BROWNCOATS
Team 7842 Engineering Notebook

Date	Location	Start Time	End Time	Week #
September 7, 2019 September 8, 2019	AvaLAN Wireless AvaLAN Wireless	3:00 p.m. 12:00 pm	6:00 p.m. 4:00 p.m.	1

Meeting Goals: Brainstorming

Team Members in Attendance:

Becca, Brooklynn, Ian, Jalynn, Joel T, Joel H, John, Megan, Nathan

Field Observations and Notes

This is the beginning of the 2019-2020 FTC season, Skystone. The challenge primarily consists of stacking large yellow “stones” on a large “foundation”. However, there a few components that stand out immediately. Firstly, this is the first FTC challenge where elements have had vision targets on them (the skystones in autonomous). Secondly, the alliance specific skybridges introduce a unique robot volume constraint – and it is very advantageous to move stones under the skybridge, as it doubles the point value of every stone in teleop. Additionally, scoring cycles will be significantly longer this year, due to the increased travel time from the elements to the scoring area. During our brainstorming and strategy session after kickoff, the team discussed the viability of various strategies and decided that there was no immediately obvious strategy for this year’s game, implying that the point values are far more evenly balanced. Additionally, most of the tasks have dependencies upon other tasks (for instance, the foundation must be moved in order to build on it, and autonomous requires stone scoring capabilities), making it less viable to focus on one task at a time this year. The team also discussed design constraints, which included the robot’s maximum height (14” to clear the alliance-specific skybridge), the capability to score elements at multiple angles (long side and short side), and the robot must be able to intake stones in any upright orientation (and potentially even on the sides).

General Summary of Meeting

After Kickoff, the Browncoats convened at AvaLAN to continue brainstorming and compare ideas. A list of necessary components that were needed on the robot was compiled and we started to formulate some goals to set for ourselves over the course of the build season. At the end of the meeting, we agreed to read over the second part of the game manual and think about strategy.

General Summary of Meeting - continued

On Sunday, we continued brainstorming, first by refining strategy discussion (after everyone had read game manual 2 more closely), and then continued with brainstorming. We discussed more ideas for depositing mechanisms, such as a linkage based “virtual 4 bar” or “chain bar” style system to quickly raise and lower the stone as the lift raises. We also discussed some changes to previously mentioned ideas, such as needing to clamp onto the stones for deposit on the short side, rather than the long side.

Overall Outcome of Session

The first thing we did was come up with constraints for the robot/field/programming. For instance, some of these constraints include the 14 inch skybridge, meaning we need to build our robot to be shorter than that if we want to safely make it under there. Also, whatever subsystems we decide upon, we need to make sure we use lighter materials, as there is a 42 pound weight limit. Last year we came very close to this limit, so this year we want to try to be farther under it if we can be. Another constraint is the wobbly stones. If we stack them high enough, the tower becomes very unstable, which becomes an issue for when we need to move the foundation in endgame. One of our solutions is to create a sort of clamp that will hold onto the last stone of the tallest tower to keep it steady while a separate subsystem grabs the foundation and moves it. This was something that almost the entire team agreed we would need. Another idea that was widely agreed upon is a wheeled intake to pick up the stones, specifically in the shorter orientation. Claws were also considered, though this also requires turning which is slower than simply driving back and forth from the depot to the foundation. One idea was to have the wheeled intake on the front, and a deposit that grips onto either side of the stone and places it onto the foundation on the back of the robot.

Strategy and Design Discussion

For autonomous, we noticed that finding a route where we won’t collide with our alliance partner will be incredibly difficult. We’re going to have to program many different paths just in case. It also seems beneficial that one partner only parks while the other does everything else to avoid hitting each other. We also decided that pushing the foundation all the way into the corner during autonomous might be best. That way when we’re stacking during tele-op, there won’t be the concern of it moving around if we accidentally bump it, and that way it should stay in the same spot the whole time until we move it during endgame.

