Team 4 - Tri-beam Solar Automated Reflector (TSAR)

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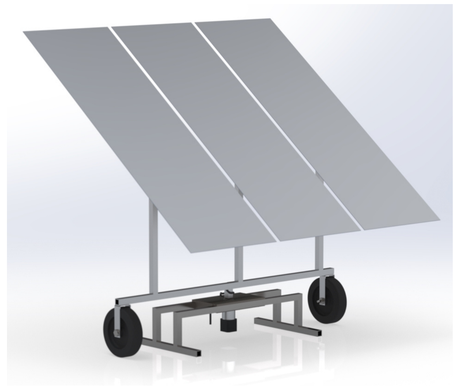
Abstract

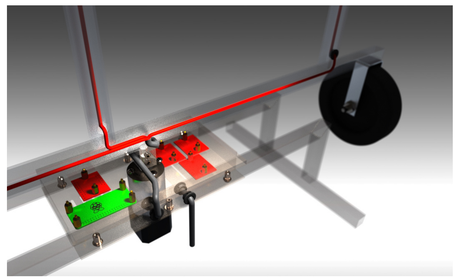
The Tri-beam Solar Automated Reflector (TSAR) is a dual-axis solar tracking reflector intended for use in a concentrated solar power plant. Our design aims to achieve precise solar tracking using the fewest number of motors per individual reflective surface. This design goal focuses on achieving maximum efficiency by minimizing the cost to produce each module and extending module lifetime by incorporating fewer, higher quality motors in the design. Additionally, this design goal optimizes the ratio of the number of motors used per reflective surface to the individual heliostat maneuverability and solar concentration. The TSAR incorporates a strong and dense welded steel frame to which the other subsystems are anchored. The design also features a durable yet lightweight aluminum rotating structure with three highly reflective panels. The tri-beam design allows for individual reflector control in the attitudinal rotational direction, giving a higher concentration ratio than conventional reflector designs. The TSAR is powered by a system of stepper motors with planetary gears. Stepper motors provide precise positioning abilities coupled with an ability to hold loads in place, allowing the module to be statically stable and precise when tracking the sun. The rotating structure incorporates 5 inch wheels in order to alleviate the load on the central motor shaft.

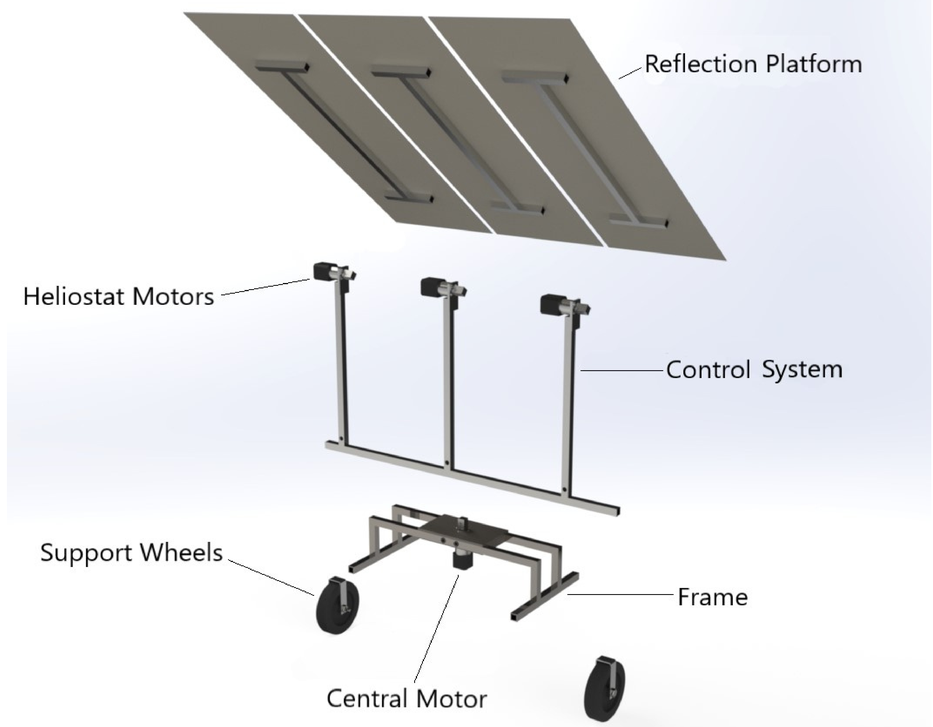
Key Features

Some of the key elements of our design are:

