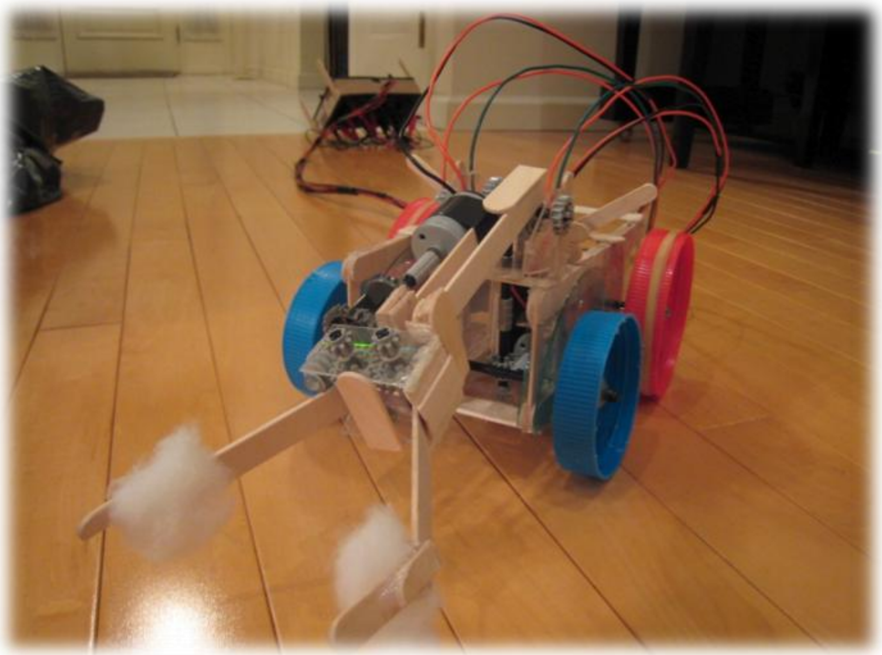


CDC Panasonic: Beach Sweeps

"The Viking"

High Technology High School

Michele Mensing Grade 11

Christian Gennaro Grade 11

Oliver Song Grade 11

Advisor: Dr. C.W. Christoe

1. Description of Design

Our device applies basic materials in a useful way. There are five major parts to our design that make it work so well: the base; the wheels and the gear system responsible for moving them; the arm and the gear system responsible for moving it; the hand and its gear system; and the TSS (temporary storage system) and its gear system.

The Base

The base, constructed out of Popsicle sticks, CDs, and hot glue, holds most of our gears. There are three length-spanning frames, each made out of CDs and Popsicle sticks. Two CDs are cut in half and parts of each end are cut off to make the design shown in FIG. 1. Six sets of these are needed- two for each length-spanning frame.

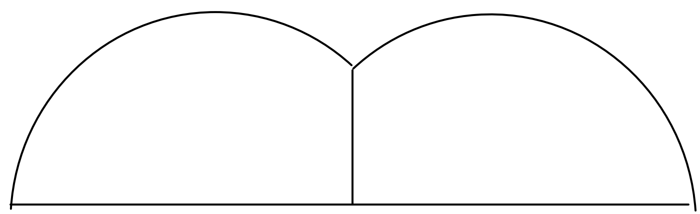


FIG. 1 – Diagram of CD sets used as walls

The two CD setups above are mounted on Popsicle stick structures. These structures are made out of 12 Popsicle sticks. Two small Popsicle sticks (2.5”x .375”x .083”) act as vertical supports and 10 large Popsicle sticks (4.5”x .625”x .083”) act as horizontal supports. Five large Popsicle sticks are used so the frame can be sandwiched together because of the space in between the four outer Popsicle sticks, as shown in FIG. 2a. We glued these supports into the shape of a rectangle as shown in FIG. 2b.

