AURA

Auckland University Robotics Association

Design Notebook World Championships 2015

Executive summary

Design and build process:

This notebook describes how we designed and built three iterations of robots for the Skyrise season. Each iteration began with a review of Skyrise strategy, including how much we thought our robots could achieve and how much we expected our best opponents to be able to achieve. Then we decided what tasks our robots had to complete to give them the best chance of winning.

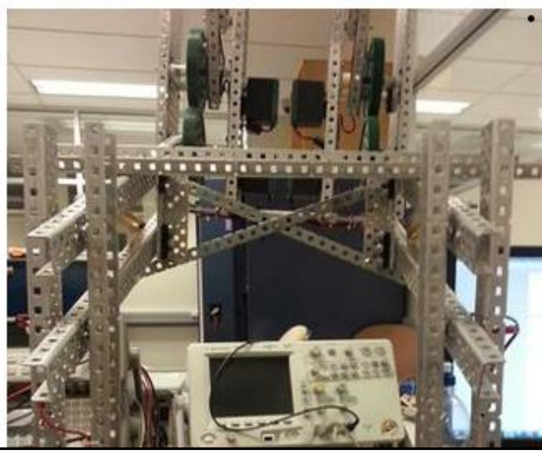
This process gave us a set of design requirements for each robot. For example, Big Mac's main design requirements were that during a match it needed to be able to score all the cubes on the field by itself, and that it needed to be able to score cubes on the skyrise in Autonomous.

Tuesday 3 June:

- Intake constructed to fold/unfold in the desired manner.
- Front unfolding piece of ramp added.
- Chassis and lift both programmed. Lift is currently clicking a bit but otherwise everything seems to be functioning well.

Tuesday 8 July:

- Tried to put reinforcement on the bottom stage of the lift to prevent torsion and thus stop the intake from swaying:



(see the braced rectangular section in the middle of the bottom stage of

Part of the build log for Moa from our Wikispaces site.

During the build process, we used a wiki to maintain a to-do list for each robot and to keep a log of build activities.

Design and strategy:

Our strategy on our first generation of robots was to maximise the number of cubes our robots would be able to score in two minutes. This meant building a 15" robot that could score cubes, and a 24" robot that could score cubes after building the skyrise.

By July, we had worked out that by the end of the season teams would be running out of cubes to score during high-level matches and that unless we stopped our opponents from scoring cubes, it would be impossible to recover after losing the autonomous bonus. We designed and built a 15" cube denial robot called Fridge for matches in which we thought we might lose autonomous. We also built a 15" cube scorer so that we could have our own high scoring autonomous routines, especially for qualification matches.

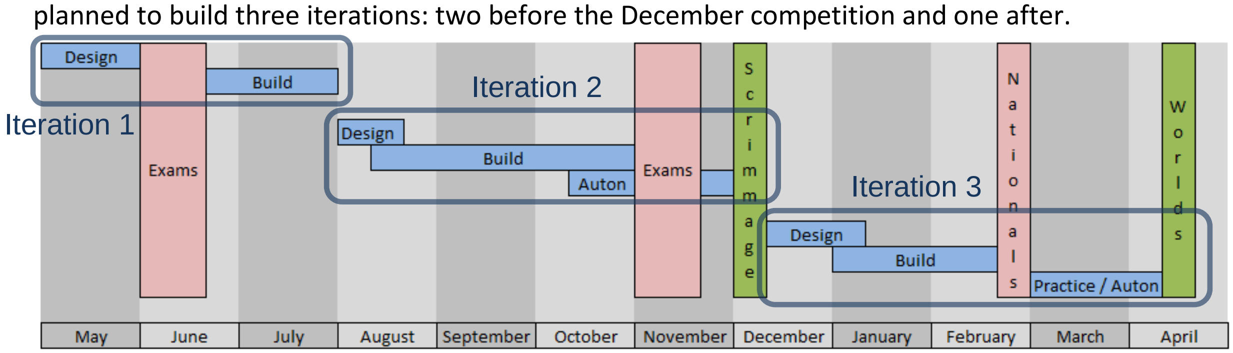
AURA		Points:	Opponents		Points:
Skyrise sections	7	28	Skyrise sections	7	28
Skyrise cubes	8	32	Skyrise cubes	8	32
cubes on posts	14	28	cubes on posts	**6**	**12**
posts owned	1	1	posts owned	**6**	**6**
floor goals	0	0	floor goals	0	0
autonomous bonus	0	0	autonomous bonus	1	10
hoarded	**8**				
Total score:		89	Total score:		88

Table showing that hoarding 8 cubes guarantees a win if the skyrise can be built with 7 sections and 8 cubes and all cubes are scored

In November, we decided that we could build a 24” robot that would be able to score all 20 non-preload cubes using a needle intake during a 2 minute match. This meant that the 15” robot would only need to build the skyrise (during autonomous), and after that would be free to play defence either by blocking other robots or by pushing opposing cubes into a corner and guarding them. This should give us a strategic advantage against any teams not using cube denial, and allow us to compete on an even footing against other cube denial teams.

Personnel, time and resource management:

We planned our time for the season based on the number of rebuilds we could fit around the events we were planning to attend. We planned to go to one competition in December and then to Worlds, so we planned to build three iterations: two before the December competition and one after.



Our available parts allowed us to build about three robots at any one time. Our members had varying levels of experience and commitment so a leadership structure was required. Our most experienced Vex builders and drivers are Jack and Lucas, so they were assigned to lead one robot each and the third set of parts was available for miscellaneous competition projects.

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1. About our Team

AURA was established in 2010 at the University of Auckland (UoA) by a group of about 12 first and second year students. We have competed at the World Championships twice: once in 2011 (Round Up), and once in 2012 (Gateway). In 2011 we ranked second in the qualification rounds, but a mechanical failure meant we lost to the seventh ranked team in quarterfinals. We also won the Judges' award. In 2012 we entered two teams, one of which was tournament finalist.

We did not send teams to Sack Attack or Toss Up Worlds, mostly due to the travel distance, but we have still been very active during the last three years. We have expanded our club, so that it now includes just over 30 people. We have extended our volunteering and mentoring efforts, winning the NZ Tertiary Volunteering Award in both 2013 and 2015 (sponsored by IET and Kiwibots respectively). This season, we had 23 members collectively volunteer for over 1400 hours both in the Vex program and doing various other robotics-related community activities.. We have entered other competitions during this time, including the National Instruments competition in Australia, a Robot Soccer competition at UoA and RoboNZ Tabletop competition in Auckland. Our members have been involved in robotics research at the University of Auckland, both as summer students and for final year projects, sometimes working on projects that began as AURA club activities.

This year, in addition to our other activities, we have been working hard on our Vex U World Champs campaign. The following sections describe the process we went through.

1.1. Our world champs delegation

1.1.1. Jack Barker

Age: 19
Studying: Part II Software Engineering
Years of Vex experience: 6
Past teams: 2915A – Lynfield College Robotics (2 world champion titles)
OYES – OYES Robotics (3 world champion titles)
Driver of Big Mac (24" Robot)

1.1.2. Lucas de Rijk

Age: 19
Studying: Part II Mechatronics Engineering
Years of Vex experience: 5
Past teams: 2941A – Oats Robotics (2 world finalist titles)
OYES – OYES Robotics (3 world champion titles)
Driver of McChicken (15" Robot)

1.1.3. Shane de Rijk

Age: 21

Studying: Part IV Mechatronics Engineering

Years of Vex experience: 5

Past teams: 2941A –Oats Robotics
FEAR – Fishbowl Engineering Association of Robotics
OYES – OYES Robotics (3 world champion titles)

1.1.4. Oliver Wilson

Age: 23

Studying: Part IV Engineering Science

Years of Vex experience: 5

Past teams: AURA – Auckland University Robotics Association (1 world finalist title)

2. Personnel, Time and Resource Management

2.1. Robot teams

During the university year in 2014, we went through three robot building iterations. In each iteration we allocated parts to one 24” robot and one 15” robot. Jack and Lucas led the build process of these two robots, because they have the most Vex building experience of anyone in our team. We also allocated parts to other Vex U robot projects, such as Flamingo, led by other people.

2.2. Weekly Meetings

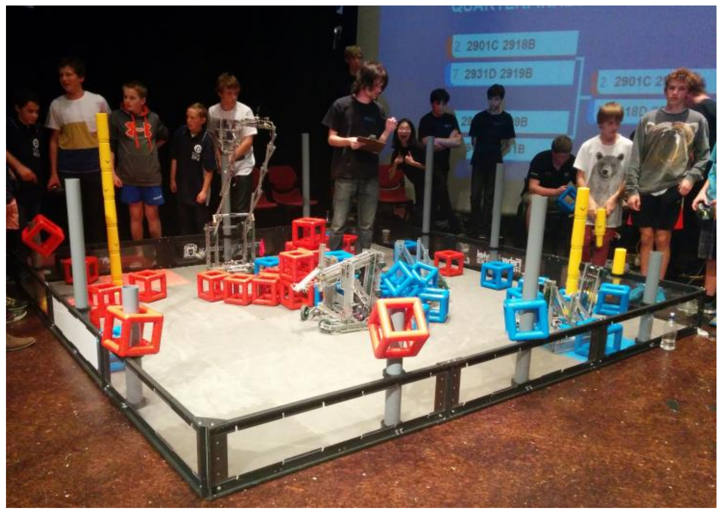
At AURA we believe that to be successful our club needs to be social as well as productive. This is one of the reasons why we have weekly meetings throughout the year, whether or not there are club activities that need doing. The meetings are long (4pm to 10pm) both to allow plenty of time for social and robotics-related activities, and so that members can come for part of the meeting at the time that's most convenient for them.

We often go for dinner together during our weekly meetings, which encourages members to socialise as well as single-mindedly working on robots.

2.3. High School Scrimmages

A major part of our time management for the season is organising volunteers to help at all the high school VRC events in Auckland. Over the Skyrise season, 23 AURA members volunteered for a total of 1100 hours at 12 different VRC events (the total number of members in our organisation this season was about 30, all of whom were undergraduate students). We are able to get these high volunteer turnouts because events are an opportunity to socialise as well as to help create a great educational opportunity for students.

A good side effect of being exposed to a large number of high school robots and matches is that we get to see what designs work and what strategies are effective. Many of our decisions this year were based on watching high school VRC games and using that information to predict what would be effective in Vex U.



2.4. Collaboration and Documentation

During the season there were several different AURA members working on the robots at different times and occasionally in different places. For this reason it was much more practical to record our design process on a wiki rather than in physical notebooks. Much of the information in this notebook is compiled from information that was written on the wiki.

2.4.1. Facebook

Most university students already have Facebook accounts, so we try to get our new members to sign up to our Facebook group shortly after they join our club. We use Facebook to remind members about weekly meetings, high school competitions and other events and to organise transport.

2.4.2. Wikispaces

AURA has had a private wiki for several years, which we use extensively to capture knowledge and document activities. We work on a lot of different robots and research projects, and the wiki gives us a way of effectively and securely collaborating on these with everyone in the club. So far there have been almost 2000 page edits of the wiki since its creation in 2011. This is the place where we do day to day design documentation, including logging the activities done during build sessions.

2.4.3. Skype

AURA has a very active communication channel through Skype. We have a group chat for the whole club, one for the exec committee and one for the team travelling to Worlds. These chats are our primary means of online communication between AURA members.

2.5. Iteration planning

Because we started in May, we knew we would have time to complete and disassemble at least one set of robots before beginning construction on any robots that would need to compete. This first set of robots is described under “First Generation” in the “Previous Robots” section. In mid-June, a Vex U scrimmage was announced for early December, so we planned to have a team of robots (a 24” robot and at least one 15” robot) ready to compete by then. These robots are described in the “Second Generation” section.

After the December scrimmage, we planned to use the knowledge we had gained to begin work on the robots we would take to Worlds. In late October, the December scrimmage was cancelled so we took a break from robot building until after exams (which end in mid-November). Despite not having the opportunity to compete in the scrimmage we had come up with some new design ideas by this point, so we began work on the robots that would become McChicken and Big Mac. Each of these robots has its own section later in the notebook.

After NZ Nationals we set aside a week from Good Friday until the following Thursday during which we stayed at Jack’s house to practice and finalise our robots’ programming. A week of intensive work with a field and practice partners available (2918a, 2915a and 2915c) gave us much more experience using our robots competitively than we could otherwise have had.

3. Strategy

The strategy behind each set of robots that we built is described in each of those sections. For a general overview of Skyrise strategy, we have included an essay written for the AURA wiki by Oliver in July, just before construction of Fridge began. At that point in the season no team was close to scoring the maximum score in a Skyrise match, but watching 2915A score in the low 70s at Scrimmage #3 in Auckland made it seem very likely that high school teams (and thus probably Vex U teams) would likely be getting scores of over 100 points by the end of the season.

There are some notes included to describe how our thoughts on Skyrise strategy have changed since.

In Skyrise, there are 22 cubes per team. A fully built and scored skyrise has 8 cubes on it, leaving 14 cubes. There are 34 spaces for cubes on all 10 goals combined. 24 of these spaces are legally unable to be descored, while the other 10 are top positions. However, the top cube position on the low post inside an alliance's starting area is not descorable in practice.

