# Compact Tilted Heliostat

EML4501 | Fall 2021 | Group 3

Jose Cespedes, Benjamin Gartside, Jacklyn Griffis, Janna Iklaas, Samuel Roshaven, Eri Vishka, Kellan Wallace, Jaxton Willman

Herbert Wertheim College of Engineering
Department of Mechanical & Aerospace Engineering
UNIVERSITY of FLORIDA

## Abstract

ARX Thermal focuses on designing a small heliostat with a minimal number of motors. The founders believe in sustainability, combining sustainable practices with reliable and recyclable materials, to foster development of renewable energy. Following its result-oriented business principle, ARX Thermal chose to increase profit per solar concentration.

One distinct feature of ARX Thermal's heliostat is the square, four-mirror array. Each mirror is tilted by a custom amount, determined by trigonometric calculations to maximize solar concentration throughout the entire field by a single adjustment. This is on top of an ability to control the pitch and roll of the array. This unique feature is inherent to ARX Thermal's heliostat design and allows for reduction in size of the central tower, while accommodating a nominal area of solar power into an area 40% smaller than a flat alternative.

ARX Thermal designed the heliostat for cost-efficiency. Manufacturing cost is reduced by combining injection molding of recycled materials with simple geometry, high tolerances, cheaper tooling, and off-the-shelf part costs. By reducing the number of motors and moving parts, it is possible to reduce the installation and lifetime maintenance costs.

The ARX Thermal heliostat is designed to last. Thus, the heliostat can track the sun any time of the year thanks to a Wi-Fi enabled microcontroller in a weatherproof box. The entire module is secured in the ground by a fiberglass pole filled with concrete, to increase its rigidity. All parts were designed to resist UV, dust, corrosion, and regular cleaning.

