Design Notebook: ([Link](https://docs.google.com/presentation/d/1iozC0z2K2rG8n37XPOOb8g1-2zswPLRI0N7431dgBjA/edit#slide=id.g51153ba3b5_0_0))

This notebook/presentation will seek to capture how CAJ follows the engineering design process. We need to show how we brainstorm, discuss, prototype, execute, and redesign our robots. This notebook must also contain a section explaining specs about each robot through the season and a documented timeline of the evolution of our bot through this season.

Outline:

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3. Prototypes
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**Intro**

“Failure is central to an engineer every single calculation that an engineer makes is a failure calculation. Successful engineering is all about understanding how things break or fail.”

––Henry Petroski

As a team of engineers, we understand that not every solution we attempt to build through this season will be a success. We will indeed face many failures, broken subsystems, and stripped screws, but in the end, we will find the joy that comes from problem-solving. This notebook is set up to record both failure and success, in order that we might understand the difference between a solution and a problem.

Throughout the past four years of the existence of the CAJ robotics team, we have learned many valuable lessons about the design process. We have seen the importance of paying careful attention to detail and the value that comes from acknowledging our mistakes in open communication. Within this notebook, we will disclose the secrets behind the CAJ design process and the ways in which this process has been followed throughout the 2018-2019 VEX Robotics Competition season.

**Define the Problem:**

It can be daunting to look at any engineering challenge, and the VEX Robotics Competition is no exception. That’s why we, 99484, attempt to start every season by carefully defining the challenge we face. Defining the problem takes multiple steps first you must understand the rules of the game, next you must understand the limitations you face both in resources and time, and next you must begin to think of solutions to the challenges the game presents.

When defining the problem that VEX Turning Point presented we first attempted to look at the rules of the game and calculate the scoring potentials to decide on which subsystems would be most beneficial for the game.

game analysis.

limitations of 99484

As a team based in Tokyo Japan, we had many different limitations that we had to consider as we prepared for the 2018-2019 season. For one, with the release of the new V5 control system, we would be preparing to start a new season using completely new hardware. Furthermore, we had no clear idea when this system would arrive in Japan. Thus we decided to build our initial prototypes using the V4 control system. Another limitation we faced was the lack of availability of competitions in Japan. This limitation meant that we would have approximately 6 months before stepping foot on the field of any Turning Point competition. This meant that we had to use our time very wisely and effectively monitor the status of designs around the world through careful research.

**Research**

Research for the VEX Robotics Competition happens on multiple levels. Primarily the research takes place on the VEX forums ([https://www.vexforum.com](https://www.vexforum.com/)). On the forums, teams and mentors post an array of materials about their robots, ideas, and share an invaluable amount of knowledge about the VEX Robotics Competition. Another way by which our team research is through watching matches on Youtube. By carefully analyzing the competitions throughout the world, our team is able to gain valuable insight into the competition and substitute the lack of opportunities to physically experience matches throughout the season with a virtual experience. Furthermore, by utilizing these resources our team seeks to network with teams across the world in order to create a better understanding of the VRC community in Japan.

**Brainstorm**

99484 seeks to hold brainstorming sessions within the team in order to emphasize communication through all aspects of the design process. These brainstorming sessions happen in organized settings through official brainstorming/reflection sessions hosted by our captains, as well as through conversations that we seek to have through casual interactions with each other. The organized brainstorming sessions happen in each of our teams at the beggining of the year and before/after each competition throughout the year. At these sessions, we seek to gain insight from every member of the team for we know how vital it is to understand the unique perspectives throughout our team. After a diligent effort of defining the problem, researching, and brainstorming we are able to move into the actual stages of building prototypes for the season. In the coming pages, we will record our designs from this season and show how they can evolve throughout the year.

**Prototype**

**Test**

**Improve**

Using notebooks like this one to carefully keep track of any changes made on the design.

**Communicate\*\***

Secret emphasis

**Prototype**

* Bobby:
  + After talking with the team, it was initially decided that the robot be a multipurpose robot: it should score in all possible ways given by the game. This includes caps and flags.
  + To score caps we used a double reverse 6 bar with a rotatable claw
  + To score flags we used a slapper.

Turning point was a game of many scoring opportunities. With flags, caps, and balls scattered across the field, our initial reaction to this year’s game was to score everything. Our robot had to be agile and flexible, so that in whatever match situation our robot would be able to perform well.

