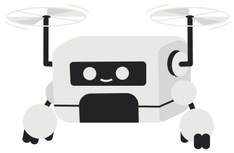
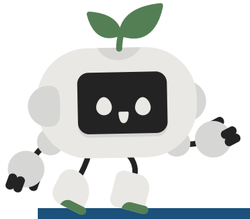
DESIGN OF ADVANCED EMBEDDED SYSTEMS

JOHN DEERE'S WAYPOINT DESTINATION CHALLENGE

11/29/2024 5TH SEMESTER 3RD PERIOD

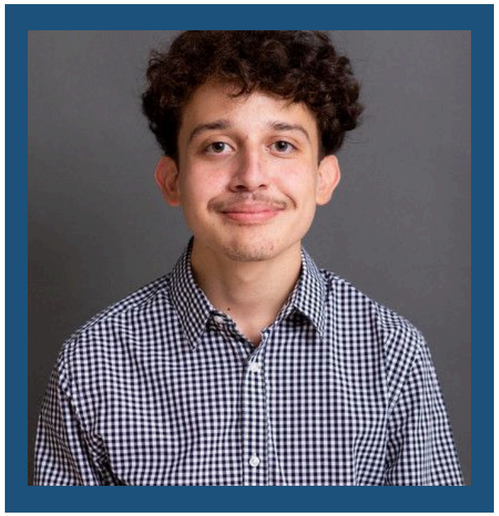


MEET OUR TEAM



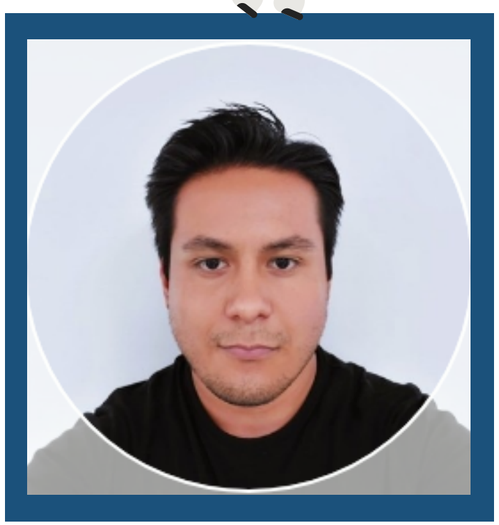
Christian Villareal

A01285465



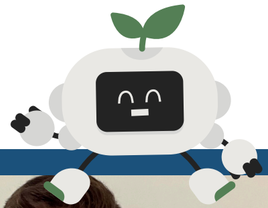
Eduardo Hernandéz

A01285233



Juan Félix

A00838053



Jorge Nájera

A01424106

PRODUCT DESCRIPTION

1. VISION

Revolutionize modern farming by offering an efficient and cost-effective solution that automatizes agricultural tasks, reduces human labor and maximizes productivity.

2. NEEDS

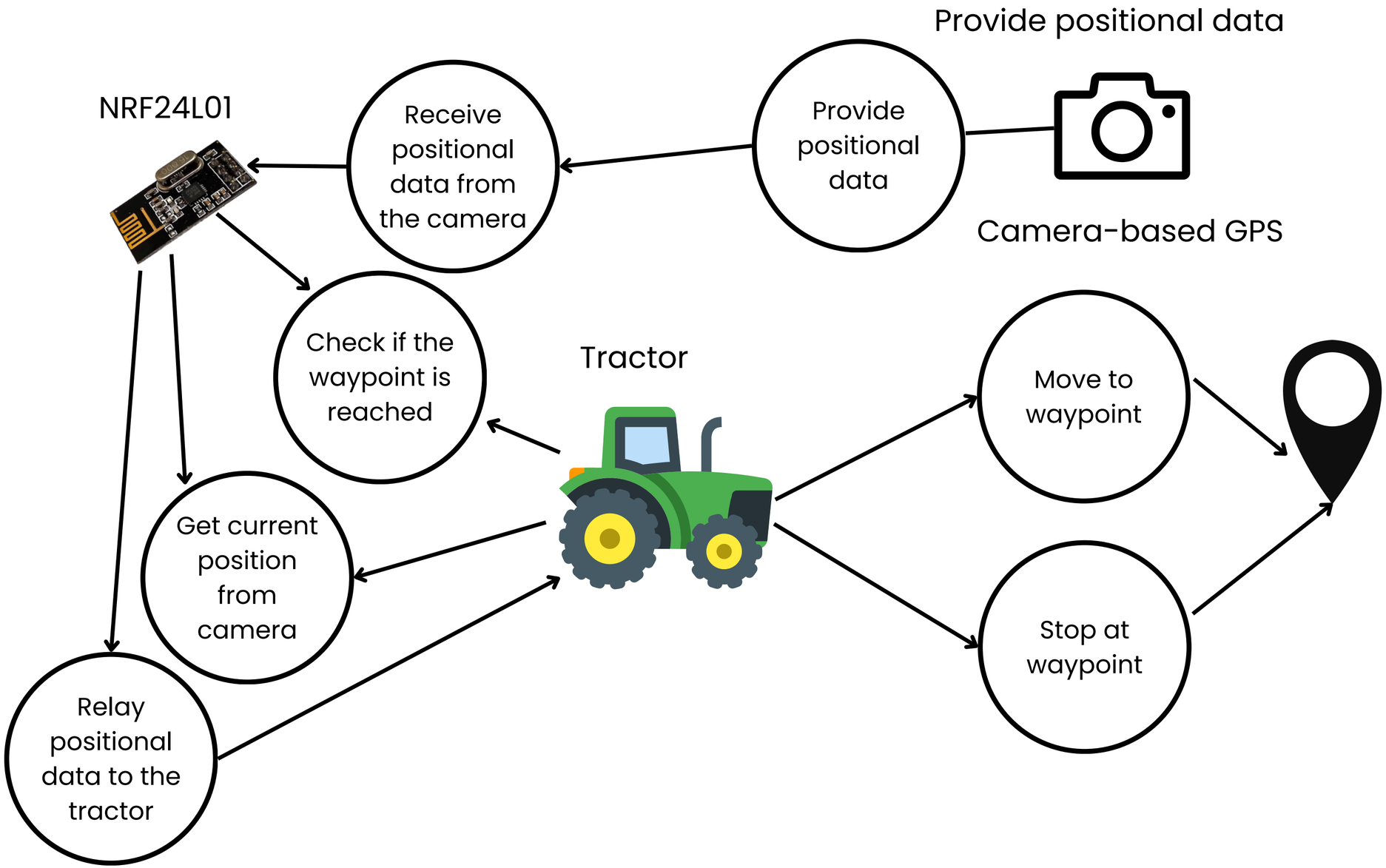
Many enterprises face labor shortages and require precision in planting, harvesting and time-consuming manual operations. Autonomous systems handle these repetitive tasks with accuracy, reliability and cost reduction.