Strategy and Design Discussion - continued

We also realized that in tele-op, one of the best ways to go about scoring, if both systems are fast, is having one robot collecting stones from the depot, and the other stacking them. It's something we'd have to play by ear, but currently it seems like the fastest solution. Another thing we discussed is how to stack the stones. Stacking one tall tower will gain us the most points, however, if we stack two towers side by side, it will reinforce it a bit, but it will also earn us less points. We're going to draw diagrams and test which one will be the best to go with once we have our field. We also calculated the minimum points we could score based on our goal to stack eight stones by December. Once we finished discussing this, we moved onto designs. Some of us had already started refining ideas and coming up with ways to improve them. A few new ideas were mentioned, and we have a lot to choose from, which we'll start narrowing down at our next meeting.

The pictures below are a summary of our brainstorming discussions and ideas.

Summary of Ideas - Constraints

1. Robot must be able to move under the 14" skybridge. Robot must not exceed about 13" in height while driving.
2. Overall dimensions of the robot at start of match should be under: 18 x 18 x 13".
3. In this game, maneuverability is critical. Mecanum wheels may be our best choice.
4. Initial Assumption: Any stone that the robot is to pick up will be upright on the field.
   Ultimate Goal: The robot must be able to pick up stones that are lying on the field in any orientation.
5. The robot must be skinny so that it can be parked in the Building Site during end game and not block our alliance partner from parking there as well.
6. The robot should weigh less than 42 pounds. Use lighter materials where possible.
7. Initial Assumption: In the early December competition, the tallest tower built will have no more than eight layers.
   Ultimate Goal: By worlds, expect that the tallest towers built will have sixteen layers.
8. Robot should incorporate lessons learned last year regarding ESD. Goal: No phone disconnects due to static.
9. Robot should be designed so that it is not possible for falling stones to get stuck inside it.
10. The robot must use no more than 8 motors and 12 servos (motors are already a potential issue).
11. The robot should be designed to be as reliable as possible. Goal: Nothing breaks during any competition.
12. Self-imposed progress goals:
    a) Keep the 1 point by 1 October milestone/goal.
    b) Need to create more: 100pts (?) by 1 Nov or something tied to a theoretical scoring maximum?

Summary of Ideas – Potential Strategies

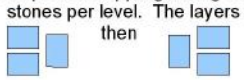
Actions that should/should not be performed.

1. There is no obvious advantage in doing one thing over another--too many variables (number of skyscrapers built, top levels of each skyscraper, unknown behavior of alliance partner, etc.) will require quite a bit of in-depth analysis to determine any advantageous scoring strategy (few tall skyscrapers vs. many short skyscrapers).
2. No strategic advantages (and a first qualifier coming one month later than last year) means that there are no advantages to prioritizing and building one hardware subsystem over another.
3. It may be advantageous to work with our alliance partner so that in teleop, one robot gets stones from the human player, crosses the skybridge, and drops the stones into the building zone while the other robot picks up the stones and lifts them onto the Skyscraper. Advantages:
   a) Robots do not get in one another's way.
   b) If one robot has a very fast lift/stacking mechanism, this scheme maximizes its use.
4. Whichever direction the foundation is finally moved in endgame may dictate how the stones are stacked. Is desirable to stack so as to brace against the movement.
5. Goals for autonomous (the idea is to score as many points as possible):
   a) Move the foundation into the building zone.
   b) Deliver at least one skystone (but be capable of scoring both).
   c) Place at least four stones onto the foundation.
   d) Navigate (park under the alliance skybridge over the tape, sensing and avoiding the alliance robot).

