Team 1796 RoboTigers
2023 Scouting Whitepaper

Contents

Introduction

Prelude

Scouting plays a pivotal role in FIRST Robotics Competition (FRC) as an essential tool that enables strategic planning for both matches and alliance selection. During a competition, teams gather valuable data to identify the strengths, weaknesses, and unique capabilities of the other teams. Scouters meticulously observe teams and record data points they have determined are crucial for that respective FIRST game. Through effective scouting, teams can develop strategies to help them turn the tides in an unfavorable match or find the dark horse pick that went unnoticed. In the world of FRC, building a great robot is not all that is required to be successful at competition. This document highlights our current scouting system. The system was implemented last year but it's important to note that it has taken us years for this system to become a reality. Shout out to team 1678 and their whitepaper for inspiring us to write our own whitepaper.

History

For the majority of our team's history, we have scouted using the old and reliable method of pen and paper. In our early days, our team was much smaller, and we couldn't allocate the necessary amount of students for scouting. However, as our team grew we were able to dedicate more time and energy to developing a better scouting system, allowing for improvements each year. A timeline of our progress can be viewed in Figure 1 and Figure 2.

In 2016, we attempted to build a digital scouting system. We built a proof of concept for an IOS app where we could gather data and then share via bluetooth. This was our first time using the technologies required to build an app so we were not able to develop something solid enough for the season.

In 2017, with a better understanding of the technologies we continued development on the IOS app until we eventually had something ready for the season. Unfortunately, during the season we experienced difficulties with bluetooth and cloud storage forcing us to pivot towards pen and paper as a backup.

From 2018-2019, due to the experiences from the past 2 years and other factors there weren't any developments.

From 2020-2021, although the pandemic halted progress in many areas for us, it allowed us to focus on other areas like our scouting system. This is when we began development on the system that we now use today, which is built on the MERN stack. The MERN stack is a set of technologies that is used to develop websites. We chose this approach as we already had a few members experienced with the stack and believed a lightweight website would avoid issues related to bandwidth while providing benefits such as ease of access and quick updates.

Figure 1: Scouting Timeline (2006-2013)

Figure 2: Scouting Timeline (2016-2023)

In 2022, this is when we were first able to test our new system and website in a real competition. Our first go at the new system proved to be very effective, enabling us to scout at a much higher level and view data in real-time.

In 2023, we made improvements to the website such as cross-referencing our data with the blue alliance for validity. Yet again, the system proved to be quite effective however during champs we faced issues with connectivity. The biggest contributing factor was the sheer number of devices utilizing the internet in close proximity which is a common issue in big venues. We have plans to address this issue which we will share later.

Overview

Our system revolves around two main technologies: our scouting website which handles the collection of data and Tableau, a tool used to organize and visualize data.

Through our website, we collect both pit and match data. Match data is broken down into objective and subjective data.

Using the same server that hosts our website we perform calculations to consolidate our data so that it can be visualized in Tableau. From the visualizations we create in Tableau, we can prepare strategies for matches as well as develop a picklist right in Tableau itself.

To briefly go over the MERN stack we mentioned earlier, it is a popular web development stack that utilizes four main technologies: MongoDB. Express, React, and Node.

- MongoDB: a flexible database that can store large amounts of data without requiring it to follow a predefined structure.
- Express: a backend framework used to build server-side applications for Node.
- React: a frontend library used to build user interfaces in a component-based manner allowing for efficient and scalable designs.
- Node: a runtime environment that executes javascript code outside of the browser meaning its handles the backend logic.

Pit Scouting

Pit scouting is done during the first day of competition to collect useful preliminary data and build rapport with teams. More specifically, scouters are broken into teams of two and given teams to pit scout. By scouting in teams of two, one person can ask questions and record answers while the other person can examine the robot and its mechanisms. Although match data is utilized more, we found pit data to still be very beneficial, especially in situations when you need additional information to help distinguish the capabilities between different robots such as for a picklist.

Data Collection

The data we collect during pit scouting is mostly the physical characteristics of a robot. This includes things such as weight, height, frame size, drive train, etc. Additionally, we take note of more external factors such as what programming language the team uses, whether they have a basic auto, and any issues that could prevent them from passing inspection. We can then pass this information to RTESS (RoboTigers Emergency Service Squad), a subteam comprised of members dedicated to assisting other teams and alliance partners. We also take pictures of robots which is done directly from the website. We have a comment button that is always visible on the screen in case a scouter feels there is something worth noting. Examples of the pit collection screen can be seen in Figure 3.