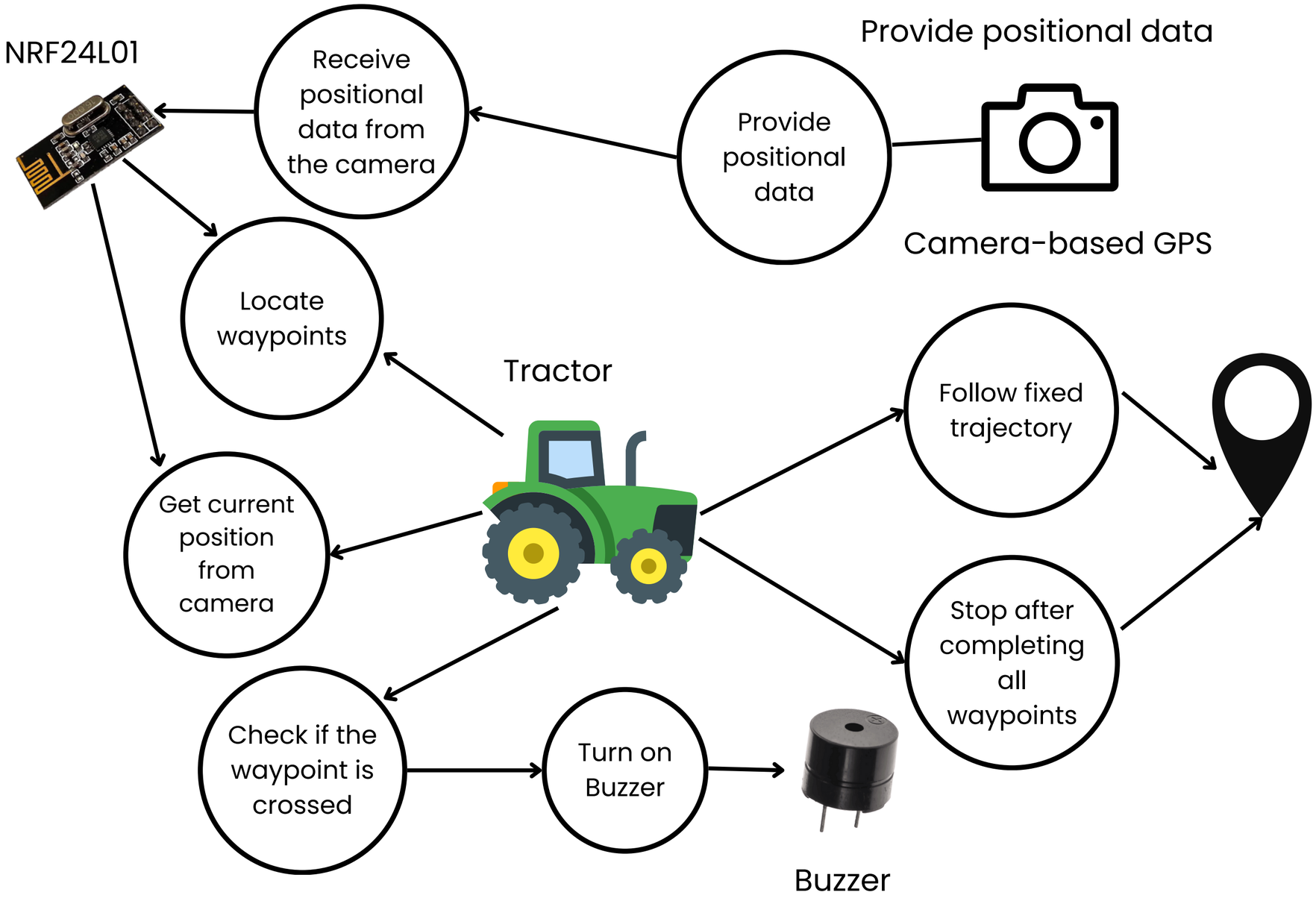
3. TARGET GROUP

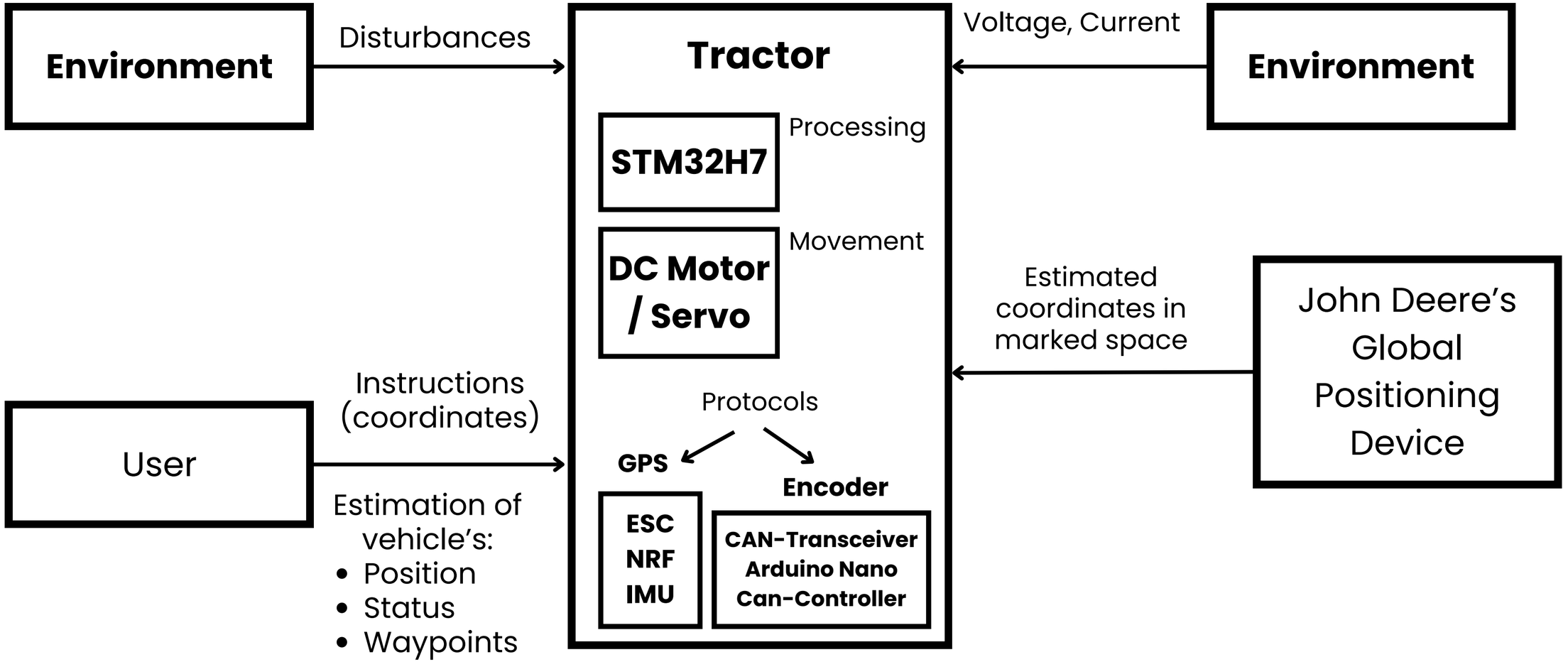
Farmers, agricultural enterprises, and agritech companies seeking to optimize farming operations. Also researchers and developers that aim to refine autonomous navigation technology.