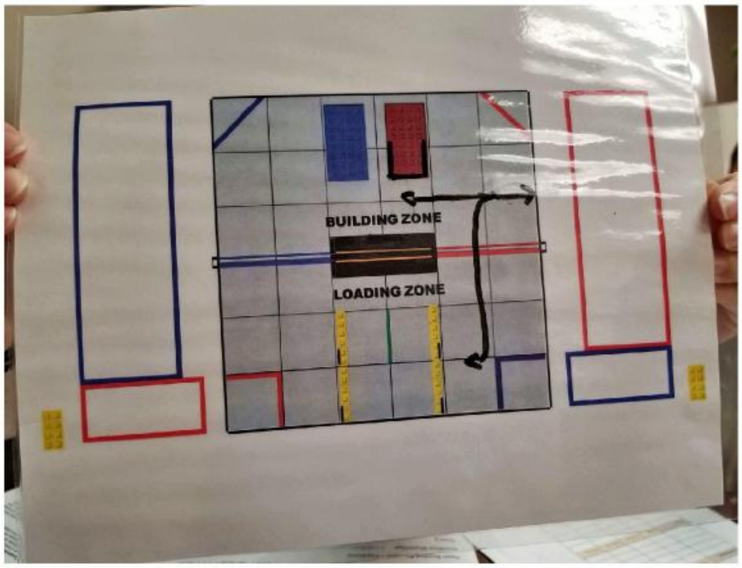
Summary of Ideas – Potential Strategies
(continued)

Actions that should/should not be performed.

6. Drivers: If a tower is built up to maximum height, start on another tower. Don't stop.
7. During endgame and while the foundation is being moved, the robot can reach up and hold down the top of the tower to prevent the tower from falling (What happens if there is more than one tower?).
8. Avoid driving under the Neutral Skybridge while carrying a stone. Good way to loose points.
9. Autonomous should build two towers consisting of as many stones as possible.
10. A new tower should be started at the beginning of teleop.
11. Work with the alliance partner to build one tower as tall as possible. Both capstones go onto that one tower (if both alliance partners can reach).
12. To prevent toppling during endgame when the foundation is moved, skyscrapers should be built from three stones per level. The layers should be interlocked and arranged as:



Summary of Ideas – Drawings



Summary of Ideas – Drive Train

The basic chassis and drive wheels of the robot.

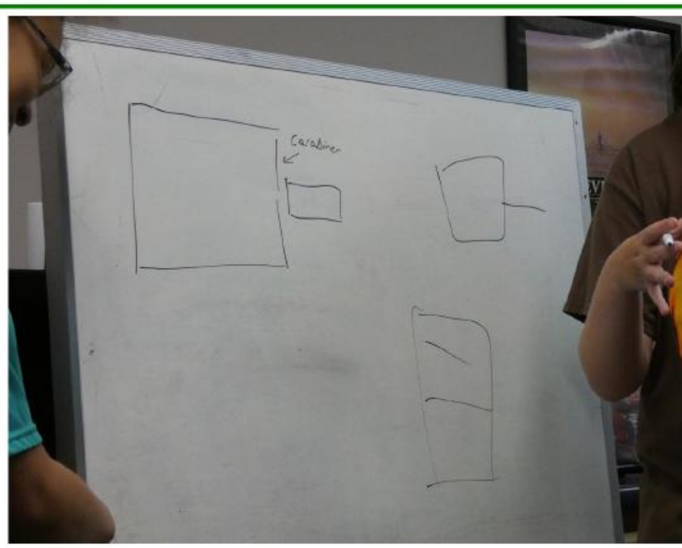
1. The robot needs to be fast and agile, yet strong enough to move a fully loaded foundation.

Summary of Ideas – Collector

The mechanism that picks stones up off of the field.

1. The collector must be fast.
2. The collector must pick up only one stone at a time.
3. The end of the intake mechanism could pivot/rotate to pick up stones lying on their side.
4. The collector could be a gripper hand.
5. The collector can be modeled after a scoop with carabiner-like tabs on either side that allows stones to enter but prevents them from sliding out.
6. The collector could be made of compliant wheels.
7. The collector could incorporate a six-wheeled intake. The second set of wheels will be unpowered. This will help orient stones that are out of alignment.
8. Robot needs a horizontal finger/arm to reach over and pull stones out of the quarry line and into the intake.
9. Once a stone is loaded by the intake, it lands inside the robot in a tray (part of the lift mechanism).
10. The robot could be built so that the blocks to either side of the skystone in the quarry are pushed out of the way as the skystone is picked up (from robot-in-a-day videos).
11. POTENTIAL ISSUE: How will a conformal wheeled collector fold up to fit within the 18" starting limit?

