INITIAL GAME ANALYSIS - *From Brainstorming*

- Immediately after we found out what the challenge was, we began analyzing the game. It was a lot to take in, as there are many different scoring possibilities in the game, but we came away with a few impressions that everyone agreed upon.

- One of the first things we noticed is how necessary driving under the alliance specific Skybridge is. So, building our robot under 14" will be key.

- Another thing we noticed was that this is a lower scoring game than previous ones in the past. Because of this, we deemed it essential to be able to score every possible point we can.

- Autonomous is extremely valuable. We need to be able to score both Skystones first, and then as many of our stones left in the quarry as we can before tele-op even begins.

- We also realized that we will need to be very fast during tele-op. Speed is essential during this game, as the depot and the foundation are completely across the field from each other. We need to be able to speedily maneuver across the field, and we need to quickly and reliably pick up the stones and score them.

- During endgame, our biggest challenge will be moving the foundation without any of the stones falling down. There are many options we can use to fix this, one of which involves clamping on top of the stones, hooking onto the foundation, and then moving it.

INITIAL ROBOT GOALS - *Discussed During Brainstorming*

- Be efficient at every scoring opportunity
- Be flexible to adapt with any alliance partner
- Build a reliable robot
- Be agile and maneuverable
- Complete every aspect of the challenge through application of engineering design principles
- Have a complete robot by our first qualifier
- Be a consistent alliance partner at every competition
- Be able to quickly intake and score stones

INITIAL GAME STRATEGY - *Discussed During Brainstorming*

- Score as many stones in autonomous as possible, starting with both Skystones, and then the rest of the quarry
- Score as many stones as possible that are left in either alliance's quarry at the start of tele-op to reduce trips to the depot
- Potentially have one alliance partner delivering stones under the skybridge and having the other scoring them for quicker scoring capabilities
- Push the foundation into the corner of the field so it won't move, and the position is always constant
- Clamp onto the top of the tower during endgame to stabilize the tower while moving the foundation
- Be able to accomplish every task in autonomous and tele-op to score as many points as possible

GAME STRATEGY	*Date*
Rank field tasks based on difficulty of software and hardware	9/8/19

Key:	Easy	Medium	Difficult

During brainstorming after kickoff, we looked at all of our subsystems and scoring possibilities, and estimated what the difficulty of each hardware and software subsystem would be.

Autonomous	Points	Hardware	Software
Moving Foundation	10		
Delivering Skystone	20		
Delivering Stones	2		
Placing Stones	4		
Going under Skybridge	5		
Teleop	Points	Hardware	Software
Delivering Stones	1		
Placing Stones	1		
End Game	Points	Hardware	Software
Capping	5		
Moving Foundation	15		
Parking	5		

Milestones set for this season
1. One point by the first week of October
2. Seventy points by our first Qualifier
3. One hundred and twenty points by the first week of April

GAME APPROACH

Now that we had ideas of what we wanted to do, we needed to know *how* to do it. We separated all of the scoring systems into subsystems and came up with multiple ideas for how these could work and what to make them out of. Then, we came up with constraints for the robot and the playing field, and we decided on our initial game strategy. This will likely change slightly once we've built the robot.

Subsystems:

- Drive Train
- Intake (Collector)
- Transfer
- Arm and Clamp (Deposit)
- Foundation Catch
- Lift

Autonomous:

- Use odometry omni-wheels for accurate navigation
- Score four to six stones, starting with the two Skystones
- Be able to reliably and consistently deliver stones
- Move foundation
- Park

Tele-Op:

- Score leftover stones from either alliance's quarry
- Cycle stones from depot to foundation quickly
- Score 8-10 stones
- Have one partner collecting stones while the other scores

Endgame:

- Continue scoring stones for as long as possible
- Place capstone
- Use a jerk limiter to move foundation
- Park

OVERALL ROBOT DESIGN DECISIONS

Robot Design

- Use compliant wheels or wheels like these on the intake to be able to collect the stones from any orientation
- Use 3.7 gear ratio motors on the intake to quickly collect stones
- Use mecanum wheels on the drive train for maneuverability, flexibility, and ease of operation
- Use a linkage for deposit for simplicity and accuracy
- Design most of the robot in CAD first to properly plan out where all of the subsystems will be placed and the constraints we'll have
- Design custom odometry omni-wheels to mount onto the drive train for software feedback for accurate navigation
- Make a deposit that can clamp the stones instead of grabbing by the studs to avoid problems once the studs start to warp during competitions
- Build a simple latch mechanism for the foundation catch that takes up little space on the robot, but is still accurate and reliable
- Use continuous rigging for our lift so we can easily go to the position needed to score stones