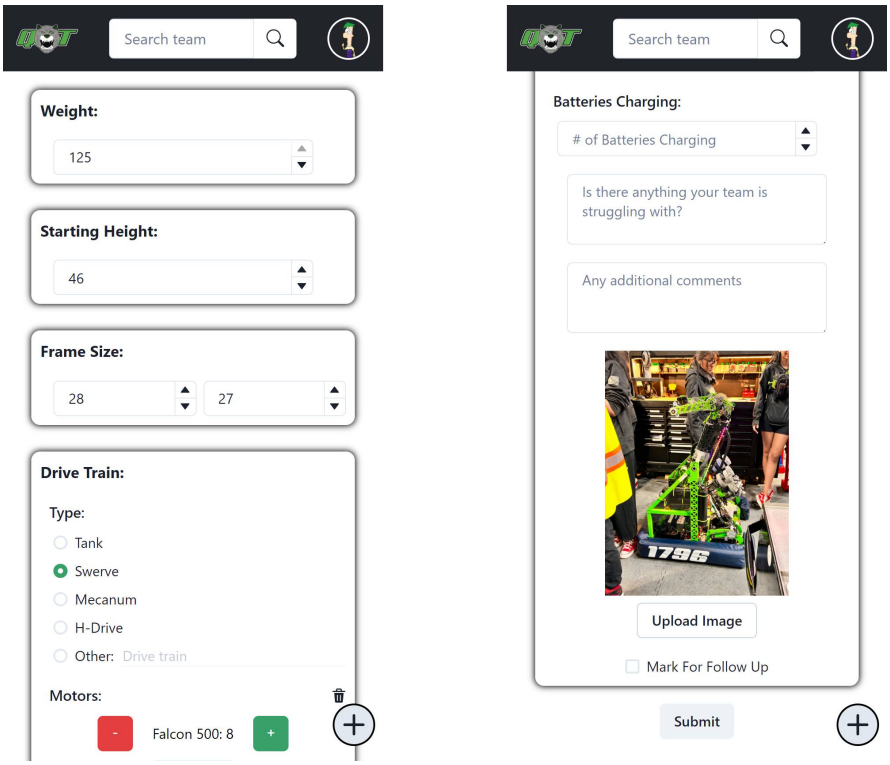

Figure 3: Pit Collection Screen

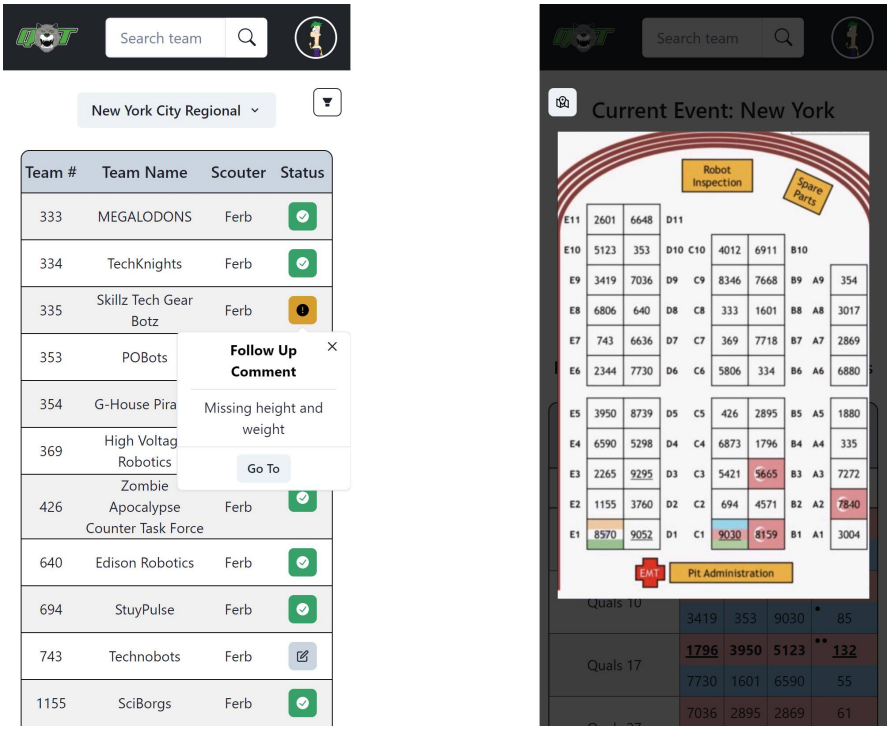

Figure 4: Pit Team List and Pit Map

Team List

To assist with the process of pit scouting we have a team list screen that displays all the teams in the competition and their status in terms of pit data collected. If a team has not been pit scouted yet their icon is greyed out, otherwise if they have been scouted it is green. If for some reason there was an issue that prevented all the necessary pit data from being collected the form can be marked for follow-up with a comment explaining the reasoning. The status icon also acts as a button that directly leads to that team's pit form, this allows scouters to make adjustments and follow up on any incomplete forms easily. An example of the team list can be seen in Figure 4.

On the homepage of our website, we have a button that opens up an image of the pit map to assist scouters in finding teams when pit scouting. We found this feature useful for all members and not just scouters which is why we decided to place it on our homepage for quick and easy access. A screen showcasing the pit map feature can be seen in Figure 4.

Match Scouting

Roles

For match scouting, there are three potential roles:

- Objective Scout: collects quantitative data such as the number of game pieces scored, charge level, and if they lost communication.
  - 1 Objective Scout per robot
- Subjective Scout: ranks the robots in an alliance on subjective data points such as field awareness and agility. Potentially also records one or two data points specific to the game like whether or not the robot is prone to tipping.
