Homework 4: Packaging Specifications and Design

Team Code Name: Autonomous Targeting Vehicle (ATV) ***Group No.*** 3

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Evaluation:

SCORE	DESCRIPTION
10	***Excellent*** *– among the best papers submitted for this assignment. Very few corrections needed for version submitted in Final Report.*
9	***Very good*** *– all requirements aptly met. Minor additions/corrections needed for version submitted in Final Report.*
8	***Good*** *– all requirements considered and addressed. Several noteworthy additions/corrections needed for version submitted in Final Report.*
7	***Average*** *– all requirements basically met, but some revisions in content should be made for the version submitted in the Final Report.*
6	***Marginal*** *– all requirements met at a nominal level. Significant revisions in content should be made for the version submitted in the Final Report.*
*	***Below the passing threshold*** *– major revisions required to meet report requirements at a nominal level.* ***Revise and resubmit.***

* *Resubmissions are due within* ***one week*** *of the date of return, and will be awarded a score of "6" provided all report requirements have been met at a nominal level.*

Comments:

Introduction

The Autonomous Targeting Vehicle is an autonomous wheeled vehicle that can navigate to targets and visually track them, all while avoiding obstacles in its path. The main aspects for the packaging of this vehicle include a chassis, motors, wheels, and room for various peripheral components. Such components include a GPS module, sonic range finder, infrared range finders, digital compass, accelerometer, webcam, microcontroller, atom board, battery, and a PCB to allow communication between all components. Two range finders will be mounted at the front, one to detect objects in front of the vehicle, and one to detect differences in ground elevation. A webcam will be mounted on top of the vehicle so that it can visually lock on a target and navigate to it, avoiding obstacles in its path. The other peripherals will be housed inside the vehicle frame. The main goal of the packaging is to provide a relatively small housing that will allow the vehicle to travel in small spaces, yet be large enough to conceal the electronics. It must also be of adequate height to give the webcam a wide range of vision.

2.0 Commercial Product Packaging

Autonomous traversing vehicles are not readily available commercially, but rather are being developed by the military and science organizations for defense and exploration purposes. Two commercial products that are similar in look and functionality to our Autonomous Targeting Vehicle are the Army's Autonomous Platform Demonstrator (APD) and NASA's Urbie Rover.

2.1 Product #1

The U.S. Army's Autonomous Platform Demonstrator (APD), despite weighing 9.6 tons and measuring at about 15 feet in length, operates in a very similar fashion to our Autonomous Targeting Vehicle. The Autonomous Platform Demonstrator is designed to autonomously navigate to a location using GPS waypoint technology, avoid obstacles, and do so with speeds of up to 50 miles per hour. The APD is designed with a large metal body, six large all-terrain wheels, and several antennae for the sensors. Although the large size of the APD allows it to travel at relatively high speeds,

Figure 2.1: U.S. Army's APD

it does not allow the vehicle to stealthily scout a location for surveillance. Also, its large size does not allow it to fit in tight spaces, which is a highly desired feature of our project. The APD runs on six wheels and includes an advanced suspension system, which enables it to run over smaller objects and climb a one-meter step. Our project only features four wheels, and does not support a suspension system. It would be a great addition for our vehicle, but with the small size limitations, there is no room for the added suspension. The object-detection sensors on the APD are located in the four-meter antenna on top of the vehicle, whereas our project will feature two sonic range finders on the front of the vehicle, and a single sensor on the webcam. One very nice feature about this vehicle is that all its electronics are concealed inside the frame of its body, which we plan to adapt in the design of our project. The packaging feature that makes our project unique is the added webcam for visually tracking an object and following it if it moves.

2.2 Product #2

The Urbie Rover, developed by the robotics team at NASA, is an autonomous traversing vehicle that is equipped with two Pentium processors, a GPS receiver, several sensors, a laser range finder (LIDAR), an omni-directional camera, and a binocular stereo camera pair. It is designed to autonomously navigate in contaminated areas where human presence is very dangerous, and to explore the surface of Mars. It is designed with a low-profile metal chassis, 360-degree revolving arms, several sensors and cameras mounted atop the chassis, and is made to be as lightweight as possible. Its small size and weight make it very portable and able to fit into the smallest of spaces. One nice feature about the design of the "wheels" on the Urbie Rover is that it has the capability to climb stairs and climb over obstacles. The two arms at the front of the Rover rotate 360 degrees, allowing it to easily climb over objects and even turn itself upright if it flips over. Our vehicle will have four separate wheels with no suspension, restricting movement to flat ground only. The negative aspect about the Rover's small size is that it limits the field of vision of the robot. Our project will feature a webcam that sits higher up on the robot, potentially allowing it to have a greater area of vision. We plan to adapt the small "footprint" of the Urbie Rover, but add additional

Figure 2.2: NASA's Urbie Rover

height for greater vision area. The distinguishing feature of our project is the four, large wheels, as opposed to the continuous tracks of the Urbie Rover.