Game Play/Field Problems

- Skybridge is only 14" tall
- High likelihood of collisions during autonomous
- Limited movement space during tele-op at the front of the field
- Moving the foundation may cause tall Skyscrapers to fall
- Stones can be unstable depending on how they are stacked

ROBOT DESIGN DECISIONS II

- Design robot in CAD–because of all the sizing constraints, we want to make sure everything fits the way it needs to
- Don't prioritize one subsystem over another–all components are key parts of the robot and are all necessary to this year's game
- Use the divide and conquer method to distribute the work amongst the team and efficiently get as much work done as possible
- Design robot to be as efficient and reliable as possible–use simple, but strong designs that effectively get the job done, with easy to change out parts in case of hardware failure
- Design robot to be maneuverable and fast–use mecanum wheels, create custom drive train

ROBOT CONSTRAINTS/SOLUTIONS

- The robot cannot exceed 13" in height due to 14" Skybridge, therefore we will need to build our subsystems with this in mind
- In this game, maneuverability is critical. Mecanum wheels may be our best choice
- Robot has to weigh less than 42 pounds. Use lighter materials when possible
- The robot must be able to pick up stones that are lying on the field in any orientation. Depending on what kind of collector we use, a second subsystem to help may be necessary
- Because it is a low-scoring game, we need a full robot with scoring capabilities by our first qualifier
- Because we can only hold one stone, we have to be fast at moving and intaking
- During autonomous, moving with an alliance partner will be tricky, so communication will be key

SUBSYSTEMS	PRIORITY	ACTION
Intake (Collector)	**Needs to have**	• 3.7 gear ratio motors for quick intake • Be reliable and fast • Multiple wheels to reorient any stone that doesn't come in straight
	Nice to have	• A way to reorient fallen stones • Spring-loaded arms
	Research	• The differences between Compliant Wheels and VEX Straight Flex Wheels and which would be better
Arm and Clamp (Deposit)	**Needs to have**	• Be able to rotate 90 degrees to place stone in any orientation • Quick deposit • System needs to be strong and reliable • Linkage arm that the clamp mounts to
	Nice to have	• Two servos rotating the linkage (Discovered this was not necessary, and are only using one) • Spring to aid the clamp's movement and take stress off the servo
	Research	• Different belts and sizes for the linkage • Whether to grab the stones by the faces or the studs
Lift	**Needs to Have**	• At least five stages • Continuous stringing • Two motors
	Nice to Have	• Six or seven stages

SUBSYSTEMS	PRIORITY	ACTION
Lift	**Research**	• Belts vs. string • Drawer slides vs. four bar linkage for heigh benefits
Transfer (No longer necessary)	**Needs to have**	• Wheels or belts to move stones through the robot once collected
	Nice to have	• Be able to also discard stones out the back of the robot
	Research	• Depending on how we grab the stones, this subsystem might not be necessary
Foundation Catch	**Needs to have**	• Strong and reliable "fingers" • Servo protection from torque • Needs to be small if on the back of the robot so it won't collide with the lift subsystem
	Research	• Whether this system needs to be along the back of the robot and closer to the floor, or higher up and reach over the wheels

MILESTONE 1: One point by the first week of October
Successful?: No **Why?**: Unfortunately due to back ordered parts and malfunctioning CNC routers, we were unable to machine all of our parts for the drive train, have it all assembled, and complete our one point by the first week of October. Even so, this didn't set us back too much and we were able to score our first point two weeks later!

REVISED GAME STRATEGY	*Date*:
Rank field tasks based on difficulty of software and hardware	1/07/20

Key:	Easy	Medium	Difficult

Now that our robot is mostly complete, aside from refinements and minor changes, we went back to look at our initial take on the difficulty of each hardware and software subsystem and updated it based on what the difficulty actually ended up being.

