PCL-PAPI

Precision Approach Path Indicator

Operations Manual

Section 1: System Overview

The PCL-PAPI Precision Approach Path Indicator (PAPI) 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 two distinct colors—red & white—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 more expensive complex systems. Comes in a 2 fixture(shown here) and 4 fixture versions.

1.1 Key Components:

- **PAPI**: A single optical assembly containing a redundant high-intensity LED light source and a color-filtering mechanism to emit red and white light.
- **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 units vertical angle to match the intended glide slope (typically PAPI 5–7° for general aviation, Typical PAPI 3-5° for GA,   and 6–8° for a helipad for both). 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:

PAPI

The PAPI provides pilots with immediate visual feedback:

- 2 fixture PAPI
    - **2 White lights:** Indicates the aircraft is above the glide path**.**
    - **1 red and 1 white light:** Indicates the aircraft is on the glidepath
    - **2 Red Lights:** Indicates the aircraft is below the glide path.
- 4 fixture PAPI
    - **4 White lights:** Indicates the aircraft is well above the glide path**.**
    - **3 White and 1 red:** Indictates the aircraft is slightly above the glide path.
    - **2 red and 2 white light:** Indicates the aircraft is on the glidepath.
    - 3 red and 1 white: Indicates the aircraft is slightly below the glidepath.
    - **4 Red Lights:** Indicates the aircraft is well below 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 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 2 miles of the approach to landing.

While the PAPI can be seen at night from miles away, its effectiveness at those distances is very limited. It is not until the last 2 miles of the final approach sequence that the PAPI becomes effective and the final ½ mile is quite effective.

1.3 Limitations:

- The tri-colored PAPI offers a single-point indication, lacking the redundancy or precision of multi-unit systems.
- ⚠️ A transitional “dark amber” zone appears briefly between green and red, which pilots must be trained to interpret correctly.
- It is best suited for visual meteorological conditions (VMC) and does not meet regulatory requirements for certified airports without additional approvals.
- Requires steeper approach angles due to the lack of precision feedback. Unlike a precision approach, where constant feedback on vertical position is provided, the PAPI indicates position within a band of light, with precision feedback occurring only when transitioning between colors. For safety, the top of the red (“too low your below glide slope”) band must be set at an angle high enough to allow pilots to react and correct without hitting obstacles or the ground. **This explains why a typical PAPI approach is ~5° center of the green and a precision precision approach is ~3°.**
- **Note:** This system is intended for experimental or private use. If you plan to install it at a public or certified airfield, consult local aviation authorities (e.g., FAA in the U.S.) for approval, as tri-colored PAPIs are not standard under current regulations and may require waivers or additional aids.