Project Packaging Specifications

The ATV's main chassis is made of laser cut Lexan panels, with heavy-duty aluminum structural components. Its dimensions are 9.5" long by 8" wide. In order to accommodate room for the atom board, batteries, GPS, sonic range finders, compass, accelerometer, magnetometer, and PCB, two project boxes that measure 8"x6"x3" will be mounted on top of the vehicle's main chassis. These boxes are made of durable ABS plastic, and will be joined together to make one continuous box. Each will have a side of the box cut off, which will allow the boxes to be joined together as one. This will allow the components to easily fit in the space allocated.

A camera will be mounted on the top of the vehicle, which will give it the best possible range of vision. A range finder will be attached to the camera to allow it to sense objects in all directions. As the vehicle navigates around an obstacle, the camera will rotate around, allowing the vehicle to detect when it has traveled past the obstacle and is safe to head toward the original destination. The other two range finders will be located on the front of the vehicle, one to detect obstacles from the front, and one pointing down at an angle to detect changes in ground elevation (such as a pothole). An external antenna will be attached on the back of the vehicle to be used with either the GPS or to enhance the WiFi signal on the atom board.

Four 200-RPM gear head motors will be used to drive the vehicle. Attached to the motors are four rubber wheels made of very durable rubber, with rims made of a sturdy nylon material. These wheels will allow the robot to carry large payloads. With a total weight of just over 6 lbs., the selected high-RPM motors along with the sturdy wheels should provide more than enough support for maneuverability.

The detailed schematics, which illustrate the relative size and shape for the ATV, can be found in Appendix A. The materials list, which includes material usage, approximate weight, tool requirements, and unit price, can be found in Appendix B.

3.0 PCB Footprint Layout

Because most of the Peripherals that will be utilized by the ATV will be connected externally, the PCB design is rather simplistic. Two H-Bridges will be used to control the speed and direction of motor movement for each side of the car. Because two wheel encoders will be used to determine small changes in position, we require two pulse accumulators to retrieve the data. In order to accommodate for this, we plan on using two Freescale 9S12C32 microcontrollers. Using two microcontrollers will also give us the freedom to split the workload between controlling the servos for the webcam, controlling the motors for movement, and acquiring data from the various sensors. The two microcontrollers will interface with headers on the perimeter of the PCB, allowing for a clean and simple connection for all the needed peripherals. Because some of the peripherals require communication via I^2C, we will use an SPI to I^2C Conversion IC to translate between the two protocols. Several logic level translators are needed for the different peripherals, along with three voltage regulators (12V, 5V, and 3.3V). The estimated dimensions of the PCB are 5” x 7”. The preliminary PCB Footprint Layout can be found in Appendix C.

Footprint Choices for PCB Parts (Preliminary):

SPI to I^2C Conversion IC: 16-pin TSSOP package
- *Either TSSOP16 or HVQFN24 package available.*
- *The TSSOP16 will be much easier to solder to the PCB.*

Microcontrollers: 32-pin microcontroller connection (used with 40-pin DIP socket).
- *Only footprint available*

Logic Level Converters: Breakout Board - 12-pin connection (connected via headers).
- *Only footprint available*

Accelerometer: Breakout Board - 4/8-pin connection (connected via headers).
- *Only footprint available*

H-Bridge: Several analog circuitry components, still weighing options.

Voltage Regulators: Still weighing the various options for power supply design.

4.0 Summary

The Autonomous Targeting Vehicle is designed to autonomously track and navigate to targets while avoiding obstacles in its path. It will feature a small footprint to allow it to stealthily scout locations for surveillance, as with NASA's Urbie Rover, yet will be tall enough to give the webcam a wide range of vision. Modeling after the U.S. Army's APD, all of the various electronics will be neatly concealed inside the body to allow for a much more aesthetically pleasing look. Because of the numerous "off chip" peripherals utilized by the ATV, the PCB will be designed as an interconnection network between all the sensors, motors, and atom board. It will feature several voltage regulators and logic level translators, along with headers to create clean connections to each of the peripherals on the vehicle.