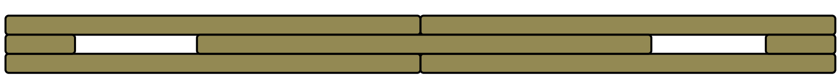


FIG. 2a- Top view of our length-spanning frame without CDs attached

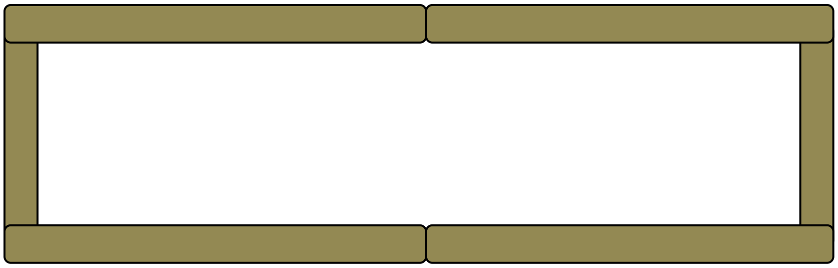


FIG. 2b- Front view of our length-spanning frame without CDs attached

We attached the CD setup onto both sides of the Popsicle stick frames with hot glue. The result is shown in FIG. 3. The CDs were peeled with tape to create transparency and make it easier for us to see inside.

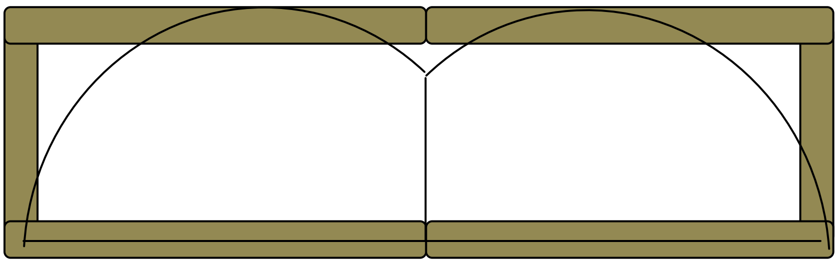


FIG. 3- a completed length-spanning frame

After making three of these length-spanning frames, we clamped each in line with 1.5” spacers in order to align them perfectly. Then we glued seven appropriately trimmed Popsicle sticks directly across the length-spanning frames on the top and bottom, creating width-spanning supports.

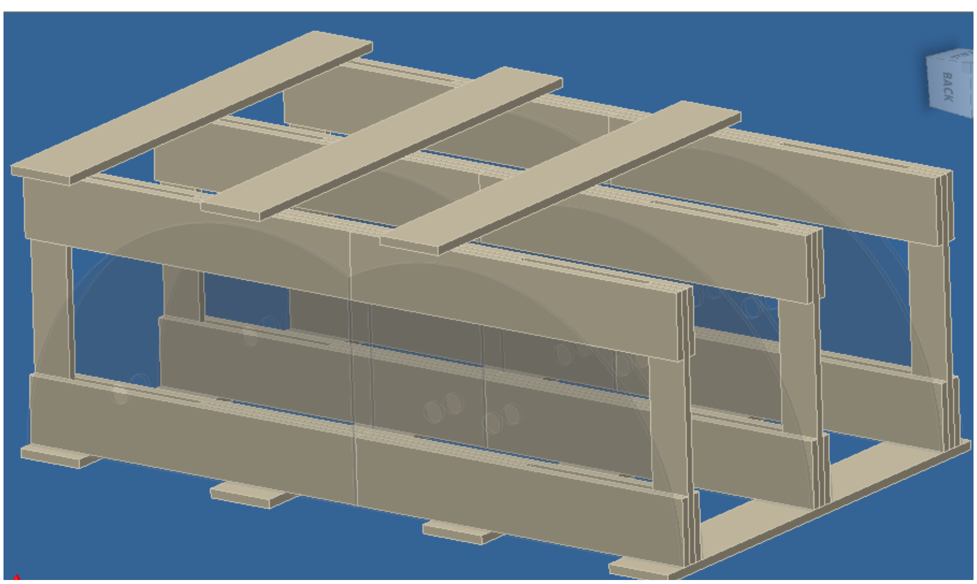


FIG. 4- full body including three length-spanning supports and multiple width-spanning supports

The Wheels and their Gears

We used peanut butter caps for our wheels. They were our first choice because of their lightness, easy manipulation, and large contact area with the ground. Several benefits were the lightness, because it lessens unnecessary load on the motor, and the lids were easy to manipulate so they were easily drilled and secured to the axles. To create more friction with the ground, we wrapped rubber bands around the surface of the peanut butter lids.

