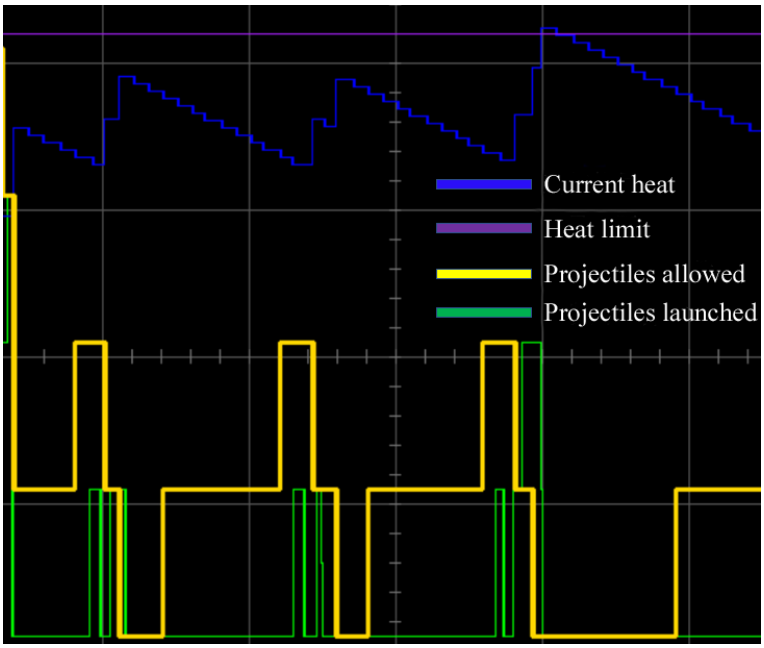
Barrel Heat Limit and Launching Strategies

*Take the rules from last year as an example

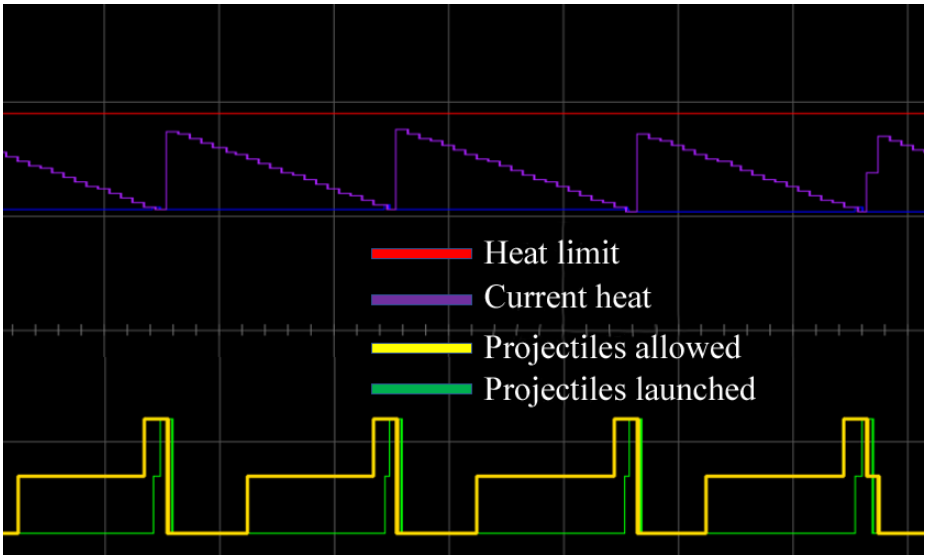
For the barrel heat limit, firstly, a key issue is that there is a delay in the barrel heat settlement. When a projectile is launched, the time delay between the robot's main controller reading the updated speed of launch data to the controller updating heat data subsequently is about 100 ms. There is a problem with this 100 ms time delay. For example, a Standard should stop after launching this one projectile, otherwise it would exceed the heat limit. However, the heat data is not updated right after the projectile is launched. The program will in turn determine that it can launch one more projectile. As a result, the barrel would overheat.
As for the delay issue, you can ignore it if the interval between two consecutive projectiles is greater than 100 ms, that is, the frequency of launch is below 10 rounds. A simple strategy can effectively limit the heat, such as setting a heat threshold. When the heat is close to the threshold, the loading dial stops. When the frequency of launch is above 10 rounds per second, the heat level will exceed the limit unless the threshold is set at a very low level (in this case the frequency of launch is very low) if the delay issue is not addressed.

In addition to the heat settlement delay issue, control of the projectile loading motor also affects the heat limit effect. Now, I would like to share one of my heat limit strategies for your reference.

