Concept Generation

This section outlines the designs that were considered for the RTC. The designs are separated by the individual modules, namely General Concepts for the RTC, Drive System, Frame, Controls, and Brakes/Wheels. The designs were developed using group and individual brainstorming sessions, along with market research of similar products and engineering innovations in the automotive industry.

1.5.1 General Concepts

The following are possible concepts for the cart as a whole.

Concept 1.

- Rectangular framed cart with 4 motorized wheels on each corner of the frame controlling the movement.

Concept 2.

- Oval shaped cart with 4 motorized wheels.

Concept 3.

- Two separate singular units
- One unit holds the recycling bin and the other holds the trash bin
- Can be used to take out the bins individually
- Each unit has three wheels on the bottom

Concept 4.

- One unit that is made up of two smaller, detachable units
- The two smaller units will holding either the recycling or trash bins
- The two smaller units can come together to form one larger unit. This could help with storage.
- Smaller units can have a triangular shape to save space

Concept 5.

- Square framed cart
- 2 caster wheels in the front of the frame
- 2 motorized wheels in the back the frame
- Rear - wheel drive
- Microprocessor, ESC, or SBC controlling the drive system

Concept 6.

- Square framed cart
- One caster wheel on the front of the frame

- One caster wheel on the back
- 2 motorized wheels in the middle of the cart
- Mid - wheel drive

The different concepts above show and highlight possible designs of the cart as a whole. The rectangular cart with a wheel on each corner is the most basic and common design possible. The oval shaped cart is designed to save space and use as little materials as possible. Two separate units have the advantage of moving independent of one another, which is beneficial if you have different garbage and recycling days. The advantage of having a detachable unit is that in the case of a big blow the cart can absorb a large force by splitting apart and dispersing the energy more efficiently. An advantage to having two motorized wheels and two caster wheels is that you can save money and space by only having to motorize and power two wheels instead of all four. The two motorized wheel design will require motors that are able to output more torque than the four motorized wheel design.

1.5.2 Drive System

The following are possible concepts for the drive system of the RTC. In all of these concepts, the drive system should be able to carry the load of two full waste containers. This is the worst case scenario.

Concept 1.

- Engine drive

Concept 2.

- Electric motor drive

Concept 3.

- Four wheel motored

Concept 4.

- One wheel motor

Concept 5.

- Two wheel motor

Concept 6.

- Front wheel drive

Concept 7.

- Rear wheel drive

Concept 8.

- Middle wheel drive

Concept 9.

- Non-motorized caster front wheel(s)
- Two motorized wheels in the back
- Rear-wheel drive

Concept 10

- Two motorized motors in the center of the cart. They are placed on either side cart.
- When one motor reverses and the other motor moves forward, this allows for zero point turning.
- Middle wheel drive

To eliminate noise and protect the environment from fossil fuel hydrocarbons, the optimal drive system is electric, not engine powered. Keeping with environmental consciousness, the drive system requires less maintenance and produces less waste if the power system is rechargeable. If batteries are used, then the RTC will consume less batteries and produce less waste if they are rechargeable.

The platform of the drive system should enable max maneuverability to avoid objects. As a great example of operation, the steering for the drive system should have the same inherent operation as a mobile wheelchair in which it can hold a heavy weight and still steer within a small footprint. Therefore, middle drive forward/reverse steering enables the smallest footprint for turns and 360 degree actions using front and rear swivelling wheels to stabilize load.

1.5.3 Power System

Concept 1.

- AC Electric cord power(tethered)

Concept 2.

- Rechargeable batteries

Concept 3.

- Disposable batteries

Concept 4.

- 12 Volts

Concept 5.

- 24 Volts

As previously mentioned, the power system will consume less resources and produce less waste, such as batteries, if it is rechargeable. The batteries for the power system should be sufficient enough to power the drive system for at least a month. This would equate to travelling from the home base to the curb and back to the home base once a week.

AC tethering inhibits the best mobility options and should not be used. Furthermore, both 12 V and 24 V operation is an acceptable power source. Using two 12 V batteries, allows you to use one as backup power or both can be separated to power any added accessories without depleting drive power. If a rechargeable power system is used, a minimum run time operation before charging is needed must be calculated (week, month, year?).

1.5.4 Frame

Concept 1.

- Plastic rectangular frame

Concept 2.

- Plastic square frame

Concept 3.

- Plastic circular frame

Concept 4.

- Plastic triangular frame

Concept 5.

- Plastic oval shaped frame

Concept 6.

- Steel rectangular frame

Concept 7.

- Steel square frame

Concept 8.

- Steel circular frame

Concept 9.

- Steel triangular frame

Concept 10.

- Steel oval shaped frame

Concept 11.

- Aluminum rectangular frame

Concept 12.

- Aluminum square frame

Concept 13.

- Aluminum circular frame

Concept 14.

- Aluminum triangular frame

Concept 15.

- Aluminum oval shaped frame

Concept 16.

- Frame with one ramp for the whole trash can

Concept 17.

- Frame with two separate ramps for each wheel of the bins

Concept 18.

- Emergency lights on the frame

Concept 19.

- Frame that holds 1 trash can; each bin will have its own trash cart

Concept 20.