1.4 PAPI Elements & Views

Image 1 side view

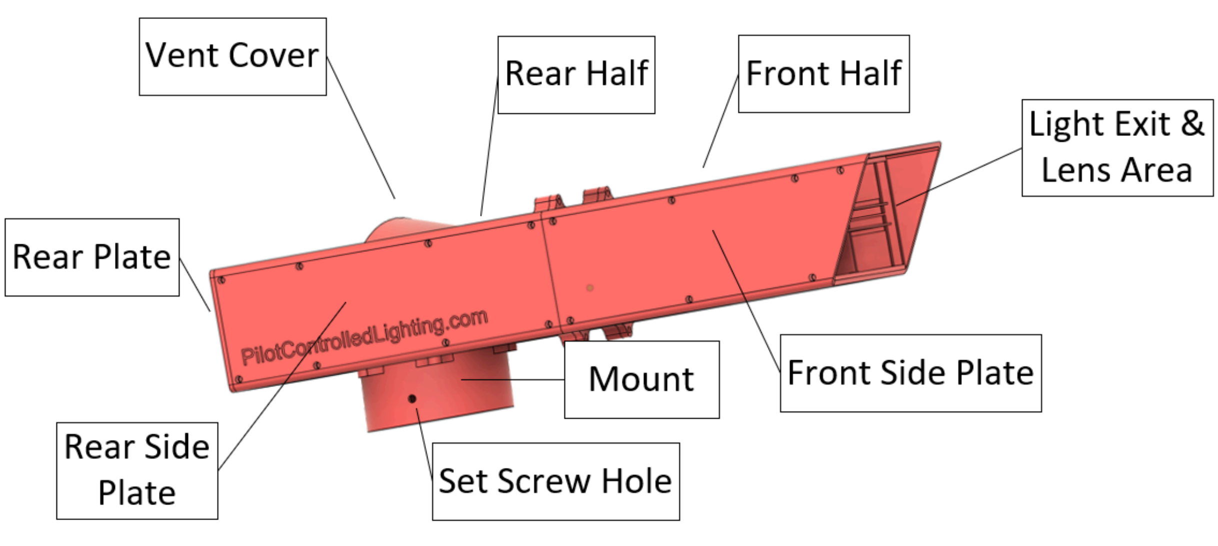
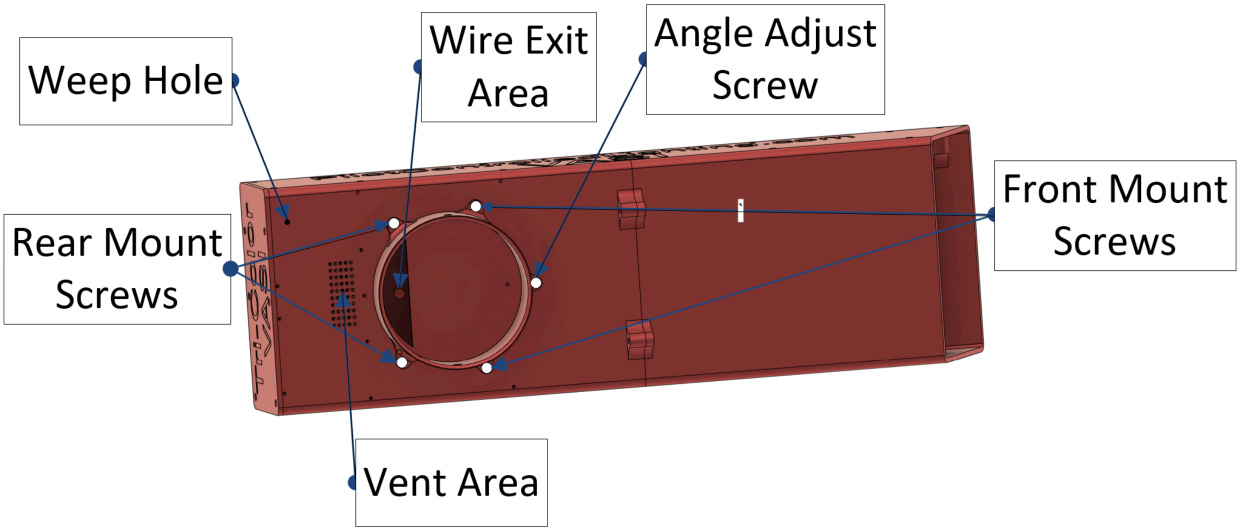


Image 2 Bottom View



Section 2: Theory of Operation

The Precision Approach Path Indicator (PAPI) operates on the principle of angular light projection, where the color observed by the pilot (red or white) depends on their vertical position relative to each light unit's optical axis. Unlike a tri-color PAPI, which uses a single fixture with multiple color zones, the PAPI achieves precision by arranging two or four discrete light units, each aimed at slightly different vertical angles to provide stepwise guidance.

2.1 Optical Design

Each PAPI light unit contains a high-intensity lamp (halogen or LED) paired with a lens and filter assembly. The optics are designed to project two distinct sectors:

- **Lower Sector (Red):** Visible when the pilot's line of sight is below the transition angle.
- **Upper Sector (White):** Visible when the line of sight is above the transition angle.

The transition between red and white is sharp, with only a narrow blending zone, ensuring that the pilot perceives a clear, unambiguous indication. By installing multiple fixtures side by side, each set at progressively higher vertical angles, the system produces distinct combinations of red and white lights that correspond to aircraft position relative to the glide path.

2.2 Glide Path Geometry

The PAPI is aligned to project a nominal glide slope, typically **3° for runways** serving fixed-wing aircraft, though this angle may be adjusted based on runway length, terrain, or obstacle clearance. For heliports, steeper angles (e.g., **6°–8°**) may be employed.

- **Four-Unit PAPI:** Fixtures are spaced laterally 6–9 m (20–30 ft) apart, beginning 15–30 m (50–100 ft) from the runway edge.
- **Two-Unit PAPI (A-PAPI):** Uses only two lights with a wider angular separation, typically positioned ~10 m (33 ft) from the runway edge.