A consequence of this is that if a team fully builds and scores the skyrise, wins autonomous and scores their 14 remaining cubes in any position, there is no way they can be beaten. Even if the other team fully builds and scores the skyrise, scores all their cubes, and owns all the posts except the one inside their opponents' starting area, they can't make up for losing the autonomous bonus. This could lead to a situation where after losing autonomous, a team is unable to win unless their opponents make a mistake.

3.1. Strategy If You Win Autonomous

If you win autonomous and can be confident of completing the skyrise, including cubes, then scoring all your cubes in any position (irrespective of whether you own posts) will guarantee a win. If you can be confident of scoring all your cubes, then scoring in undescorable positions is more important than owning posts. Your opponents should be trying to stop you from scoring cubes on posts, so a fast drive on the post-scoring robot would be helpful to evade a robot that is trying to block you.

3.2. Strategy If You Lose Autonomous

In order to win against a team who won the autonomous bonus and is capable of fully building the skyrise and scoring all their cubes, you have to make sure they don't score all their cubes. This means denying them either goal space or cubes. Denying goal space would be similar to blocking Toss Up stash goals, but much more difficult because they have much more posts to choose from. Cube denial may be the more promising option. Optimally, we would have an alternate robot or set of robots to use in matches where we expect to lose autonomous, because the right strategy after losing autonomous is very different to the right strategy after winning autonomous. However, the time and effort it would take to build those robots would almost certainly be better spent trying to get our main robots to max out the game and win autonomous.

Note: For our second generation, we did decide to build a cube denial robot (Fridge) which would have been at its best when catching up from a lost autonomous period. We started building Fridge after working out that hoarding 8 cubes would allow us to win any match in which we could also build a full 7 section, 8 cube skyrise and score all our cubes.

There are 17 spots for cubes on posts on either side of the field, so a team can score all of their cubes just on their side with three spaces to spare. If you deny them access to their high goal and all of your goals, then they can score 12 of their 14 cubes. If you also deny them access to their centre corner low goal, then they can score 10 of 14. This equates to a denial of 10 points, at great cost to your own scoring capability. To make goal space denial worthwhile you would have to deny access to either or both of their medium goals, which would be very difficult since once they become aware of your strategy they can just have their post-scoring robot escape from your blocking robot in autonomous. Goal space denial is probably a very difficult strategy to pull off, and might be completely infeasible.

3.3. Cube Denial

If you can deny your opponents access to their cubes in the pyramid plus the two cubes on your side of the field, then they have only 8 cubes left. This allows them to complete the skyrise and possibly win autonomous, for a maximum of 70 points. With your skyrise plus the cubes in the pyramid, you can exceed this score. Again this is probably easy for them to avoid if they simply drive their post scoring robot into the pyramid at the start of autonomous so that they don't get cut off from their cubes.

Note: the above paragraph describes a cube denial strategy that would be hard to achieve, but also not really necessary in order to win. As stated above, the number of cubes a team needs to hoard to win if they can score all their own cubes is 8. This is harder for the opponents to counter than taking their entire half of the pyramid.

3.4. Counter Strategy to the Lost Autonomous Strategy

If you win autonomous and your opponents are playing to stop you from scoring cubes then you are already heavily favoured, but there are things you can do to increase your chances. An obvious example is to have an autonomous on your post-scoring robot that drives up next to the pyramid so that both goal space denial and object denial become much more difficult for the other team. If an opposing team brings a robot to the field that looks like a goal space denial or object denial robot, you can run this autonomous.

3.5. Conclusion

Because it is likely to be extremely difficult to recover from a lost autonomous bonus, AURA should aim to win the autonomous bonus against every other team if we want to win the competition. We can achieve this by making autonomous skyrise building our top priority, and having a 15" robot that can score the remaining cubes on posts during driver control to guarantee a win if the strategy of winning the autonomous bonus and completing the skyrise is successful.

Note: At the time when he wrote this, Oliver was still overestimating how difficult Skyrise would turn out to be. It is possible to build a 7 section skyrise with 8 cubes and score the remaining cubes on posts using a 24” cube scoring robot and a 15” skyrise building robot, even if the 15” robot scores no cubes in driver control. This is part of the reason why we didn’t feel we needed a 15” efficiency robot, so in our third iteration we built McChicken to be able to play pure defence (especially cube denial) during driver control. McChicken can also score cubes, but it is optimised for defensive driving rather than cube scoring.

This is of course the boring strategy, but I believe Skyrise is a game where the boring strategy is the best strategy. There are strategies that can attempt to beat it, but I don’t think they will be able to do so consistently. I think we have to just go all in on the boring strategy and accept that if anyone who can max out the game can also beat us in autonomous then we will very probably lose to them.

In terms of season goals, implementing this strategy will mean that we should start design on our first specialised autonomous skyrise building 24 inch robot at our next meeting (22/07/2014). If we complete our first iteration of the robot before we stop for exams, then we can program it after people finish exams and before the December 1 scrimmage. Assuming our strategy doesn’t change, we will have time to build at least one more iteration of the robot between the December 1 scrimmage and the World Champs.

Note that the argument given here assumes that the top teams (hopefully including us) will be able to reliably score close to the maximum possible amount. If this isn’t the case, then score differences without the autonomous bonus will be larger. That would mean that building a robot to perform better in driver control at the cost of autonomous performance wouldn’t result in automatic losses against better teams and might be a reasonable trade-off.

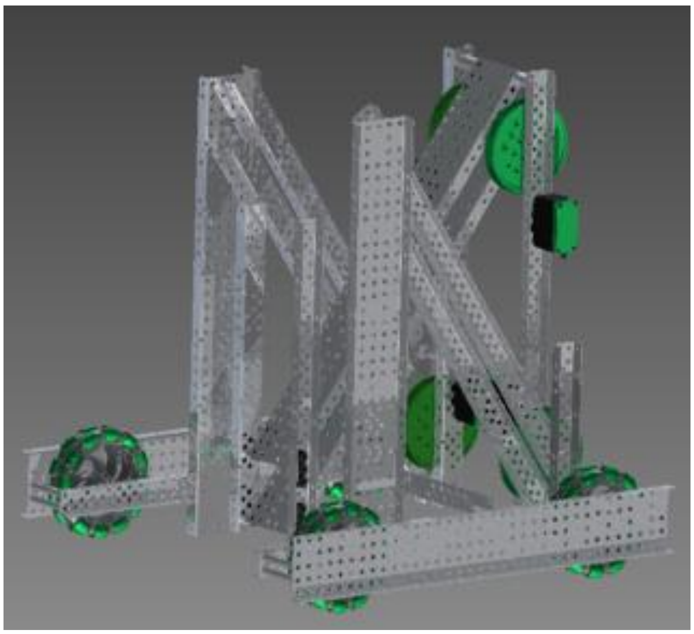
4. Robot Generations

4.1. First Generation

Our first generation of robots were intended partly to test ideas, and partly to give us some experience with mechanisms which would be useful later in the season. These robots weren't intended to compete, but the roles they were designed for were a 24" skyrise builder / cube scorer (Big Robot) and a 15" cube scorer (Moa). The logic behind these role choices was that a 15" robot did not have space to build the skyrise effectively without making serious compromises that would hurt the performance of the robot for the rest of the match, whereas the large amount of free space on a 24" robot would allow the addition of a skyrise builder without hurting the robot's ability to score cubes.

4.1.1. Big Robot

Worked on: May 12th - Late June



Big Robot was designed to be an early prototype of a 24" cube scoring and skyrise building robot. Its design requirements were:

- Build the skyrise quickly
- Have a capacity of 4 objects
- Lift cubes onto goals quickly

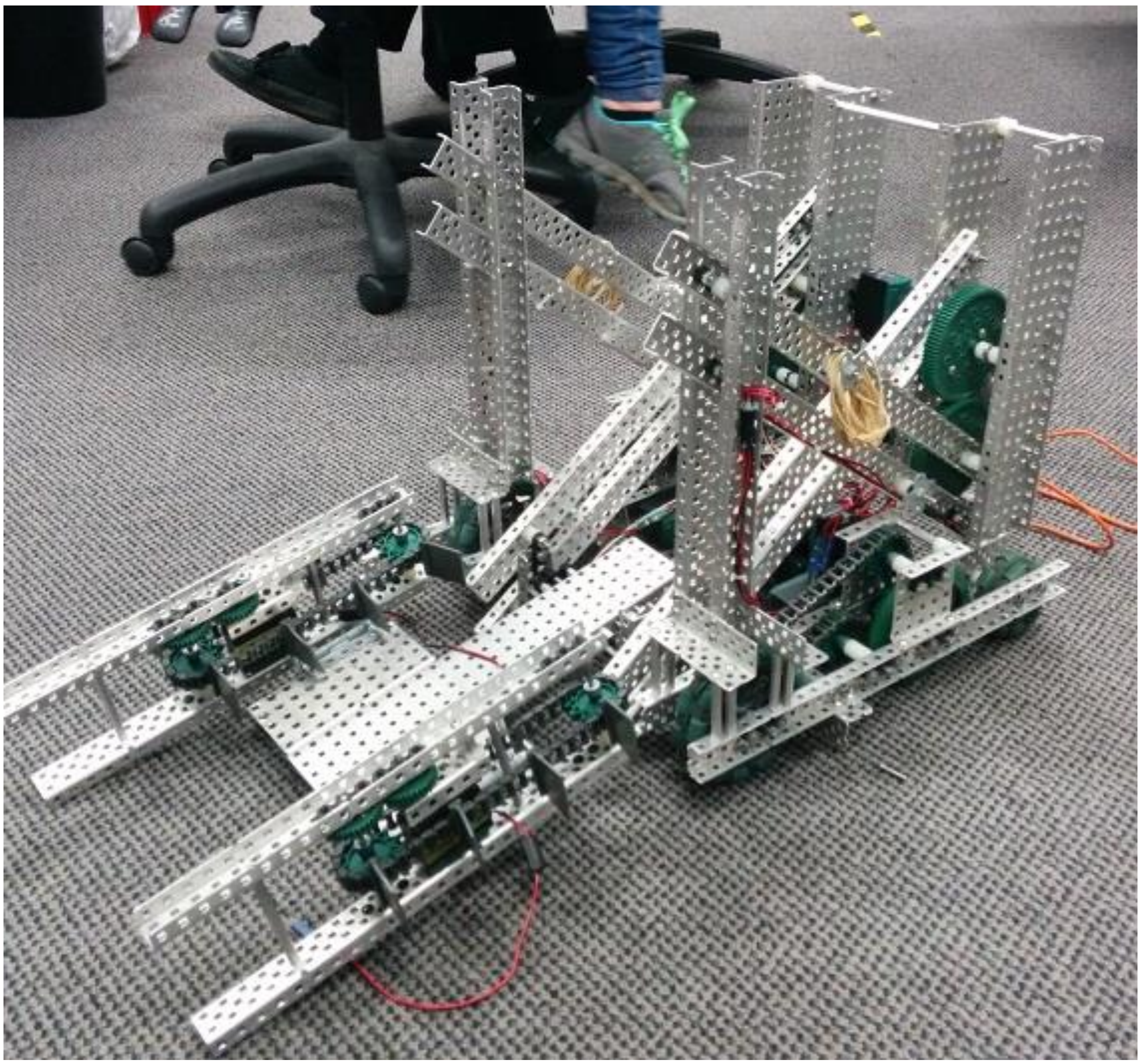
Big Robot used tank drive because of driver preference and because of its simplicity and reliability. Its lift was two separate 4-bars, with each one moving independently and powered by its own set of motors (unlike a reverse double 4-bar, where the two stages are mechanically linked). This allowed the lift to move linearly straight upwards, while also allowing it to follow a range of nonlinear paths depending on the relative speed of the two sets of motors. One feature was that the lift could be programmed to lift so that the centre of mass of the lift was always over the centre of the robot (unlike a reverse double 4-bar, which moves the centre of mass of the arm forward as it lifts).

4.1.2. Moa

Worked on: May 12th - Late June

Moa was the primary companion robot to Big Robot. It was a 15” robot designed to score cubes. Moa’s design requirements were:

- Hold and score at least 3 cubes at a time.
- Reach all goals (but not the skyrise) ie. up to 47".
- Pick up cubes quickly in any position, on any orientation.
- Score cubes accurately and quickly.