The front wheels, which are freely rotating, have a diameter of 3”. The driven wheels that are connected to the drive axles and powered by the motor have a diameter of 3.5”.

The gear set up we use provides a large amount of mechanical advantage (app. 48) to translate the motor’s 5220 shaft RPM into manageable 85.833 wheel RPM. This wheel RPM translates to a speed of 13.5 in/s for our device. This gives an added advantage of more torque and, provided that our wheels have enough traction, an easier time climbing ramps. The gears go as follows: a worm gear driving a 24-tooth 1” diameter gear, that gear shares an axle with an 8-tooth 3/8” diameter gear, that gear then drives a 24-tooth 1” diameter gear which has the drive wheels on its axle. Our gear setup is shown in FIG. 5.

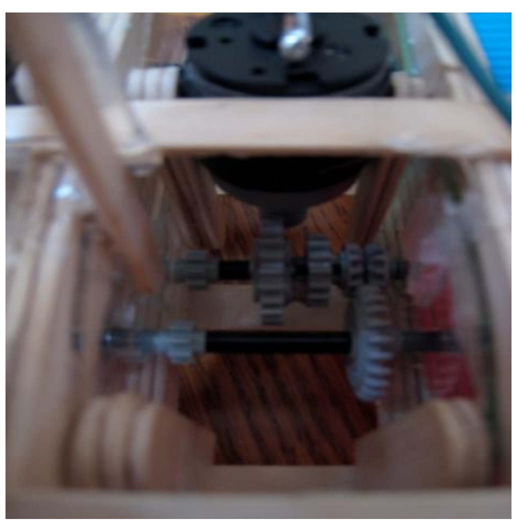


FIG. 5- Wheel gear setup for one of the wheels (the other gears in the picture are just place holders)

The Arm and its Gears

The arm is made of Popsicle sticks, CDs, gears, and a battery holder. It is controlled by a motor stationed in the base of vehicle near the front right side. The arm only moves up and down, not side to side. The hand allows for perpendicular degrees of freedom. The motor in the base has a worm gear on it (wg1), which turns a 16-tooth 5/8" diameter gear (g1). That gear has an axle protruding upwards through the ceiling of the base. At the end of the axle another worm gear (wg2) was set up that turned a 24 tooth 1" diameter gear (g2). This gear (g2) is on an axle that rotates the arm up and down. Since this is strictly a rotating motion, the hand at the end must be at a slant to be flush with the ground when lowered.

This multiple-worm-gear set up is ideal for the arm because it maximizes the torque that can be applied to the arm and slows the speed down to a manageable rate. The final product of the motor and gears is an axle turning slowly about the axis of rotation of the arm. The actual arm is slid onto and secured to this axle so it turns with it.

FIG. 6a- First part of double worm-gear setup (first worm-gear connected directly to the motor)

