

Component Analysis

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Team: 6 **Project:** Garbage Collecting Boat
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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Analysis of Component 1		x2		
Analysis of Component 2		x2		
Analysis of Component 3		x2		
Bill of Materials		x6		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

Relevant overall comments about the paper will be included here

1.0 Component Analysis:

The major components required for the Garbage Collecting Boat include the microcontroller, brushless DC motors, brushed DC motor, break beam sensors/light dependent resistors, Global Positioning System (GPS) module, and Wi-Fi module.

- The microcontroller serves as the primary medium for communicating and transmitting the commands and information between the boat and the computer-based user interface, which requires and utilizes the cellular radio data communication.
- Brushless DC motors are used for turbojets. Motors are controlled by the ESC to adjust the speed of the motors and the commands received from the microcontroller to adjust the direction.
- A brushed DC motor is used for the conveyor belt to collect garbage.
- Break beam sensors/light dependent resistors are used to detect the filling level of the storage room.
- GPS module receives the GPS coordinates set route from the computer-based user interface and sends current coordinate information to the user interface.
- Wi-Fi module is used to communicate between the boat and the user interface and transfer data between the user interface and the boat.

1.1 Analysis of Component 1: Microcontrollers

The microcontroller needs to contain enough amount of I/O pins, power, voltage, and RAM to interface with various component modules. Additionally, the microcontroller needs to interface with the Wi-Fi module, GPS module, and the break beam sensing circuit through PWM, UART, ADC, and SPI. Three candidates from the STM microcontroller are taken into considerations. The detailed specifications are shown below. The STM32L496Zx series is selected primarily due to its low power mode which allows switching off certain peripherals to save power. Additionally, comparing with STM32F756BGT6, STM32L496Zx has the same number of RAM, Flash, and ADC channels, thus overweight the STM32F756BGT6 in term of price.

Part Name / Properties	STM32L496Zx [1]	STM32F051R8T6 [2]	STM32F756BGT6 [3]
Features	Low power mode	Low price	High end
Operating Voltage	1.71-3.6V	2.4-3.6V	1.7-3.6V
RAM	320 KB	8 KB	320 KB
Flash	1024 KB	64 KB	1024 KB
USART/UART/LPUART	3/2/1	2/0/0	4/4/0

ADC Channel (number of channels)	3 (24 ext. + 5 int.)	1 (10 ext. + 3 int.)	3 (24 ext. + 5 int.)
GPIO Pin Count	115	55	168
Price	\$ 7.4	\$ 1.74	\$ 11.61

1.2 Analysis of Component 2: Brushless DC Motors and ESC

There are numerous selections for the brushless DC motors. A proper selection of brushless DC motors is crucial for deciding batteries for the desired power and voltage usage. The primary comparative metrics are voltage, current, and KV. These metrics are essential because the motors consume a large amount of power to overcome water drag. For this project, we select the 9T 4370KV + Waterproof ESC combo. By comparing it with the rest of the motors, the 9T 4370KV + Waterproof ESC provides relatively high motor KV (numbers of revolution per minute with 1V voltage supply) which positively related to the speed of boat on the water. The 9T 4370KV + Waterproof ESC also features higher ESC continuous current and burst current thus allowing the boat to accelerate fast. The HobbyWing 2040 and uxcell XTI-3674 motors are appropriate for the project, but they are relatively expensive than 9T 4370KV + Waterproof ESC. The 9T 4370KV + Waterproof ESC beats Kinexsis 1/10 4-Pole for its cheaper pricing and smaller diameter and length for the motor.

Part Name / Properties	HobbyWing 2040/12T [4]	9T 4370KV + Waterproof ESC [5]	uxcell XTI-3674/3D [6]	Kinexsis 1/10 4-Pole + Waterproof ESC [7]
Motor Voltage	< 12.6 V	< 12 V	< 27 V	4.5 - 13.0 V
Motor Current	< 20 A	< 66 A	< 90 A	< 70 A
Motor KV	4800	4370	2200	4000
Motor Diameter * Length	20 * 40 mm	35.8 * 50 mm	46 * 76 mm	37 * 52 mm
Weight	60 g	155 g + 133 g	322 g	158 g + 75 g
ESC Continuous Current	N/A	60 A	N/A	70 A

ESC Burst Current	N/A	320 A	N/A	290 A
Price	\$ 34.99	\$ 30.99	\$ 46.37	\$ 74.99

1.3 Analysis of Component 3: Brushed DC Motors for Conveyor Belt

The conveyor belt requires a single motor to drive and to transfer the garbage to the storage unit constantly. In order to ensure to lift the garbage at a slow speed, the motor should feature enough torque and appropriate motor speed. Additionally, the current and voltage should not exceed the voltage and current limit of the chosen battery. By searching several motor providers on the internet, the data specifications of potential motor candidates are listed in the chart below. Considering all these motors have the appropriate ranges of voltage and current, torque becomes the critical metric for choosing the ASR-00016 as the conveyor belt motor since the ASR-00016 has relatively high torque and low price comparing to the other two motors.