- Frame can hold the trash bin and the recycling bin

Plastic is the ideal material for the RTC, because it can withstand the rain without corroding. Emergency lights on the RTC can ensure greater visibility for pedestrians and drivers to avoid collisions. A rectangular shape for the RTC will allow for an easier design to assemble and holds both the recycling and regular garbage bins; it will offer the best stability when the RTC is moving. Having a rectangular shape, also makes it easier to design a gate and a ramp to unload the bins quickly with minimal difficulty from the RTC. Ideally, building a frame as low

as possible reduces any extraneous effort that users would normally not exert when taking out the trash. Providing a ramp that allows the containers to be rolled out of the cart rather than lifted out further reduces the stress put on users. It is assumed that the waste engineers will return the waste bins to the RTC once they have disposed of the garbage; therefore, the users only need to place the waste bins in the RTC the very first time they get an RTC. There is no need for users to take the waste bins off the cart, since they will be able to dispose of garbage bags into the waste bins while they are on the RTC. Lastly, it is cheaper to design one cart rather than two separate units.

1.5.5 Control System

Concept 1.

- Single board computer (SBC)

  They are faster than MCUs and small enough to fit on the unit itself. It can act as the control center for the drive system and the various sensors needed for the RTC. They have larger amounts of memory for various application capabilities, such as image or video processing, pattern recognition, sonar or radar, and GPS. The larger amounts of memory will be needed for autonomous applications. One possible way to add autonomous functionalities to the RTC is by creating a neural network, which will require a database. This needs large amounts of memory, which SBCs can provide; however, they are more costly than MCUs and more complicated to use

Concept 2.

- Microprocessors and Microcontrollers

  They can be used for a variety of control applications and are cheap, easily replaceable, and depending on the brand, have numerous open source development tools. They can be combined with a single board computer to delegate tasks. Certain tasks that do not require as much memory or speed can be controlled with a microprocessor, while more computationally heavy tasks can be performed by the SBC.

Concept 3.

- Electronic Speed Controller (ESC)

  This is a plug and play electronic motor control device with a lot of open source resources and software tools. It also allows for dual motor speed control; however, if we are using omni-directional wheels, then we will likely need one for each motor. The ESC is made specifically for motor control and many come with basic wiring done. This will simplify the installment to the power supply and motors.

Concept 4.

- Custom Game Controller

  A custom game controller can be used in conjunction with an SBC, MCUs, and/or ESC for user control of the RTC. A game controller uses a platform that many users would already be familiar with, which will simplify the user interface and enhance the user experience. It could cut down on the learning curve for user control of the RTC.

A combination of the options laid out above would be ideal. Using an SBC, provides enough memory and the speed needed to add autonomous controls to the RTC. The application specific qualities of ESCs make it ideal for motor control of the drive system and frees up memory and resources on the SBC to enable other features, such as sonar, image or video processing, and pattern recognition. The use of microprocessors and microcontrollers as cheap control solutions for simple tasks, which will also free up even more resources for the SBC. An SBC is compatible with various communication protocols, such as Wi-Fi and Bluetooth, and can allow for remote access. This will allow for the use of a wireless controller. Retrofitting a gaming controller for the RTC gives users some familiarity. This will shorten the learning curve needed to use the RTC. If more control capabilities are needed for user control, then there are a variety of remote controls available to meet our specific needs for the RTC.

1.5.6 Brakes

The following are concepts for the brakes of the RTC.

Concept 1.

- Drum Brakes

Concept 2.

- Disc Brakes

Concept 3.

- Single Circuit Hydraulic Brakes
- Do these brakes need to be moved more often than conventional brakes?

Concept 4.

- Dual-Circuit Hydraulic Brakes

Concept 5.

- Air Brakes

Concept 6.

- Power Brake Booster

Concept 7.

- Parking Brakes

Concept 8.

- Emergency Brakes

Concept 9.

- Electronic braking built in to motor

The RTC will need to travel to the drop-off location and securely stay in place until the waste bins have been emptied and returned to the RTC by the waste engineers. In order to ensure this process happens smoothly several times a year, multiple concepts must be considered for the brakes. A simple braking system, such as the drum and disc brakes, is a good options due to simplicity of frictionally braking. Another slightly more complex and expensive braking system is the hydraulic braking systems using pressure. The simplest and least expensive braking concept that we generated was a parking or emergency brake that prevents the cart from rolling and moving at all.

1.5.7 Wheels

Concept 1.

- Wheels should have small rubber spokes to grip the terrain better

Concept 2.

- Wheel made of a cast iron/semi-steel

Concept 3.

- Wheel made of forged or ductile steel

Concept 4.

- Wheels are made of nylon and glass
- They are good for high temperature applications

Concept 5.

- Wheels are made of hard rubber

Concept 6.

- Wheels are made of phenolic resin

Concept 7.

- Wheels are made of rubber wheels filled with air

Concept 8.

- Wheels are made of polyolefin

We need to consider a wheels durability, lifespan, and the RTCs weight in order to ensure a durable, cost-effective option. The overall grip and maneuverability of the cart can be improved by including small rubber spokes around the wheels. The cast iron/semi-steel wheels have exceptional durability; however, their weight and cost are issues. The hard rubber wheels are good for high load capacity and easy rolling. The phenolic resin wheels have a high load capacity, are inexpensive, and are very durable. Lastly, the polyolefin wheels are a hard tread wheel. They are lightweight, economical, and are resistant to water.