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ELEMENT/ COMPONENT	REQUIREMENT	VALIDATION / VERIFICATION			
		INSPECTION	DEMONSTRATION	TEST	ANALYSIS
Drive Train Sub-System	Requirement 3.2.1	X	X		See 1.1 Autonomous Movement
	Requirement 3.2.2		X		See 1.2 Basic Movement
Payload Transportation Sub-System	Requirement 3.1.1		X		See 2.1 Carrying Payload Capacity
	Requirement 3.1.2		X		See 2.2 Minimum Pushing Payload
	Requirement 3.1.3		X		See 2.3 Maximum Pushing Payload
Ultrasonic Sensor	Requirement 3.1.9	X			See 3.1 Object Detection
	Requirement 3.1.10			X	See 3.2 Object Avoidance
Physical Setup	Requirement 3.5.1	X			See 4.1 Max Length
	Requirement 3.5.2	X			See 4.2 Max Width

1. Drive Train Sub-System

1.1. Autonomous Movement

Requirement 3.2.1 states that the system shall be autonomous. This will be accomplished using a Teensy 4.1 Microcontroller that implements a set of basic commands of basic forward, backward, clockwise, and counterclockwise movements that

can be implemented with color, infrared, and ultrasonic sensors into an algorithm. The microcontroller was programmed using an arduino IDE and controller along with an H-Bridge module for movement. With these components wired together, the expected result would be that the vehicle operates without any external assistants from users. This result was validated through inspection and demonstration by running a line following algorithm that utilized color sensors to follow a colored line autonomously.

1.2. Basic Movement

Requirement 3.2.2 states that the system shall complete objectives by moving the vehicle forwards and backwards, rotating the vehicle clockwise and counterclockwise, and stopping the vehicle. This system's movement functions are wired to the Teensy and H-Bridge (see circuit schematic for wiring detail). After programming the movement functions with a test code, the vehicle shall move forward, backwards, clockwise, and counterclockwise in 2 seconds intervals. A demonstration of this test code validated that the requirement was met.

2. Payload Transportation Sub-System

2.1. Carrying Payload Capacity

Requirement 3.1.1 states that the system shall carry a minimum mass of 1 kilogram up an 18.5-degree ramp and should carry a maximum of 5kg up a 40-degree ramp. This was accomplished by designing the vehicle to use low speed/high torque motors and ensure its payload was distributed evenly. When carrying the payload the expected result would be the vehicle traveling up the specified degree of incline that corresponds to its weight. This would be 18.5 degrees for 1 kg and 40 degrees for 5 kg. This can be validated by running a simple program to drive the vehicle up the ramp at the specified angles with the corresponding weight placed on the top of the vehicle.

2.2. Minimum Pushing Payload

Requirement 3.1.2 states that the system shall push 1 kilogram of mass up an 18.5-degree ramp. This was accomplished by designing a bumper guard that was placed on the front of the vehicle, helping to push the payload up the 18.5 degree ramp. This can be validated by running a simple program to drive the vehicle up the ramp at the specified angle with the corresponding weight placed in front of the vehicle.

2.3. Maximum Pushing Payload

Requirement 3.1.3 states that the system should push 5 kilograms of mass up an 40-degree ramp. This was accomplished by designing a bumper guard that was placed on the front of the vehicle, helping to push the payload up the 40 degree ramp. This can be validated by running a simple program to drive the vehicle up the ramp at the specified angle with the corresponding weight placed in front of the vehicle.

3. Ultrasonic Sensor

3.1. Object Detection

Requirement 3.1.9 states that the system shall identify obstacles in the field. This was accomplished with an IR sensor wired to the Teensy (see schematic for detailed wiring). When presented with an obstacle in front of the vehicle, the IR sensors will send a HIGH signal to the Teensy, informing the algorithm that an obstacle has been detected in front of the vehicle. Physical confirmation can also be made with the onboard LED. This function can be validated and verified through inspection by providing power to the infrared sensor and viewing the serial monitor output and LED reaction when an object is placed in front of it.

3.2. Object Avoidance

Requirement 3.1.10 states that the system shall avoid and redirect itself between two walls, or a wall and a boundary separated by 600 mm. This was accomplished with ultrasonic sensors and color sensors wired to the Teensy (see schematic for detailed wiring). When given the HIGH signal from the IR sensor, the vehicle shall turn to one of its sides and continue towards a side boundary of the field until an opening in the obstacle wall is detected. If no opening is detected, a 180 degree turn will be performed at the field boundary and the vehicle will then travel in the opposite direction towards the other boundary until an opening is detected. This needs to be validated through a testing on the physical obstacle field.

4. Physical Setup

4.1. Max Length

Requirement 3.5.1 states that the vehicle shall not exceed a length of 530 millimeters. This can be validated by inspection with a measurement device.

4.2. Max Width

Requirement 3.5.1 states that the vehicle shall not exceed a width of 280 millimeters. This can be validated by inspection with a measurement device.