Autonomous	Points	Hardware	Software
Moving Foundation	10		
Delivering Skystone	20		
Delivering Stones	2		
Placing Stones	4		
Going under Skybridge	5		
Teleop	Points	Hardware	Software
Delivering Stones	1		
Placing Stones	1		
End Game	Points	Hardware	Software
Capping	5		
Moving Foundation	15		
Parking	5		

GAME STRATEGY FOR HOT SPRINGS QUALIFIER 1/11/20

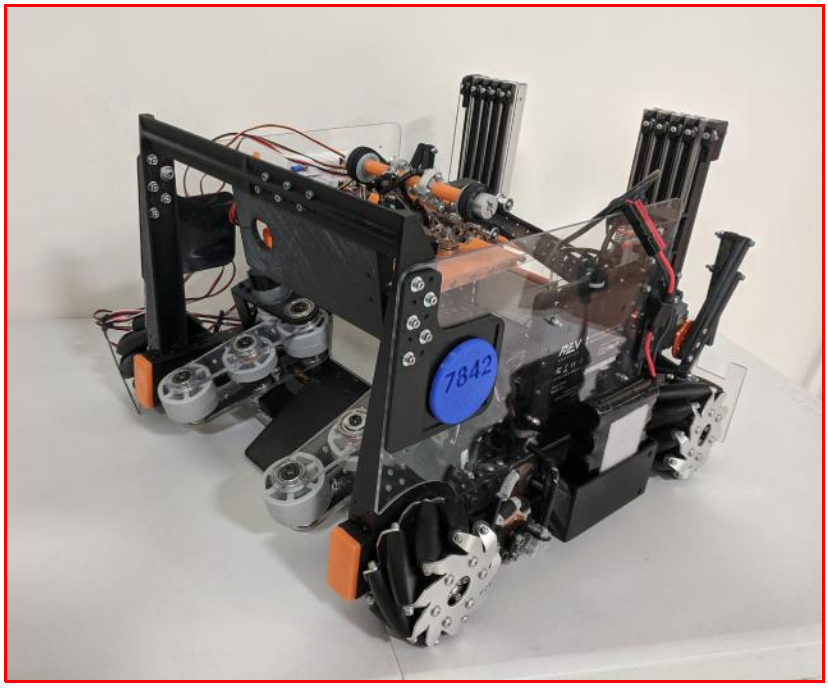
Autonomous:
- Score both Skystones
- Deliver Skystones onto foundation
- Move foundation into building zone
- Park

Tele-Op:
- Stack six stones
- One partner delivers stones while the other one scores
- Deliver stones remaining in quarry after autonomous

End Game:
- Cap tallest tower
- Move Foundation
- Park

ROBOT

Full Picture of the robot we took to Hot Springs *Taken: 1/05/2020*



LESSONS LEARNED FROM HOT SPRINGS QUALIFIER 1/11/20

Things that went right (Strategy):
- Delivered Skystone onto foundation
- Moved foundation into building zone
- Parked
- Stacked six stones
- One partner delivered while the other stacked
- Delivered stones remaining in quarry after autonomous
- Moved foundation
- Parked

Things that went wrong (Strategy):
- Only delivered one Skystone
- Didn't cap tallest tower
- Moving foundation into building zone during autonomous was inconsistent

Things that went right (General):
- Communication with alliance partners before matches
- The robot worked consistently
- Good communication between drivers and drive coach

Things that went wrong (General):
- Never go into a match without testing something (In this case, our capstone had been untested and turned out to be too heavy, resulting in a knocked over tower)
- Don't leave autonomous to the last minute–those points are extremely valuable
- We didn't have spare parts for key components (In this case, a servo on our deposit that was clearly on its last legs)
- Never send a human player into a match without clear instructions for what they have to do

Lessons Learned:
- Driver practice is essential
- Autonomous points are extremely valuable
- Having one partner delivering stones while the other scores is the fastest strategy we've found so far
- Communication is a key part of this game–always get with alliance partners to discuss before matches
- Have fun! Going in with little stress leads to the best performanc

MILESTONE 2: Seventy points by our first Qualifier

Successful?: Yes
How?: During our first match, we and our partner were able to score seventy points together. One Skystone was scored, the foundation moved, and both robots parked in both autonomous and endgame. During tele-op, a stack of seven stones was built.