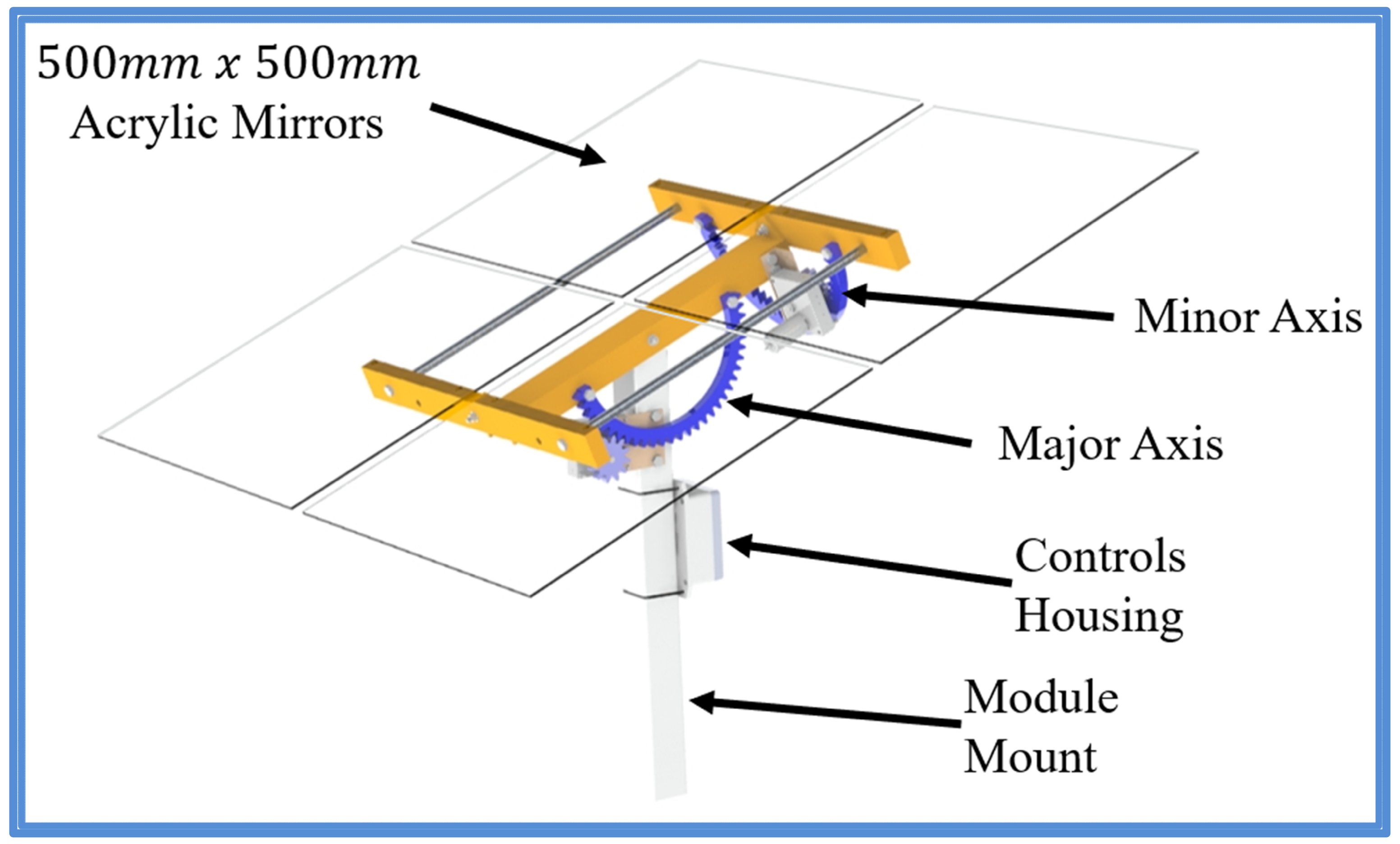
## Functionality

The ARX Thermal heliostat manipulates a four-mirror array to track the sun throughout the day and reflect the incidental rays onto the central receiver tower. The mirrors, made from acrylic, are tilted at 0.1227 degrees with respect to the array center point. This angle was determined to be the average tilt angle in the array field, decreasing the reflected light dispersion as well as possible given a non-adjustable tilt. The array can travel a maximum of 150° along the azimuth axis and 70° in the elevation axis and is driven by a set of gears combined with two stepper motors. Each controls the array's pitch or roll, respectively. Each heliostat module is equipped with a Wi-Fi enabled microcontroller, responsible for communication between the motors and the central computer. The controller is enclosed within an IP65 housing, mounted to a 2-inch PVC pipe with two UV-resistant, nylon-12 zip cables. To prevent sliding, the position of the zip cables is secured with a small, recessed feature on the outer wall of the pipe.

## Cost Analysis

| | |
|---|---|
| OTS Parts | $14.43 |
| Modified OTS Parts | $19.40 |
| Raw Materials | $27.67 |
| Manufacturing Labor | $33.78 |
| Energy Consumption (Monthly) | $0.05 |
| Assembly Labor | $8.11 |
| **Total** | **$103.44** |