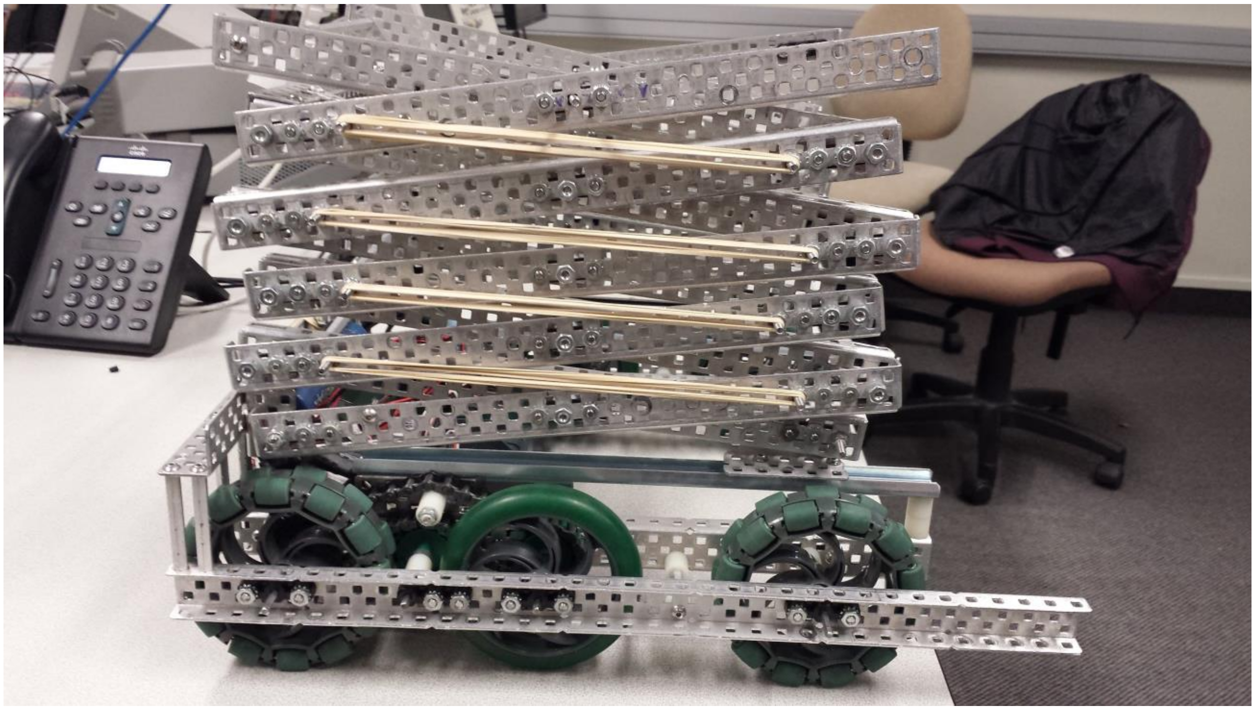


Moa featured a:

- 6 motor 1:1.6 drive on 4” wheels.
- 4 motor 7:1 reverse double four bar lift.
- 2 motor side roller intake, which was designed to hold 3-4 cubes.

4.1.3. Flamingo

Flamingo was an early attempt at a 15" robot that could score both cubes and skyrise sections. The design was to achieve this by putting a closed claw through a single cube, then lowering the cube over a skyrise section in the Autoloader, then picking up both and building them on the skyrise..



4.2. Second Generation

The motivation for our second generation of robots was that it became clear that good Vex U teams at Worlds could be expected to max out the game (i.e. score all 7 Skyrise sections with a full 8 cubes, and score all or nearly all of the cubes). As discussed in the earlier Strategy section, a team that builds a 7 section 8 cube Skyrise and scores all their cubes will always win the game if they win the autonomous bonus. This meant that against teams who were better than us in autonomous, we had to plan to be able to prevent them from scoring some of their cubes (since there are very few ways to interact with another team's skyrise building or autonomous without risking breaking the rules). One way to do this is by limiting their access to cubes, so we designed a 15" robot (Fridge) to carry an opponent's cubes around inside it while scoring cubes of our own colour.

Because Fridge was largely a defensive robot, its 24" complement needed to be able to both score the skyrise and score cubes, preferably scoring cubes on the skyrise in autonomous after building it autonomously.

This strategy was planned for teams who could beat us in autonomous, but it wasn't optimal for teams against whom we had an autonomous advantage. Against those teams, our goal would be to score as many points as possible, allowing us to then score SPs. For this purpose we designed a 15" scoring robot

(Chilly Bin) to use as a third robot. We would have used Chilly Bin for qualification matches, then unveiled Fridge for eliminations to give our opponents as little time as possible to react.

This set of robots was going to be used for the NZ Vex U scrimmage in December, so we stuck with them from when we began construction in June until the scrimmage was cancelled in October.

4.2.1. Fridge

Worked on: Late June - Late October

Fridge was intended to be a “secret weapon” robot that would hoard the opponent’s cubes and leave them without enough cubes to win the game. If our team completed a full skyrise (7 sections, 8 cubes), and scored all our cubes, then hoarded 8 of the opponent’s cubes, then the opponent couldn’t have won even if the autonomous bonus and all of the post ownership points were in their favour (except the post in our alliance station). This made it a good strategy if backed up by a very capable 24” robot, especially if our opponents weren’t expecting it.

AURA			Opponents		
		Points:			Points:
Skyrise sections	7	28	Skyrise sections	7	28
Skyrise cubes	8	32	Skyrise cubes	8	32
cubes on posts	14	28	cubes on posts	**6**	**12**
posts owned	1	1	posts owned	**6**	**6**
floor goals	0	0	floor goals	0	0
autonomous bonus	0	0	autonomous bonus	1	10
hoarded	**8**				
Total score:		89	Total score:		88

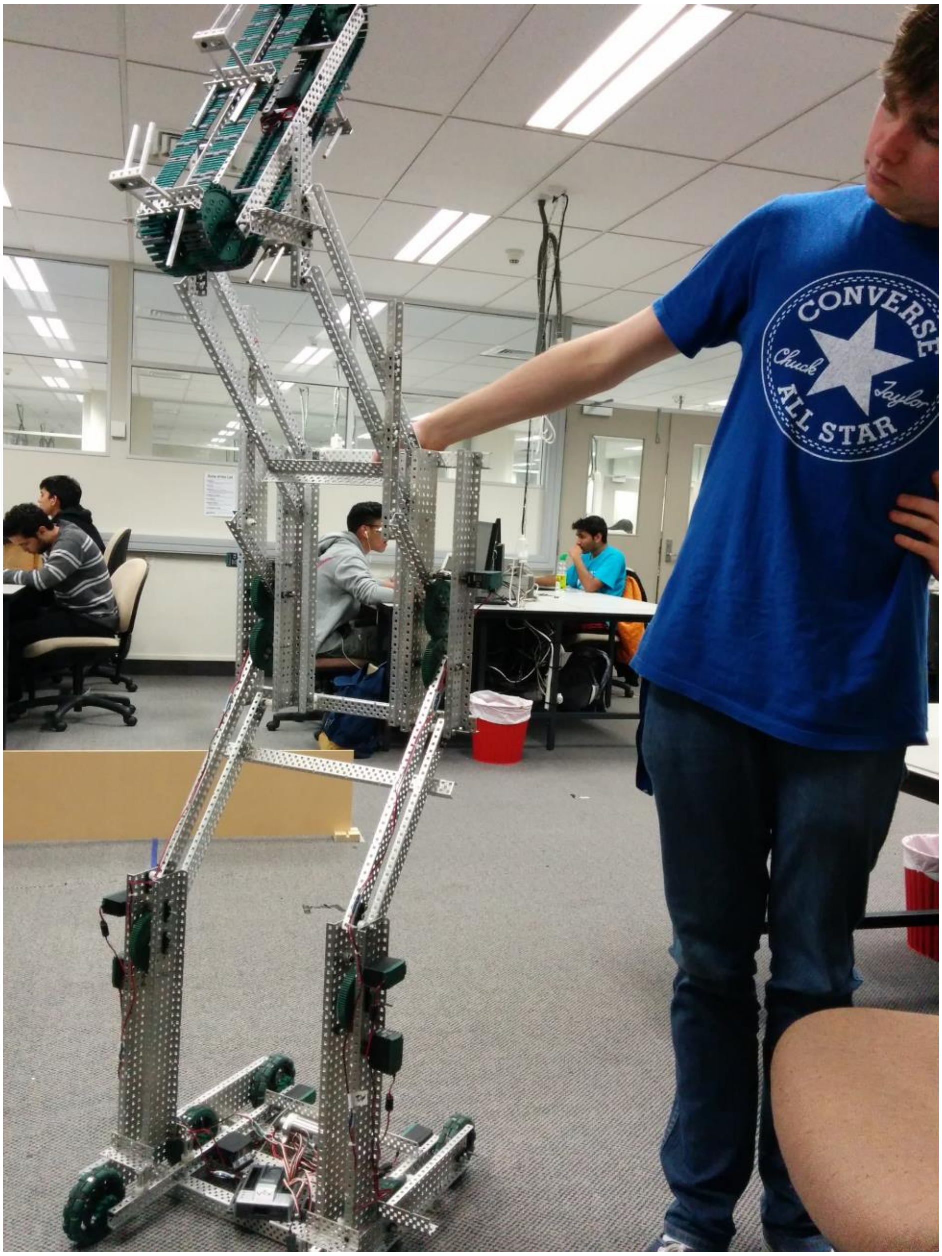
Fridge was designed to be a scissor lift that would expand under elastic power at the start of the match and stay expanded, with chain running all the way up the robot as an intake and a space inside the robot to store the opponent's cubes.

Fridge at a University of Auckland open day

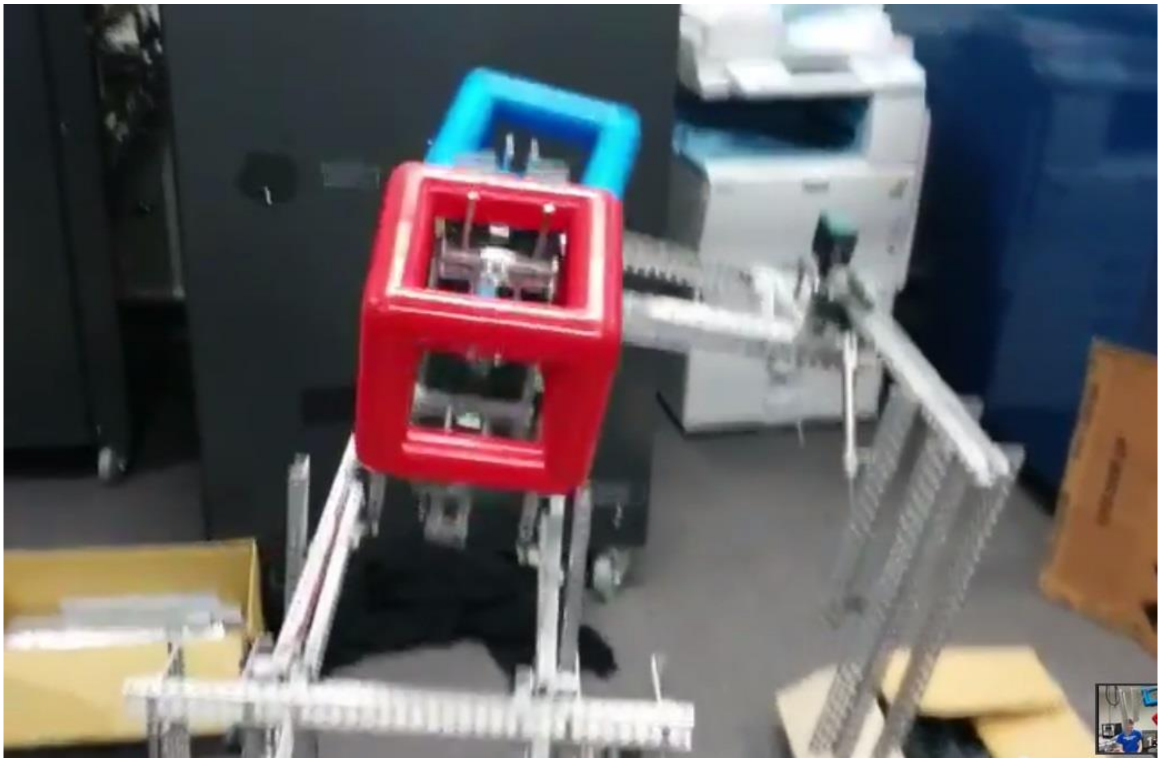
4.2.2. Freezer

Worked on: Late June - Late October

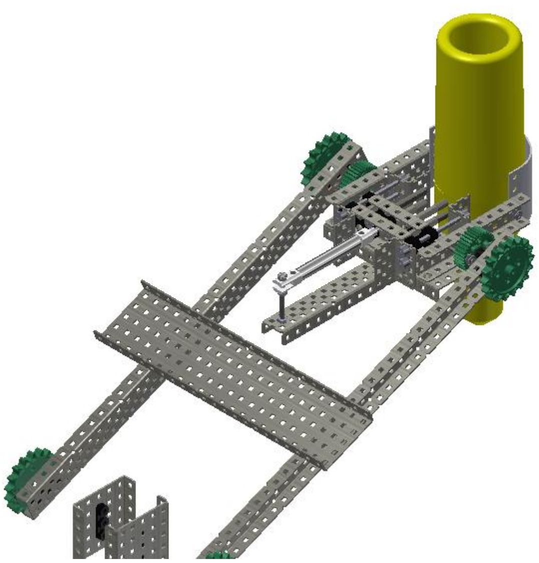
Freezer was designed to be an all-round robot, scoring the skyrise in autonomous and then having the ability to score most or all of our team's cubes during driver control. Its basic design was similar to many of the high performing high school robots in NZ at the time: A reverse double 4-bar lift with a three cube conveyor intake.