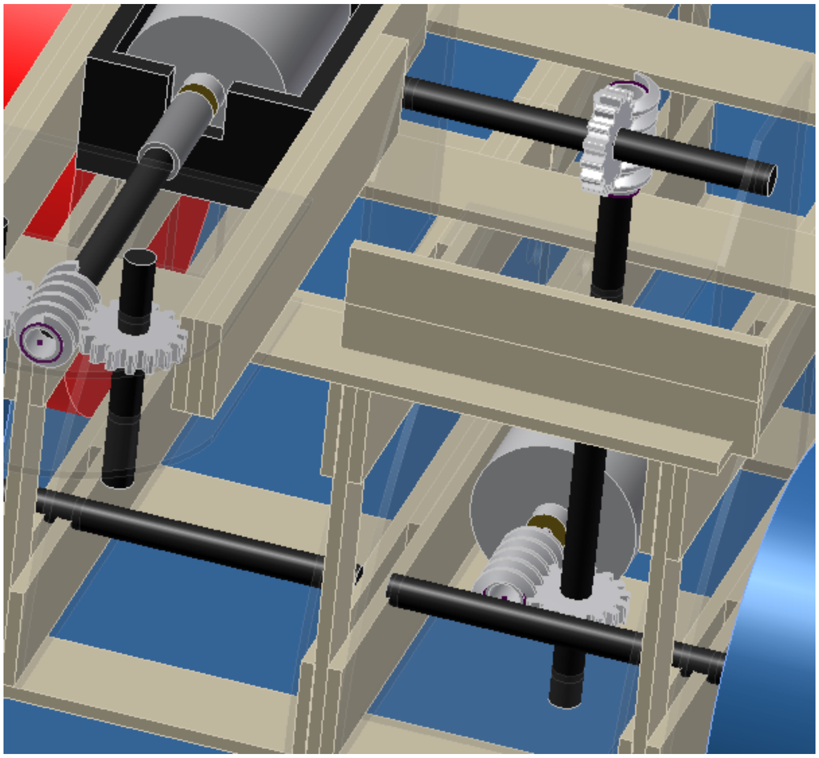


FIG. 6b entire worm gear set up

The Hand and its Gears

The hand is comprised of Popsicle sticks, CDs, gears, and a battery holder. The hand employs the idea that if a worm gear turns two gears simultaneously on each side, they will spin in opposite directions. We attached a Popsicle stick to each axle of these oppositely spinning gears in order to have them open and close, creating a hand. The hand has a motor as close to the axle of rotation of the arm as possible to minimize resistance on the motor that rotates the entire arm. The hand's motor drive shaft has a connecter piece glued to with a long axle protruding outwards and a worm gear at the end, effectively extending the drive shaft of the motor. The worm gear fits between two 16-tooth 5/8" gears. Pieces of Popsicle sticks glued together and then each attached to one of the axles holding the 16-tooth gears act as the hand.

The axle that holds the worm gear is held parallel by a CD piece perpendicular to the Popsicle sticks, similar to the fashion which the two hand gears are held by a CD gear box.

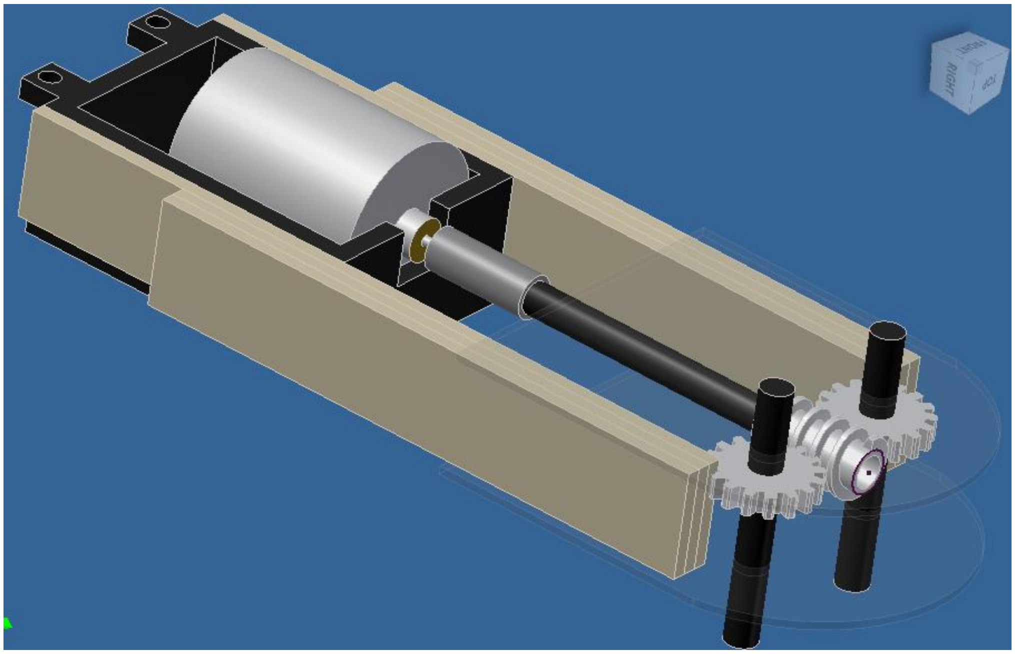


FIG. 7- Motor connected to a worm gear driving two oppositely turning gears

Temporary Storage System

The TSS is one of the more clever aspects of our design. The system uses two slip gears driven in opposite directions to create a two-output, one-input device. We only had one motor left to use for our storage system and we needed to store two different materials. We solved this problem by setting up the gears so when the motor turned one way, only one of the compartments would lift and the other compartment would go the other direction, getting stopped by the vehicle. The slip gears allow this to happen without jamming the design, which changes the angle between the two compartments and makes it possible for only one compartment to move at a time.

