1. Key Specific Robot and Gameplay Rules

1.1. Robot weight must not exceed 125 lbs.

1.2. Robot Size Restrictions:

- Maximum 120” frame perimeter in starting configuration
- Maximum robot height 60”
- After start of match robot may extend 12” outside of frame perimeter

1.3. During the last 30 seconds, there are no horizontal size restrictions when the robot is in contact with their return platform.

1.4. Teams may preload their robot with 10 Meteors and/or 1 Mineral prior to the start of a match.

1.5. A Robot may only control one Mineral at a time. (FOUL)

1.6. An Alliance’s robots must begin the autonomous period in contact with their drivers station wall.

1.7. Teams may not launch or shoot a Mineral. (FOUL)

1.8. Teams may not cross the mid-field line during the autonomous period. (FOUL)

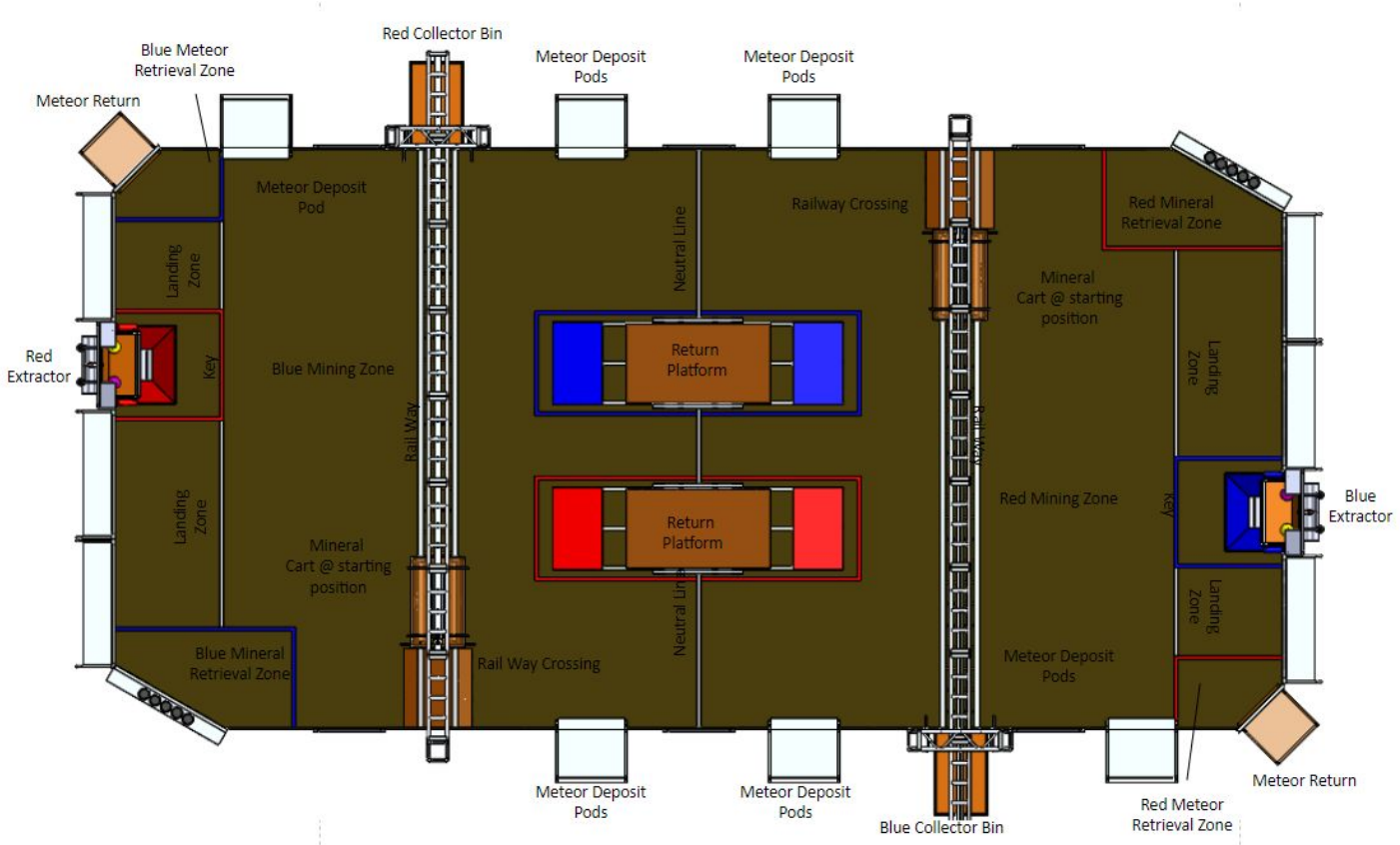
1.9. Robots who create contact with an opponent in contact with their Extractor key boundary for more than 5 seconds. (FOUL)