Summary of Ideas – Drawings

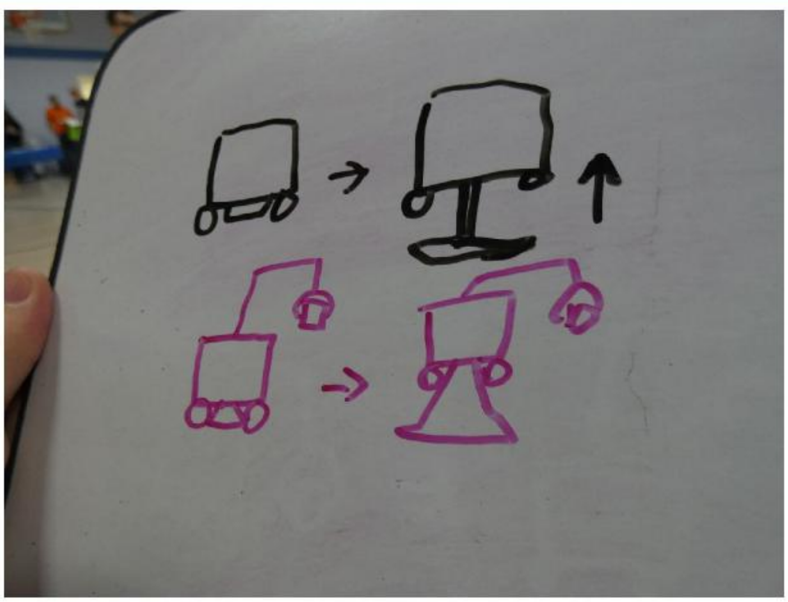


Summary of Ideas – Lift

The mechanism that lifts stones and capstones vertically for placement on the tops of skyscrapers.

1. The lift should be tall enough to build the tallest tower envisioned, but no taller. Saves space and weight.
2. The lift mechanism should be made from slides.
3. Use three motors on the lift for speed.
4. Instead of lifting the stones in a cradle, lift the entire robot on jacks from underneath.
5. Use a chain lift to raise the stones up the already extended arm. Saves time by eliminating the need to raise/lower the entire arm to lift each stone.
6. The collector mechanism deposits stones into a tray in the body of the robot. The entire tray is raised by the lift, then an arm/gripper mechanism removes the stone from the tray and places it onto the skyscraper.

Summary of Ideas – Drawings

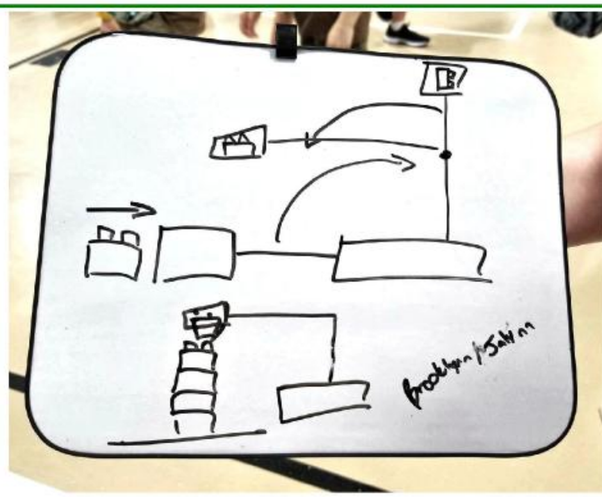


Summary of Ideas – Arm and Clamp

Mechanism on the lift that cradles stones, moves them horizontally through space, and places them onto skyscrapers.

