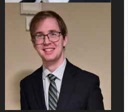
Mini-AWACS



<u>Group 3</u>

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Sponsored by U.S. Southern Command

Motivation and Background

- Current drone training methods involve really expensive airborne radar systems, because they need to scan the skies for all airborne vessels. Airborne Warning and Control units or AWACs cost several hundred thousand to operate and even more to make.

- Our sponsor, SOUTHCOM, looks to drastically reduce the cost of the of drone training by utilizing the new Starlink system and building a new system utilizing a marine radar on a smaller plane or balloon going up into the sky.

Goals and Objectives

Our project’s objective is to design and build a cost-effective mini-AWACS system that provides small unmanned aerial systems (UAS) with real time radar data for safe operation during training exercises.

Goals:

- Build a motion platform to support and drive the radar.
- Transmit radar and IR data to UAS via Starlink and a cell phone.
- Identify and integrate mechanical systems to achieve precise radar motion.

Project Specifications

To create a suitable radar scanner for airborne drone training, we have laid out several key specifications to ensure the functionality of our prototype design

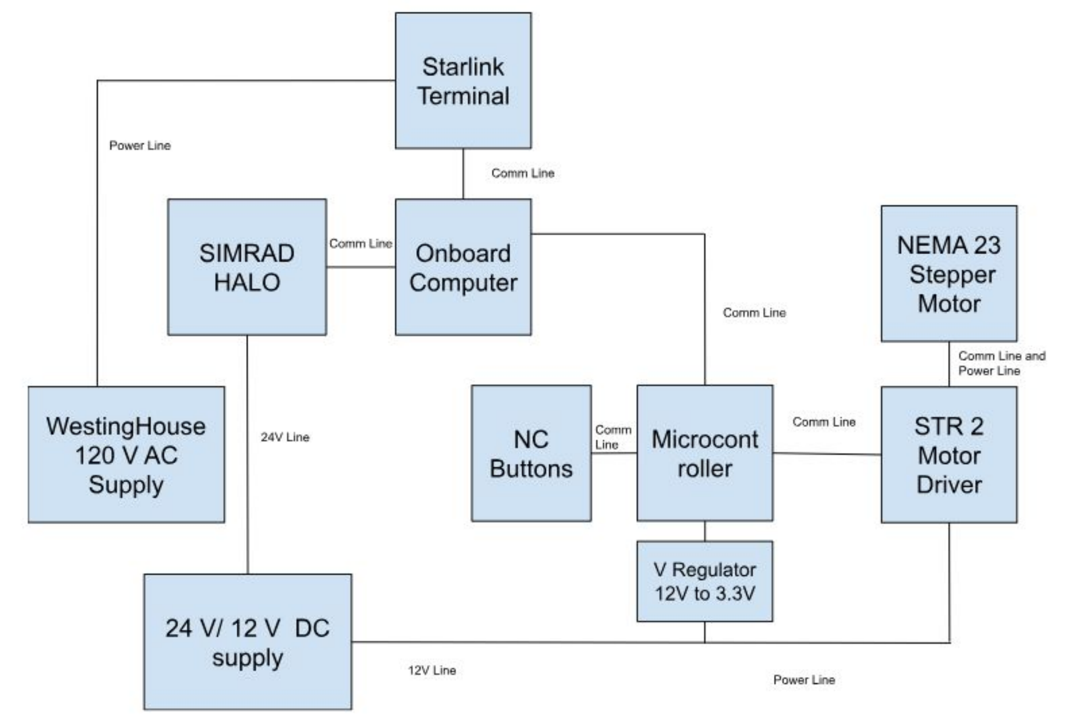
- Stable information link through Starlink which contains data transmitted from the radar and processed by the onboard computer, with a delay less than 3 seconds
- A 60° rotation arc centered towards the bottom of the payload, which will move the radar across
- Consistent speed across the movement of the arc and recorded and transmitted to the onboard computer to process the positional information of the radar

Engineering Specifications Table

Parameter	Specification
Rotating wheel rotation angle	60° range of motion, centered downwards
Motor Rotation Speed	Should complete one 60° cycle in 5 seconds Seconds, at least 12°/s
Starlink connection communication time	Less than 3000 ms
Dimensions	No more than 2 ft x 2 ft x 8 ft

Hardware Design

Our General Hardware Layout to fit the project specifications is shown below.