The system is used to sort metal and plastic garbage and dumps the garbage off of the left side of the vehicle. At the present, the construction has not been completed so we do not know whether the motor will exert enough torque to cause the slip gear to slip. One problem that is inherent in the storage system is storing garbage in them in the first place. We will need to drop the garbage from high up and hope that it falls into the appropriate container. If there are any spots of the hand that are clinging to the garbage, the trajectory of the garbage will be affected.

We will need to address and resolve these problems before the final challenge in a little less than one month. A preliminary design is shown in FIG. 8

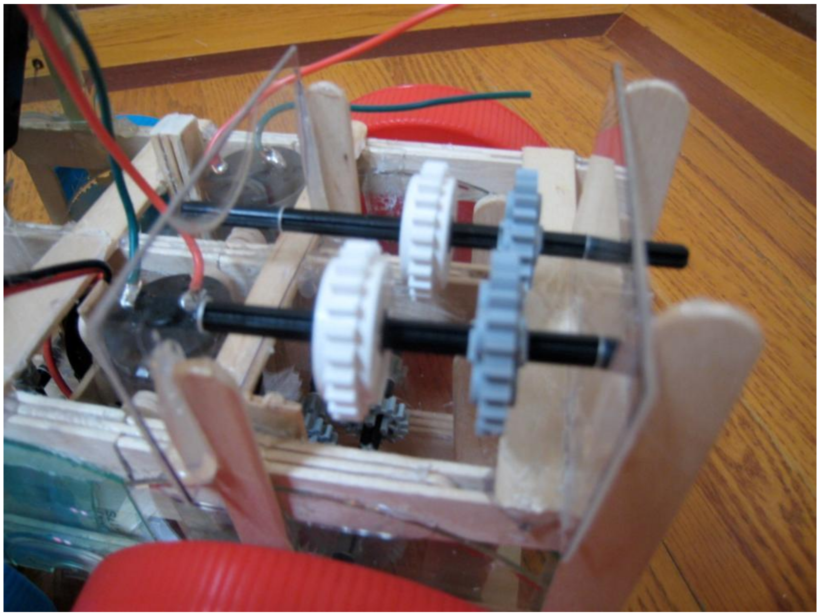


FIG. 8- the two slip gears would be driven in opposite directions as the motor (not shown) drives the two regular gears from below

2. Brainstorming ideas and Principles employed

We had many brainstorming ideas. We even created separate preliminary prototyping designs when we independently generated two different approaches to solving the problem. One of them was a structure with a CD base with axles spanning across. The multiple axles held two CDs parallel to each other while simultaneously acting as motor axles. This design had the advantage of being light, durable, and easy to control. However there were many disadvantages. For example it was too small so it wasn't able to store any garbage. Also it was not able to fit worm gears into the parallel axles, so we would not have been able to use them. We eventually discarded this idea and settled on our alternate and current approach to solving the problem.

We used many principles in the designing of our vehicle, including lever equations, gear ratios, rotational and linear velocity, momentum, power, friction, and circuitry.

Lever equations

We extensively used lever mechanical advantage calculations to determine the best position for the parts of our arm and hand gear boxes. For example, we extended the drive axle of one of our motors so that we could place it closer to the axis of rotation in our arm.

Gear ratios, rotational and linear velocity, and momentum

We also extensively used worm gear and regular gear mechanical advantage calculations to determine the rotational velocity of our wheels, arm, and hand. We found the wheel rotational velocity to directly calculate the linear velocity of our vehicle. It was an easy step to find the momentum of our vehicle after this. Calculations for the rotational velocity of the arm were useful for ensuring that the torque and mechanical advantage of the arm gear system would be large enough for the arm to function. Following this, we also used calculations for the rotational velocity of the hand to ensure that the collision between two "fingers" would not break the fragile components of the hand.

Friction and Circuitry

We used calculations for coefficient of kinetic friction to determine the minimum coefficient of kinetic friction needed for our vehicle to travel up the ramps. In addition, we found the minimum coefficient of kinetic friction needed for our hand to grip the heaviest piece of garbage

We used electricity calculations for voltage and resistance of a certain wire length and diameter to determine the appropriate voltage to use for each of our motors.