1. The robot needs some kind of gripper mechanism to place stones onto the foundation or skyscrapers.
2. The gripper (?) at the end of the arm needs a joint so that stones can be rotated 90 degrees as they are placed onto the tops of the skyscrapers. A servo powers the joint.
3. The gripper (?) uses rubber treads on the gripping surfaces to prevent stones from slipping.
4. Use a forklift-like device to slide under stones to lift/place onto towers rather than a gripper.
5. When placing stones onto towers, a thin-walled gripper is used to pickup the stones. The thin walls allow stones to be set next to one another.
6. Use a clamp that drops over the stud on the top of a stone to hold them from the short side while setting stones next to one another (from robot-in-a-day videos).
7. A gripper mechanism clamps onto the stone, then swings on an arm moving up, over, and out horizontally over the foundation. The swinging motion is driven by the lift motors and happens automatically as the lift is raised. As the lift is lowered, the gripper and arm will swing over its pivot and back into the tray automatically. This system will have 3-degrees of freedom (up/down/horizontal, pivot one axis of the stone to keep it level as the top-swinging arm moves, rotate the stone gripper 90 degrees).
8. Use a conveyor belt within the body of the robot to move stones/capstone into the proper position to be lifted.
9. Use a horizontally swinging arm (bearings on z-axis). Since the sideways/horizontal movement is not lifting the weight of the stones, it could be powered with a servo.
10. An over-the-top swinging arm may double as a clamp that braces a skyscraper while moving the foundation.

Summary of Ideas – Drawings



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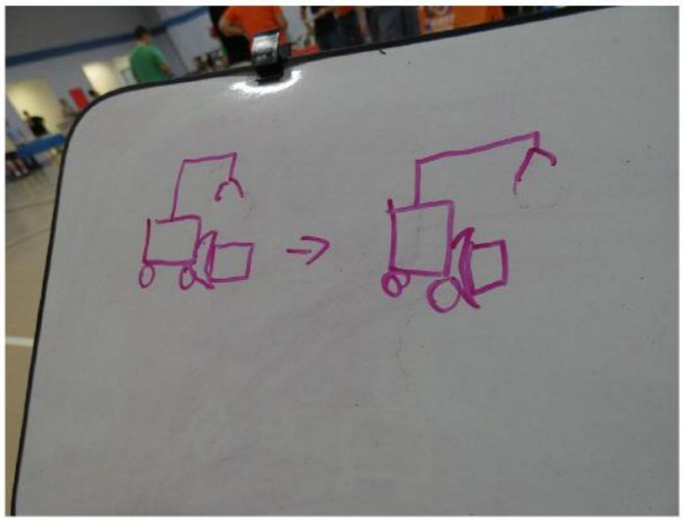

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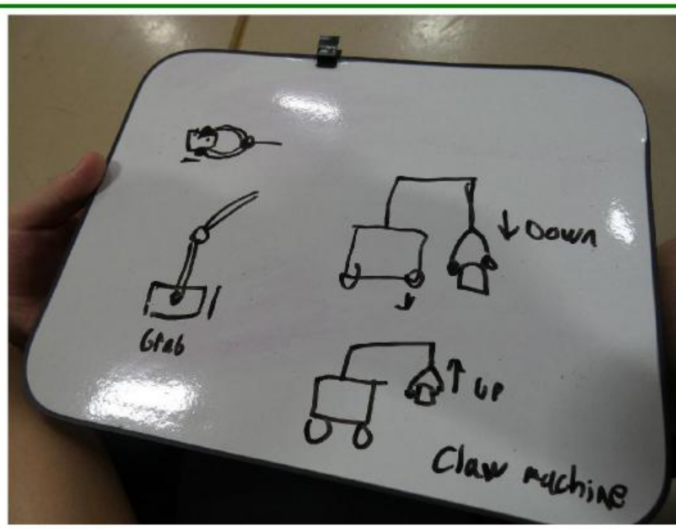