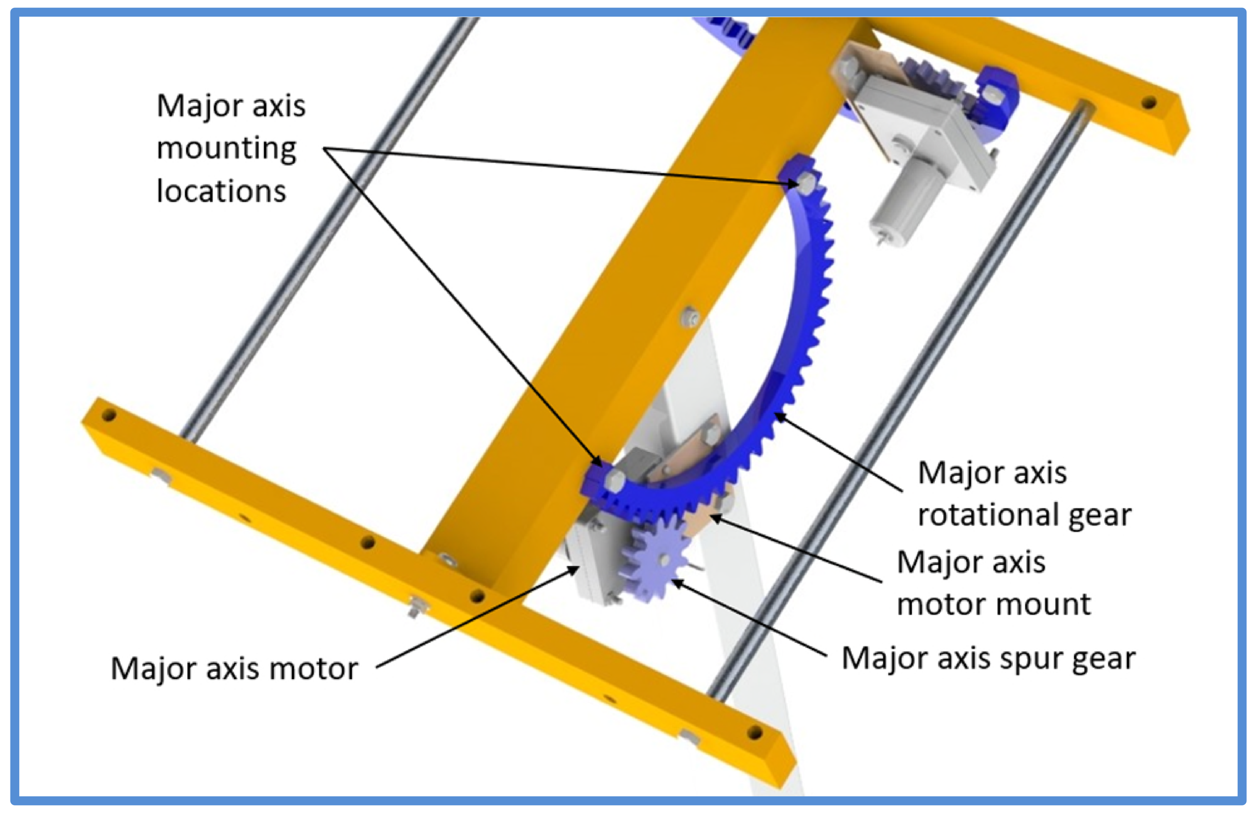
## Full System Render

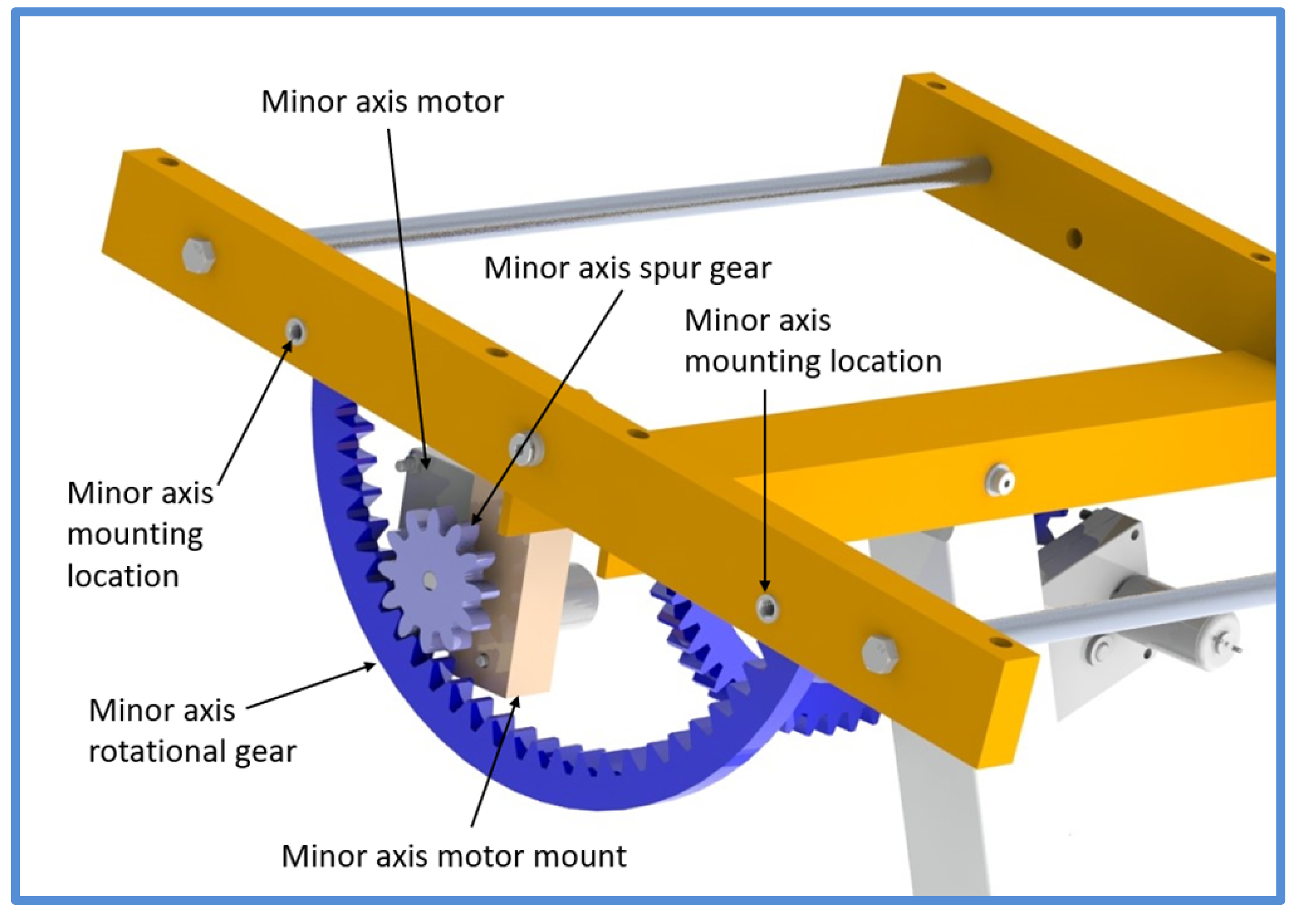



## Key Features & Subsystems

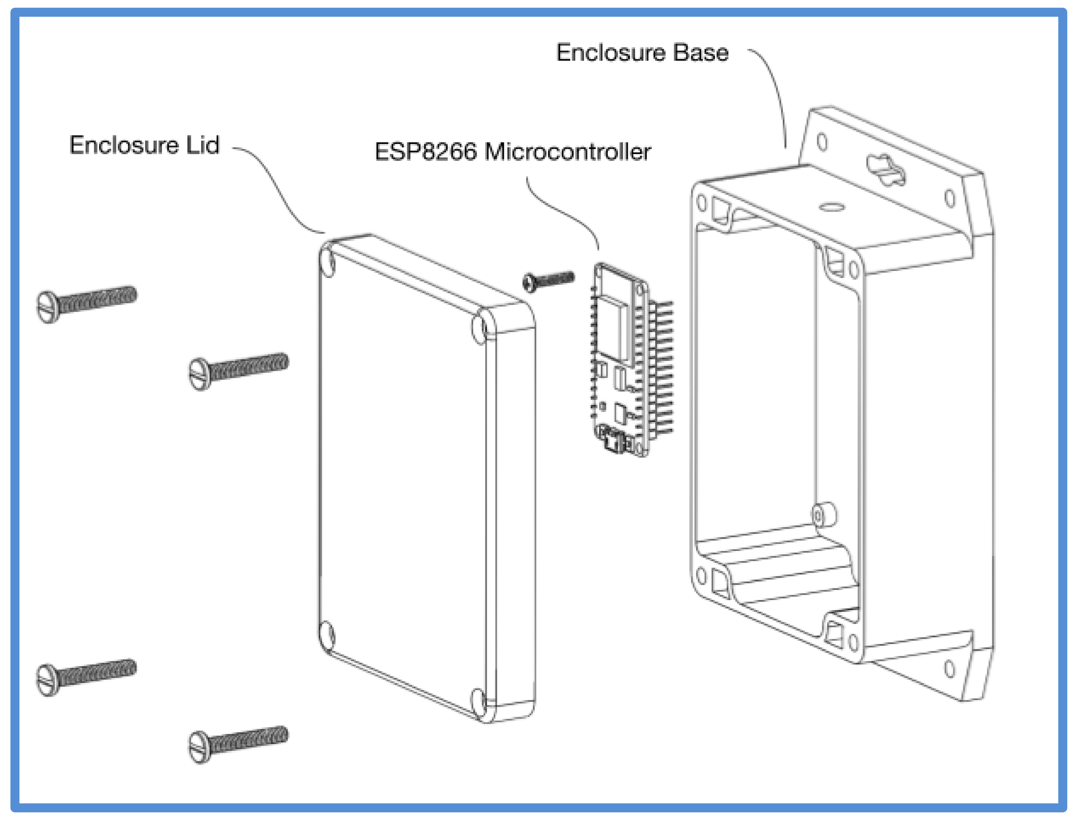
**Mirrors:** Four 500mm x 500mm acrylic mirrors are mounted to an injection molded ABS frame. Acrylic mirrors are lighter weight and have higher flexural strength compared to glass alternatives. We plan to use recycled ABS from plastics found in the ocean. The frame is engineered so that the mirrors have a slight angle inward when mounted to increase solar concentration. The frame also makes use of flanged sleeve bearings which are more resistant to outdoor weather conditions and longer lasting than traditional ball bearings.