3. How the team functioned

Everyone functioned well together. The team, while divvying up tasks evenly, was open to everyone's individual ideas about the design and construction of the vehicle. Each team member was a part of every step in the process of creating the device. Different team members contributed very much in their areas of proficiency.

Michele was the main contributor to the logbook. She documented the events and ideas of the group in real time as we met and built the vehicle. If not for her efforts in delineating our concepts, our documentation efforts would have been sorely incapacitated. Along with this, Michele contributed many creative solutions to problems that arose as a result of our brainstorming. For example she thought of the idea to have a long axle running up the arm from the motor to maximize the mechanical advantage of the arm's gear system.

Chris came up with the basic design for the vehicle, which with help from the team was later adapted to our final design. Throughout the project Chris contributed many ideas. He also constructed a large portion of the design. Chris also did most of the wiring for the vehicle and the control box. In a larger context, Chris played a large part in the decision making process. For example he pushed for the reconstruction of the body in the preliminary competition, which turned out to be the correct choice.

Oliver functioned mainly in the brainstorming and construction process. He streamlined the preliminary concepts suggested by Chris and reduced the concepts to practice. For example, while Chris proposed the general concept behind the TSS (using slip gears to adjust angle between two axles), Oliver designed the TSS and applied the concept to the available materials. Oliver constructed a large portion of the vehicle. Things he made include the TSS, the wheel gear systems, the arm gear systems, and parts of the body.

4. Biggest Obstacle

Our biggest obstacle was accurate drilling for all of our gear boxes. The drilled positions of our axle holes caused us the most grief. The gears were very specific sizes, so the tolerance we had to work with was less than 1/10 of an inch. Any greater or less than the ideal positions for the axle holes and our gears would either crunch together or pop away from each other under enough force. Another implication was the requirement that two adjacent gears' axles had to be parallel. There were many scenarios in which we failed to meet these conditions. We had to retrace our steps and redo work many times.

We had troubles with the wheel gear box holes. They were misaligned multiple times. We eventually realized that our holes were skewed because we hadn't clamped the base of the drill to the ground and the drill station was shifting slightly with every rotation of the drill. This caused a crisis a week before the preliminary challenge when we discovered that the wheel gears were slipping from not meshing properly. Because the holes and axles were too far apart, we had to change our motor gears from 8 tooth gears to 12 tooth gears so that their radius would be long enough to offset our drilling error. Therefore, our mechanical advantage changed, subsequently changing our vehicle speed from 9 in/s to 13.5 in/s.

With our wheel gear box holes, we accidently made them too close together. This caused the wheels to be extremely close (about 1/16 of an inch apart). The friction generated by this between the wheels ousted the possibility of our using wheel treads to generate wheel-to-ground friction. To solve this, we swapped the wheel axle and the axle for the idler gear. This created more space for the wheels. However, as a side effect to this we did not have enough room to include our motor in the preplanned position. We had to improvise secondary motor shelves and insert the wheel motors vertically as opposed to horizontally. This also created additional weight on our vehicle in the form of vestigial motor shelves.

We had troubles with the arm and TSS gear boxes with angle and misalignment. We did not use the drill press for these axle holes; instead, we used a hand drill and aligned the CD gear boxes while hot gluing them into position. However we were not able to align them correctly. This caused the axles to not be parallel and generated a lot of friction which reduces our motor efficiencies. As a result of this we had to refit our arm and TSS gear boxes.

These positioning mistakes delayed our construction process considerably because we had access only to a drill press only once a week. If we got it wrong one week, we had to tear the CD off of our popsicle stick frame, remake a CD, remark the position, and try again.