A skyrise claw was added to Freezer, but the fact that it was off-center caused some problems with lateral stability.



A solution to this was a skyrise manipulator on a chain bar arm, which would be mounted on the robot's centreline towards the back of the intake and swing over the robot from front to back. The pictured mechanism was built, but it was much too heavy so instead of putting it on the robot we decided to leave the problem until we could build a skyrise manipulator from lighter materials (3d printed plastic and/or plastic block).

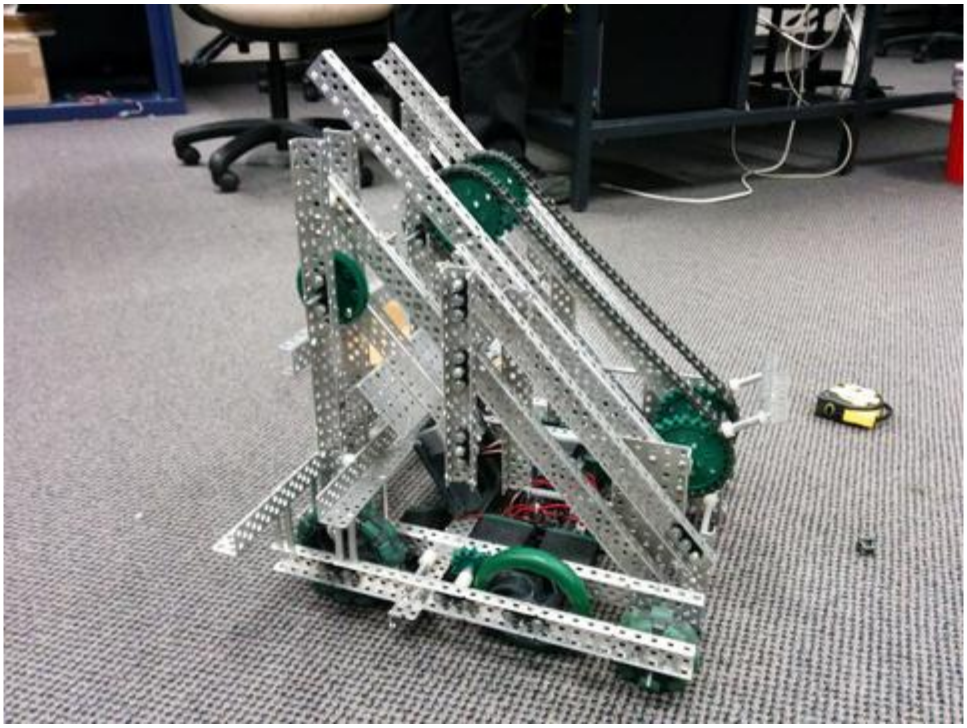


In October, during Freezer's construction, the December scrimmage at which it was supposed to compete was cancelled so work on the robot stopped. The robot would be replaced by Big Mac, but with the skyrise scoring ability moved to McChicken (for better autonomous scoring, among other reasons).

4.2.3. Chilly Bin

Worked on: Late July - Late October

Chilly Bin was a 15 inch robot focused on scoring cubes, and was the spiritual successor of Moa. Chilly Bin was designed as a fast scoring robot, mostly for qualification matches where scoring a lot of SPs is important. It also would have allowed us to keep Fridge a secret until late in the competition.



Chilly Bin featured a:

- 6 motor 1:1.6 drive on 4” wheels.
- 4 motor 5:1 6 bar lift.
- 1 motor conveyer intake, which held 2 cubes.

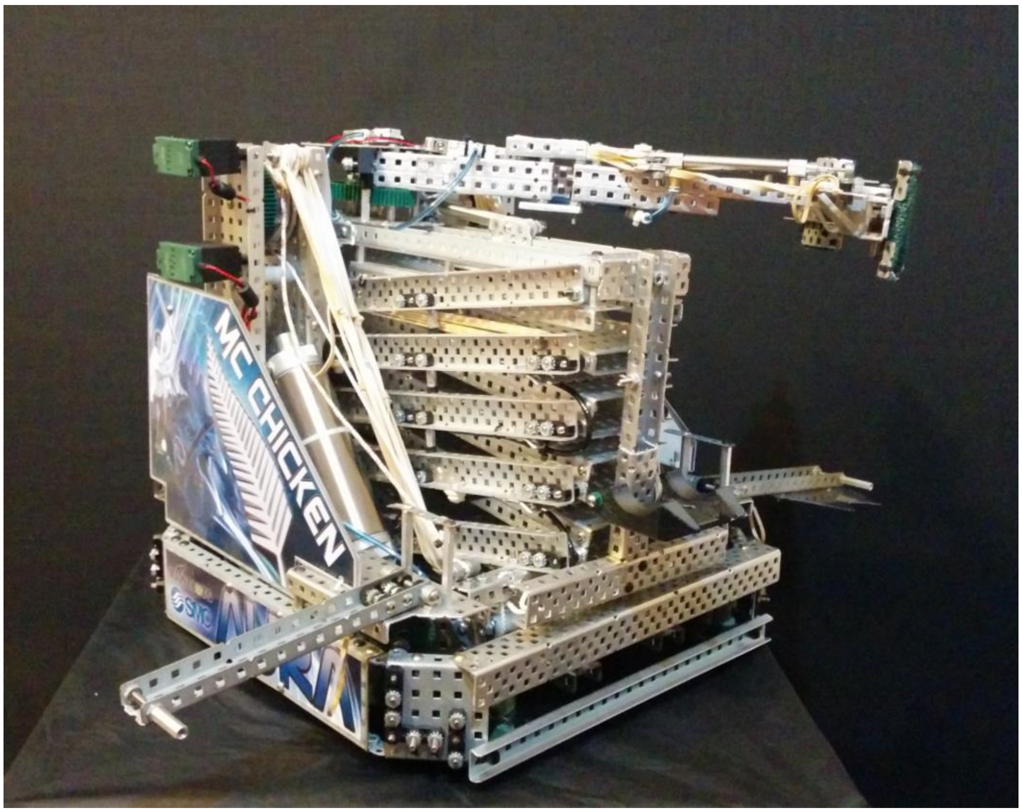
Chilly Bin was able to reach the high posts, but could not score on a skyrise higher than five sections.

4.3. Third Generation

The third generation of AURA robots were based on designs and strategy formulated over the exam period, with official planning beginning in late November. The designs revolved around the idea that we could build a 24” cube specialised robot that was capable of scoring all of the cubes on the field by itself within the duration of a game. This meant that the 15” robot only needed to be able to build the skyrise, and then fulfil whatever role was most useful afterwards. This could vary from game to game between defending the 24” robot from being blocked, blocking the best scoring robot on the opposing team, hoarding the opposing teams’ cubes in the corner, or contesting the bonus points for the top cubes on posts.

5. McChicken

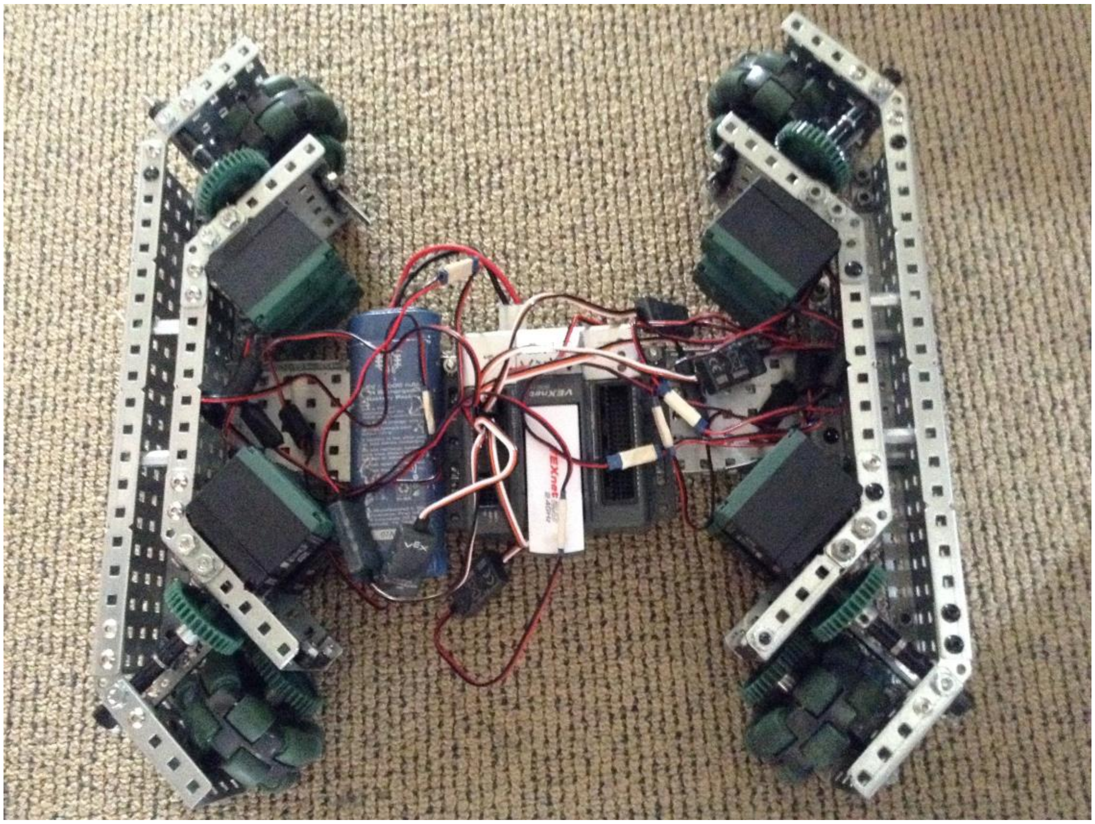
15” Robot
8 motor 1:1.6 X-Drive (2.75” wheels)
4 motor 1:5 winch powered scissor lift
Pneumatic swingarm and skyrise claw
Passive cube hook
Worked on: Late November 2014 - April 2015



McChicken is AURAs 15” robot, it is oriented around quickly and reliably building the skyrise at the beginning of the autonomous period, then moving to control the opposition’s objects to make it much harder for them to score. If we win the autonomous bonus, McChicken can make it impossible for the opposition team to acquire enough points to beat us by removing so many cubes from play that their theoretical top score is still lower than our current score. It was also important that McChicken be competitive in skills, despite its defensive orientation.

5.1. Drive

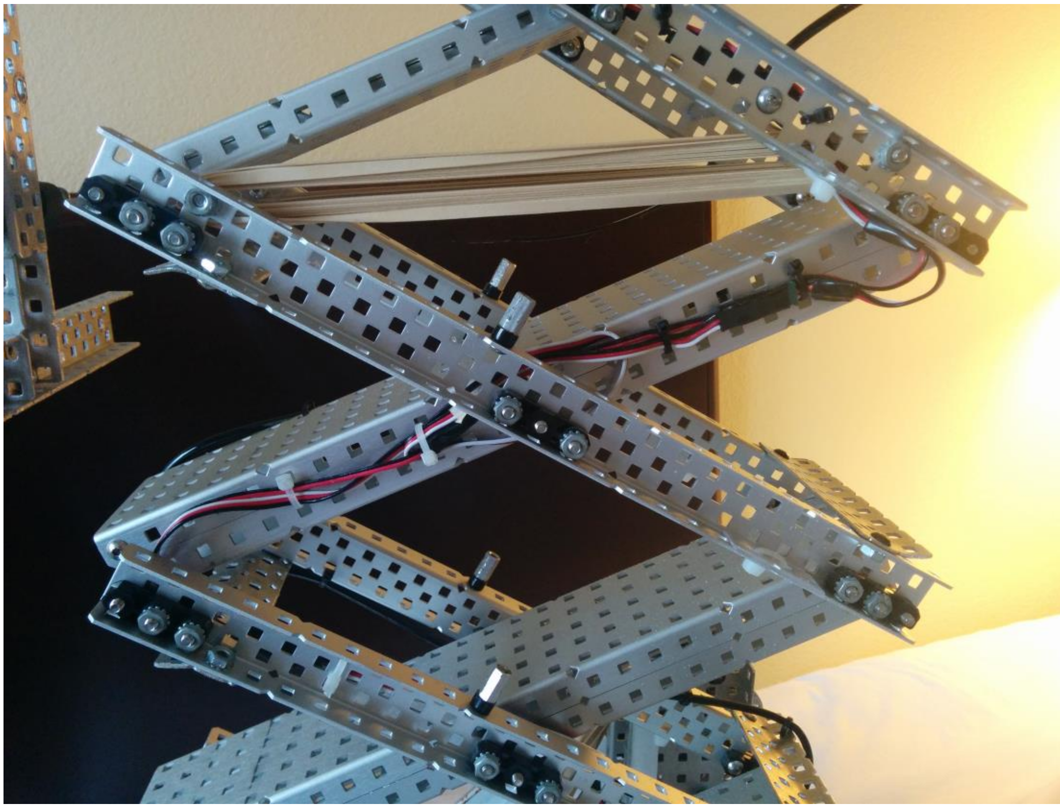
Because McChicken will be used to control the opposition objects and robots it was important that it had enough drive force to push large numbers of cubes, and keep any opposition away from them. To ensure we had sufficient torque, while still maintaining enough speed to out-manoeuvre any opposition attempt to get past. McChicken is equipped with an 8 motor direct drive speed X drive on 2.75” wheels, which is the equivalent of a 1.55:1 drive on 4” wheels, making it approximately the same speed as the most common competitive tank drives in the VexU competition. The X drive also makes McChicken much better for blocking, because it doesn’t have to spend time turning before changing direction, making it almost impossible to get around with a conventional drive. The ability to move omni-directionally also makes McChicken very good at lining up on the second skyrise base during skills runs, because it can make fine adjustments in any direction without turning away from the skyrise.