The geometry ensures that a pilot at distances of 0.5–2 nm can reliably distinguish the red/white combinations, with the on-path condition appearing at the intended glide slope angle.

2.3 Pilot Perspective

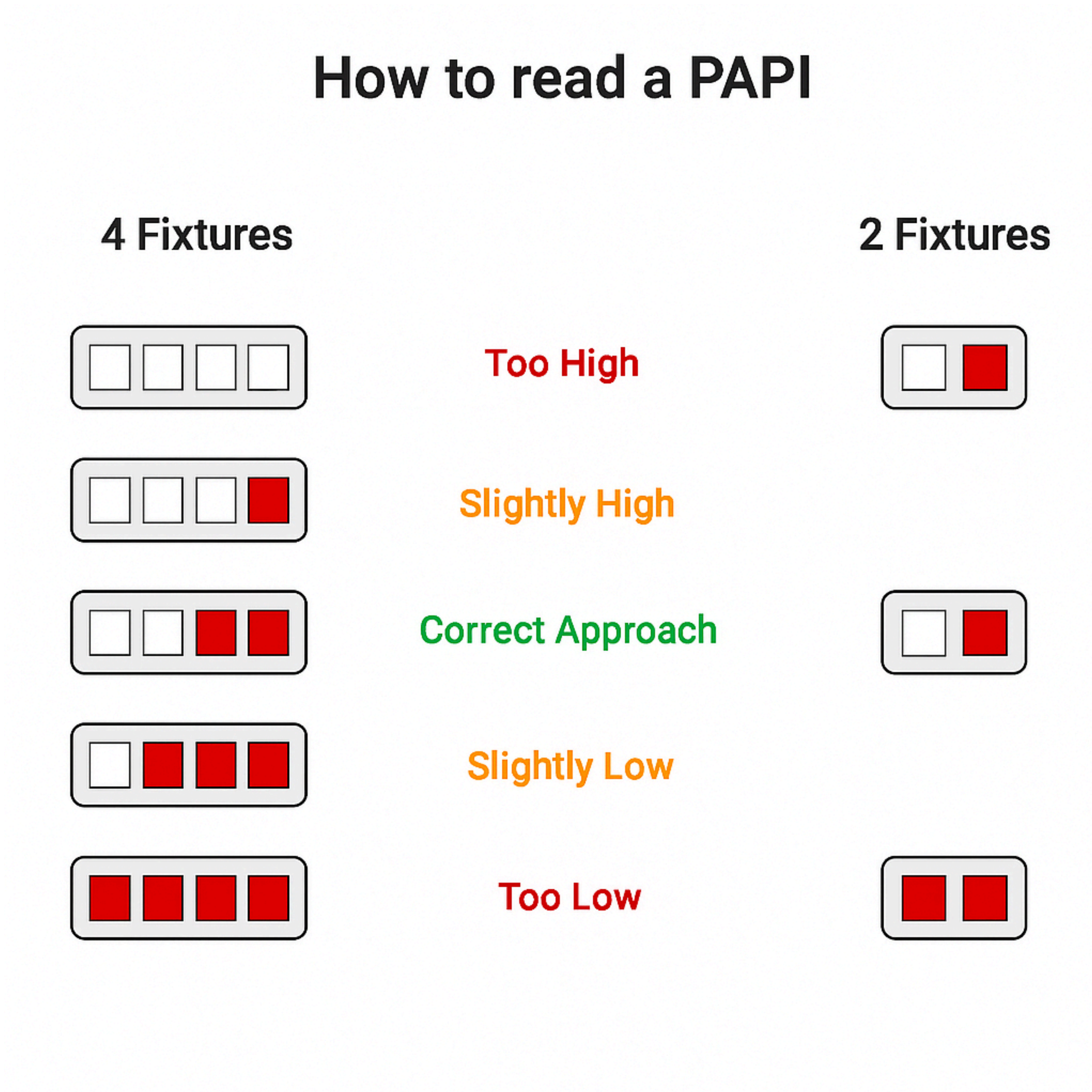
From the cockpit, the pilot interprets the combination of visible red and white lights:

- **4 White:** Too high — descend more steeply.
- **3 White / 1 Red:** Slightly high — descend slightly.
- **2 White / 2 Red:** On the correct glide slope — maintain approach.
- **1 White / 3 Red:** Slightly low — increase descent rate slightly.
- **4 Red:** Too low — climb or reduce descent rate immediately.