  - 1 Subjective Scout per alliance
- Head Scout: Oversees all scouters and assists with any issues that may arise. Also reviews any scouted data flagged as incorrect after it has been cross-referenced with data from the blue alliance.
  - 1 Head Scout for the entire event

Pre-Match Form

Before starting their scouting session each objective and subjective scout is given an alliance station and alliance respectively which remains the same for that session. On a screen before the actual scouting form, they input their alliance station or alliance and the match number, which pulls the appropriate teams from the blue alliance. As these input values, excluding match number, don't change until their next session they are saved in the browser so that they don't have to be inputted every time. This system is put in place to ease the amount of information the scouters have to remember while

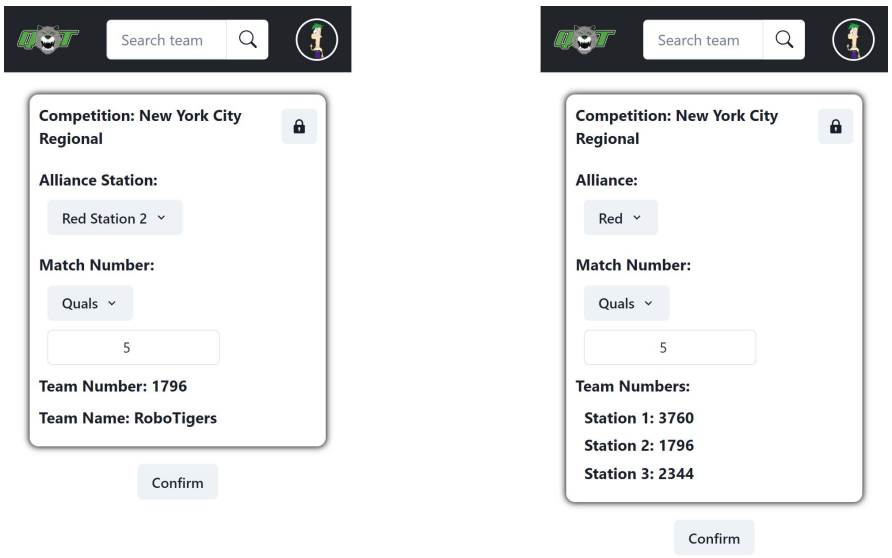

Figure 5: Pre-Match Form, Objective (Left) and Subjective (Right)

also ensuring all teams are scouted. As a backup, a scouter can always manually input the team number in case something goes wrong. An example of these screens can be seen in Figure 5.

Objective Scouting

As mentioned previously, objective scouting is concerned with collecting quantitative data, meaning measurable data that is not open to interpretation. Our objective form is broken into four sections: starting position (pre-auto), auto, teleop, and endgame. We will go over each section explaining some of the metrics we collect and the reasoning behind them.