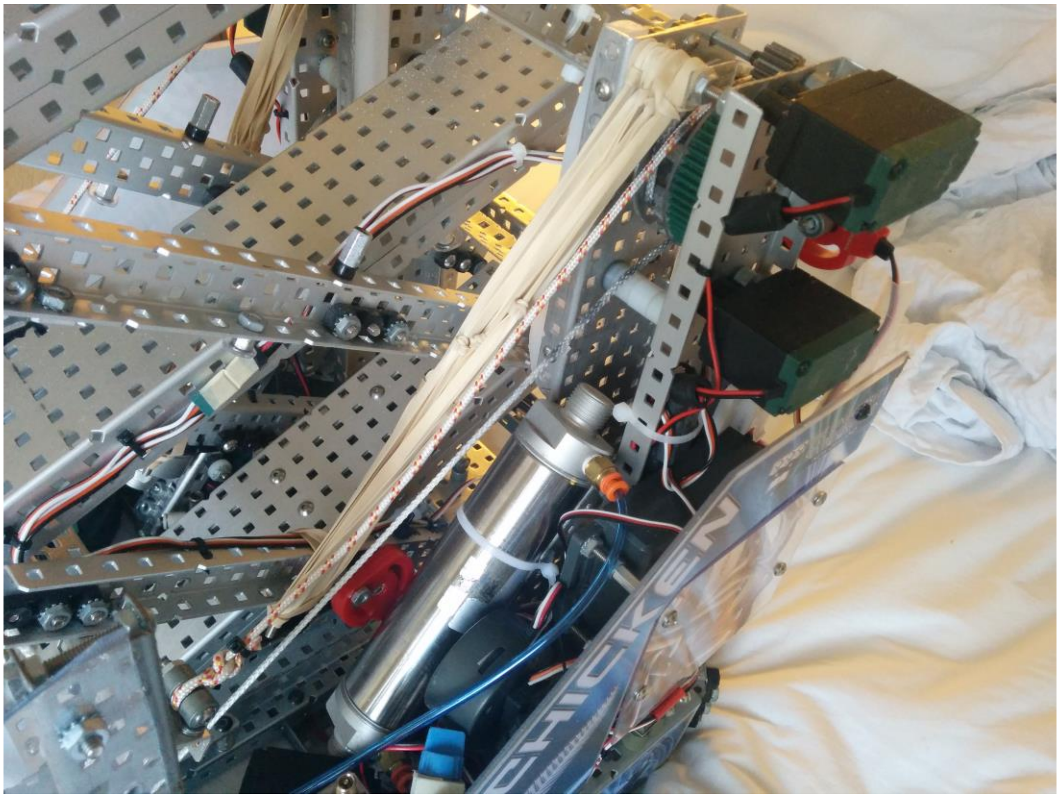
Because an X drive requires 4 independently powered wheels, we chose to put 2 motors on each wheel. These motors are linked to each other and the wheel using 36 tooth gears. This gearbox arrangement allows each side of the X drive to use up much less width than a conventional X, leaving the required room for the lift in the middle. McChicken’s wheels are mounted high up inside the chassis, meaning that it has a very low ground clearance. This lowers the centre of gravity, making skyrise building more stable, and also allowing us to fit a pneumatic brake.

5.2. Lift

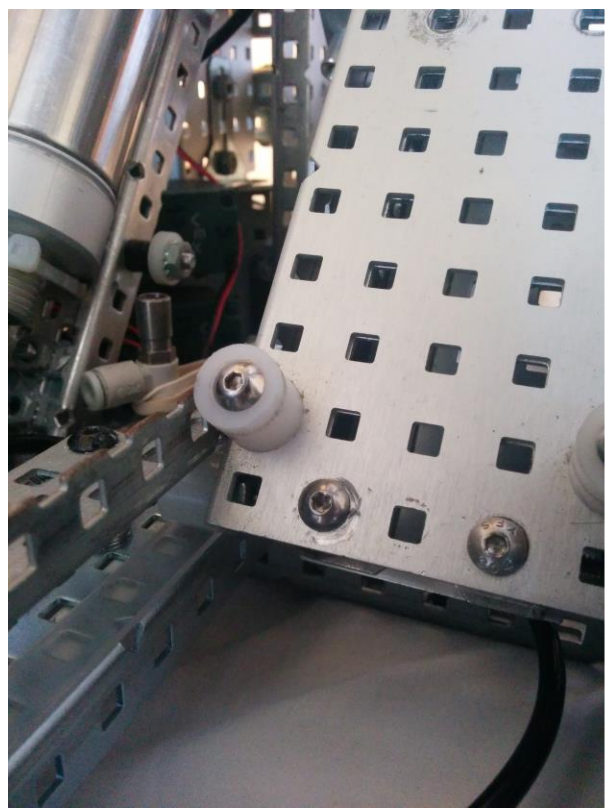
McChicken uses an unusual winch-scissor arrangement to lift the skyrise sections and cubes to goal height. This allows us to have the back-front stability and linearity of a scissor, while minimising the power lost driving the scissor on non-perpendicular angles (which is a common problem with scissors). it is also highly space-efficient, because all the lifting motors and gears are located on the towers, which would be required for bracing anyway. The five stage scissor lift gives McChicken just enough height to score cubes on the high goal, and build the 7th skyrise section. It cannot and does not need to be able to score cubes on the 7 high skyrise, as it relies on its partner to do this.



The winch scissor works by having a large driven gear on a tower at the back of the robot. This gear is attached to a spool that uses strings to pull the lift up and down as the winch is wound. The string to raise the lift runs straight off the spool and is connected to the bottom arm, and string to lower the lift is run from the spool, and around a roller at the bottom front of the robot.

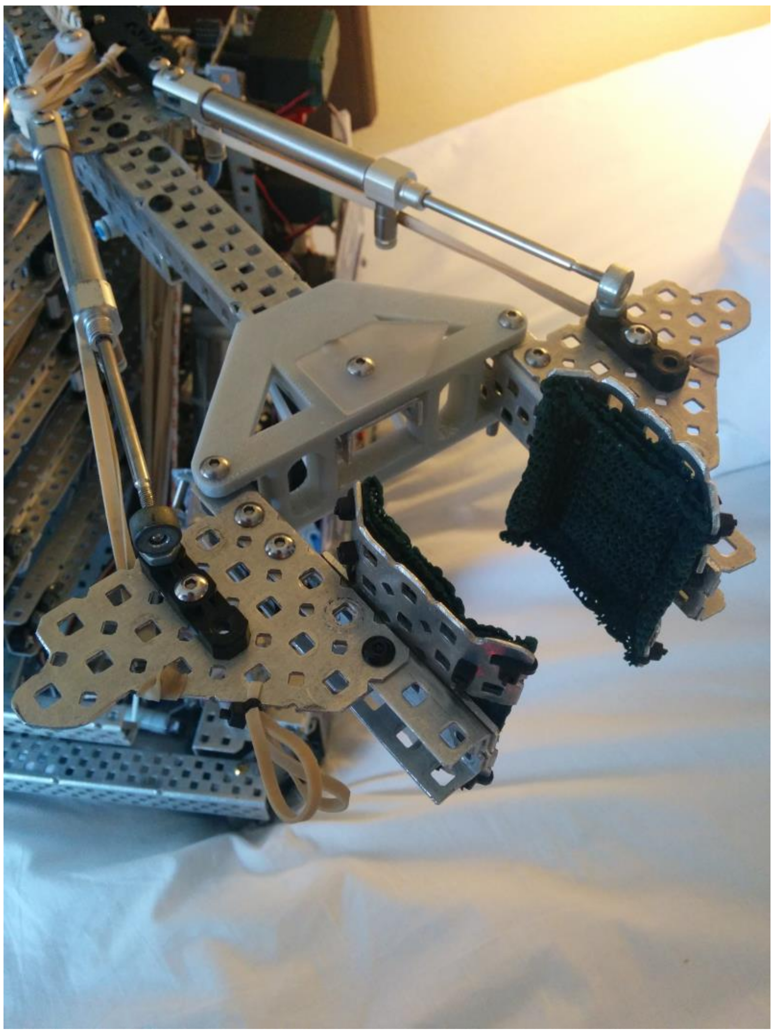


McChicken’s lift uses boxed channels made from two 5x25 aluminium c-channels bolted together. This greatly increases the polar moment of area, reducing twisting deformation when the scissor is extended. The stability of the lift is critical as it must be stable to build the skyrise sections quickly and reliably. To this end, the lift also uses custom sliders involving nylon spacers sliding along strips of polycarbonate. These are greatly superior to the Vex sliders which involve plastic on metal or metal on metal sliding. The custom sliders provide improved stability and less friction, allowing the lift to be faster and more stable.

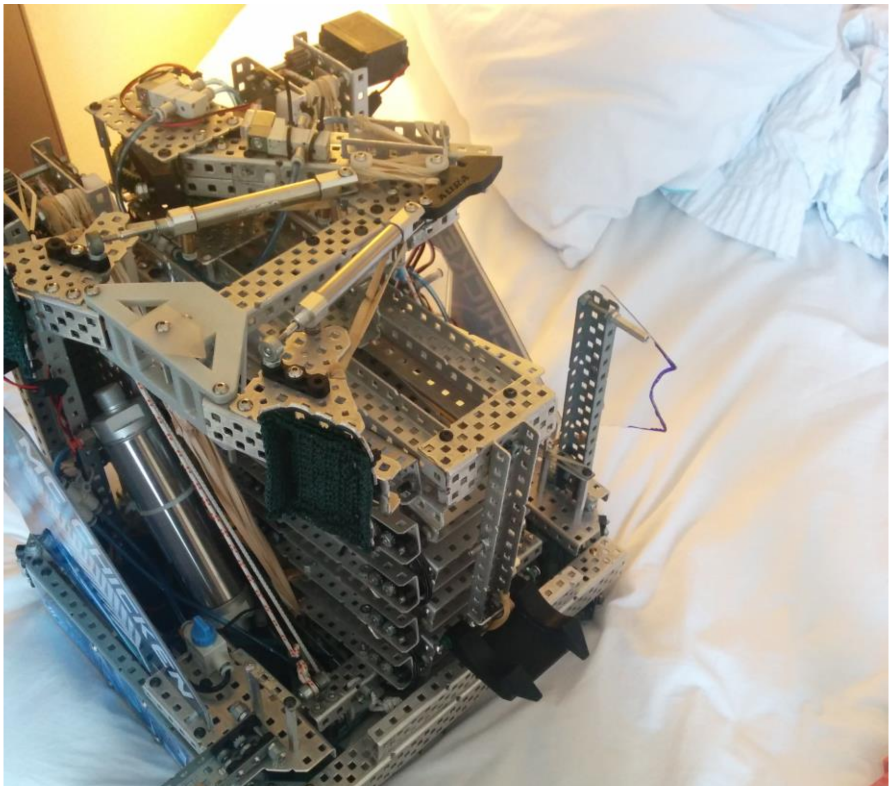


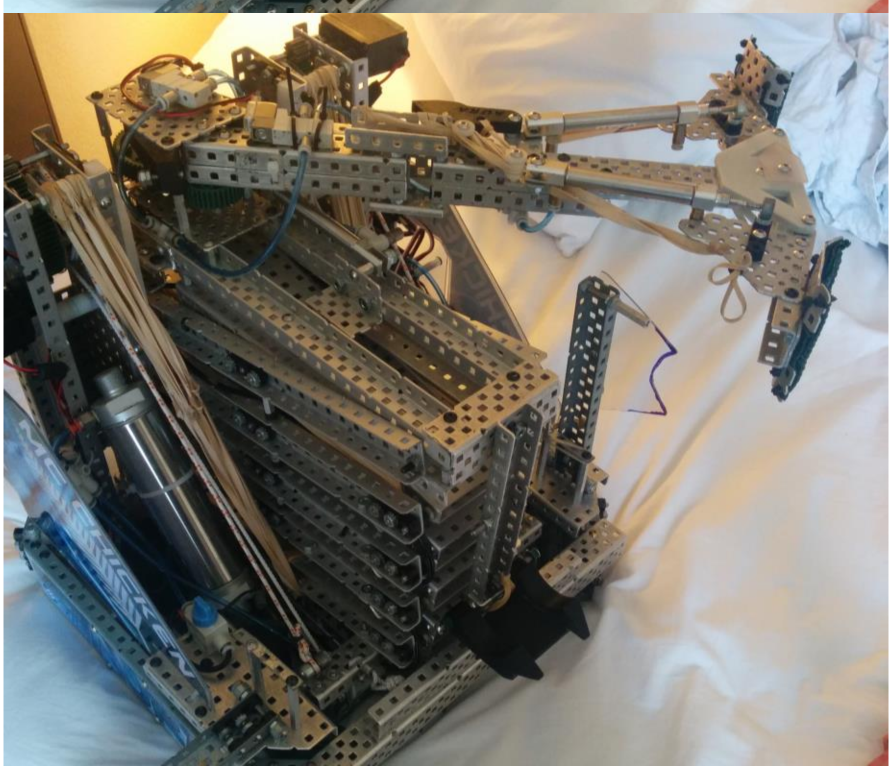
5.3. Scoring

McChicken uses 2 separate, different scoring mechanisms. The primary manipulator is used for skyrise sections. It consists of a pneumatic powered swing arm and claw. The swing arm is used to move the claw between the skyrise and the autoloader without the robot having to drive. This reduces the time per section, and allows the skyrise to be built much faster and more reliably than driving between them with a stationary claw. It also means that the robot can stay fully within the tile at all times, so is always under the protection of rule <SG9>, which prevents opposing robots from interfering with the building of the skyrise. The claw itself uses 2 pistons to close and open, which means it has enough grip to build 2 full skyrises on a two tanks of air. This is also important to allow the robot to operate on any field, as the force required to remove the skyrise section from the autoloader varies. The claw is designed so each side can fold back behind 90 degrees, which allows the swingarm to swing past a section in the autoloader without contacting it.