For a two-unit system:

- **2 White:** High
- **1 White / 1 Red:** On path
- **2 Red:** Low

This stepwise logic provides more precision and less ambiguity than color-shift systems such as the tri-color PAPI.



2.4 Environmental Considerations

PAPI units are weatherproof, designed to operate in dust, moisture, and temperature extremes. LED variants reduce heat buildup and extend service life, while ventilation features prevent condensation.

Visibility of the lights can be reduced by adverse weather (fog, rain, snow, or glare from the sun). In such cases, pilots must rely on alternate navigation aids (e.g., ILS or RNAV).

2.5 Operational Sequence

PAPI systems are often linked to airport lighting circuits and may be activated by **pilot-controlled lighting (PCL)** or tower control. Once energized, the pre-calibrated angles ensure accurate color transitions.

During approach:

1. The pilot activates runway and PAPI lighting (if not already on).

2. The system projects red/white visual cues aligned to the glide slope.

3. The pilot interprets the cues, making small pitch adjustments to maintain the desired light pattern (e.g., 2 white / 2 red).

2.6 Airports vs. Heliports

PAPI angles differ based on aircraft type and operating environment:

- **Fixed-Wing Aircraft (Airports):** Standard approach angles are 3°–4°, balancing obstacle clearance with stable descent rates and efficient runway use.

- **Helicopters (Heliports):** Higher approach angles (6°–8° or greater) are common, allowing safe obstacle clearance in confined or urban environments, reducing hover time, and improving pilot visibility of the landing zone.

Regulatory standards such as FAA AC 150/5345-28 and ICAO Annex 14 provide guidance on installation geometry and angle selection for both applications.

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 PAPI light assembly no washers. Ensure the angle adjust screw in the mount does not

extend beyond the thread so that the PAPI can sit flush with the mount for now. Image 2 Bottom View.
5. The PAPI assembly is now ready to be installed.

Section 4: Choosing a Location to Install

Selecting the proper location for your PCL-PAPI 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 PAPI 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 OffsetFrom the Runway:** For a 2 fixture installation, the ideal lateral offset if ~30 feet from the runway edge to avoid interference with aircraft wings or ground operations while keeping it within the pilot's peripheral vision. A 4 fixture installation is ~50 feet. However, your site location may not allow for this and closer to as little as 10 feet has been demonstrated to work as well.
- **Lateral Separation between fixtures:** Lateral separation between fixtures should be ~25 feet. However your site may not allow for this distance. As little as 8 feet between fixtures has been demonstrated to be effective to an approach distance of 1.5 miles.The greater the spacing between the fixtures, the farther from the runway threshold the PAPI remains effective.
- **Height Above Ground:** The international standard for runway edge lights is 14" above ground to the top of the light. For a PAPI 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 PAPI, as described in Section 5: Bollard & PAPI Stand Installation.
- **Other Lights:** There should be no other lights within 50'' of the PAPI to avoid color wash out, discoloring, or mis-identifying the PAPI 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 PAPI.

4.2 Glide Path Geometry:

The location must support the intended glide slope (e.g., 3° standard, or alternatives of 5° or 7° for steeper approaches), determined by the vertical aiming angle of the PAPI relative to the runway aiming point. Below are some calculation examples for height and distance to help support your install location, using the tangent function to determine glide path heights.

- A 3° glide slope starting 300 feet from the threshold requires the PAPI to project the on-path signal (e.g., two white/two red for a 4-unit system) at approximately 15.7 feet above the runway threshold at that point. This is calculated as:
    - Height = Distance × tan(Glide Slope Angle) = 300 ft × tan(3°) ≈ 300 ft × 0.0524 ≈ 15.7 ft.
- For alternative steeper slopes:
    - At 5°: Height = 300 ft × tan(5°) ≈ 300 ft × 0.0875 ≈ 26.2 ft.
    - At 7°: Height = 300 ft × tan(7°) ≈ 300 ft × 0.1228 ≈ 36.8 ft.
- To achieve this, the PAPI units, typically mounted about 10-40 inches (0.83-3.33 ft) above ground on frangible supports, must be positioned such that their optical axes align with the intended glide path, intersecting the runway at the desired touchdown point (typically 1,000 feet from the threshold for standard runways, or adjusted for shorter ones).

