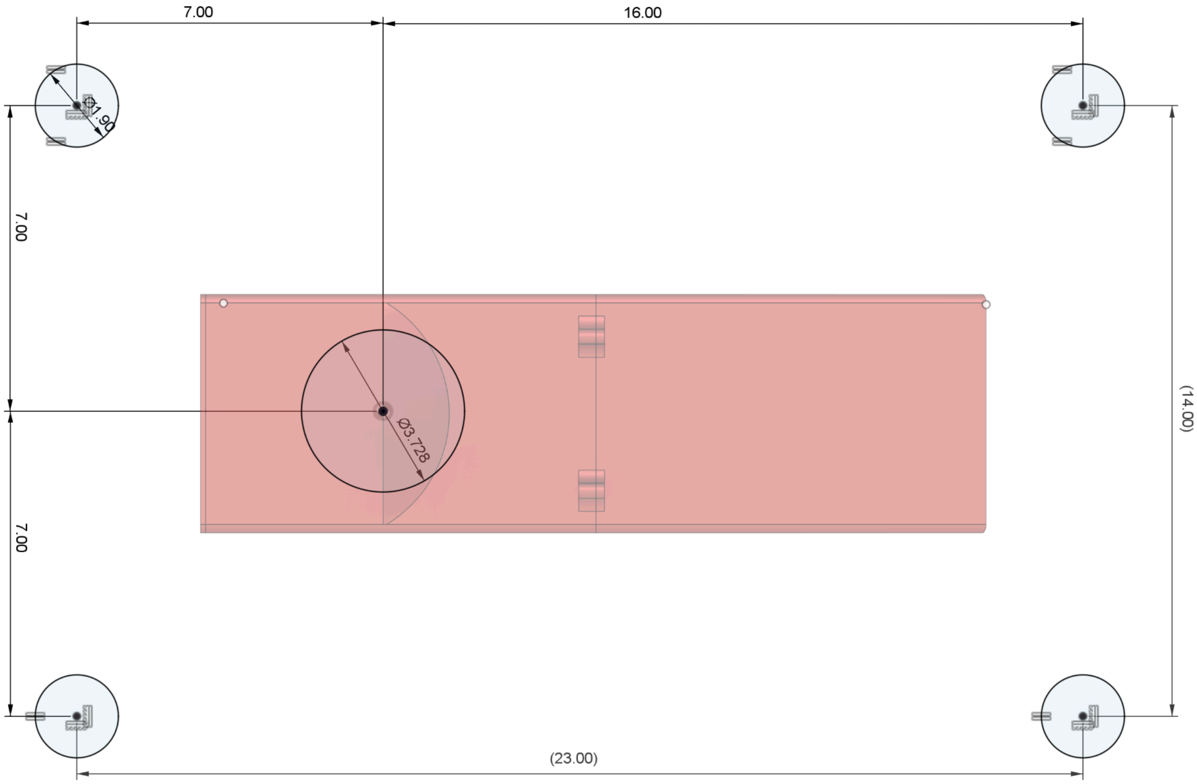
Appendix A:

Bollard Layout

Below is a typical bollard layout in inches using 1.5” Schedule 40 PVC as the bollards and 3” Schedule 40 PVC as the standing pipe support for the VASI. The layout assumes the aircraft is landing from right to left and this is a top down view.

VASI Stand: Positioned off center of the layout, with the 3” PVC pipe offset to account for the non-centered VASI mount.

- **Bollards:** Four 1.5” PVC pipes arranged around the VASI:
    - Bollard 1: 16” forward and 7” left of the VASI stand.
    - Bollard 2: 16” forward and 7” right of the VASI stand.
    - Bollard 3: 7” back and 7” left of the VASI stand.
    - Bollard 4: 7” back and 7” right of the VASI stand.
- **Orientation:** The rectangle of bollards are aligned such that the VASI’s light projection (toward the right, for landing aircraft) is unobstructed within a 10° horizontal arc.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