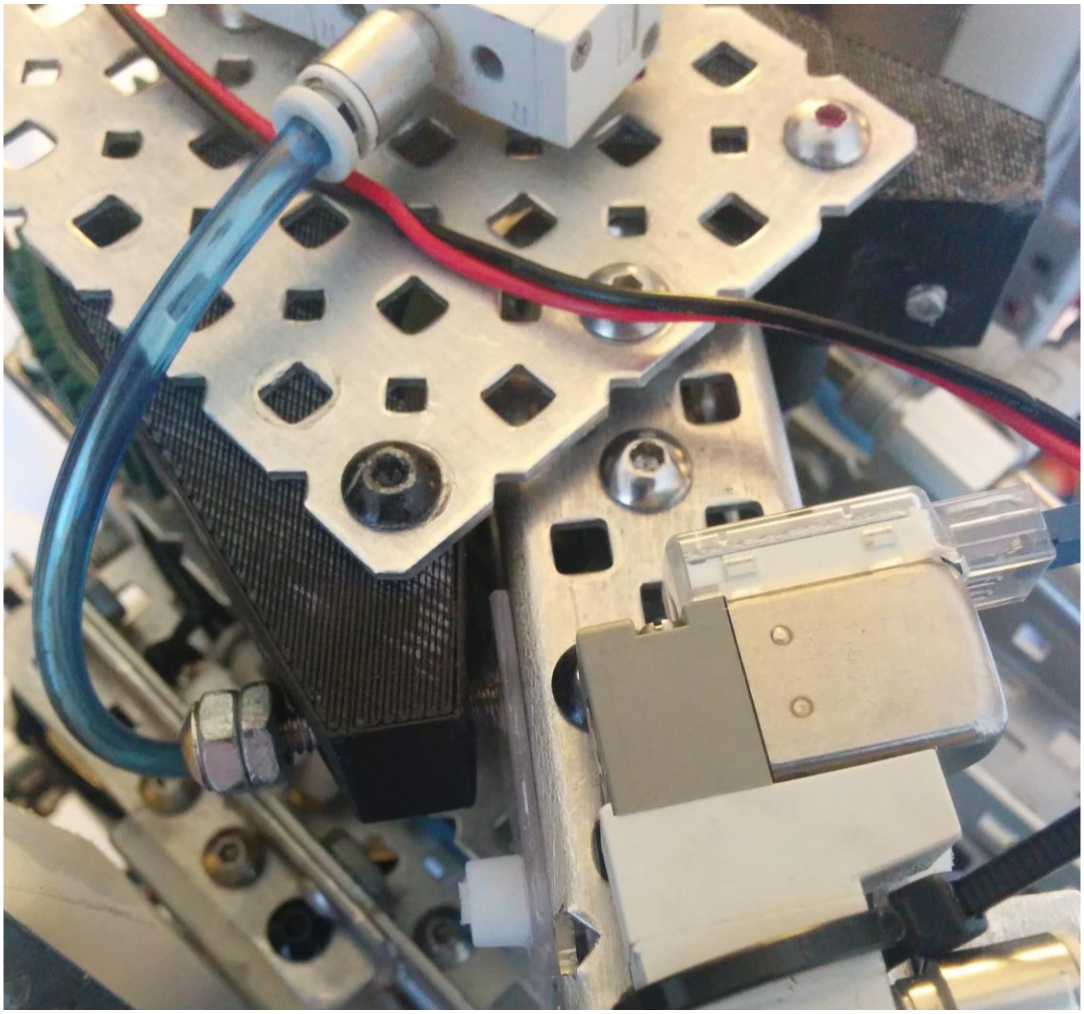


Because Mcchicken was a 15” robot, the swing arm had to fold back to be within size limit. To accomplish this, we used a hinge and latch arrangement, which is rubber banded to unfold when the robot lifts at the beginning of the match.





In order to build the skyrise a robot needs to line up exactly to the field. Because not all fields are the same this means that the swing arm needs to be adjustable to be able to line up on any field. Because it is possible that we will need to do this before every game it is important that it takes as little time as possible. To solve this problem we made a 3d printed stop, which adjustably limits the swing arms travel. The only tool required to set the travel is a single spanner, which is taken to the field with the driver, allowing him to tune the intake specifically for the field.

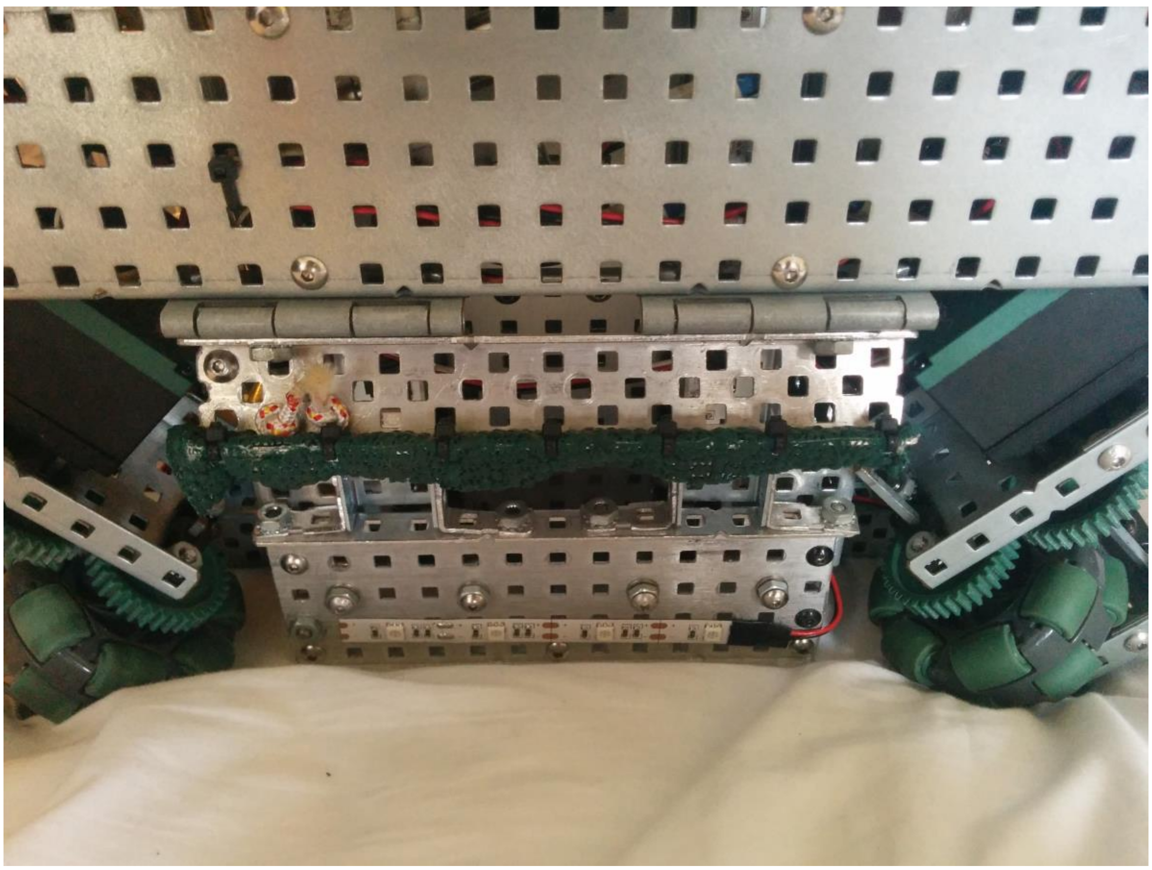


To score cubes McChicken has a single-cube passive hook, which is designed to slide into the cube as the robot drives into it, then lock in place, holding both the position and the angle of the cube. The hook was 3D printed to result in a sturdy intake with the perfect dimensions required to slide in under a cube sitting on the field, and also easily pull away from a cube that has been lowered onto a goal.

5.4. Other features

5.4.1. Brake

McChicken has more than enough torque to hold its own in any pushing battle, but the robot features a pneumatic brake to aid in consistency when building the skyrise. Due to the violent motion of the pneumatic swing arm, the chassis tends to also shake violently as the arm moves side to side. This was sometimes resulting in the robot rotating as it built the skyrise, causing it to miss later sections. The pneumatic brake is a c-channel covered with anti-slip mat which is pushed down onto the foam tiles with a pneumatic piston, which prevents the chassis from rotating while the skyrise is being built. The brake is retracted when McChicken begins to drive after the skyrise build is complete.



5.4.2. Sensors

When designing McChicken we used many physical stops to help control the robot, rather than programming with sensor feedback. This is because a well-made physical limit is faster and more robust than a programmed stop, and also doesn't require tuning. This means the only sensors we need are a potentiometer to control the height of the lift, a gyro on the chassis to control the turning of the robot, and a single encoder on one of the wheels to control drive distances. During the autonomous period the gyro and encoder are used in combination on drives across the field to get McChicken accurately to the intended destination, any error is corrected by the gyro as the encoders run a proportional controller on the drive distance.

```
void driveStraight(int time, int distance){
//This function allows the robot to drive straight using one encoder and a gyroscope.
//The inputs are a time in miliseconds, and a distance in encoder ticks.
//The distance can be negative if a backward drive is required.
  SensorValue[gyro] = 0;                          //reset sensors and declare variables
  SensorValue[driveEncoder] = 0;
  float leftPower;
  float rightPower;
  float Kp = 2.0;
  int power;
  int turningFactor;

  time1[T1] = 0;
  while(time1[T1] < time){
    power = distance - SensorValue[driveEncoder]; //calculate proportional control for drive distance
    turningFactor = SensorValue[gyro] * Kp;       //calculate proportional control for straigtening
    if(power < 30){
      turningFactor = SensorValue[gyro] * 0.5;    //decrease straightening factor at end of drive
    }
    leftPower = power + turningFactor;
    rightPower = power - turningFactor;
    setDriveMotors(leftPower,rightPower);
  }
  setDriveMotors(0,0);                          //stop
}
```