Starting Position

The starting position screen displays an image of the starting area which can be rotated to accommodate for different views due to seating availability. A scouter can click anywhere on said image that has been deemed valid as a starting position where a green circle will then appear confirming the selection. As an example, a robot starting on the charge station is not possible thus clicking on it would not create/move the green circle. Scouters also take note of any game piece that the robot may have pre-loaded. An example of the starting position screen can be seen in Figure 6.

Auto and Teleop Scoring

Both scoring screens for auto and teleop display a grid of buttons that are meant to capture all the possible scoring locations. When a game piece is scored the scouter clicks on the appropriate button, increasing the value inside the button. Each row is meant to represent a row on the field grid with those being top, middle, and bottom. As there are two game pieces, each row has two main buttons with the yellow and purple buttons being for cones and cubes respectively. There is also a smaller red

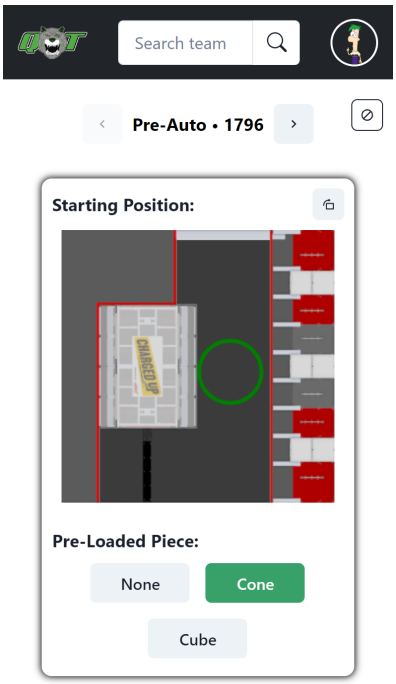

Figure 6: Starting Position Screen

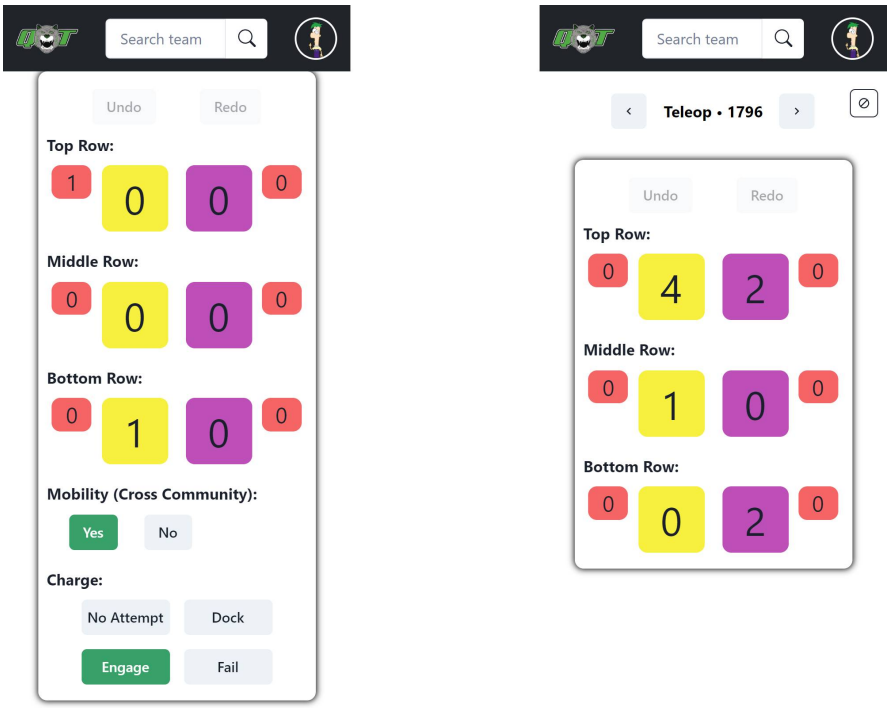

Figure 7: Auto (Left) and Teleop (Right) Screen

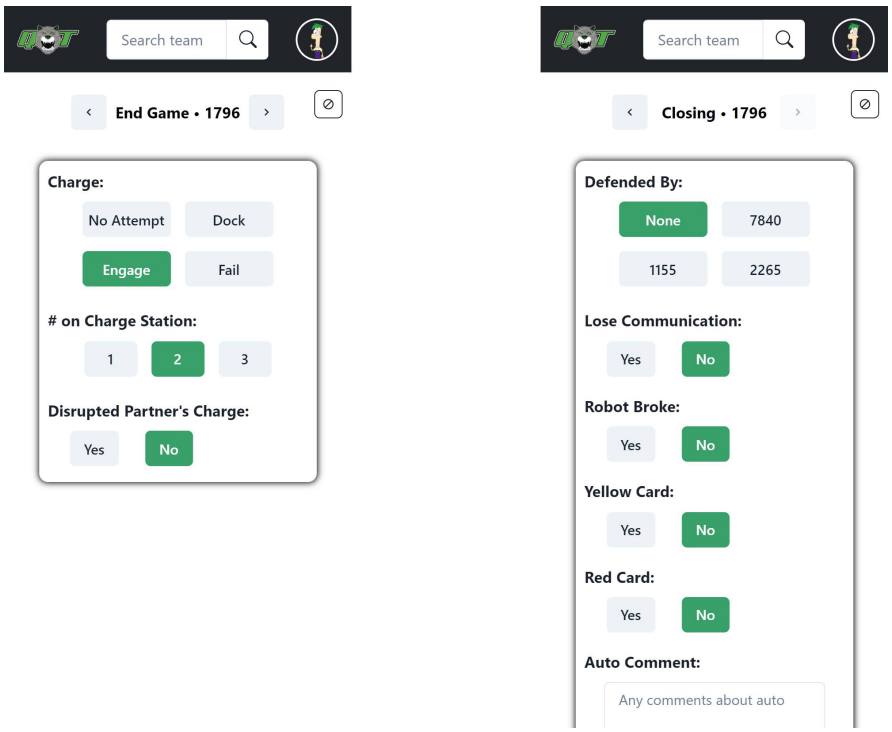

Figure 8: End Game Screen

button next to each of the main buttons, it is used to record a failed attempt at scoring such as missing the placement of a game piece. We believed recording missed game pieces was important as in high-level play accurate placement was vital for efficient cycles and links being completed.

The scouters can undo or redo an action using the two buttons at the top in case they make a mistake by clicking the wrong button. As an added feature, holding down any one of the buttons for a few seconds will reset their value back to 0 in case of catastrophic mistakes.

The scoring screen for auto has two additional metrics, whether or not the robot crossed the community line for mobility and what kind of charge, if any, it achieved. Examples of the auto and teleop screens can be seen in Figure 7.

End Game