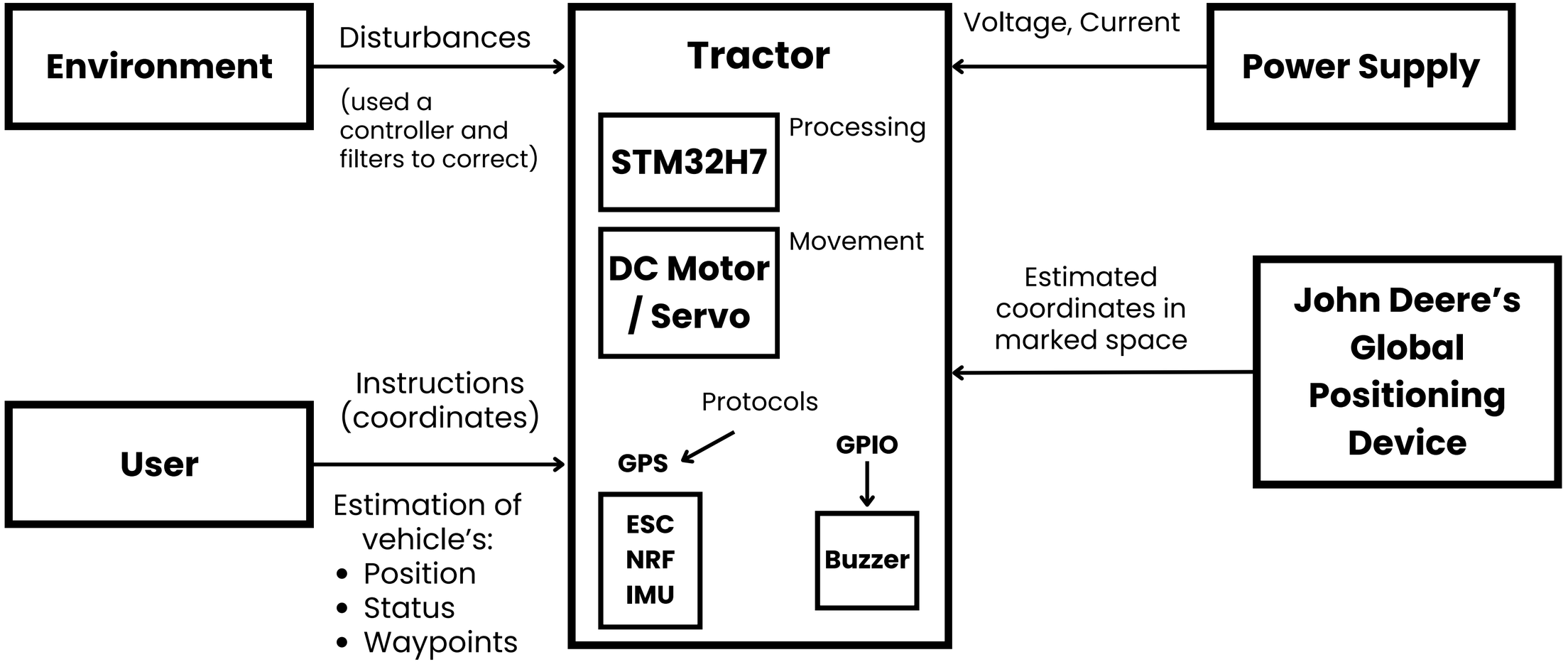
4. SOLUTION

Tractor that uses waypoints powered by wireless communication, camera-based positioning, and inertial measurements. Eliminates human intervention, improves efficiency, reduces errors and enables scalability.


Provide positional data
NRF24L01
Receive positional data from the camera
Provide positional data
Camera-based GPS
Check if the waypoint is reached
Tractor
Move to waypoint
Get current position from camera
Stop at waypoint
Relay positional data to the tractor


NRF24L01
Receive positional data from the camera
Provide positional data
Provide positional data
Camera-based GPS
Locate waypoints
Tractor
Follow fixed trajectory
Get current position from camera
Stop after completing all waypoints
Check if the waypoint is crossed
Turn on Buzzer
Buzzer