Part Name / Properties	ROB-11696 [8]	ASR-00016 [9]	SKU:FIT048 [10]
Motor Voltage	1-3 VDC up to 12 VDC	3.7 V - 6 V	6 V
Motor Current	110 mA	30 mA	60 mA
Motor Speed	6600±10% RPM	100 RPM - 150 RPM	105 RPM
Torque	N/A	relatively high	1.0 kg.cm
Reduction	N/A	200:1	150:1
Price	\$ 1.95	\$ 9.95	\$ 12.26

1.4 Analysis of Component 4: Break Beam Sensors/Light Dependent Resistors

To monitor whether the garbage storage unit is full, break beam sensors or LDR circuits will be used. When the emitted light gets blocked by the garbage, the sensor receives no light and provides feedback to the microcontroller. The Adafruit provides two types of break beam sensor with different features of emitting and receiving. Two Adafruit products have similar voltage and current range, but the sensing distance is different. Since one sensing distance is up to 1 meter and another is only about 25cm, both break beam sensors do not satisfy the project's need of sensing the fulling of the storage unit. Thus choosing the light dependent resistor becomes the better option with adjustable sensing distance between the emitting light and the light dependent resistors and the lower price.

Part Name / Properties	IR Break Beam Sensor - 3mm LED (adafruit PRODUCT ID: 2167) [11]	Laser Break Beam Sensor (adafruit PRODUCT ID: 2122) [12]	Light Dependent Resistors [13]
Feature	Emitter & Receiver	Emitter only	Laser emitter and LDR
Voltage	3.3-5.5 VDC	4.5-5.5 VDC	< 320 VDC
Current	Emitter: 10-20 mA Receiver: 100 mA	25 mA	75 mA
Sensing Distance	25 cm/10"	up to 1 m	N/A
Response Time	2 ms	2 ms	N/A
Size	20mm x 10mm x 8mm / 0.8" x 0.4" x 0.3"	20mm x 18mm x 10mm / 0.8" x 0.7" x 0.4"	13mm x 13mm x 6.6mm
Price	\$ 1.95	\$ 17.5	\$ 0.14

1.5 Analysis of Component 5: GPS Module

Regarding choosing the proper GPS module, metrics such as position accuracy, time to first fix, the number of channels, package type, and power consumption becomes essential. The table below shows three different modules that satisfy the needs of the project. All three GPS modules feature UART and SPI modules, and thus the interfacing between the GPS module and the microcontroller would not be a significant concern. Since all three modules have approximately similar voltage and current range, the main differences between the parts are the number of channels and position accuracy. For higher position accuracy and larger number of channels, the Adafruit 746[14] is chosen to be the GPS module.

Part Name / Properties	Adafruit 746 [14]	NEO-6M [15]	Maestro A2200-A [16,17]
Chipset	MTK3339	NEO-6M	FstarIV
Voltage	5 V	3 V - 5 V	3.3 V
Current	20 mA	10 mA	41 mA
Channel	66	50	48

Position Accuracy	1.8 m	2.5 m	3 m
Time-To-First-Fix (Cold Start)	34 s	27 s	35 s
Package	Breakout Board	Breakout Board	Module
Price	\$ 39.95	\$ 15.66	\$ 16.39

1.6 Analysis of Component 6: Wi-Fi Module

The Wi-Fi module is a critical component for the design which communicates the computer-based user interface with the microcontroller on the boat. In order to interface with the microcontroller successfully, the Wi-Fi module must support SPI or UART interface and satisfy the power consumption of the microcontroller. By searching the internet, three modules from different manufacturers were found, and the specifications of each component are shown below. Since all modules have the same frequency, protocol, interface, and data rate, and the range of voltage and current are within the power constraints of the microcontroller, choosing the ESP-WROOM-02 is more economical since the ESP-WROOM-02 is the cheapest among all three similar Wi-Fi module.

Part Name / Properties	ESP-WROOM-02 [18]	ATWILC1000-MR1 10PB [19]	ESP8266 [20]
Voltage	2.7 - 3.6V	3.3 - 4.3V	0.25 - 3.6V
Current	120 - 170mA	29-230mA	62-215mA
Frequency	2.4 - 2.5GHz	2.4GHz	2.4GHz
Protocol	802.11 b/g/n	802.11 b/g/n	802.11 b/g/n
Interface	SPI/UART	SPI/UART	SPI/UART
Data Rate	72.2Mbps	72.2Mbps	72.2Mbps
Price	\$5.00	\$7.34	\$6.95

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