The end game screen is designed to address any scoring opportunities that occur near the end of a match or other data points that can be postponed until after a match is done. We record the level of charge and if it is a dock or engage we take note of how many teams were on the charge station. We took note of the number of teams on the charge station because we wanted to be able to evaluate a team's experience with multi-team charges, especially when evaluating teams for our picklist. Additionally, another metric was whether or not a team disrupted the alliance's charge. An example of this could be a robot trying to drive onto the charge station but unfortunately pushing an alliance partner that was near the edge of the charge station resulting in

that partner falling off the charge station. This data point is meant to act more as a warning flag, indicating that the team could jeopardize a charge.

The second part of the end game screen is meant to record metrics that can be left for after a match has concluded. Most notably these include things such as whether a robot lost communication, broke in some way, and any penalties they may have received. If there was being defense played on the team we also recorded which opposing team was playing said defense. Although we were not able to utilize this information in the way we wanted to, it still helped us compare a team's performance against defense versus against no defense. An example of both end game screens can be seen in Figure 8.

A key feature we implemented this year was reporting any issues recorded during objective scouting to RTESS if the team with the issues was a future match partner. For example, if we were to play with team 1 in our next match and a scouter just recorded that in their current match, they lost communication, RTESS would receive a message specifying the issue and the estimated time of our match with that team. This addition was incredibly helpful in ensuring all our match partners were good to go for our matches.

Subjective Scouting

Subjective scouting is used to address metrics that are more open to interpretation which is why it is necessary to observe the whole alliance. In that way, the metrics can be measured on a scale from 1-3 and the robots can be ranked relative to the other robots in their alliance. For example, a 3 on the scale would indicate the robot was the best in that metric out of all the robotics in its alliance. No two teams can have the same score for a metric.