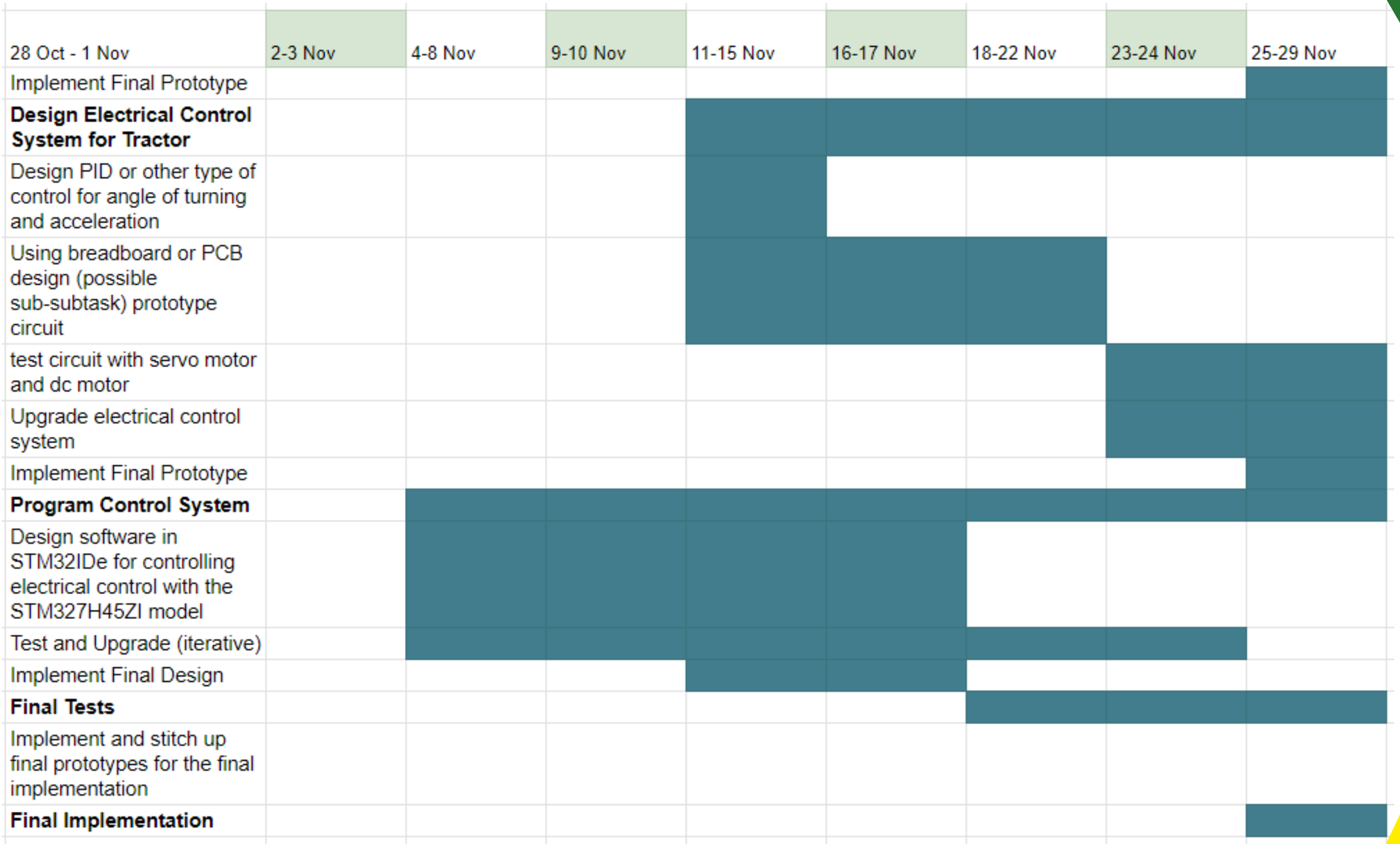

Environment
Disturbances
Tractor
Voltage, Current
Environment
STM32H7
Processing
DC Motor / Servo
Movement
Estimated coordinates in marked space
John Deere's Global Positioning Device
User
Instructions (coordinates)
Protocols
GPS
Encoder
Estimation of vehicle's:
• Position
• Status
• Waypoints
ESC
NRF
IMU
CAN-Transceiver
Arduino Nano
Can-Controller


Environment
Disturbances
(used a controller and filters to correct)
Tractor
Voltage, Current
Power Supply
STM32H7
Processing
DC Motor / Servo
Movement
Estimated coordinates in marked space
John Deere's Global Positioning Device
User
Instructions (coordinates)
Protocols
GPS
GPIO
ESC
NRF
IMU
Buzzer
Estimation of vehicle's:
• Position
• Status
• Waypoints

