Abstract:
The purpose of this study is to develop a complete portable system to facilitate long distance communication via the weak signal mode, Earth-Moon-Earth Transmission (EME). EME setups traditionally require large antenna arrays with manual rotation systems used to align the forward end of the array with the Moon. [1]While EME communications has fallen out of favor due to the complexity of tracking the moon, the emergence of low-cost microprocessors has created an opportunity for us to create a new inexpensive system for tracking, which we anticipate will make the system much more cost effective and could lead to a resurgence in popularity. The development of this system would allow for near autonomous transmissions, by tracking the Moon using a dual axis rotation system. It would also allow for long distance communication to be accomplished in locations where standard antenna systems can't operate efficiently. This project aligns itself with NASA Mission Directorate A.2: Human Exploration & Operations Mission Directorate (HEOMD), falling under the subcategory of space communication and navigation. This system could also provide a new method of emergency communication for the West Virginia University Amatuer Radio Club.

Background:
Earth-Moon-Earth Communication is a method of radio communication that uses the Ultra High Frequency (UHF) band to bounce signals off the Moon and back down to Earth, allowing signal transmission around the world. It was first discovered by U.S. Navy radar technicians. EME is favored over other weak signal radio methods due to its reliability and longer reach. However, many amateur radio operators are discouraged from EME due to its tendency to use large costly antenna arrays and expensive radio systems. While EME communication is possible on many bandwidths, the 70cm (432 MHz) band is widely recognized as the most effective frequency range due to its low levels of signal loss and small wavelength.[2]

Problem Statement:
Earth-Moon-Earth communication generally requires large antennas and expensive rotation equipment, or to be manually aligned with the constantly changing position of the Moon. These characteristics make it difficult for radio operators to communicate with these systems effectively.

Solution:
Design and build a low cost, portable antenna system to communicate via EME. This includes an autonomous rotation system to keep the antenna pointed at the Moon and a solar charging system to create a truly portable set up.

Project Timeline:

Phase 1: Antenna Design and Rotor Design (September-November)
During this phase, students will research and design possible 432 Mhz antennas, based on their Standing Wave Ratio (SWR; a common efficiency measurement for antenna systems) and portability. A design will also be made for the two axis rotation system. This includes a full circuit diagram and CAD mockup of the rotator enclosure.

Phase 2: Antenna Construction and Testing (November- January)

This phase will be used to construct the designs formulated in the previous phase and test their response on the 432 MHz band using an antenna analyzer. The most effective antenna will be used in the final set up.

Phase 3: Rotor Construction and Testing (January-March)

This phase implements the coding and physical construction of the rotator system. This includes testing the rotator using the antenna designed in the previous phase. If the system works, contacts with other amateur radio operators around the world will be scheduled to test the functionality of the system.

Phase 4: Data Analysis and Presentation (March-May)

The data from previous phases, including antenna ratings, rotator test data, and the completion of radio contacts will be compiled and formatted for presentation. A detailed Article will also be submitted to the ARRL Monthly Magazine QST.

Budget:

Component	Quantity	Cost per	Total Cost
Antenna Components			
PVC Piping	70ft	0.30	21.00
Wire Mesh Screening	100sqft	1.60	60.00
Coax Cable	50 ft	1.00	50.00
Feedline			
4ft Aluminum Beam	2	10.00	10.00
⅛ inch aluminum tube 3 pack	4	8.00	32.00
Antenna analyzer	1	55.00	55.00
Rotator Components			
DC Motor	2	15.00	30.00
DC Driver	1	18.50	18.50
3 axis magnetometer	1	15.00	15.00
Intel Quark Microcontroller	1	13.00	13.00
Motor Shaft Coupler	2	1.75	3.50
Tripod stand	1	30.00	30.00
Power system			
100 watt solar panel	1	155.00	155.00
Solar battery	1	25.00	25.00
Salary			482
Grand Total			1000.00

References:

[1] Hall, G. L. (1990). *The ARRL Antenna Handbook*. Newington, CT: ARRL.

[2] Reisert, J., W6fzj. (1974). Successful 432MHz EME Antennas. Retrieved 2020, from http://www.ka9q.net/moonbounce-notes