We also wanted to keep some key designs from previous years. Just last year we were starting to get better, especially in our designs. Our small, nimble, 25x25 chassis was something we loved about our robot, thus, we wanted to keep that element in our new design. Additionally, we appreciated the extra power that came from an 8 motor chassis, and we aimed for that in this new design.

Thus began the new plans for the prototype that would later become Bobby. We laid out the plans for motor distribution:

* 2M lift
* 2M shooter
* 1M intake
* 1M claw
* 1M rotator
* 4M chassis

Unfortunately, with the plans we had in mind, we could not have a strong chassis and be an all-around robot at the same time. So, we decided to give up chassis strength for flexibility.

The chassis was built with a standard H-frame, similar to many of the designs made around the VEX community. With our plans for a lift, we also needed our robot to have a low center of gravity, focused towards the middle. Motors, since they were heavy enough to affect this point, were placed in the middle, and chain was used to transfer power to the wheels. Posts were then added as an method of attachment for the lift.

Thus, the Bobby was made to fit that mindset. It was a multipurpose bot: to score flags, Bobby had a rubber band intake inspired from those from Nothing But Net.

Our shooter, however, was slightly different. Towards the end of Nothing but Net, we saw the potential in punchers, however, I was interested in more of a rotary design, like a kicker. Our robot used a 2 motor small kicker to propel the ball towards the flags.

The lift was then copied from designs used in In the Zone. We needed something light and efficient, so our lift was composed of half-cut c-channels, with hinges utilizing double nut screwing (to reduce slack in a joint). As for the wrist, I used a turntable and discovered a new method of attachment between HS collars and standoffs, where you place the standoff through the collar as a sort of reinforcement or attachment. For grabbing caps, I just used a claw.

After the robot was done, we got it ready for testing. However, there were many problems, as every prototype normally has them. First of all, I wasn’t exactly thinking when I decided to go small base with a tall lift; whenever Joseph drove too fast, the robot would tip and bend. Our shooter was also tested with lighter balls than what was going to be used in the game, and it barely shot the game balls forward. Overall, it was a mess, and normally we could just give up, but this experience helped us realize what was good and what wasn’t, see more strategy in the game, and lead us into one of our more prominent designs.

**Puncher**

When we analyzed the game this year, we realized that it was important for our robots to be able to toggle the top flags in order to earn a sufficient amount of points. To do that, we decided to make our robots shooter bots. Since there are many different varieties of shooters that we could possibly build, we chose to narrow down our options to a catapult, flywheel, and a puncher.

To make it easier for me to understand these shooters, I decided to make analogies for each. A catapult (a double ball shooter in particular) was like a shotgun. It was effective in a closer range and could shoot two balls at once. A flywheel would be a sub machine gun. It would be effective in shooting many balls at a short period of time. And finally, a puncher would be a sniper. It was effective in long range shots with enough strength to be able to toggle a flag from the opposite side of the field. Though we can’t shoot as much

**Schtyna**

Our first robot, Bobby was an all-rounder that could score caps on the posts, shoot at the high flags, and flip caps. However, we weren’t very effective in any of those three areas meaning we could do it all, but not very well. Realizing this and the fact that we didn’t have time to address all of the issues of the robot, we decided to re-evaluate our approach. Analyzing the game further made us realize that because the field is divided into two sections -- flags and posts separated by platforms -- specializing in one of these areas made more sense. The narrow space between the platform and the field perimeter is bound to cause traffic as robots try to move from one area to the other. So instead of trying to do everything, we decided to specialize in one area: flags.

We chose flags because of the higher scoring possibility it possessed over caps. This meant that the shooter component on our robot was going to be crucial to our design. We settled on the double catapult idea since we could, in theory, hit two flags in one motion. However, it was much easier said than done and it took us a while to figure out how to get both of the balls to shoot at the flags with enough power in the right angle.

**Beetlebot**

* Profile
  + Motor Distribution
    - 8M chassis
    - why we chose to use this robot instead of the previously planned robot
      * + cover briefly strats (defense)
        + realized simple was better than many subsystems

On the day of the ASIJ competition, due to many issues with our original robot, we chose to use this robot instead of our previously planned robot. Compared to many of the robot designs found in the competition, Beetlebot stood out quite a lot. We did not have any motors used on it except for the drive and had no shooters and no intake. The one thing we had were the two “horns” made out of standoffs to enable us to toggle the bottom flag, and our passive “flipper”. Our flipper was a feature which proved successful in our design as it could flip caps without any motors. It used the momentum of the robot to get the cap to follow through the curves on the metal which was shaped in an opposite S shape.