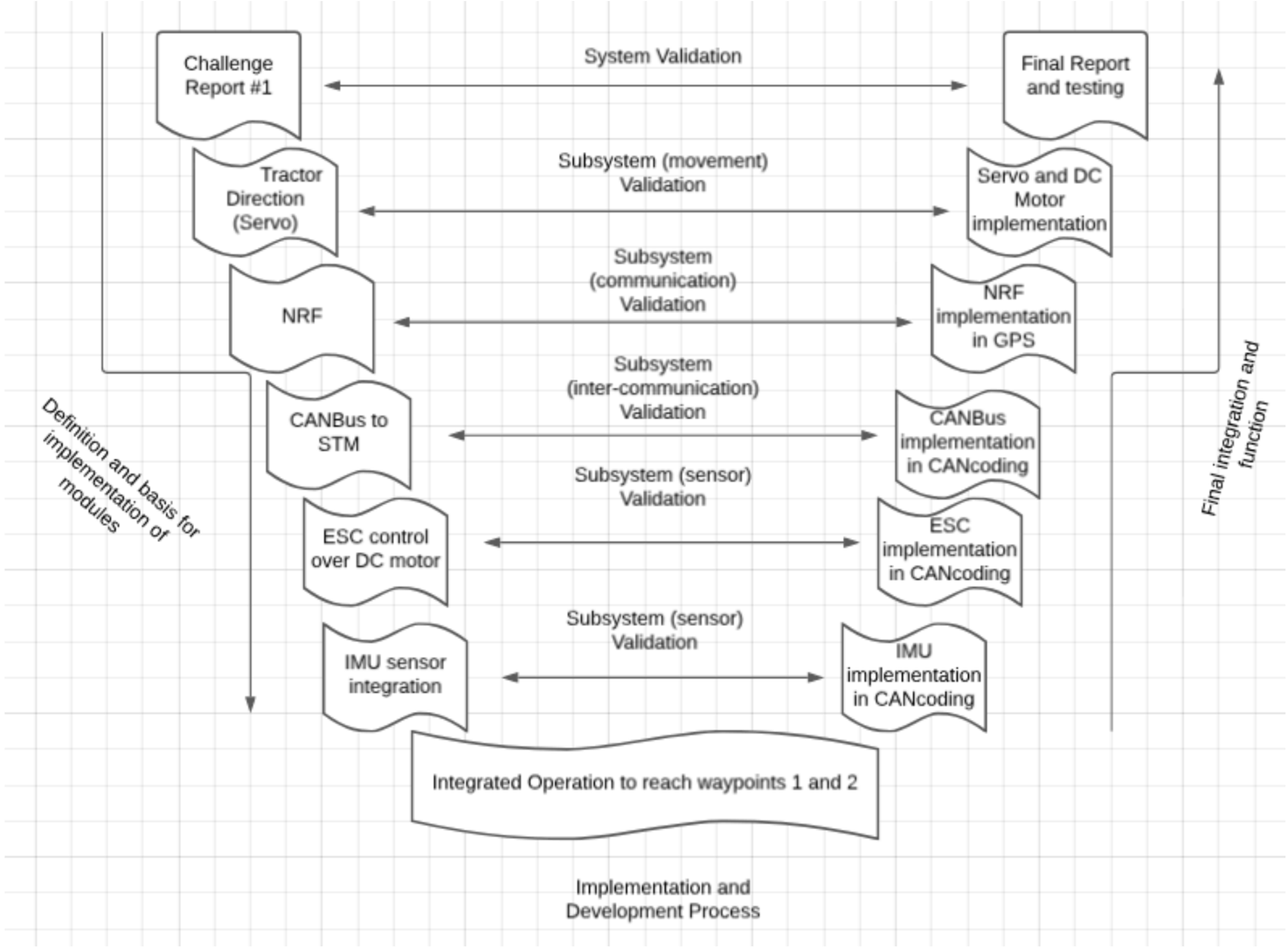
METHODOLOGY BREAKDOWN

	5 Aug - 8 Sept	9-13 Sept	14-15 Sept	16-20 Sept	21-22 Sept	23-27 Sept	28-29 Sept	30 sept - 4 Oct	5-6 Oct	7-11 Oct	12-13 Oct	14-18 Oct	19-20 Oct
Research functionality and possible implementation (generally)													
Understand the functionality of a real tractor and how it fulfills its tasks (order, method and control)													
Understand separate parts of the tractor (suspension, wheel axle, vehicular manual control systems electrical control, etc.)													
Understand our tools and material necessary for the construction and implementation of our own practical tractor													
Build Physical Tractor													
Brainstorm of obtain blueprints for building first prototype													
Obtain first materials for aforementioned tractor													