- Two 6-inch support wheels
- Individually controlled motors providing 3.7 N-m torque
- Central motor with 39 N-m torque capacity
- Raspberry Pi Zero W Microcontroller with wifi capabilities.
- 3 independent rotating reflective surfaces coated with silver and protective glass covering
- Lightweight aluminum upper frame rotates azimuthally
- Rigid and durable steel lower frame for structural stability
- Custom welded motor shaft couplers



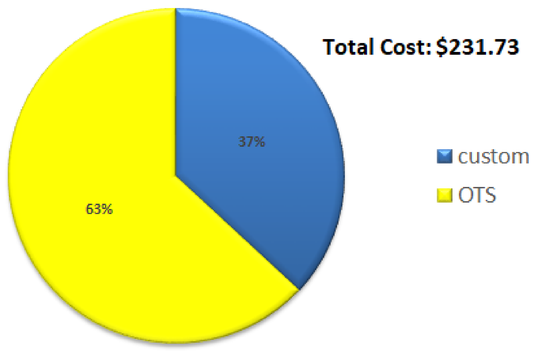


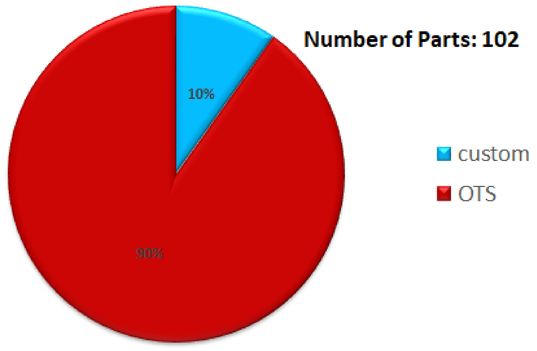


Summary of Functionality

The TSAR is a heliostat unit capable of reflecting sunlight to a central receiver, to generate electricity using the thermal power reflected from the sun. One of the main features of the TSAR are the 3 independent rotating reflection surfaces that are capable of tracking the sun with the precision and accuracy given by quality stepper motors. Additionally, providing the structure full capacity, the control system is allowed to rotate in a full circumference using a central motor. Another key feature of the TSAR is a pair of wheels attached to the extremes of the rotating top assembly, providing two support reactions that allow the module to be stable and reduce the stress on the central motor shaft. This unit comes equipped with an electronic safety protocol which places the mirrors at a specific angle to avoid potential damage due to high-speed winds and storms. With all the TSAR modules strategically placed in the field, the project would be capable of providing over 1MW of power.

Material Cost Overview





Customer Needs and Design Features Map

Control Platform	Need 4	Number of axis of rotaion	Azimuth and Altitude
	Need 6	Up to 100 m tall	Vertical motors capable of 180° rotation capacity
	Need 7	Cost < $100/m2	Thin aluminum square tubing less expensive than aluminum stock
	Need 8	Motor sensitivity	Central stepper motor capable of +200 steps per rotation
	Need 10	% Cost of OTS Parts	55% of the total cost is driven by OTS parts
	Need 15	LT > 20yrs	Aluminum Rust Resistant Platform
Reflective Platform	Need 1	Reflection area < 1m2	Total reflection area of 1.00 m2
	Need 3	Error < 40%	3 Individual heliostats for less compound error
	Need 7	Cost < $100/m2	Parts source from overseas vendors and manufacturers
	Need 10	% Cost of OTS Parts	55% of the total cost is driven by OTS parts
	Need 11	Sensitivity of Materials	Silica glass protecting the silver back coating
	Need 12	Collect 1 MW	Input power of 3184 kW (~3.2MW) at 45 degrees
	Need 13	C >1000	Field consists of 1490 modules
	Need 14	Area of reflection-ind.	Individual reflection area of 0.33 m2
	Need 16	> 5.5 kWh/m2/day	Reflected power of 3.62 kW
Frame	Need 2	2-16 heliostats	Total of 3 heliostats per module
	Need 5	Xspacing ≥ Xshading	1 row of heliostats to avoid shading
	Need 7	Cost < $100/m2	Thin steel square tubing less expensive than steel stock
	Need 9	Ratio of Areas	Area of heliostat support is ~10% of area of reflection
	Need 10	% Cost of OTS Parts	55% of the total cost is driven by OTS parts
	Need 17	Spacing ≥ 3.0m	Modules spaced 3 meters apart for cleaning procedures
	Need 18	Frame to ground contact	Support Wheels and frame structure