- For a touchdown point 1,000 feet from the threshold on a 3° glide slope, the glide path height at the threshold is:
    - Height = 1,000 ft × tan(3°) ≈ 1,000 ft × 0.0524 ≈ 52.4 ft above runway surface.
- For alternative steeper slopes at the same touchdown point:
    - At 5°: Height = 1,000 ft × tan(5°) ≈ 1,000 ft × 0.0875 ≈ 87.5 ft.
    - At 7°: Height = 1,000 ft × tan(7°) ≈ 1,000 ft × 0.1228 ≈ 122.8 ft.
- Adjust placement farther or closer if terrain slopes upward or downward, ensuring the on-path transition zone (e.g., typically ±0.35° around the glide slope for PAPI precision) aligns with the desired touchdown zone. For example, on a 3° glide slope:
    - If placed 200 feet from the threshold, the on-path height would be ~10.5 ft (200 ft × tan(3°) ≈ 10.5 ft).
    - If placed 400 feet from the threshold, the on-path height would be ~21.0 ft (400 ft × tan(3°) ≈ 21.0 ft).

- For alternative steeper slopes at 200 feet placement:
  - At 5°: ~17.5 ft (200 ft × tan(5°) ≈ 17.5 ft).
  - At 7°: ~24.6 ft (200 ft × tan(7°) ≈ 24.6 ft).
- At 400 feet placement:
  - At 5°: ~35.0 ft (400 ft × tan(5°) ≈ 35.0 ft).
  - At 7°: ~49.1 ft (400 ft × tan(7°) ≈ 49.1 ft).
- Avoid locations where the glide path would intersect obstacles (e.g., trees, buildings) before the runway. For a 3° glide slope, the path rises gradually; steeper alternatives require even greater clearance:
  - At 1,000 feet from the PAPI on 3°: ~52.4 ft high (1,000 ft × tan(3°) ≈ 52.4 ft).
  - At 5°: ~87.5 ft high (1,000 ft × tan(5°) ≈ 87.5 ft).
  - At 7°: ~122.8 ft high (1,000 ft × tan(7°) ≈ 122.8 ft).
  - Ensure no obstacles encroach within a ±1° vertical arc around the glide slope (e.g., 2°–4° for 3°, or up to 6°–8° for 7°) to maintain visibility of the white, red, and transition zones, per FAA guidelines.

Practically speaking, installing the PAPI ~300–1,000 ft from the threshold (depending on runway length), with a 3° aiming angle on the units is a good starting point (or 5°/7° for alternatives), and the actual alignment will be adjusted during commissioning using precise aiming devices.

Glide Slope (Degrees)	Distance from Threshold (ft)	Height Above Ground (ft)
3	200	10.5
3	300	15.7
3	400	21
3	500	26.2
3	1000	52.4
5	200	17.5
5	300	26.2
5	400	35

5	500	43.7
5	1000	87.5
7	200	24.6
7	300	36.8
7	400	49.1
7	500	61.4
7	1000	122.8

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 PAPI.
- **Lighting Interference:** Position the PAPI away from any artificial lights (e.g., hangar floodlights, road lamps, runway edge lights) that could wash out the fixture light 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 PAPI 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 set of fixtures at the opposite end.

Section 5: Bollard & PAPI Stand Installation

Protecting the PCL-PAPI 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 PAPI 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 PAPI, 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. FAA Drawing C-6046 couplings, as per AC 150/5220-23 cover all the details of frangibility. In summary, 3" and 1 ½" PVC easily meets the requirements for PAPI frangibility.

5.1 Materials Required for a single fixture:

- **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 PAPI 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 PAPI 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 PAPI 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 PAPI, ensuring the light’s projection path remains unobstructed. See Appendix A: Bollard Layout for a recommended configuration.
- **PAPI Position:** Note that the PAPI mount is not centered on the bottom of the PAPI. 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 PAPI 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 PAPI 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 PAPI 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 PAPI 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 PAPI 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 PAPI 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 PAPI 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 PAPI 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 PAPI during testing to allow for removal of the PAPI for installing front mount shim washers