Data Collection

The two data points we record in the subjective form was agility and field awareness. Agility represents the ability of the robot/driver to maneuver around obstacles, overall speed, etc. Field awareness represents how aware the drivers are of the state of the field. This means things such as where game pieces are located, where opposing robots are playing, etc. For example, if a game piece is near the grid on the floor and the robot can pick it up, then if the drivers have good field awareness they should pick that piece up rather than driving towards the substation. As mentioned previously, 3 indicates the best robot and 1 indicates the worst robot in that metric in the alliance.

There were some additional metrics we recorded related to defense however we found them unrefined and decided not to include them towards the end of the season. An example of the subjective screen can be seen in Figure 9

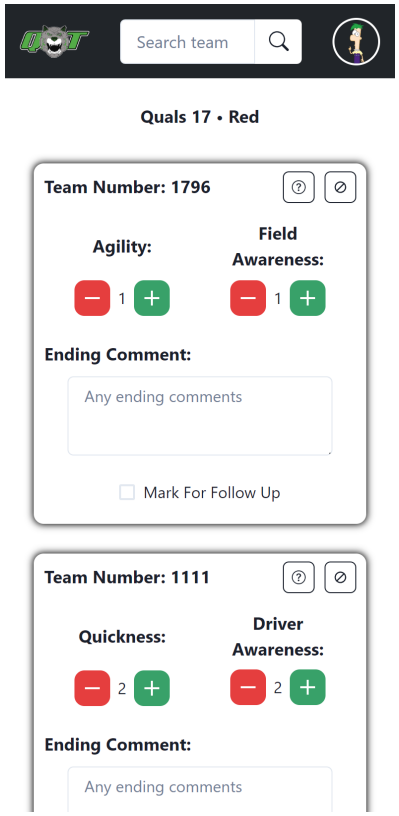

Figure 9: Subjective Screen

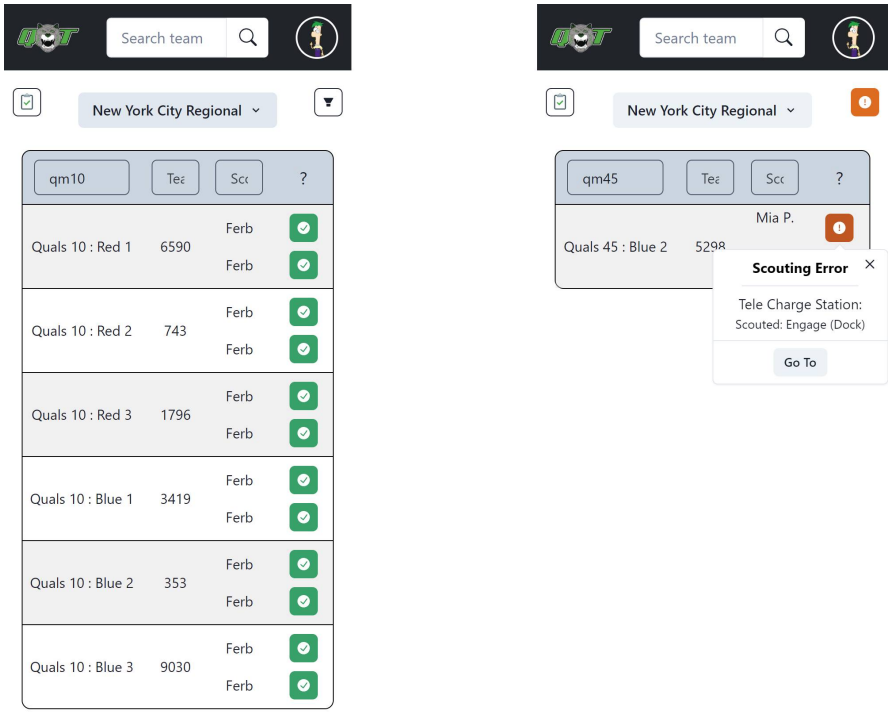

Figure 10: Match List Screen

Match List and Data Validation

Similar to the team pit list we have a match list screen that lists all the objective and subjective forms. This allows us to quickly access and edit any forms that have been marked by a scouter for having some fault in them. More importantly, we have a button in the top left corner that validates the data in the match forms by cross-referencing them with data from the blue alliance in an attempt to point out any differences. For example, it was important for us to always have the correct data regarding the charge station. This information is provided by the blue alliance and thus if there is a difference between the scouted value vs the value from the blue alliance then we mark that match form as having an error. However, it's important to mention that the team might have been awarded a dock or engage because of the G209 rule so perhaps the scouted value is correct. Examples of the match list screen and a scouting error can be seen in Figure 10.