List of References

[1] A. Cameron. (2010, June 23). *Precision Guidance: U.S. Army Testing Rugged, Autonomous Robot Vehicle* [Online]. Available: http://www.gpsworld.com/defense/precision-guidance/news/us-army-testing-rugged-autonomous-robot-vehicle-10101

[2] B. Boen and B. Dunbar. (2001, June 26). *Urbie, the Urban Robot* [Online]. Available: http://www.nasa.gov/vision/earth/technologies/urbie.html

Appendix A: Project Packaging Illustrations

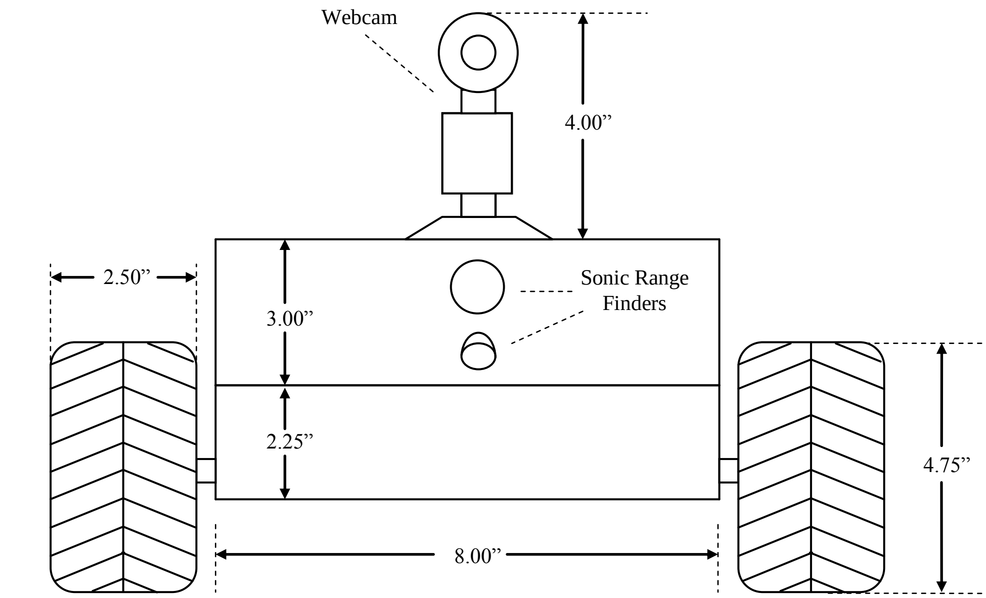

Figure A1: Front View

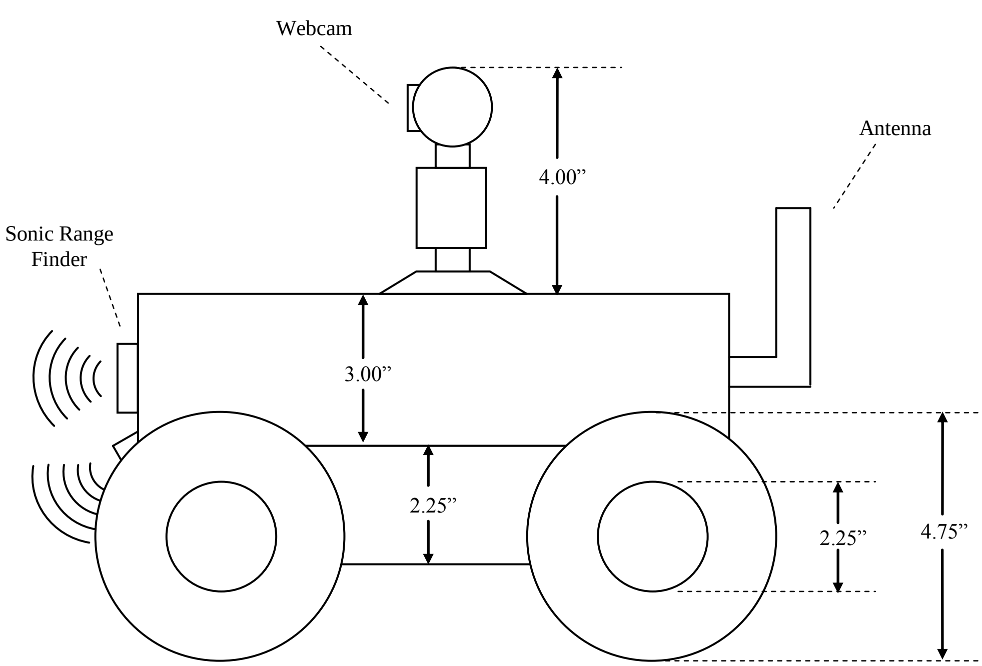

Figure A2: Side View

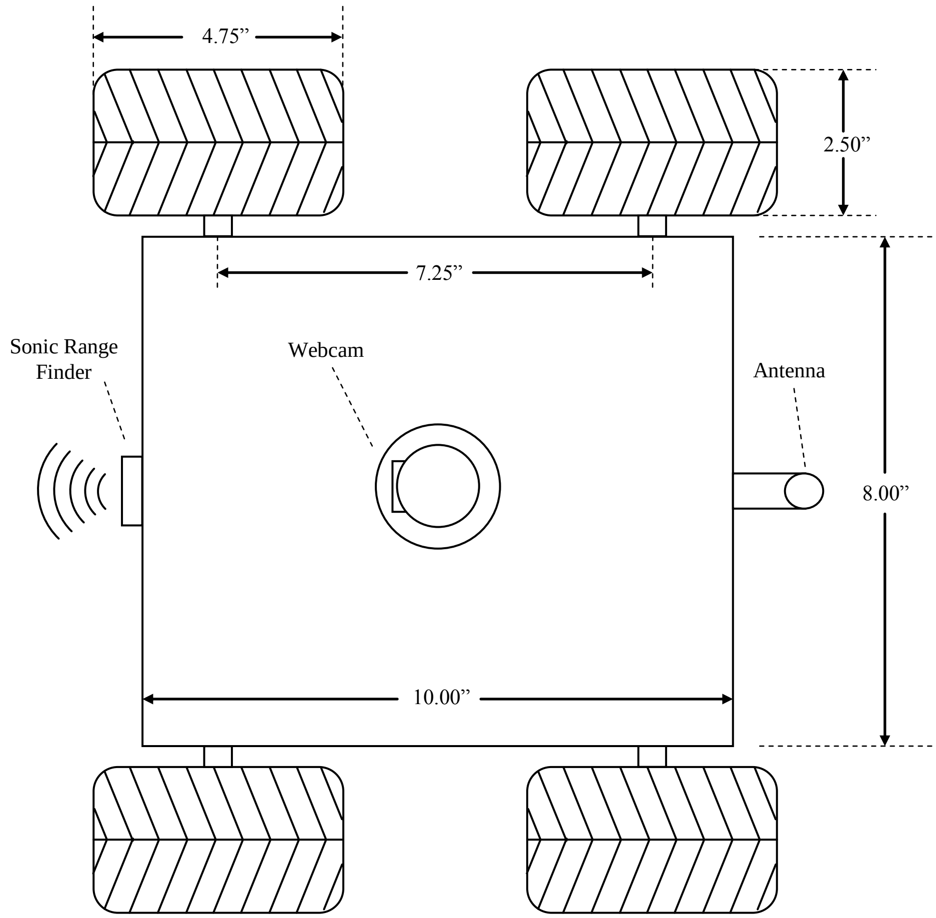

Figure A3: Top View

Appendix B: Project Packaging Specifications

Item	Usage	Weight (oz)	Tools Required	Unit Price ($)	#	Total Price ($)
Robot Chassis	Robot Body	~ 8	None	82.15	1	82.15
Gear Head Motor	Turn Wheels	4 x 4.26	None	21.95	4	87.80
Quadrature Motor Encoder	Precision Movements	2 x .05	None	25.95	2	51.90
Off Road Robot Tires	Travelling	4 x 6.40	None	25.00	2	50.00
GPS (20 Channel)	Sensing Location	0.56	Soldering Iron	59.95	1	59.95
Ultrasonic Range Finder	Detecting Objects	~ 0.05	Soldering Iron	49.95	1	49.95
Infrared Sensor	Detecting Objects	~ 0.05	Soldering Iron	14.95	2	29.90
Accelerometer	Sensing Movement	~ 0.01	Soldering Iron	29.95	1	29.95
Magnetometer	Sensing Direction	~ 0.01	Soldering Iron	49.95	1	49.95
Misc. Hardware	PCB Connections	~ 5	Soldering Iron	~ 100.00	1	100.00
Atom Board	Communication	~ 8	None	0.00	1	0.00
Webcam	Object Detection	~ 1	None	49.95	1	49.95
PCB (populated)		~ 3	Soldering Iron	0.00	1	0.00
Housing Box	Conceal Electronics	~ 4 x 4	Table Saw	6.99	2	13.98
Battery	Power	~ 16	None	49.95	1	49.95
Total Weight		**~ 100.42**	**Total Price**			**705.43**