All of the motor and angle communication hardware operates on a 12 V line from our DC supply, the SIMRAD radar utilizes the 24V line from the dual supply from our power output. The starlink is wired independently on our supply provided initially in our sponsor hardware.

Mechanical Design

There were several different methods we could use to rotate the radar

- Piston/Actuator Wheel Rotation
  - Complex dynamics, with simplified signal control
- Rack and Pinion system to rotate a shell
  - Simplified dynamics, less strain on the motor through the gear ratio
- Directly rotating a shaft with a motor
  - No dynamics, rather steep motor torque requirements with little flexibility

Mechanical part selection

With rack and pinion design, several motor types exist to rotate the gear

- DC motor
  - Simple, high torque, imprecise
- Stepper motor
  - More expensive, high torque, great precision when the motor torque is not exceeded
- Brushless
  - Even more expensive, higher efficiency, low startup torque

Software Selection

Radar Software Development Kit (Provided by sponsor)

- Raymarine SDK was selected by SOUTHCOM for radar data processing

Code Composer Studio

- Used to program and debug the MSP430 microcontroller for radar movement

Visual Studio

- Integrated Development Environment used by CS team to interact with the SDK

Hardware Selection (Sponsor Selections)

Raymarine Cyclone 6 ft Open Array (provided by sponsor) (previous design iteration)

- Chosen for its low power consumption (55W) and light weight (15.4 lbs)
- Due to proprietary hardware specifications and proprietary software, working with and troubleshooting operating the Raymarine outside of normal conditions was extremely difficult, and data could not be read properly without other components.

Simrad Halo Radar (Updated Radar)

- Chosen for ease of implementation as its code is open source.

Starlink Roam Mini Terminal (provided by sponsor)

- Enables real-time radar data transfer in remote locations.

Samsung Galaxy S24 (provided by sponsor)

- Acts as primary mobile radar interface.
- Supports 5G, real-time alerts, and radar visualization

Hardware Selection (Sponsor Selection) - Continued

Intel NUC (provided by sponsor)
- Handles local radar data filtering

HP Laptop (provided by sponsor)
- Used by CS team for development and debugging

Westinghouse iGen160s (provided by sponsor)
- Multi hour battery life
- Powers Starlink Terminal

Talentcell 24V/12V Lithium ion Rechargeable Battery
- Light weight (1.39lbs)
- Multi hour battery life
- Powers Simrad Halo and STR2 Motor Driver

DIYhz Normal Closed Button Switch
- Calls interrupt when button is pushed by sweeping rack

Hardware Selection - Stepper Motor

Motor Model Name	Holding torque	Frame Size	Cost
HT08-230D NEMA 8 High Torque Stepper Motor w/ double shaft	2.69 oz-in	NEMA 08	$53.00
HT11-020 NEMA 11 High Torque Stepper Motor	7.08 oz-in	NEMA 11	$58.00
HT17-268 NEMA 17 High Torque Stepper Motor	32.1 oz-in	NEMA 17	$48.00
HT23-601D NEMA 23 High Torque Stepper Motor w/ Double Shaft	269 oz-in	NEMA 23	$110.00

Hardware Selection - Microcontroller

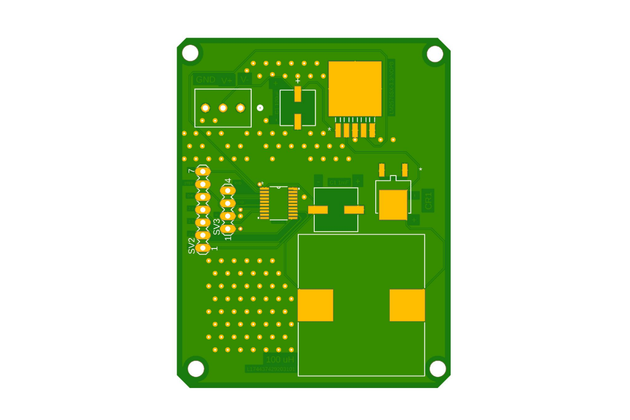
Microcontroller	Pros	Cons
STM32	- Performs well in timing critical conditions. - Power Efficient	- Complex IDE - Tough to learn
Teensy 4.1	- Very Fast - Power Efficient	- More expensive - Limited in its logic
Arduino Due	- Simple to use	- Slower - Not as accurate on timing critical applications
MSP430	- Extremely low power consumption. - Team has familiarity with the MSP430	- Slightly slower