Since there should be a limit to the heat, we should make a plan to control projectile launching from the beginning. For example, the current heat for a level one Standard is 0, the heat limit is 90, and speed of launch is between 18 m/s to 19 m/s. The projectile loading motor is controlled by a speed ring. In this case we can set the speed of launch threshold as 20 m/s, so that the maximum number of projectiles that our Standard can launch is equal to the upper heat limit minus the current heat and further divided by 20, which is (90-0)/20, rounded off as 4. Knowing the number of projectiles currently allowed to launch, we also need to know how many projectiles have been launched by the Standard. The real-time speed of launch can be read via the referee system. If there is a data update, it means that one projectile was launched, so on and so forth. When the number of projectiles already launched by the Standard equals the amount of projectiles allowed to be launched, the projectile loading motor stops. By doing so, excessive projectile launching due to heat settlement delays can be addressed. And when should the count of launched projectiles be cleared to prepare for the next launch? We could have determined that this round of launching is over when the projectile loading motor stops and the number of projectiles launched should be cleared. If this was case, then due to the heat delay, the projectile loading motor would stop when the number of projectiles that have been launched reached the number of projectiles allowed. Subsequently, the number of projectiles launched is cleared to 0. However, because the heat data has not been updated yet at this point, one or two rounds of projectiles are still allowed to be launched. In this way, the problem of excessive launching still exists, as shown in the graph below.



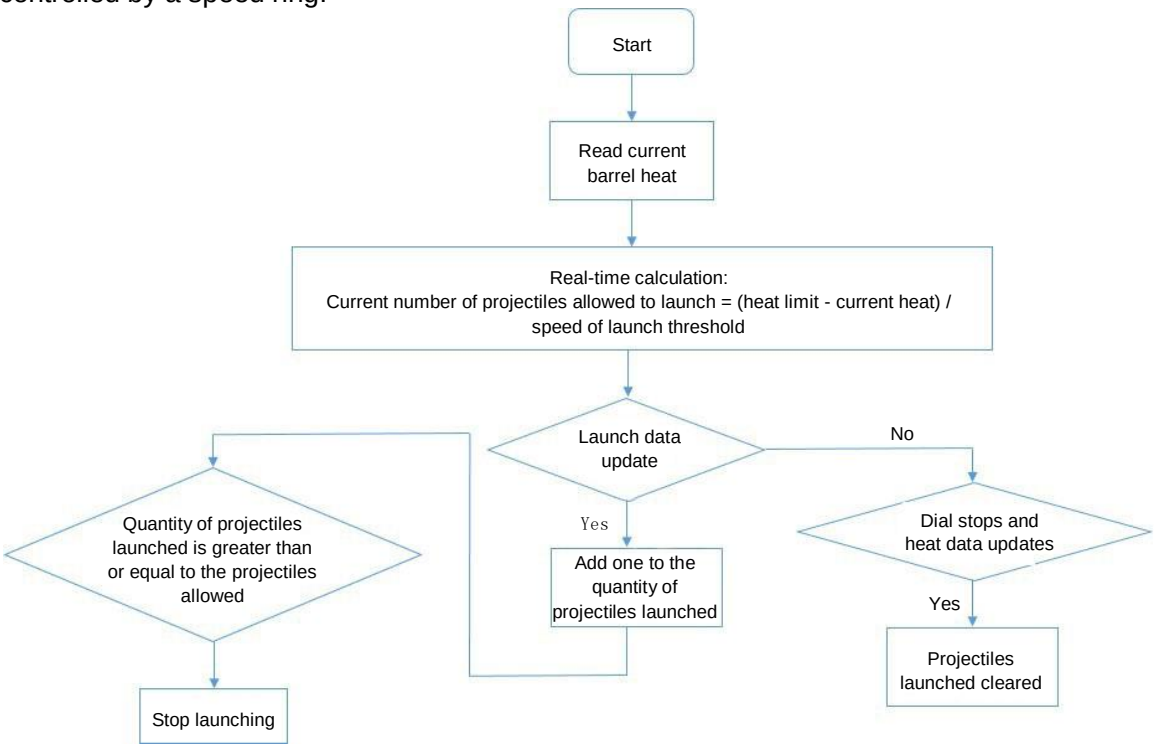
Therefore, the preconditions to clear the number of projectiles launched should include the stop of the loading motor as well as after the heat data updates. The strategy here is to start counting from the first round of launching and record the heat data at the same time. After waiting for 100 ms, calculate the difference between the received data and the data we recorded. If the heat data is updated, the difference at this time should be roughly equal to the speed of launch of the last projectile (don't forget the heat value will decrease within 100 ms), as shown in the graph below.



Now that the issue with heat data delay is addressed, it is time for the loading motor. When it is loaded, a loading motor controlled by a speed ring can easily launch one or two more rounds of projectiles than it should have launched due to its failure to stop in time when the rotating speed is high and motor output is large. This is where a loading motor controlled by a speed ring becomes uncontrollable. You can either adjust the PID parameters to improve the motor response speed, or limit the maximum output when the loading motor can drive a full load of projectiles; or even leave an allowance of one or two rounds of projectiles (the motor stops when the projectiles launched equals the projectiles allowed minus one). This way you won't exceed the heat limit even with a launch frequency of 20 rounds, enough to meet the requirements for most teams.