The reason why our robot was focused mainly on passive systems was due to our focus as a defense robot. Since we did not use motors for our subsystems, we were able to add 8 motors to our drive. This way we had enough strength and speed (due to the small size of the robot) to be able to push around other robots. In this game, we read that having a shooter is a vital way to earn points and a defense bot was something we could use to go against them. While the shooter bots took aim to shoot, we could push it around so that it will miss.

Beetlebot was a vital piece in our design process due to the fact that it made us realize the importance of defense as well as the need of a simple robot. Robots with many subsystems ended up not using many of their features. Beetlebot, on the other hand, could specialize in one job without wasting any motors or adding more weight to the robot.

**Velos**

* Profile
  + Motor Distribution
    - 4M chassis
    - 1M intake
    - 1M shooter

**Althea**

After what we learned from the ASIJ competition, we have decided to change our robot completely to fit our new approach to this year’s game. From the simplicity of Beetlebot, and the design converging to efficient shooters, we switched to a design that could counter the “meta”.

We did some research from other designs floating around in the vex community, and we noticed the two bar dumper that was common on teams. It was simple and efficient.

*What if we just had a drive with a two bar dumper?*

This was simple: almost too simple. It was scary almost, to switch from an agile shooter to a simple defensive robot that could score caps. However, after working it out with the strat-team, we decided to go through with the design.

Since our aim was to be defensive, our chassis had to be solid: rock-solid. However, we also needed to anticipate our motors burning out. Of course, there’s 6 V5 motors, so it’s hard to think of what could go wrong. However, with defense as our focus, one key aspect that needed to be implemented in our robot is consistency and durability. We needed to have the motors readily available to switch out to achieve this goal.

One design we saw online was 5225A’s robot for In the Zone, which had a set of gears running a wheel, connected to motors which could easily be swapped out for fresh ones. We used this design in our robot. In this way, our center of gravity could be low but also centered.

For the lift, we used two c-channels firmly attached to our chassis as support beams for the axles of the two bar. Each axle used a screw, and used the double nut screwing method for joints:

to reduce friction between two pieces of metal on a joint, the screw is first tightened to one of the pieces to reduce wobble, then the other nut acts to keep the system together.

Our intake was a product of trial and error: sometimes, we don’t always know what works and what doesn’t; and we just build something and tune it as we go. Joseph was constantly working on the intake, whether it be adding specific standoffs, or more antislip, recording the effects and its benefits or downsides, and this process led to a finalized intake that was well tuned, just as the driver wanted it.

**Althea 2.0**

* Profile:
* Motor Distribution
  + 6M chassis
  + 1M 4 bar
  + 1M swing bar dumper

The results from the competition proved successful, and we wanted to slightly improve this design for our final iteration. After studying the game, we learned that the higher high posts are almost guaranteed points in a field of robots who generally cannot descore posts that high. Thus, we decided to use our last motor to elevate the 2-bar to score the high posts.

Normally, we would’ve just build a Connor-bot (very impressive Cap-bot in the scene), however, though we love and respect and design, we wanted something unique, something of our own as well. Our lift from 1.0 was very effective; why not add another component and focus on making it better?

Initially I had focused on making the robot light - which is fine, unless you’re advertising yourself as a defensive robot. So, with lightness usually comes with a sacrifice of strength, and boy were we weak. So, we had to switch back to a stronger, more reinforce design.

I’d have to say that this was the hardest, most time-consuming part of the build. Though it’s as simple as saying, “We added a second section to our lift.” There was so much more going on. We wanted to keep elements such as our direct center parking, so we had to move the lift posts around, move the battery and V5 brain forward; essentially a bunch of trial and error before we could get to where we wanted:

TRIALS:

* original lift was made slightly stronger
* lift was taken apart, replaced with full c-channels
* intake was replaced as it was bending, also used full c-channels with reinforcements
* posts were taken off and moved more forward, direction of four bar arc changed.
* battery and cortex were moved forward to add more weight to the front, shift center of mass to increase chances of direct center parking

After the highest stack AND the center park worked, it was finally a job well-done, and the bot was ready to drive.