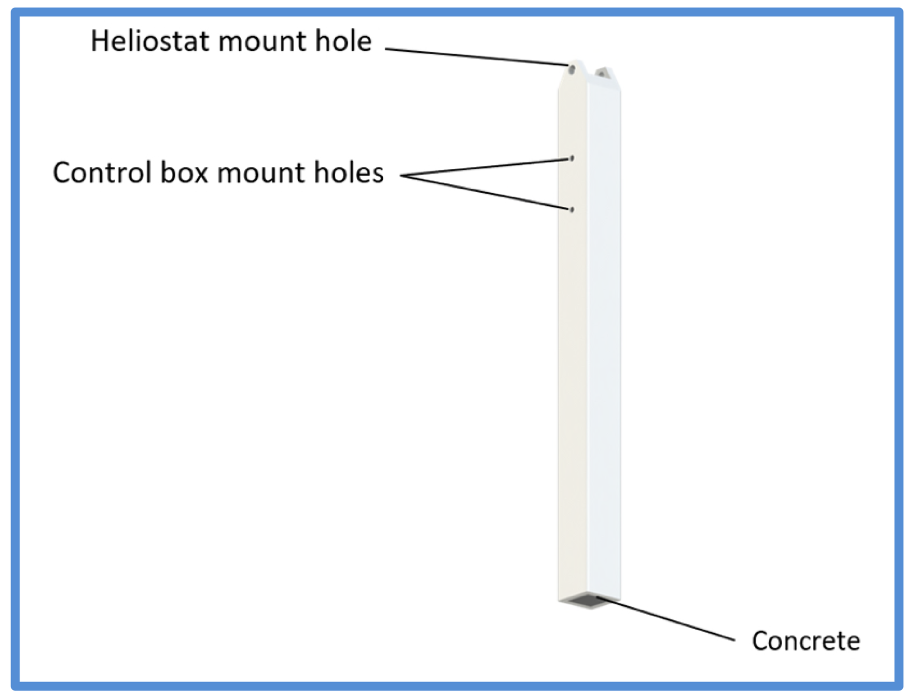
**Drivetrain:** The drive train is composed of a major axis rotating in the solar elevation direction and a minor axis rotating in the azimuthal direction. The major and minor axis are each driven by a stepper motor and ABS injection molded gear. The minor axis gear is attached to the mirror top and bottom frame bars. The minor axis rotates around the central crossbar which in turn is attached to the major axis gear. The central crossbar rotates around a pivot at the top of the module mount. Each motor is protected by an ABS injection mold secured by snap fits.




**Controls Housing:** The heliostat is controlled by a ESP8266 Wi-Fi enabled microcontroller sourced from Alibaba. To ensure the proper function of the control electronics in our operational location, a weather-rated controls housing was selected. The housing shown below is IP67 rated, which will protect the electronics contents from water, dust and sand. An important material property to consider in the controls housing is EMF shielding, since Wi-Fi signals must be sent and received from inside. The chosen material for the housing is ABS plastic, chosen over polycarbonate due to its lesser cost.




**Module Mount:** A square, tubular 2-inch PVC pipe is used as the support structure for the entire heliostat. A concrete base is used to the pin mount into the desert ground. The design has an innovative feature where concrete is filled inside the tube, serving as extra structural rigidity to prevent bending and deflection failures. Additionally, the pipe features a custom-molded wall thickness of 1/3rd of an inch to prevent failure from internal thermal pressure expansion from the concrete due to the swinging high and low temperatures of Nevada. The mount has holes near the middle-center to mount the controls box, and features a band saw machined part at the top with chamfered edges to perfectly fit the heliostat mount to the module using a shoulder screw.

# ARX Thermal Customer Needs Map

Herbert Wertheim College of Engineering
Department of Mechanical & Aerospace Engineering
UNIVERSITY of FLORIDA