Visualization

To effectively utilize the data we have collected we use Tableau, a data visualization tool that allows you to quickly create tables, graphs, and charts to perform analysis. A limited number of licenses for the full version of Tableau are provided in the virtual kit of parts. There is also a free version of Tableau called Tableau Public which has fewer features compared to the full version but is still more than enough. To expedite the process of importing our data into Tableau we use something called a web data connector, a feature created by Tableau that supports connecting to a database through a website. Using that, we created a web data connector on our website which we connect to on Tableau once, and then any current and future data will be imported into Tableau.

We have two main dashboards in Tableau, one for match analysts to get a general overview of the teams in a match and another for picklist. Throughout an event, we may also create other dashboards such as one purely focused on cube robots or one visualizing the overall trend of a team. We believe the ease of creating new dashboards and visualizations is one of the biggest perks of working with Tableau.

Match Analyst

The match analyst dashboard displays information on up to 3 teams at a time, intended so that you can analyze a whole alliance at once. The information on a team is broken up into 3 sections: teleop, end game/charge Station, and general statistics. The teleop section is a graph showcasing match number vs game pieces scored, allowing us to visualize the overall trend of a team's offensive performance. The end game section shows the charge achieved for each of their matches. The general section simply lists various statistics such as the number of yellow cards, red cards, loss of comms., etc.

We also have an equivalent dashboard for auto where the first two sections remain the same, with the only difference being the data is from auto rather than teleop. The third section changes from general statistics to mobility information.

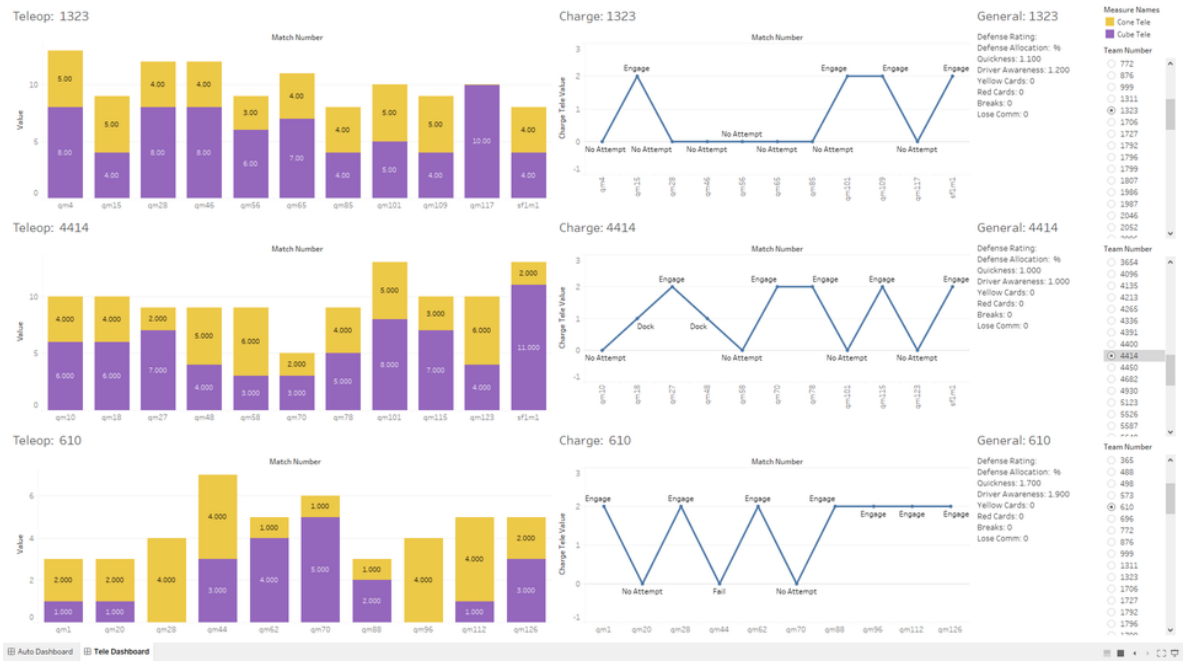

Figure 11: Match Analyst Dashboard

Both of these dashboards allow match analysts to get a general idea of the capabilities of every team in a match. An example of the match analyst dashboard can be seen in Figure 11

Picklist

The picklist dashboard is used when creating our picklist for alliance section. It displays a list of teams along with various metrics. We can sort the list based on various weights and metrics depending on the current pick we are deciding. For example, for our first pick, offense was important and thus we placed a heavy weight on grid scoring capabilities. On the other hand, for our second pick, having a compatible and engage in auto was an important factor.