1.10. Robots may not contact their opponent's mineral cart or contact an opponent robot in contact with their mineral cart. (FOUL), (Tech foul if it prevents opponent from pushing their mineral cart to collector bin)

1.11. During the last 30 seconds of a match, robot may not contact an opposing alliances robot that is within their Return Platform Zone (Tech Foul for 1st Contact and 1 Robot on Centered Platform will be awarded for repeated contact)

1.12. Human Players must return meteors to the field before bin overflows (Foul every 5 seconds not emptied)

THUNDERATION Field Markings and Layout



2. Game Strengths and Highlights

The game's strength is in the vast variety of strategies teams can employ and the range of possible robot designs. With two separate game pieces, robots can specialize in one or the other. The lowest slots on the mineral cart are positioned so that robots can accept minerals from the human loader station and place them with a stationary mechanism, and the rim of the Extractor is well within the starting configuration height limits. This guarantees that robots don't require complicated subsystems to be relevant to gameplay. However, the game also encourages creativity and rewards high reaching teams, offering alliance-wide efficiency bonuses for teams that can shoot and score into the Preprocessor and the decreased cycle time afforded by shooting meteors into the Extractor. Robots can intake meteors either directly from the pods or off the ground. Different height slots on the mineral cart allow teams great flexibility for integrating this manipulator mechanism with other subsystems. With very few rules limiting endgame activities, teams that attempt to access the return platform can earn points even if things don't go quite right and they are stuck or unbalanced, encouraging teams to be daring and ambitious. This can ensure exciting gameplay for audiences. The wealth of scoring options leaves plenty of room for teams to interpret the game and design unique robots.

Several of the field elements and their scoring systems bring more complex strategic elements to the game. The best example of this is the minecart, because alliances have to decide when to deposit their minerals into the collector bin. Teams could take the time to regularly deposit minerals every few cycles, securing their points with certainty. However, it would be equally possible for an alliance to only deposit their minerals once, at the very end of the game. This strategy could be risky, but may save time in more efficient cycles and allow the mineral cart to be strategically deposited during an efficiency bonus, greatly rewarding coordination between robots on an alliance. This risk-reward payoff is involved when scoring in both the Pre-Processor and the mineral cart, as it is possible that teams may not receive points for game pieces they place. Should a team shoot into the Preprocessor but not manage to get it to empty into Extractor, those meteors do not count in any way towards their score. However the resulting 20 second period after the Pre-Processor dumps, in which all meteors and minerals scored are worth double, could be a strategic motivation for ambitious teams. Alliances of the highest tier could theoretically even cycle so that the efficiency bonus never turns off, chaining one 20 second period after another. Neither of these risk-reward delayed gratification scoring systems have been used in a FRC game, and pose a unique new challenge to team and alliance strategy.

The game Element is integral to the construction of the endgame Return Platform. We saw it as an opportunity to introduce unpredictability and force teams to innovate. By the nature of the suspended platform, it can both tilt and swing, which means teams must be adaptable and take the possibly chaotic movement of the platform into account in their designs. This extra degree of freedom and movement adds a layer of complexity ro robot interactions with this field element. The maximum range of motion, both swinging side to side and when tilting, was considered when the Return Platform was designed. CAD models were used to decide on what physical configuration of the chains between the platform and frame would restrict its swinging from being too far off the ramps at either extreme or tilting at too steep an angle. Other realistically engineered field elements: Meteor Deposit Pod activation is an unpowered, simple, human independent mechanism. Easy to reset the entire field after a match. The minecart is on a slight incline so it naturally moves back to its starting position and will never end up stranded in the middle of the field.

Rookie or Under-Resourced Team Accessibility:

- Protected Key Shooting for the Preprocessor or Extractor
- Low Height Extractor for Meteor Dump Design Robots
- Retrieval Slot for Mineral is same as Low Delivery Slot for Mineral on the Minecart
- Minecart is sized to accept 14 minerals through the low slot, and the cart is easily pushable by a robot with simply a frame making the one of the two additional available ranking points easily accessible by under resourced or rookie teams.
- Contributing a high amount of end game points by a single team does not require complex mechanisms for execution, an appropriately spaced 6 WD wide bot or 8WD bot can access the platform and participate in a double robot balance.