Section 6: Commissioning the Device

Commissioning the PCL-PAPI 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 PAPI's LED light units project the intended red & white signals along a glide slope, integrate with the pilot-controlled lighting (PCL) system, and meet performance expectations for visibility and reliability. Commissioning ensures the system supports safe descents to the runway or heliport, particularly for the final 3-5 miles of approach during the day or up to 5 miles at night, 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 PAPI projects accurate color signals for your desired glidepath (e.g., all red below ~2.5°, two white/two red from ~2.8°–3.2°, all white above ~3.5° for a 4-unit system) aligned with the glide slope centered at ~3° (or alternatives at 5° or 7° for steeper approaches), intersecting the runway at the desired touchdown point (e.g., 400–1,000 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 PAPI's signals from at least 3 statute miles during the day and 5 miles at night in clear conditions, under visual meteorological conditions (VMC).

Document performance for pilot briefings and maintenance records, noting the sharp red-to-white transition zones 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 PAPI 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 PAPI 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 PAPI 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 PAPI stand and bollards for stability, ensuring no movement or settling in the cement bases. Check plumbness of the PAPI stand and bollards.
   - Confirm the PAPI’s height (<14” above ground) meets with the runway edge light standard (<14” to top of the PAPI).
2. **Test Electrical System:**
   - With the electrician present, activate the PAPI 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 PAPI’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 PAPI mount for adjustment**
   - Remove the front mount screws see image 2 bottom view

- Loosen the rear mount screws see image 2 bottom view
- The PAPI should have 3 points of contact now with the mount, the 2 rear screws quite loose, and the front angle adjust screw.
- Adjust the PAPI inclination using a digital level or inclinometer to the desired approach angle. ~3° 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 PAPI as your indication of angle.
- Stand ~20' behind the PAPI, looking towards your approach path and align the PAPI to a point on the extended runway centerline ~ 1 mile final.
- Check that reflective tape or high-visibility paint on bollards (Section 4.4) is intact for ground crew visibility.
- Configure the PAPI fixtures to the desired approach angle using this chart below.

Light Indications by Approach Angle for 3°

Approach Condition	4-Fixture Display	2-Fixture Display	Pilot Action
High (>3.5°)	4 White, 0 Red	2 White, 0 Red	Descend
Slightly High (3.2°)	3 White, 1 Red	2 White, 0 Red	Slight descent
On Glidepath (3.0°)	2 White, 2 Red	1 White, 1 Red	Maintain
Slightly Low (2.8°)	1 White, 3 Red	0 White, 2 Red	Slight climb

Low (<2.5°)	0 White, 4 Red	0 White, 2 Red	Climb immediately

PAPI Installation Angle Specifications

Standard 3-Degree Glideslope Configuration

System Type	Fixture Position	Box Number	Angle (Decimal)	Angle Delta from Box 1	Recommended Distance from Runway edge
4-Fixture PAPI	**Closest to runway**	**Box 1**	**3.50°**	**0.00°**	**15m (49 ft) from runway edge**
		Box 2	**3.17°**	**-0.33°**	**24m (79 ft) from runway edge**
		Box 3	**2.83°**	**-0.67°**	**33m (108 ft) from runway edge**
	Furthest from runway	**Box 4**	**2.50°**	**-1.00°**	**42m (138 ft) from runway edge**

2-Fixture PAPI	**Closer to runway**	**Box 1**	**3.17°**	**0.00°**	**10m (33 ft) from runway edge**
	Further from runway	**Box 2**	**2.83°**	**-0.34°**	**19m (62 ft) from runway edge**

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 PAPI'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).
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.
    - Your initial tests are about setting box 1 red zone. You want the pilot to be able to fly well into the red zone and be safe doing so. Once box 1 is set to

the desired red zone location, the other boxes can be adjusted to it as a reference based on the table above.

- Have the aircraft continue to make approaches and go-arounds giving feedback over the radio to the ground crew on color viewing , height above ground, and distance starting high on the glide path, and slowly working down the glidepath angle until reds are seen at the minimum 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 desired red & white 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 on all devices 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 PAPI approach in the upper portion of the red zone.
- Make any adjustments necessary using the adjustment angle screw and the digital level or inclinometer on box 1. Adjustments should be made first to box 1 to ensure that the red appears there first and at the height and angle desired. Then using box 1 as the reference base line, adjust the others to it based on the chart above.
- Gather feedback to ensure the red and white transitions are positive and easy to interpret.
- Document what you're doing, the pilot's feedback, and adjustments made. Document the final inclination of the PAPI’s 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 2-mile visibility requirement (Section 1.2).
7. **Complete PAPI installation**
    - Measure each of the final PAPI inclinations and document it in the maintenance log
    - Gently pull the PAPI and mount off the PVC stand and install shim washers (included) if needed between the mount and the PAPI 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 PAPI 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 PAPI 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
        - Visibility distance
        - 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 7 Maintenance