After we initially sort the list based on some weights we move down the list and perform pair-wise comparisons on the teams, deciding if the team should move up or down. Another important feature of this dashboard is that we can click on a team which will move into the picked section. We utilize this as teams get picked during alliance selection. This feature is especially helpful during alliance selection where you only want to focus on teams still available. An example of the picklist dashboard can be seen in Figure 12

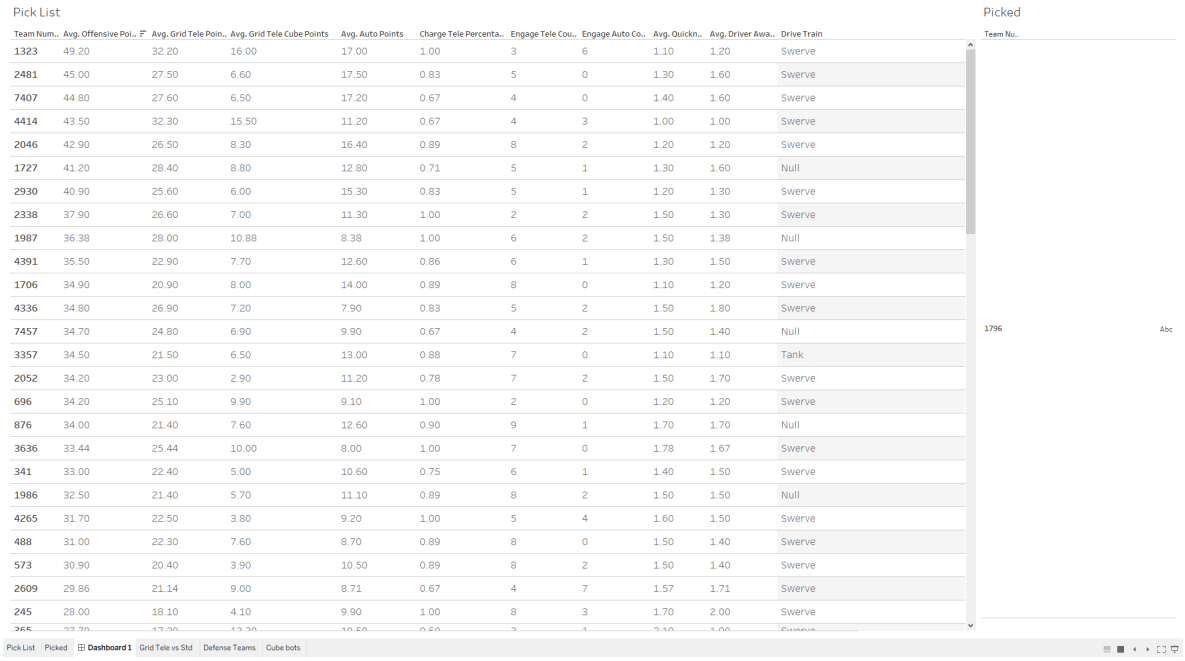

Figure 12: Picklist Dashboard

Closing

Next Steps

As mentioned previously, an issue that arose during champs was connectivity issues due to the high load. To address this issue, for the next season, we are planning to turn our website into a progressive web app. By doing this our website will be more like an app, with the pages from the website being cached allowing for access even without the internet. In addition, we will implement a QR code system such that even without internet access to submit the forms we can scan a QR code containing the recorded data. After a sufficient number of QR codes have been scanned we can move to an area with internet access and upload it there.

We would also like to move to Google Sheets when working on our picklist because a downside of Tableau is the difficulty in sharing information. With Google Sheets, everyone would be able to access the picklist improving the level of discussions during meetings. We would still be able to create graphs and other visuals directly in Google Sheets meaning there are little downsides in switching.

Conclusion

We hope that you were able to take something away from this whitepaper and wish you luck in future scouting endeavors. If you have any questions feel free to contact us at robotigers1796@gmail.com.