# Recreating Wonder Woman's Invisible Plane

## A Quantitative Analysis of UAV Visual Signature Manipulation via Counterillumination

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## Abstract

This study analyzes the effectiveness of an optical camouflage method called counter-illumination, and its effectiveness on an unmanned aerial vehicle (UAV). This is achieved by emitting blue light on the bottom of the UAV to blend into the sky. Preliminary results are underwhelming, but design modifications can be made to improve the performance of the system. Further testing is required in order to collect any usable data. Due to the COVID-19 Pandemic, unfortunately, this project could not be completed.

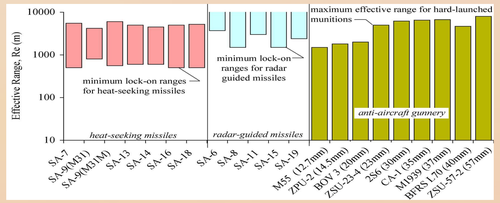
## Introduction

Invisibility has always been at the forefront of science fiction. One method of achieving "invisibility" is counter-illumination. Counter-illumination is "...[the production of] light to obliterate their silhouettes seen against the downwelling ambient light" and is very prevalent among deep-sea animals, like the squid below.

Other areas of optical camouflage, such as fiber optics and retro reflection, have been studied previously; however, these methods are often expensive and impractical. In comparison, little research has been performed studying counter-illumination.

## Application

Depending on the hue chosen, this system can decrease or increase the detectability of a UAV. In the former case, this will be useful in surveillance applications such as defense, allowing UAVs to fly below the range of radar as seen below. This will also be useful for wildlife monitoring applications.




When used to enhance detectability, this can be utilized to make commercial UAVs more visible in daylight conditions, significantly reducing the hazard that UAVs create while operating in the national airspace. This could also be used in Search & Rescue applications to increase visibility from below.

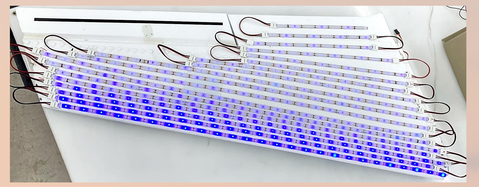
## Objective

While similar projects using electroluminescent sheets, like the one shown below, have shown this concept to be effective, the weight penalty was significant. This was solved using a translucent UAV and only covering non-translucent areas with EL sheets.

This project studies using LED light strips wired in series to reduce the required power supply and decrease the weight penalty of the system.

## Methodology

Counter-illumination is achieved by applying a voltage to a light source, such as LED strips, that emits light of a similar wavelength to the sky. These LED light strips are adhered to the underside of the UAV and wired through the fuselage.



The UAV is then observed using MATLAB's image analysis tools to determine its ability to blend in or stand out to the sky. We applied LED lights to one side of the UAV, as seen above, with other wing acting as our control. Ideally, we would see a ~50% reduction in visibility.

## Future Work

We installed an initial, series lighting system to begin flight testing. However, the circuit design needs to be improved by wiring the lighting system to the main UAV power supply. The initial design also required a large amount of ballast to balance the aircraft, which caused significant flutter and wing warping.

Further testing will require an improved design, as well as the use of a range finder to determine the altitude of the UAV for trial consistency. Unfortunately, the COVID-19 pandemic has prevented us from collecting any conclusive data on the effectiveness of this system.