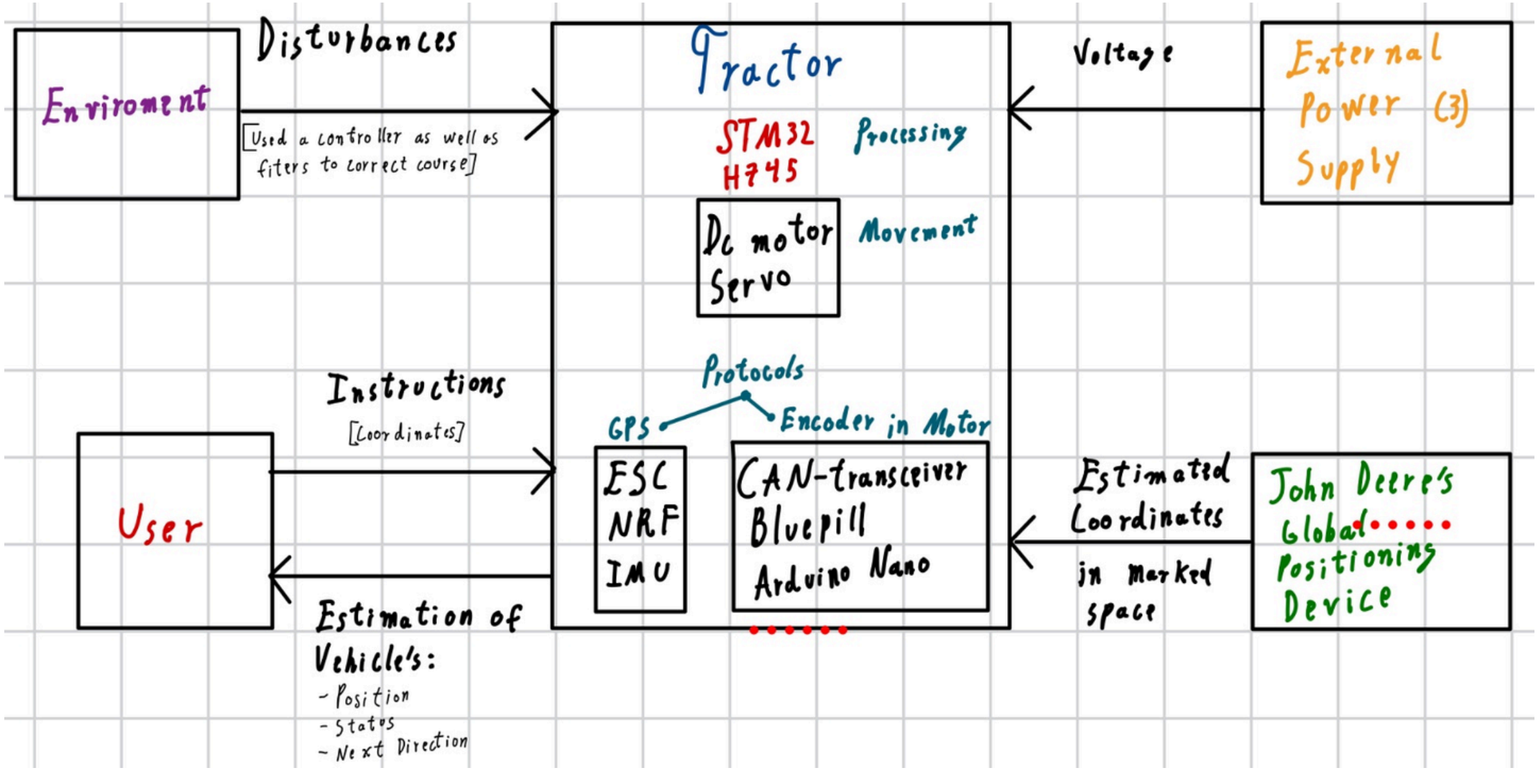
METHODOLOGY BREAKDOWN



METHODOLOGY BREAKDOWN



CONTEXT FUNCTIONALITY DIAGRAM



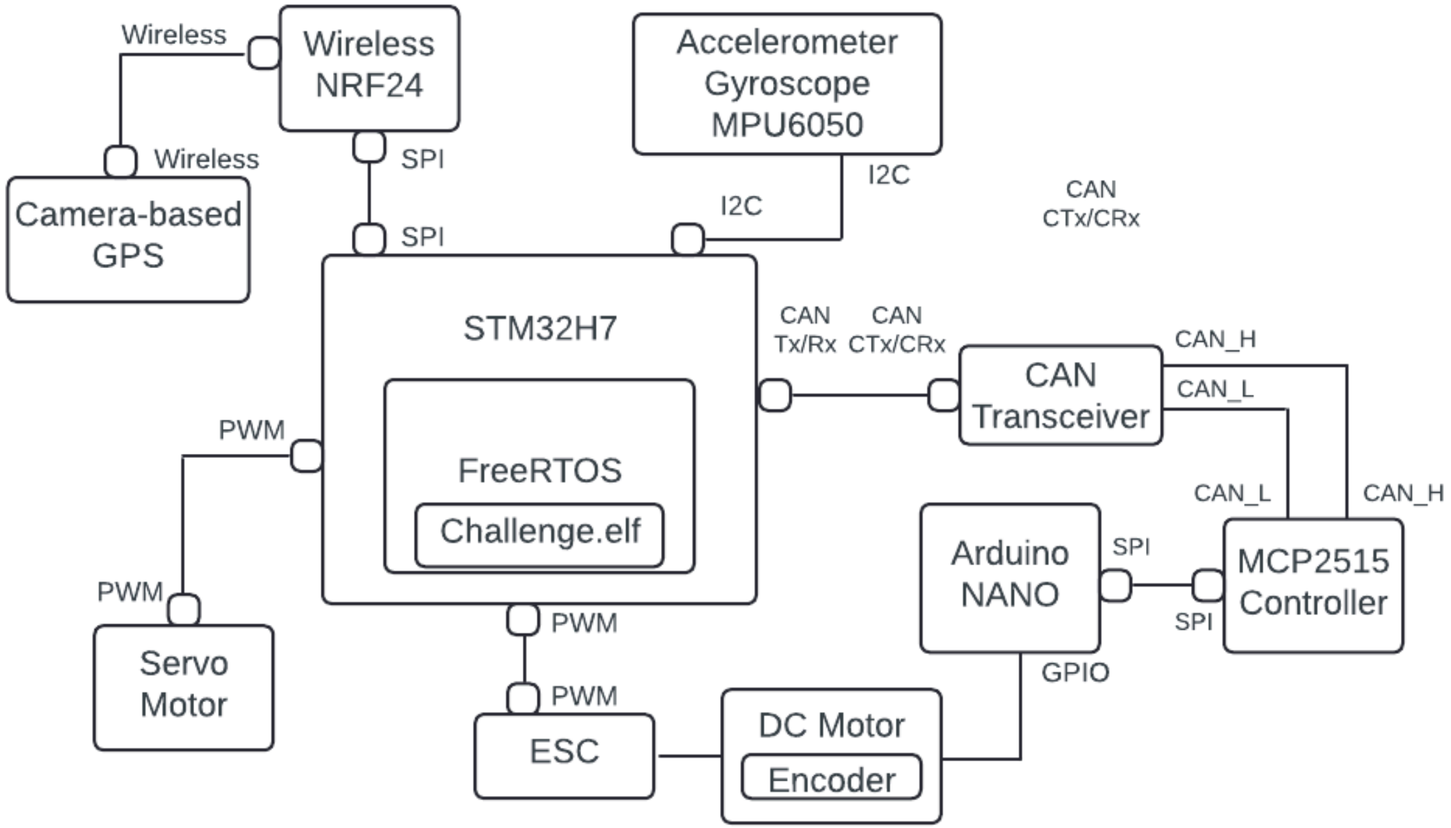
- Corresponds to the Requirements Definition Stage.
- System's high-level purpose and boundaries are defined.
- External actors such as waypoint data inputs, sensors and environments interact with the system.

REQUIREMENTS TABLE

Name	John Deere Tractor with Waypoint Navigation System.
Purpose	Waypoint Navigation System for John Deere tractor.
Inputs	John Deere Global Positioning device nRF24L01 module Encoder Inertial Measurement Unit
Outputs	Wireless data with position estimation obtained through the Deere device and sensors.
Functions	R.1 Receive and store data from its multiple sources. R.1.1 Receive real time position data from John Deere Global Positioning Device. R.1.2 Receive Data from Encoder in CAN message format. R.1.3 Receive Data from IMU in UART / SPI / I2C message format. R.2 Estimate position using sensor information. R.2.1 Analyze data from the John Deere GPS Device to estimate relative position. R.2.2 Analyze data from Encoder and UART to estimate conditions and contents of the environment. R.3 Generate a route for the next waypoint based on analyzed data. R.3.1 Navigate through the route. R.4 Send wireless information of the estimated position obtained through the Deere device and sensors.
Performance	Gets Real Time Position Data within 1 sec of movement.
Manufacturing Cost	Approx. 1000 MXN.
Power	Approx 15 - 20W.
Physical Size / Weight	Length: 17-22in. Width: 8-14in. Height: 5-9in.

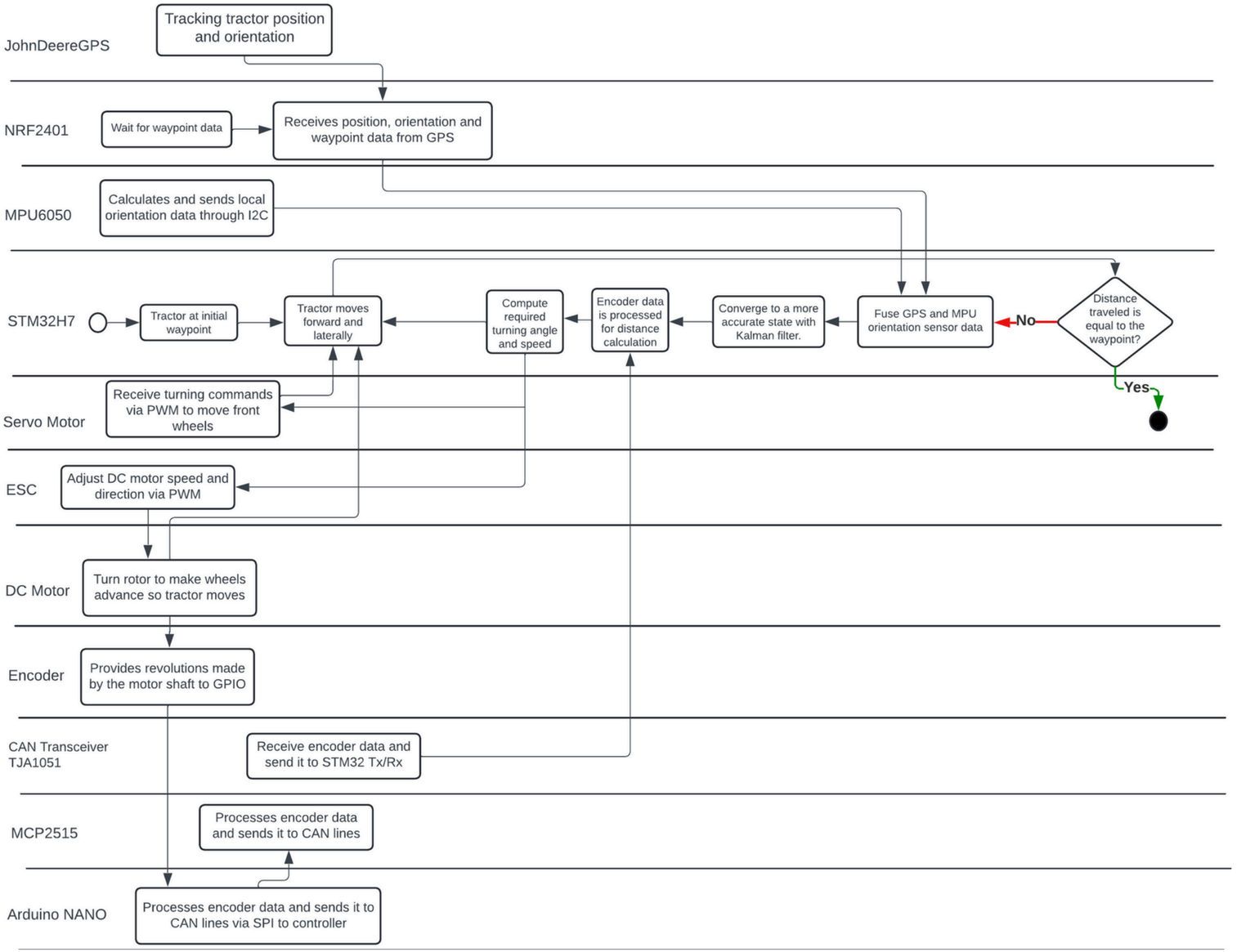
- Corresponds to the Requirements Analysis Stage.
- Structured overview of the system's requirements, where all stakeholders understand what to do.
- Tractor receives position and orientation data, IMU provides orientation stability and encoder measures rotation and distance travelled.