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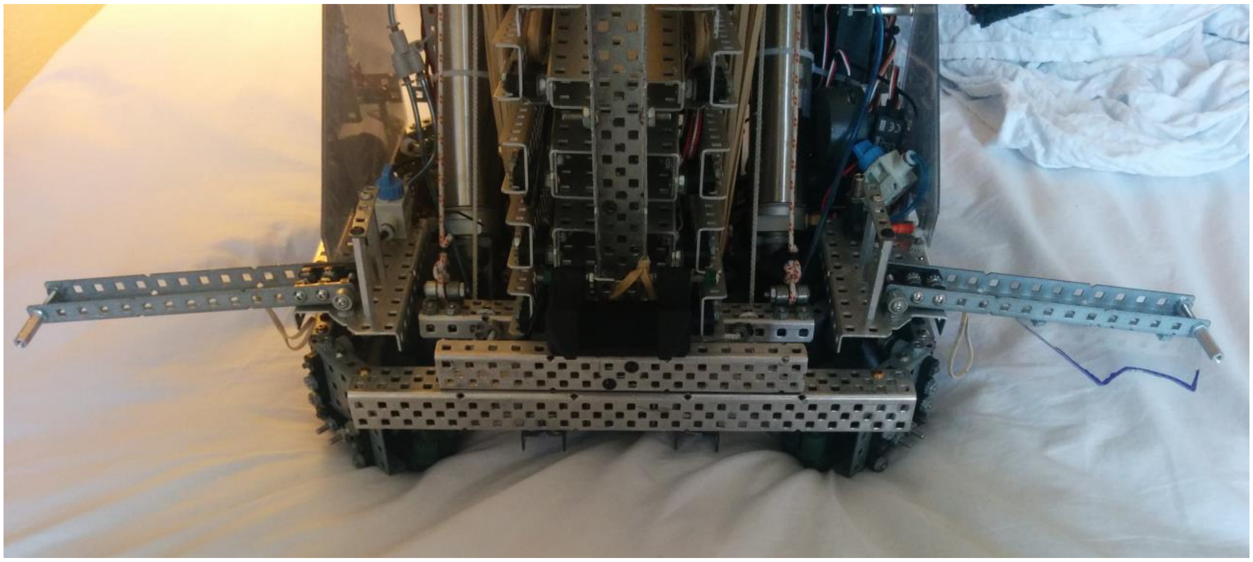
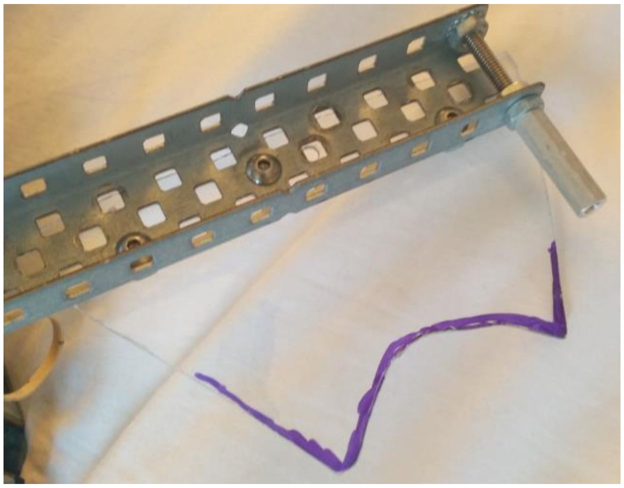
5.4.3. Wings

Since one of McChicken's main goals is to hoard the opponents' objects, it needs an effective method of pushing the opposition cubes across the field. To widen the effective area over which McChicken can push cubes, the robot has folding down wings. These are also used to block the opponent, making it more difficult for them to reach objectives. The wings are held up by rubber bands which are released from the drive gears when the robot drives backwards after the skyrise is built. The wings can be held up by rubber bands for the duration of the match if it is decided that we do not want to play defensively for any particular game.



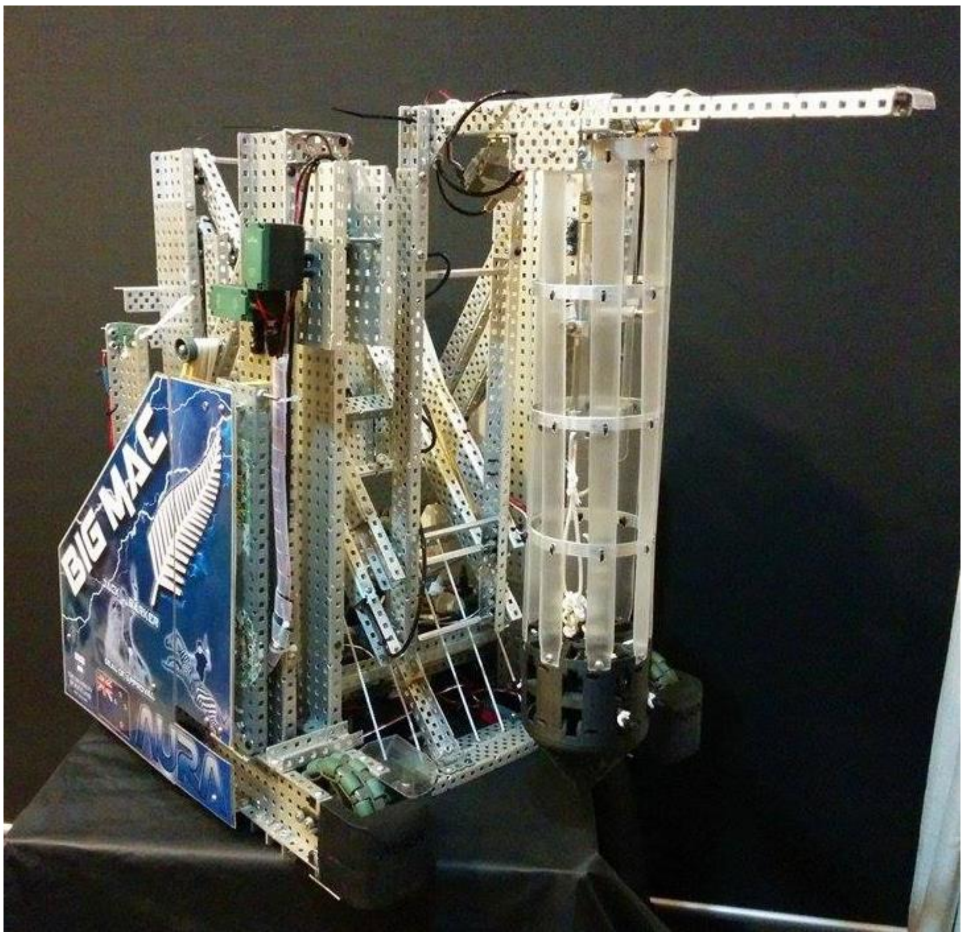
5.4.4. B. A. T. M. A. N

The Base Alignment Tool for More Accurate Nesting, better known as B.A.T.M.A.N, is a shaped polycarbonate plate used in the robot skills challenge to line the robot up on the far skyrise base, making the robot far easier to drive, as only the distance between the claw and the skyrise section in the autoloader needs to be lined up. The B.A.T.M.A.N is bolted onto the wing for skills runs but is easily removed for actual games where it would serve no purpose and may be damaged.



6. Big Mac

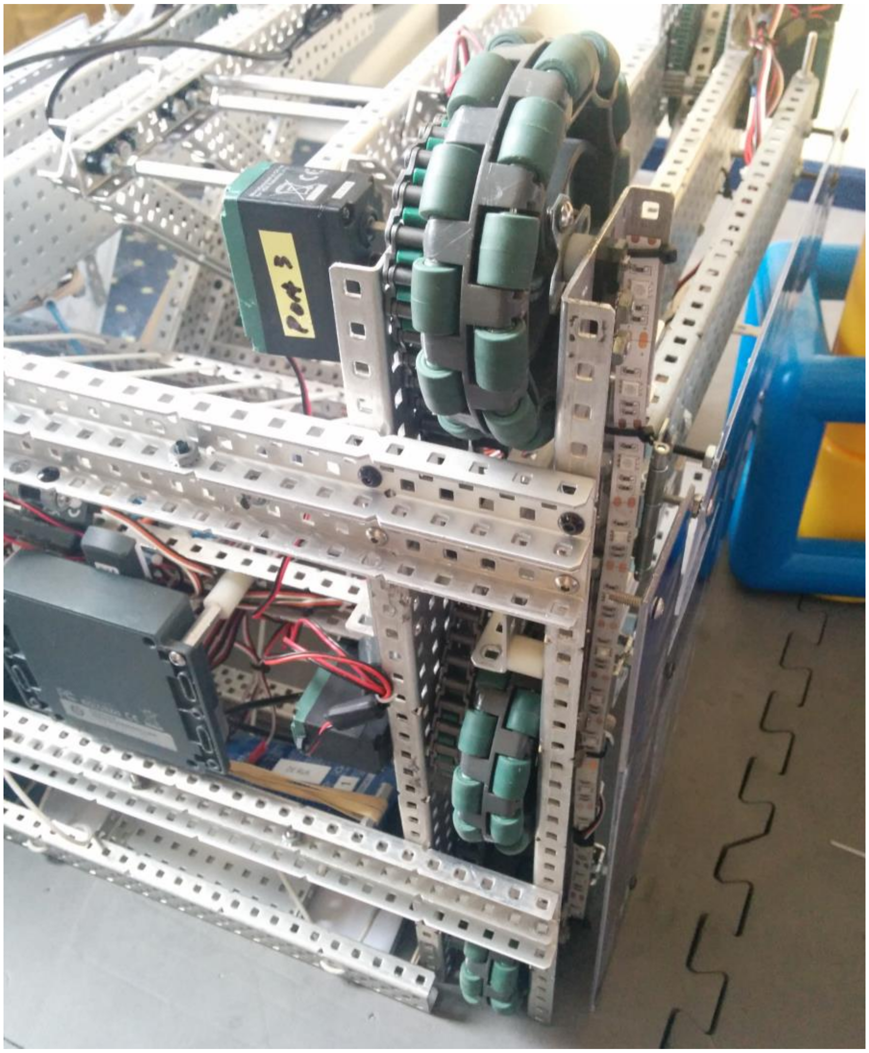
24" Robot
6 motor 1:1.6 tank drive (4" wheels)
6 motor 1:7 reverse double four bar
Pneumatic needle
Worked on: Late November 2014 - April 2015



Big Mac is AURA's final 24" robot for the Vex Skyrise season. It is designed as a robot dedicated to only score cubes, and ignore building skyrise sections, as these are handled by its smaller counterpart McChicken. Big Mac takes advantage of the 24" size limit to score three cubes at a time extremely quickly, able to score the whole field by itself easily within the duration of a match, making it a powerful robot in both skills and gameplay.

6.1. Drive

Big Mac has a 6 motor drive geared internally for speed (1:1.6). It has six omnidirectional wheels for the best possible drive performance. It was found that six wheels performed better than four wheels, particularly when turning, presumably because of better weight distribution and accordingly less pressure on the wheels. Big Mac requires a drive train with sufficient speed to move around the field and scores cubes at a high speed, but also enough torque to avoid being pushed around and harassed by other robots. Many practice games were played with the current drive ratio to ensure it has a good balance of torque and speed.



All of the wheels on each side of the drive are chained together with high strength chain to ensure that if the robot's weight moves around due to acceleration, holding cubes, or contact with other robots, all of the motor power can still be used to power a wheel in contact with the ground. While we could replace the middle omnidirectional wheel with a high traction wheel to avoid the robot being pushed sideways, we decided the negative influence on drive performance was not worth the extra resistance to defensive play.

6.2. Lift

Big Mac requires a lift that is extremely fast, but also is able to reach very high, as it needs to reach 3 cubes over a full 7 skyrise for both game and skills. We initially employed a scissor lift of a similar design to McChicken's, but found that the lift was slow, unreliable, and caused the 2 inch bolts to shear due to high stress and fatigue.

Because of this we instead built a reverse double four bar, powered by 6 motors and driven with a 7:1 reduction. This was a huge improvement in speed, reliability and maximum height compared to the previous scissor lift. The lift is easily able to reach over a full skyrise, and lifts to full height very quickly. Another advantage of the reverse double four bar is that it is linear, the intake does not move back or forward as the arm travels through its range of motion.

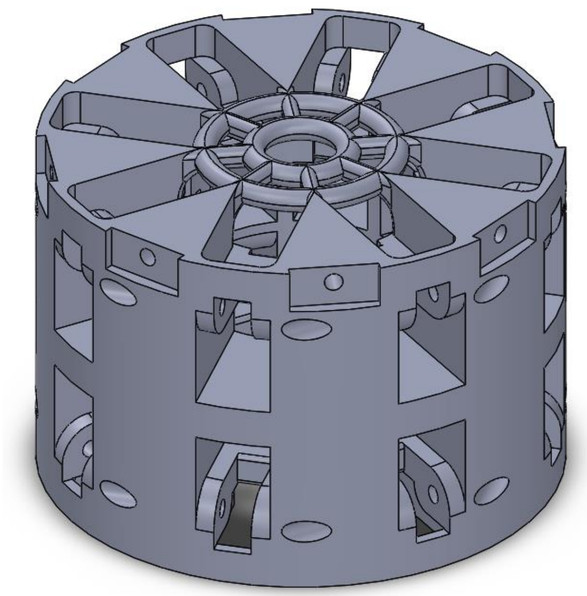
The bottom stage of the reverse double four bar is braced by a “boxed” channel made of two 5x35 C Channels bolted together. This brace has a huge amount of compressive and torsional stability, and very little additional bracing is required to keep the two sides of the lift synchronised.

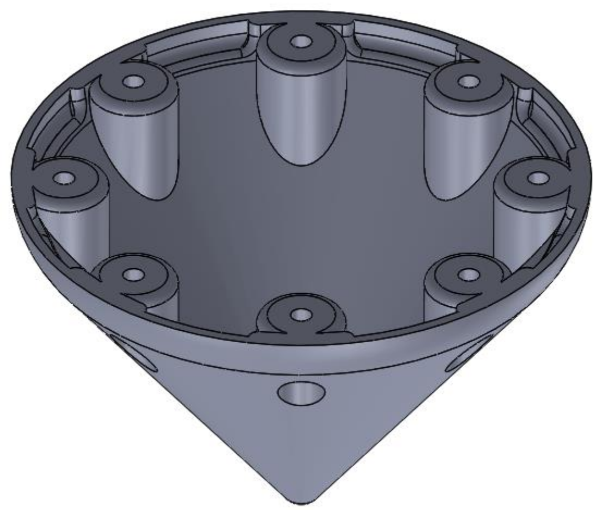
6.3. Scoring

It was decided that a needle was the best intake design for the 24” robot for several reasons. The first was that it could drop all held objects almost instantly, and accordingly there was not a risk of capping the goal for each object that was dropped, as long as the needle was lined up initially. The second was that it could pick up the stacks of three cubes in the centre of the field very quickly, which made it very strong for the skills challenges. Finally, the needle only required pneumatics, which meant it did not use any motors that were required by the drive or lift.