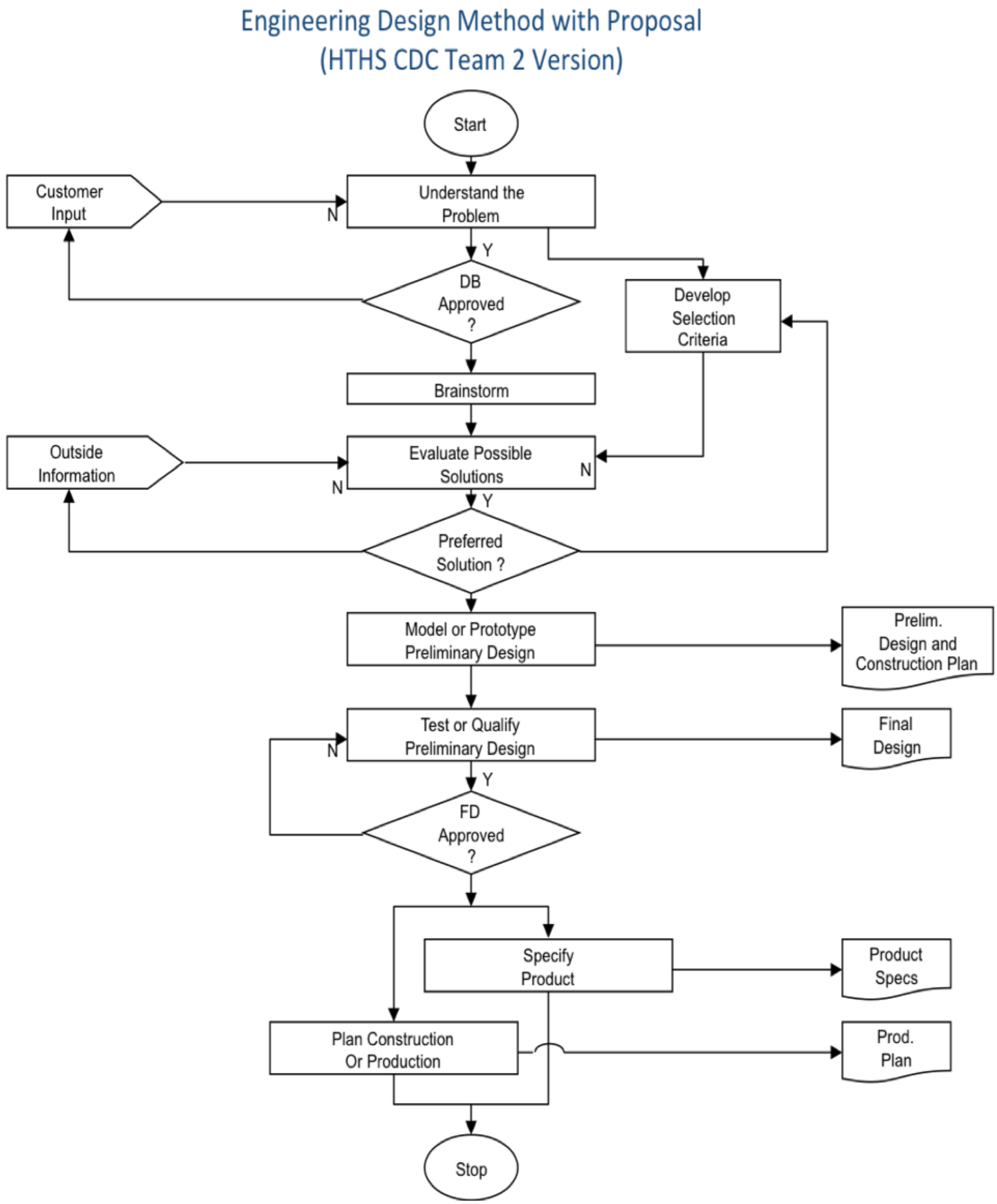
Appendices

Appendix A: Macro/Micro Schedule Gantt Charts

Appendix B: CDC Team 2 Customized Engineering Design Method

Appendix C: Assorted Pictures of Design and Construction Process

Appendix B


Engineering Design Method with Proposal
(HTHS CDC Team 2 Version)
Start
Customer Input
Understand the Problem
N
Y
DB Approved ?
Develop Selection Criteria
Brainstorm
Outside Information
Evaluate Possible Solutions
N
N
Y
Preferred Solution ?
Model or Prototype Preliminary Design
Prelim. Design and Construction Plan
Test or Qualify Preliminary Design
N
Final Design
Y
FD Approved ?
Specify Product
Product Specs
Plan Construction Or Production
Prod. Plan
Stop