DEPLOYMENT DIAGRAM



- Corresponds to the System Architecture Stage.
- The physical structure of the system with its coomponents and connections are displayed.
- Key components: NRF24 receiver, camera GPS, IMU, encoder, wireless communication channel and control unit that manages navigation via actuator tuning and sensor data.

ACTIVITY DIAGRAM

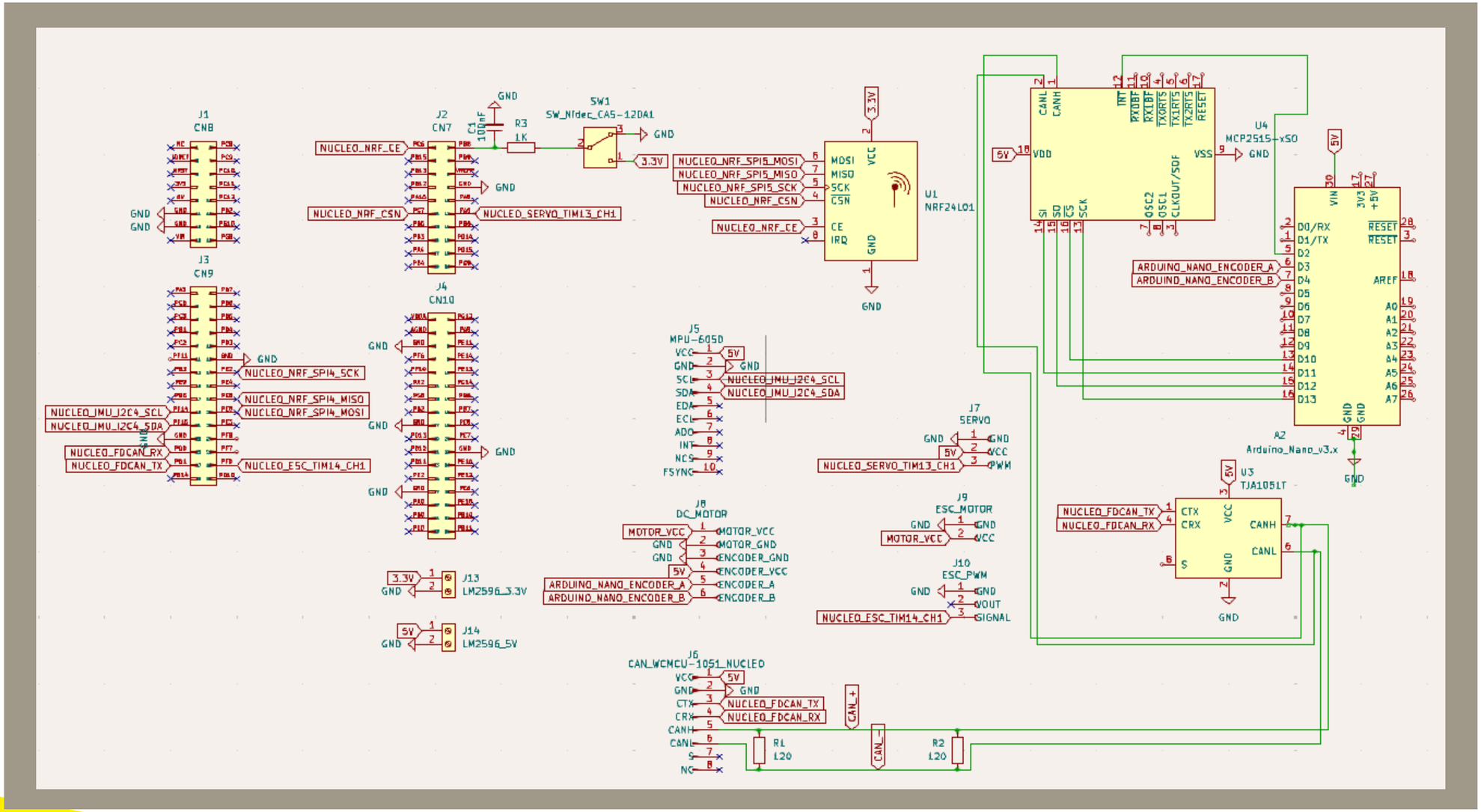


- Corresponds to the System Design and Validation Stage.
- Sequence of operations within the system is shown.