Table B: Project Parts Specifications List

Appendix C: PCB Footprint Layout

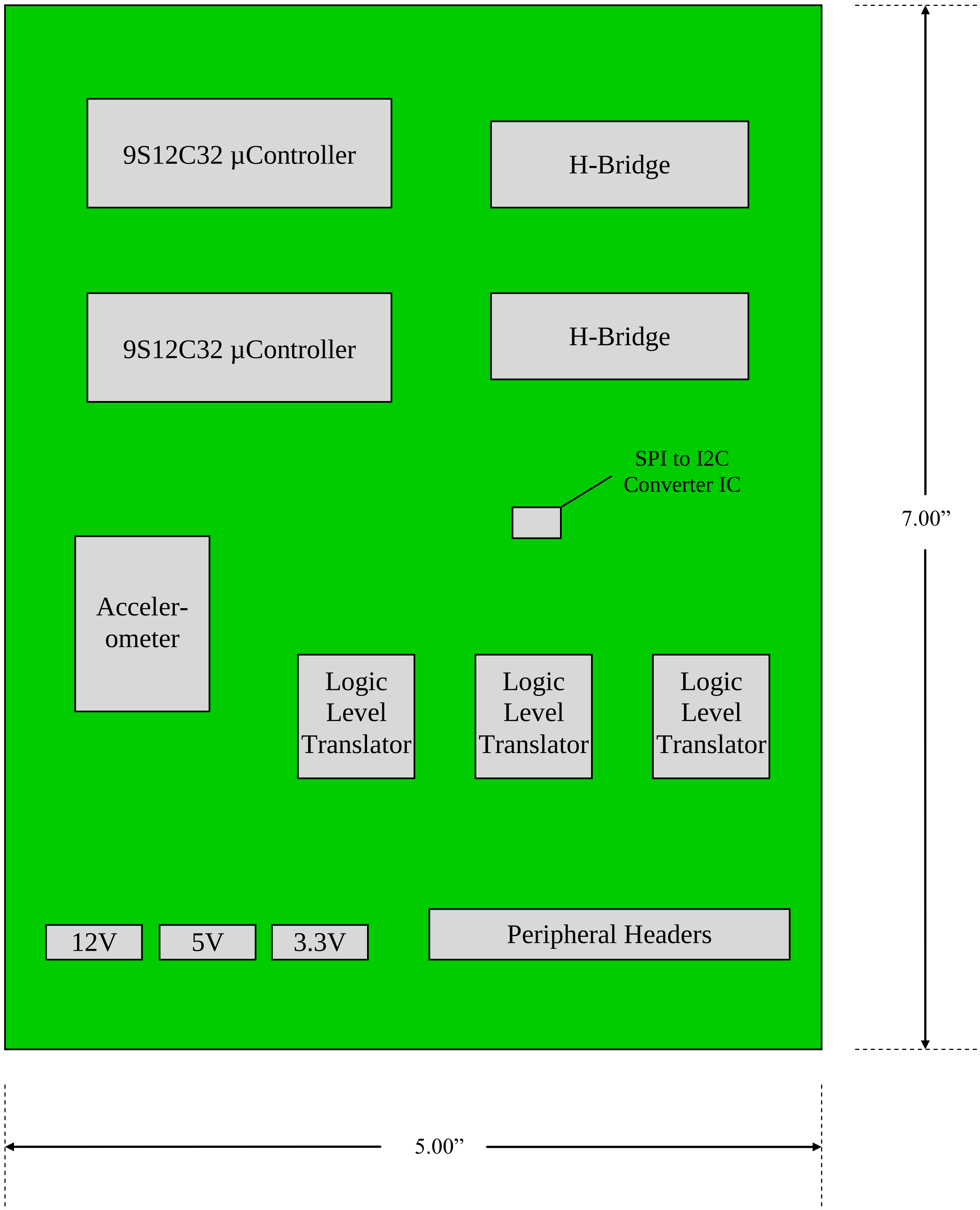

Figure C: Initial PCB Footprint Layout