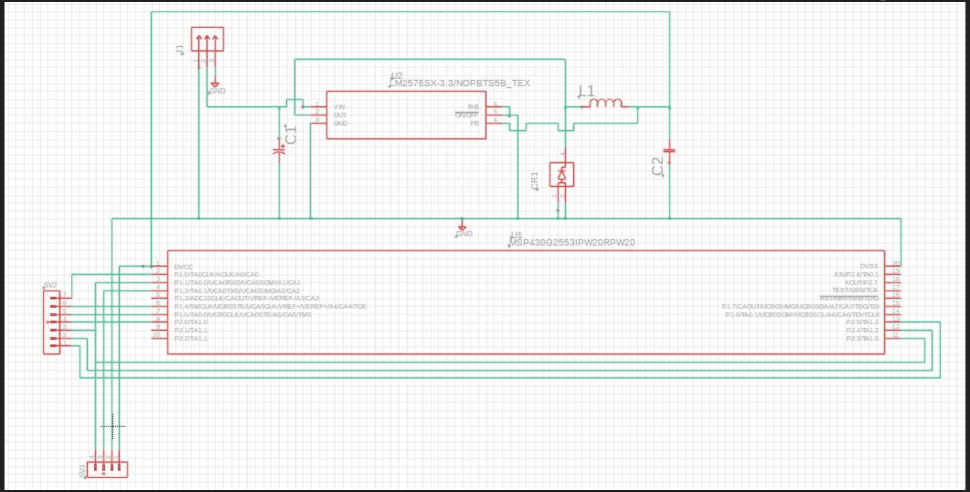
Software Selection - Communication Protocol

Communication Protocol	Pros	Cons
UART	- Ease of implementation - Widely supported by all microcontrollers	- No clock line so timing can be an issue - Slower when passing large data at high speeds
I2C	- Built in clock provides more timing accuracy	- Slower when passing large data at high speeds
SPI	- Fast - Good for high frequency data	- More complex setup - More wiring (space issue)