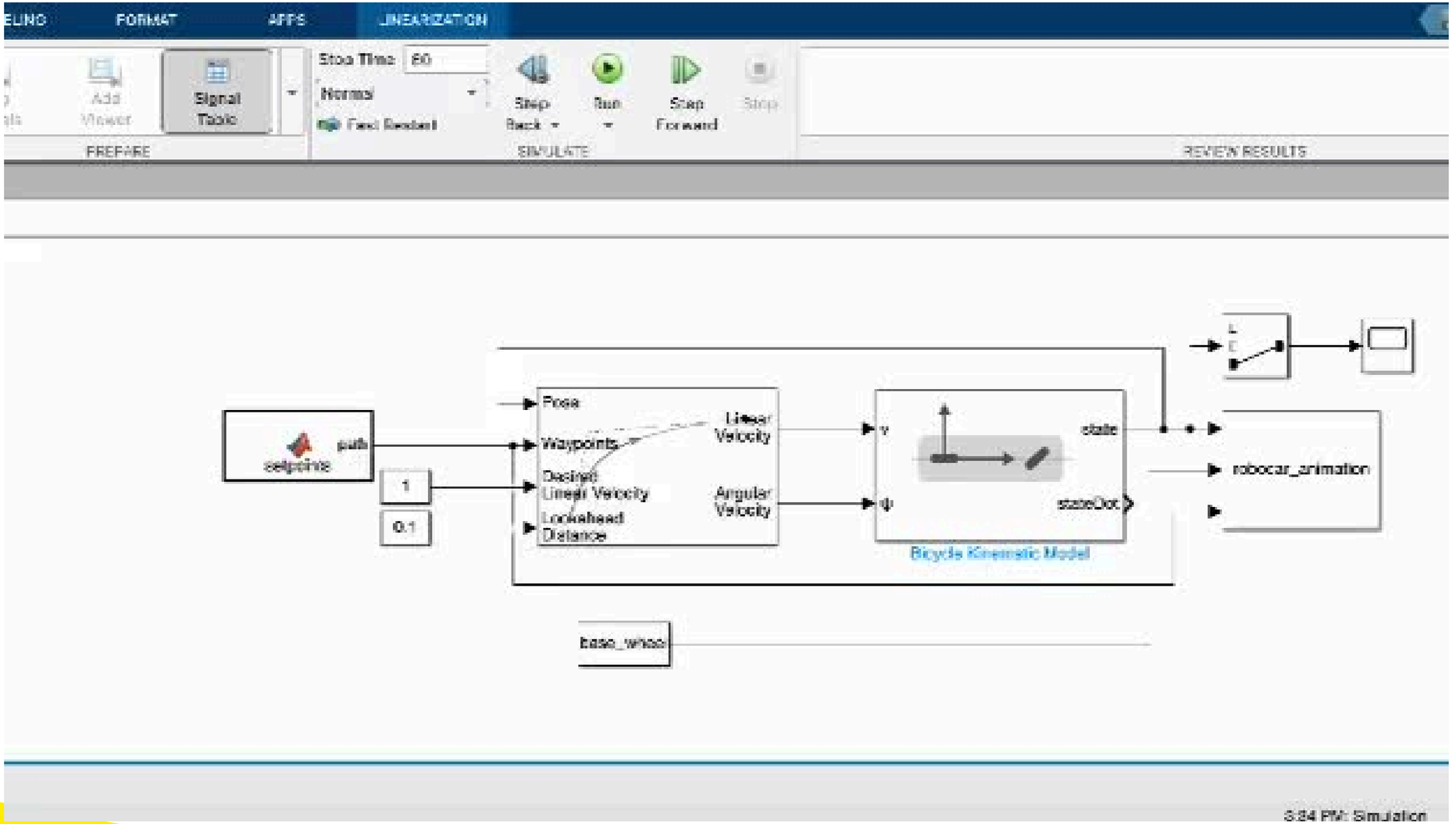
Activity Flow

- Waypoint data via GPS is transmitted and encoder and IMU data are received.
- Data is filtered and computed for required movement quantities.
- Lineal and angular movement is performed.
- Waypoint is continuously monitored.

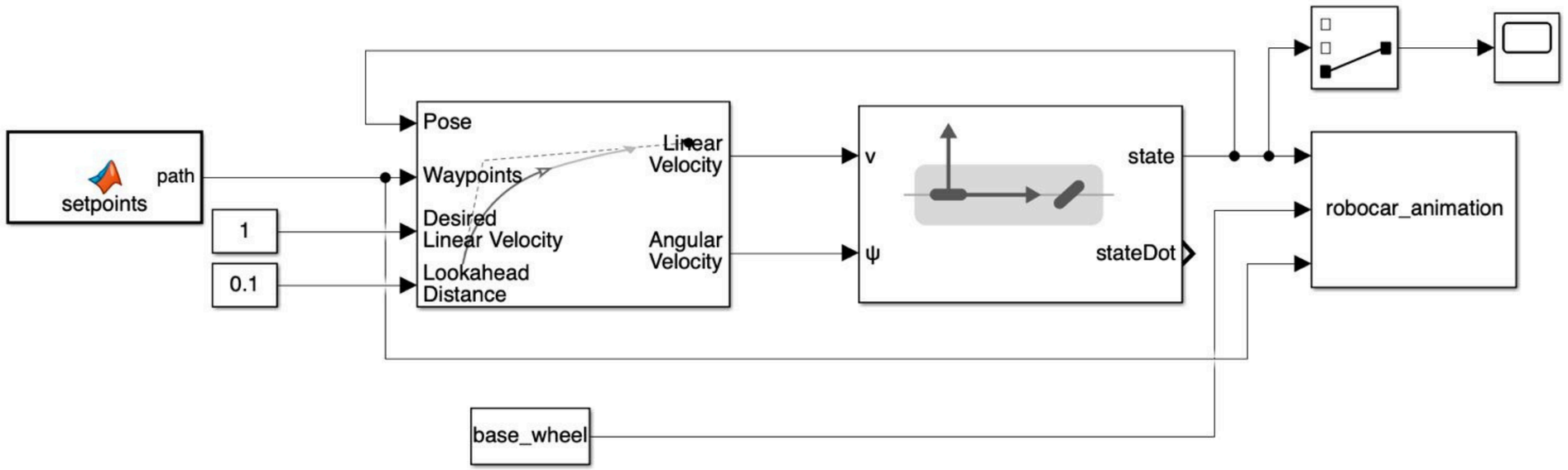
SYSTEM SCHEMATIC DIAGRAM



SYSTEM CONTROL



SYSTEM CONTROL



REFLECTIONS AND CONCLUSIONS

Throughout this challenge, I developed crucial skills in the definition of the high-level purpose, requirements, physical structure and the operations of a proposed solution. Additionally, gained knowledge in the use of communication protocols, parallelization schemes and implementation of algorithms dedicated to autonomous navigation.

Worked under realistic industry protocols and achieved complete control over data sent and received from and to our truck and its route and movement.

It was quite instructive to develop a project that required a development from scratch (electronic design, embedded system programming, intelligent behavior implementation) for an application area whose modernization is becoming increasingly relevant.

It was really fun to envision a solution to the problems that current agritech enterprises face, especially through many concepts affiliated to robotics and digital systems. I experienced a lot of excitement and investment in the development of the solution’s control system, programming and electronics.

THANK YOU!

JOHN DEERE