7.1 Scheduled Maintenance Checks

- Monthly Maintenance Checks
    - Check the bollards and PAPI 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 PAPI for clearness of the lens's. Ensure no critters have penetrated the PAPI 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

7.2 LED Bulb or Socket Replacement

The PAPI 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
- Remove the rear section side plate cover.
- Remove the rear section 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.

7.3 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.

7.4 PAPI 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 PAPI inclination with a digital level or inclinometer
- Remove the PAPI from the stand and take it to a workbench for disassembly
- Remove the mount from the PAPI and document any shim washer locations
- Split the PAPI 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 8 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. PAPI 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

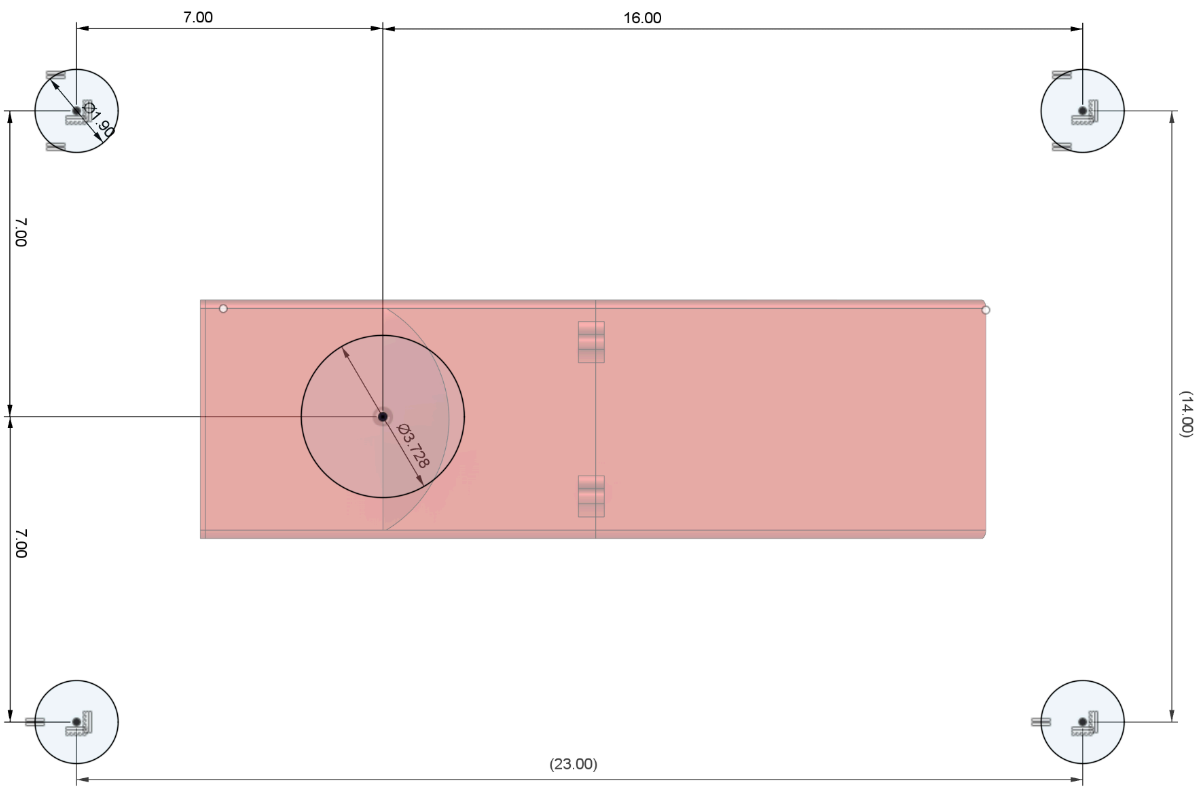
Appendix A:

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 PAPI. The layout assumes the aircraft is landing from right to left and this is a top down view.

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

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



7.00
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