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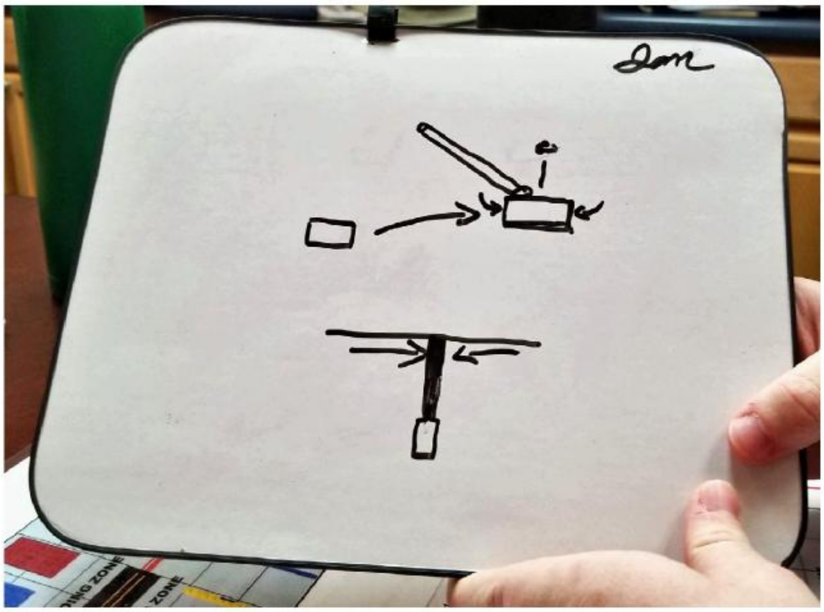

Summary of Ideas – Fingers / Fork

Mechanism that grabs/hooks the foundation so that it can be moved.

1. Could the mechanism that grips the foundation and the mechanism that pulls stones out of the quarry line be the same device?
2. In autonomous, there is no room to maneuver to push or pull the foundation into the building site. Instead, drive to the side and drop a u-shaped fork into the edge of the foundation, then drive forward and strafe into the corner/build site. The same fork could grab the foundation in end-game.
3. Rather than grabbing the edge of the foundation to move it, slide a large forklift-like fork underneath it. Perhaps even lift it before moving.

Summary of Ideas – Software Automation

Teleop operations that can be sped up or made more reliable through software automation.

1. Utilize automation in teleop to speed things up. For example, let the robot sense when crossing into the build zone and begin moving the lift. Also, need a button to go back down if we missed something.
2. When dragging the foundation during end game, need a button to slow the drive train so the skyscrapers won't tip over.
3. Implement a "jerk limited motion profile" in software for moving the foundation and skyscrapers in end game.
4. Incorporate as much automation as possible into skyscraper stacking or finding and setting a relative position to the foundation.
5. Need accurate navigation software to drive autonomous. May also have applications in teleop, like automatically finding the correct position to stack the next stone onto a skyscraper under construction.

Summary of Ideas – Capstone

The team scoring element.

1. Constraints: Min size = 3 x 3 x 4". Max size = 4 x 4 x 8". Electronics not allowed. Must be labeled with the team number (only once) and legible from 12 inches away. Same mechanical constraints as the robot.
2. The team capstone needs to incorporate a 3-D printed Serenity space ship model.
3. Team capstone could be a shape of a 1 stud stone, cast of clear material, with a 3-D printed Serenity model inside.
4. Design the capstone with a pendulum anti-sway counterweight (a tuned mass damper) to help stabilize the skyscraper as it is being moved in endgame.
5. Preload the capstone onto the robot and use a separate, dedicated arm to lift it onto the skyscraper in endgame.
6. Preload the capstone onto the robot so that it can be deposited into the lift mechanism where it would be lifted and placed onto a Skyscraper with the same mechanism used for stones.
7. Have the human player put the capstone onto the field at endgame. The robot picks it up along with a stone and lifts both into place at the same time.

Summary of Ideas – Sensors

What sensors will be needed and why.