The same concept applies if a position loop is used to control the loading motor. If the allowance is four rounds, then set it to stop after four cut teeth. A position loop is more controllable because it does not have the issue of missing the stop by rotating too fast.

The diagram shows a logic diagram for the barrel heat limit of a Standard with its loading motor controlled by a speed ring.



Now we have limited the heat level. In the 2018 Rules, a level up mechanism has been added in addition to the heat level mechanism. With every level up, the robot's heat limit and cooling rate will increase accordingly, thus making your launching strategy much more flexible than before. Different launching strategies produce very different results in the competition. In order to ensure maximum gain, the choice of launching strategy is a decision that participating teams should not take lightly. Here I would share some of my thoughts on launching strategies.

There are currently three common launching strategies, which are single shots (one trigger pull per projectile launched), automatic shots (projectiles are launched for as long as the trigger is held down), and multiple shots with one pull (one trigger pull per round launched). Take Standards as an example. In the latest version of the 2018 Rules, the official projectile supplier will issue a total of 1,100 rounds of projectiles in a match. There is an ample supply of projectiles, so there is no need to consider using the single shots strategy. A mix of the automatic shots strategy and multiple shots with one pull strategy is a viable option. These two strategies may look similar, but there are differences between them nonetheless. Given the heat limit, the automatic shots strategy is more suitable for occasions where chances of a hit are unlikely. For example, if you are in a chaotic fight with the enemy Standards, it is better to score a few hits with automatic shooting than nothing with multiple shots with one pull and have to wait for it to cool down when opportunities for hits do appear after that random firing. The multiple shots with one pull strategy is desirable for occasions where chances of hits are high, like with bases, Heroes and large armor plates on Sentries.

A Supplier robot must not possess any projectiles at the start of a round. When the round starts, an external projectile supply tube delivers 200 17 mm projectiles to the Supplier robot. Following this initial distribution, 150 17 mm projectiles will be delivered to the Supplier robot every minute.

For participating teams, a launching strategy involving a low launch speed and high launch frequency will always bring more benefits than the other way around. However, people tend to overlook the fact that a low speed of launch will lead to a ill-performed trajectory. Robots which adopt this strategy will almost have be face-to-face with enemy robots to get a hit. Targets at a

medium to long distance away and on high grounds are simply impossible to hit. It is worth considering how to improve trajectory by increasing the speed of launch as much as possible without reducing the frequency of launch too much. For the speed of launch, my advice is to increase it as the robot level increases. Since level 1 Standards have a low heat level, it is recommended to use a low speed of launch to ensure a certain frequency of launch can be generated. From level 2, Standards' frequency of launch is enough to pose a threat to Heroes. At this time, the first instance of HP deduction should have occurred. If you produced the first instance of HP deduction of the opposing team's robot, their Sentry's chassis is powered off for 60 seconds. The speed of launch can be increased within reason to improve the trajectory, so that we can better strike at the opposing team's Heroes and Sentries. As for level 3 Standards, the maximum frequency of launch under the heat limit already exceeds the maximum frequency of launch for the launching mechanism of most Standards in the competition. Of course, they can continue to increase their speed of launch for the sake of long-distance shooting.When it comes to frequency of launch, you can start with a high launch speed of high launch frequency, then limit the frequency of launch using the heat limit. If you don't have enough confidence in the heat limit, you can wait for a level up just like with the speed of launch.

Robot Level	Maximum HP	Barrel Heat Limit	Barrel Cooling Value Per Second	Revival Time	Value of Experience Points
Level 1 Standard	750	90	18	5	2.5
Level 2 Standard	1000	180	36	15	5
Level 3 Standard	1500	360	72	30	7.5

The Open Zone contains two bunkers: one that accelerates the cool-down value of barrel heat, and another that enhances defensive abilities. When a robot occupies a bunker, it receives a 50% defense bonus and the barrel cool-off rate is increased five times. Only the robots of the team that first occupies the bunker gain this bonus.

Here I would like to stress the importance of bridge top platforms, bridge end platforms, and bunkers in the competition area. Once a robot steps in one of these three areas, its cooling speed will multiple by five, which is equivalent to a level up for Standards. In addition, there is another 50% defense buff for occupying a bunker. When a Standard seizes these positions, RFID interaction information can be picked up by the referee system, allowing the robot to automatically increase the speed of launch. A reasonable increase in speed of launch is appropriate now because the opposing robots will not want to engage in close combat with you. A higher speed of launch yields better hit rates for medium and long distance targets.