Progressive Complexity in the Game:

- Progression in autonomous, where teams can drive out of the landing zone, score a Mineral in the Minecart, Score Two Minerals in the Minecart, Empty a Pod's worth of Meteors into the extractor, empty a Pod's worth of Meteors through the Preprocessor, score a Mineral in the Minecart plus score a Pod's Meteors in the Preprocessor or Extractor.
- Teams with vision tracking software can use reflective tape to more accurately and autonomously score Meteors in the Preprocessor and Minerals in the Minecart.
- Teams able to process high volume of Meteors can earn efficiency bonus points.
- Teams with adjustable mechanisms for minerals can deliver higher on the mineral cart and continue to earn points after scoring the required 14 minerals for the ranking point or bonus.
- Teams must take the ground clearance and track width into consideration so that their robot may quickly and effectively push the minecart as well as cross the rail-way at any point along its length.
- Teams must consider a special mechanism and robot frame perimeter to support balancing the return platform with 3 robots.

Accessibility and Excitement to 1st time Watchers

- The all field elements are scored in real time either by processing Meteors or by scorekeepers keeping live talley of mineral scored therefore creating the opportunity for back and forth lead changes.
- Critical end game actions result in last second achievements tied to delivery of the minecart's load to the bin and centering/balancing a robot or robots on the platform.
- Close matches will often be determined by referees post match evaluation of successful parks, accesses, or centers on the platform holding the crowd in suspense after close matches.

Veteran Team Experience

- This game at its highest levels of play has multiple strategic opportunities that require many layers of scenario evaluation while allowing under-resourced teams to be key contributors, thus preventing veteran teams from falling into a position to push less capable teams into a low-value portion of a matches strategy.
- Even legacy teams will be forced to evaluate their design priorities in order to achieve what they deem to be the most effective set of strategies. A team could design up to 8 unique mechanisms to play all possible aspects of the game and still find themselves needing to choose whether to focus on achieving the win through platform centering versus pursuing the two additional ranking points via the Extractor and the Minecart delivery process.

- Field elements are strategideliberately made of see through materials, strategically set at certain heights and carefully oriented to make sure field visibility is not overly cumbersome for drive teams.

3. Field Element Engineering Considerations

The field elements were designed and theorized with the engineering required for proper scoring and operation of an actual field.

- **Mineral Cart Scoring.** The full design of the mineral cart and its overhead rail were designed to function during actual gameplay. Levers on the side of the cart force the doors to open automatically when the cart is over the collector bin. No additional mechanism or control is required to release the minerals from the cart. A limit switch would register every time the cart is pushed over the collector bin and the change of weight in the collector bin would be used to determine how many minerals were deposited for automatic scoring. The limit switch and simple logic can be used to determine a score is changing and to wait a short amount of time until the initial dynamic weight of the minerals being dumped settles out before updating the score value, thus removing the score jump that would happen with the 2013 frisbees. The limit switch logic will also ensure that the minerals are scored during the appropriate period, even if the boost ends before all the minerals have their score counted.
- **Mineral Cart Rail Protection.** To protect the minecart and the overhead rail, the minecart swings at the wheel bogie so if it is hit hard by a robot it will not bend or break any structure. The swinging also adds another element of challenge when scoring in the side.
- **Preprocessor Consistent Dumping.** To ensure that the preprocessor fully dumps the balls into the extractor each time, a gate latch and solenoid would we used to hold the preprocessor in the downward position for the entirety of the boost period.This guarantees that all balls are emptied into the Extractor and that it does not raise back up mid dump. After the boost period ends the solenoid would release the latch and the preprocessor would raise to its normal position. A deflector above the pre-processor guides balls shot into the preprocessor to then roll out into the Extractor.
- **Preprocessor Balance Calibration.** The ball weight required to cause the preprocessor to dump can easily be adjusted by changing the dump counter weight which is a hanging basket filled with stuff. In actual competition a luggage scale should be used to ensure that both dump at the same weight, the exact weight it dumps is not critical for game play and could be changed as the competition progresses.
- **Extractor Ball Scoring.** To ensure that the large volume of balls is accurately counted the interior of the extractor was designed specifically for high speed accurate ball counting. Inside the extractor funnel are four channels, a single ball width wide. Under the channels would be a sloped moving belt that eases the balls forward. A light beam sensor at the back would be offset from the ball center over each channel. As the balls pass they will clearly break the beam but being off center of the balls there will be a gap even if the balls are touching. The channels empty into full width rollers which raise them up to crate height and spit them out. This will provide consistent and accurate jam free ball scoring. Balls in the extractor will continue to be processed for a fixed amount of time after an auto period, boost period or the end of the game to ensure everything is scored properly.