1. The robot should be designed for software performance. Sensors should be thought about up-front and incorporated into the initial design, not added as an afterthought.
2. Sensors that will be needed include:
   a) Color sensor looking downward to detect crossing under the Skybridge.
   b) Encoders on each motor to help track position.
   c) Encoders on omni wheels under the robot to accurately measure distance traveled as an input to the navigation software.
   d) Ultrasonic sensors to detect other robots and avoid collisions.
   e) Limit switches. Used to re-zero the lift when returned to a known starting position.
   f) Limit switches to detect when the hooks that capture the foundation are down.
   g) Limit switches to detect the position of the stone positioning arm and gripper.

Summary of Ideas – Other

Notes, General Observations, and Uncategorized Ideas.

1. Need visual aids and/or a standard script when coordinating with alliance partners.
2. Need better placement of the power switch (so as to not be almost disqualified at worlds).
3. The Red/Blue alliance markers can be fastened to the side of the robot with velcro.
4. DO NOT step over the skybridge--this is a safety issue that will be penalized during competitions. Get into the habit NOW of exiting the field to go from one side to the other.
5. Unlike last year, we cannot build half the robot before the first competition and the other half afterwards. Instead, we need to build a complete robot immediately, then spend the rest of the season practicing and refining.
6. Do not get fixated on a single design--do not be afraid to redesign/replace any specific component (but be mindful of the time available until the next competition).
7. Collisions with other robots during autonomous will be a problem. Pre-match coordination with partners will be critical to preventing collisions.
8. We must be careful not to be touching any skyscraper when time runs out--If the robot is touching, the skyscraper will not count. Perhaps some mechanism(s) could be spring loaded so that they pull back slightly when power is removed at the end of a match?
9. Be mindful that the Human Player could put stones onto the field in any orientation (may not be under our control if the Human Player comes from the alliance partner). The only remedy is to make the collector able to handle any stone orientation.

Open Questions & Concerns

- Strategy Research: John T's Spreadsheet
- Collector: Competing options
- Arms:
  - How tall / How many stages?
  - How many motors?
- Dispensor: How does it work?
- Arm & Clamp: Competing options
- Capstone: Stabalizer idea:
  - Needs some research into tuned mass damper – Do the math
  - Excellent Engineering Notebook opportunity
  - May not be practical – Heavy weight may be perceived as a safety issue.

Open Questions & Concerns
(continued)

- Autonomous considerations:
  - Vision – Find skystones, navigation fixes – Need external webcam(s)?
  - Navigation – Needed to do autonomous well.
- Phone Holder for New Phones: Joel T. is working
- More experiments to assist in strategy, skyscraper building, and bolster engineering notebook (Can be treated as POPs!):
  - Tuned Mass Damper: Do the theory & math (see above) AND test experimentally.
  - Stability test: Build many different styles/orientations of skyscrapers a fixed height. Push laterally with a yard stick from a stable vertical platform and record how far each tower can be displaced before they topple.
  - Others?

Motor / Servo Budget

	Motors (8 Total)	Servos (12 Total)
Drive Train	4	0
Collector	1?	?
Dispensor	1?	?
Lift	2? 3?	0
Arm & Clamp	0?	2? (Grip, Pivot)
Foundation Catch	0	1? 2?
Other?	?	?

Expectations

- When a POP is completed:
  - Need **Pictures** for the Engineering Notebook
  - Need a brief write-up of what was learned (also for Engineering Notebook)
  - Need to **share** results with everyone else on the team.
- Decisions:
  - Discuss with majority of teammates and get agreement.
  - COMMUNICATE: Write up the decision for the Engineering Notebook.
  - COMMUNICATE: Please make sure that the Coaches & Mentors know!
- Design Reviews:
  - Done after design is complete but before prototype construction begins.
  - Informal and short: Show the team what you're thinking about building.
  - Show design work, POP results, models, flowcharts, sketches, CAD drawings, whatever.
  - Major input into the Engineering Notebook.