GAME STRATEGY FOR SPRINGDALE QUALIFIER 1/18/20

Autonomous:
- Score one Skystone
- Deliver Skystone onto foundation
- Move foundation into building zone
- Park

Tele-Op:
- Stack six-seven stones
- One partner delivers stones while the other one scores
- Deliver stones remaining in quarry after autonomous

End Game:
- Move Foundation
- Park

ROBOT

Full Picture of the robot we took to Springdale *Taken: 1/13/2020*

LESSONS LEARNED FROM SPRINGDALE QUALIFIER 1/18/20

Things that went right (Strategy):

- Scored one Skystone
- Moved foundation into building zone
- Parked
- Stacked six stones on Foundation
- One partner delivered while the other stacked
- Delivered stones remaining in quarry after autonomous
- Moved foundation
- Parked

Things that went wrong (Strategy):

- Didn't stack seven stones

Things that went right (General):

- Autonomous worked well and consistently
- The driver practice before the competition really paid off
- Collecting stones from the opposing alliance near the foundation worked well–we just have to make sure we don't interfere with their scoring
- Communicated with many other teams–several are now considered friends
- Judging was much improved the second time around
- Nathan got a field promotion and went into judging–and did an excellent job!
- We were able to provide parts and some help to other teams
- The software version control system worked. We were able to successfully back out some software changes that were unnecessary due to an inconsistent practice field

Things that went wrong (General):

- The deposit servo broke and we had no way to repair it
- Half of the team was unavoidably missing. We missed having them!

Lessons Learned:

- Everyone needs to practice as the human player. We gained an appreciation of how difficult the job can be, and everyone needs to be prepared to jump in
- Though judging went well during both qualifiers, there is still room for improvement. More practice is needed.
- A foundation only autonomous path would have been helpful during one of our matches–to investigate before states
- Automation on the lift would have been helpful during matches
- Idea: figure out how to use sensors to detect when systems are broken to help prevent further damage

GAME STRATEGY FOR ARKANSAS STATE CHAMPIONSHIP 2/15/20

Autonomous:

- Score two Skystones
- Deliver Skystones onto foundation
- Move foundation into building zone
- Park

Tele-Op:

- Stack seven-eight stones
- One partner delivers stones while the other one scores
- Deliver stones remaining in quarry after autonomous
- Take stones that opposing alliance has delivered but hasn't scored yet (be careful not to interfere with scoring)

End Game:

- Cap tallest tower
- Move Foundation
- Park

ROBOT

Full Picture of the robot we took to the Arkansas State Championship *Taken: 2/8/2020*

LESSONS LEARNED FROM ARKANSAS STATE CHAMPIONSHIP (2/15/20)

Things that went right (Strategy):
- Scored two Skystones
- Delivered stones onto foundation
- Moved foundation into building zone
- Parked
- Stacked seven-eight stones
- One partner delivered while the other stacked
- Capped tallest tower
- Moved foundation
- Parked

Things that went wrong (Strategy):
- Autonomous wasn't completely consistent
- Didn't consistently score two stones
- Didn't consistently move foundation

Things that went right (General):
- Capped nearly every time
- Had more time for partner strategy
- Focused on alliance strategy which helped us in the long run during finals
- Judging practice paid off
- When autonomous worked, it worked well
- Worked well with alliance partners (good communication)
- We hit our stacking cap (eight and a capstone)
- We had a clear scouting goal in mind, and our data reflected that
- Had spare parts for the foundation catch which broke during our first match

Things that went wrong (General):
- Need more driver practice
- Foundation catch broke
- Issues with REV Hub that we weren't able to solve

Lessons Learned:
- Mitigated problems with REV Hub by observing a correlation between REV Hub behavior and long power on times of the robot, so we powered down the robot between matches
- Discussing strategy with final alliance partners instead of running our robots on the field before final matches resulted in a clear game strategy as elimination matches progressed

LESSONS LEARNED FROM ARKANSAS STATE CHAMPIONSHIP (2/15/20) (CONTINUED)

Lessons Learned:

- Don't leave autonomous to the last minute - consistency is key
- When drivers stay calm, matches go much smoother
- We observed that after we replaced the hub on the arm, the arm set position was wrong in tele-op - needs to be fixed before Alabama State
- Autonomous needs to be tuned to consistency before Alabama State
- Capping points are very valuable - need to aim to cap in every match

GAME STRATEGY FOR ALABAMA STATE CHAMPIONSHIP 2/15/20

Goals:

- Improve autonomous to be more consistent
- Be more consistent in driver control and try not to knock over towers

Autonomous:

- Score two Skystones
- Deliver Skystones onto foundation
- Move foundation into building zone
- Park

Tele-Op:

- Stack eight stones
- One partner delivers stones while the other one scores
- Deliver stones remaining in quarry after autonomous

End Game:

- Cap tallest tower
- Move Foundation
- Park

ROBOT

The robot we took to the Arkansas State Championship is the same we took to the Alabama State Championship. The only changes made between the two competitions were software. (See page D-14 for picture)