Initially Big Mac used a square polycarbonate needle that required the cube to be square relative to the robot’s chassis in order to be picked up. We identified that this was a big problem for both autonomous and user control; in autonomous it would be too difficult to only be able to approach from square angles, and in user control it was wasting a lot of time. The solution was to make a needle that could pick up the cube on any orientation.

To build this we used 3D printed parts. Both of the allowed large 3D printed parts are used to make the tip of the needle, one of them being a nose cone and the other being the mechanism for the teeth that hold the cubes onto the needle.





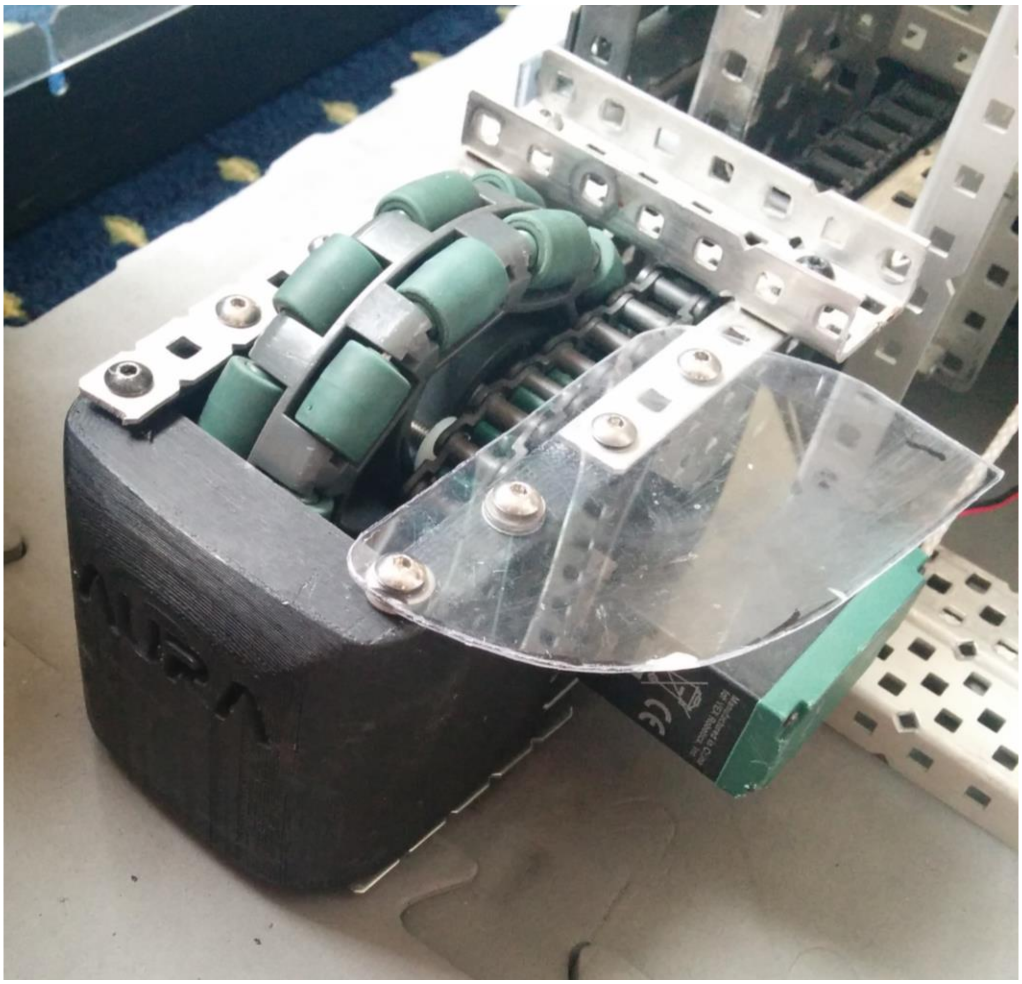
The shaft of the needle is made from a combination of polycarbonate strips and rings of aluminium sheet metal to hold it in shape. The round shape of the needle coupled with the length of the teeth allows the needle to pick up cubes on any orientation. The needle is mounted far enough forward on the robot such that regardless of the orientation of the cube, the needle will pick it up if it is touching the front of the chassis, which makes the robot far easier to drive and program.

As well as the pneumatic piston to control the movement of the needles teeth, there is an additional piston and another set of teeth which act as a set of locks. The locks are designed to hold the bottom cube down onto the lower section of the needle and stop it from rotating. This helps the needle to align on the post or skyrise when it is lowered. If the cube is locked in place and the post is anywhere within the cube, the point of the needle is guided into the top of the pole.

6.4. Other features

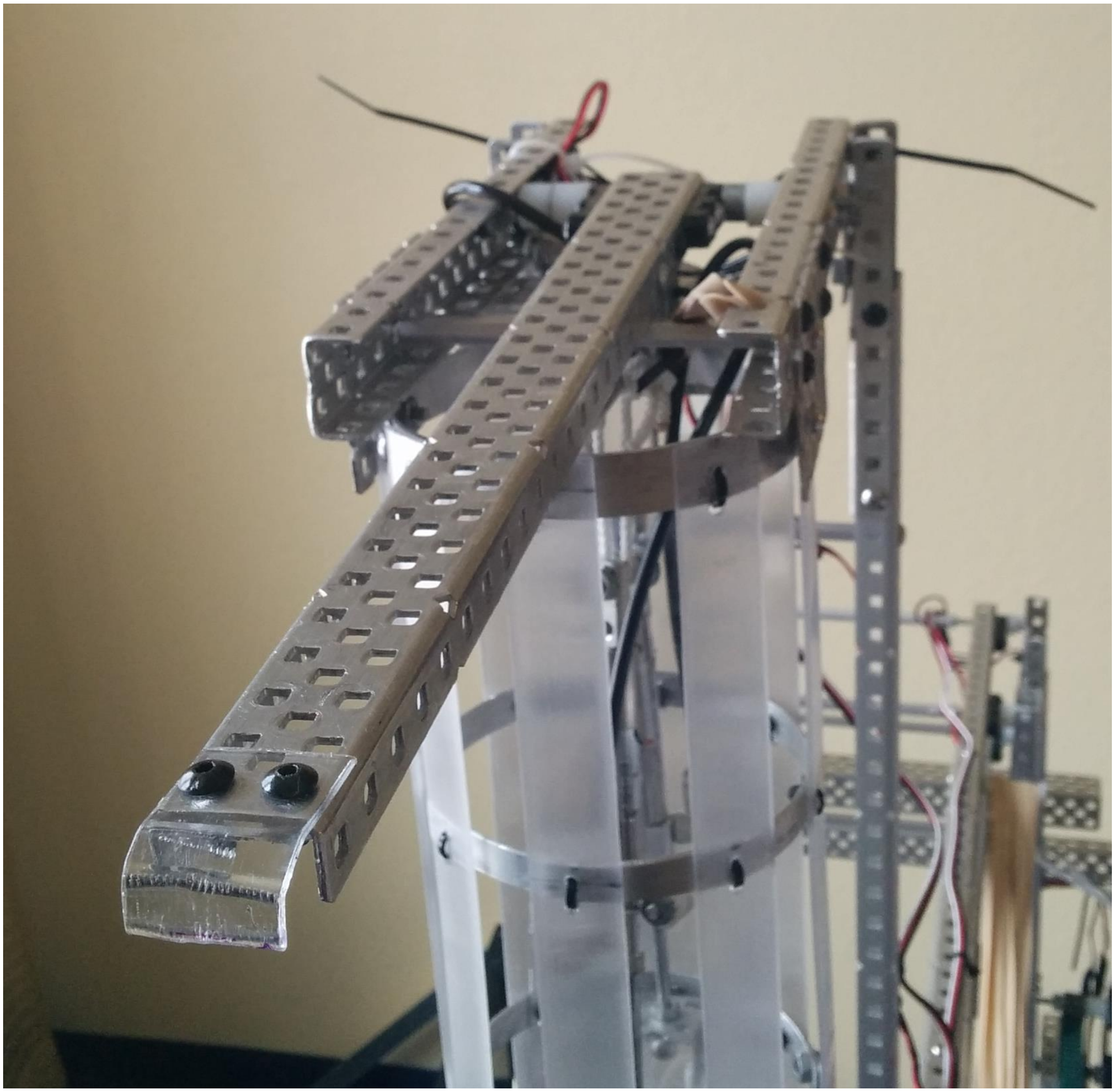
6.4.1. Wheel Guards

Big Mac has 3D printed wheel guards which stop cubes and other robots from interfering with the rotation of its front wheels. We found that without wheel guards attached it was very difficult to drive the robot around the field due to the front wheels driving up inside stray cubes. The wheel guards allow these cubes to instead be pulled into the chassis to be picked up, or pushed away without wasting time. They also allow Big Mac to push other robots without having its front wheels catch, or risk having them damaged.



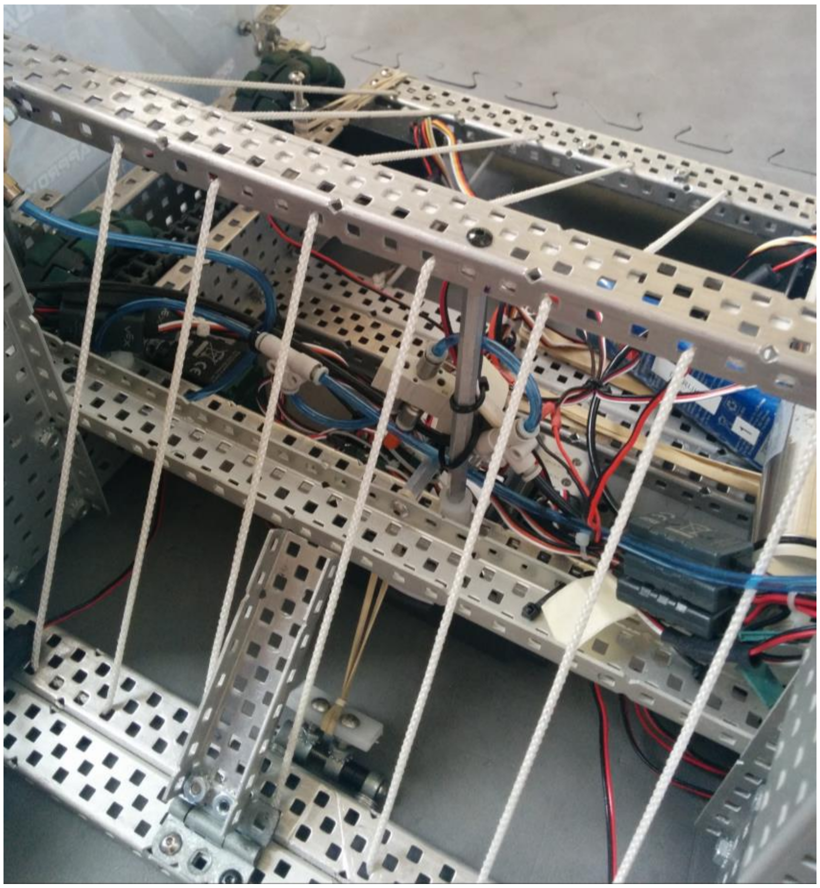
6.4.2. Descorer

Since the top cube on each post is worth a bonus point, being able to quickly contest the top points is valuable. To this end, a flip out descoring bar was added to Big Mac to allow it to quickly descore an opponents' cube and then immediately drop one of our own coloured cubes onto the post to replace it. The descorer also serves the dual purpose of holding the lift down at the start of the game to meet the 24" size limit.



6.4.3. “Rib Cage”

The rib cage is an array of string covering the flat areas of Big Mac’s chassis. This stops cubes from falling on the robot and becoming stuck. This was previously a problem, as it stopped the robot from lowering the lift. The cubes act like a trampoline, bouncing any falling cubes off the chassis onto the ground. String was used because it is lightweight, strong, and less likely to get entangled than rubber bands.



6.4.4. Sensors

Big Mac uses two integrated motor encoders on the drive, one on each side, as well as a potentiometer on the lift. The encoders are used to control the movement of the robot around the field in autonomous. Only encoders are required for the 45 second autonomous period due to strong encoder programming. The lift is controlled using the potentiometer and a PID controller.

6.4.5. Drive Code

The key to successful programming is stability, functionality and simplicity - so it's easy to modify, and it isn’t confusing going back to it. To do the robot's movement, we call a single well-commented, 60 line function. The function is powerful enough to efficiently and accurately move/turn the robot. The parameters include direction, to go forwards, back, or turn left or right, a distance which is either centimetres or degrees depending on direction, and a flag to flip the turns for simple autonomous. The heart of the code is a simple P controller that corrects between movements.