PCB Design

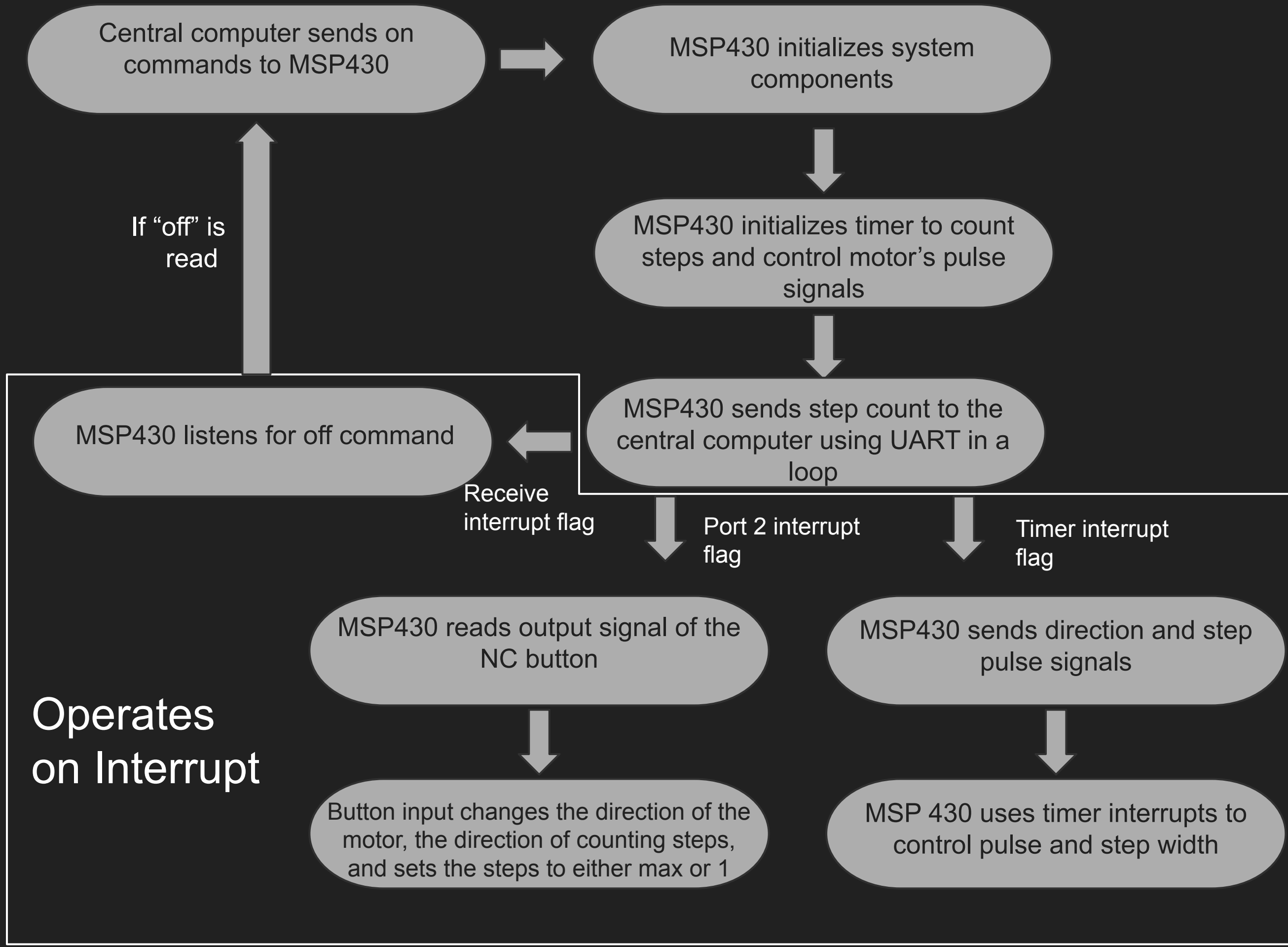
Although our sponsored project does not have significant PCB Design, our general PCB Layout is shown below (initial PCB design on the left, Schematic on the right). Our PCB provides a method to power the microcontroller communicating with both the motor and the encoder, with 3- pins reserved for the motor and 3 reserved for the encoder. We also wired it to enable UART communication on the TXD and RXD pins.





Software Design

Shown on this slide is our ECE software flow chart. We implemented the following software components to control the project's hardware and send the radar position to the centralized computer to make necessary calculations for radar data.



Budget

Component	Name	Cost
Radar	6’ Raymarine Cyclone	$8249.99
Radar Software	Raymarine Software Dev Kit	$500
Data Transmission	Starlink Mini Terminal	$450
Laptop	HP Core i7	$600
Computer	Intel NUC	$350
Portable Power Supply	Westinghouse Portable Power Supply	$130
NEMA Stepper Motor	HT23-601D NEMA 23 High Torque Stepper Motor	$110
Motor Driver	STR 2 Motor Driver	$123
Microcontroller	MSP430G2553	$5
Radar Housing	Custom	$200

Budget

Component	Name	Cost
Radar	Simrad Halo 24	$3099
Portable Power Supply	Talentcell DC Battery	$60.99
NC Buttons	DIYhz NC Buttons	$9.99
Wheel rollers	Steelex 2-inch wheels	$12.99
PCB	JLCPCB	$44
Board Components	Mouser	$100.53
Frame	Wood Frame Materials	$15
Frame	Wood Screws	$10

Work Distribution

Hardware Design - Phillip Jones

Controller & Communication Software Design - Ido Yaari & Phillip Jones

Mechanical Design - Phillip Jones & Ido Yaari

Transformation Algorithm & Software Design - Computer Science Team, Evan Stevens & Christina Nguyen

Mobile Application - Computer Science Team, Evan Stevens & Christina Nguyen

Prototyping & Testing - Phillip Jones & Ido Yaari

Further Development

Finalize radar casing with updated design

- Finalize plan to mount the Simrad HALO in an aerodynamic case on the bottom of the aircraft

Test the prototype on a small aircraft.

- Air test the system to ensure complete functionality

Phillip Jones
Electrical Engineering Major

Ido Yaari
Computer Engineering Major