Targets and Metrics

The targets listed below are in order of importance. These targets will be used to test the functionality of the autonomous vehicle. For each target, a ‘green,yellow,red’ ranking system will be used to determine whether or not that metric is within acceptable limits. A ‘green’ mark is designated for a metric that is within +/- 5% of the target value. A ‘yellow’ mark is designated for a metric that is within +/- 10% if the target value. A ‘red’ mark is designated for any metric that is more than +/- 10% from it’s target value. This is a no-go marking, and means that the metric needs to be reevaluated, or major design changes are required to bring this metric within standard.

Target summary:

Target 1 quantifies the necessary success rate for our vehicle navigating around the track. Out of 10 attempts, the car needs to successfully navigate the track five times for marginal success or eight times for ideal success. A successful run will be determined by the car completing the lap without bumping into a wall or getting turned around. The marginal target was chosen at 50% because this would give us a successful run one out of every two tries. The competition states that points would be deducted for each time the car bumped into a wall, thus a 50% success rate would give us a decent, yet obtainable chance of completing the course with no collision deductions. This target is rated at an importance of 5/5 because collisions are one of the biggest causes of point deductions per the competition handbook. Furthermore, safe and successful autonomous driving is the ultimate goal of the Formula 1/10th competition and thus, this target should be of the highest importance.

Target 2 quantifies the ability for the user to switch from autonomous navigation to a manual override with the flip of a switch on a controller of some kind. This is one of the customers needs plus a competition regulation, so its level of importance will be a 5/5. This target will be measured simply by observing if the control of the vehicle switched from autonomy to remote controlled upon flipping the switch.

Target 3 quantifies the necessary distance needed to detect objects and wall surfaces by our sensors. For our vehicle to navigate autonomously at the desired rate of speed the vehicle needs to be able to detect objects a good distance away as it approaches . The value was chosen based on the total hallway length the max distance of Dr. Hooker’s hallway is around 17.3 meters. The Zed camera has a max detection of around 19.3m and exceeds the hallway length. This target was given a 3 because it makes our system more accurate to navigate the hallways and allows for a faster possible speed the sooner the next upcoming turn is detected. Failure to meet this requirement would mean the vehicle wouldn’t be able to travel as fast as intended.

Target 4 quantifies the necessary runtime for our vehicle. The total distance needed to be traveled by our vehicle is ten laps around the 3rd floor hallway around Dr. Hookers office in building B of the FAMU-FSU College of Engineering. To leave room for program testing and design, 3 race distances are sufficient to get a total continuous run time of about 15 minutes. The ideal would be 20 minutes if more programming time is needed. This target is rated a 4/5 because it's vital to the prototype and testing phase to be able to test the vehicle multiple times on one charge. This will cut down significantly on the time required during this phase. This metric will be measured using a stopwatch and noting the time until the vehicle no longer has the ability to move.

Target 5 quantifies the necessary cost to build and manufacture the autonomous F1/10 vehicle. Researching other F1/10 team's projects, their total cost averaged to approximately $3000. The ideal cost is less than $2000 since that is our budget limit without needing specific permission from our sponsor. This target will be monitored closely in the budget report. Budget is quite the limiting factor when choosing the best and lightest components, so this target is rated at a 4/5 on importance.

Target 6 quantifies the battery capacity needed to power our processing and drive components: A Nvidia Jetson TX2, sensors (such as the Zed stereoscopic camera), Wifi dongle, Teensy microcontroller, drive motor, and steering motor. The marginal value was selected in two part: First we took two times the Nvidia Jetson's required power plus the microcontroller's and dongle's for the full 15 mins. This whole electronic system consumes 15 watt hours at 7.4 volts, creating a draw of 2000mAhs. So for a 15 min run our processing components will pull 500mAh. Second, the need of our vehicle tis to complete ten laps around Dr. Hooker's Hallway. The value chosen was a 4600 mAh battery since the run time of the motor is for 15 min with a maximum current draw of 60 amps at 3500 rpms . 4500mAh was the calculated capacity needed meet those requirements for 15 mins. Combined, this dictates a need for a 5000mAh battery powering these components for the design and test phase of this project. A 6000mAh battery would be ideal to allow for more flexibility on run time, but at some point the weight of the battery may be a limiting factor. This is rated a 4/5 because it coincides directly with target number 5 (run time) and the power source is vital to every component of the autonomous vehicle.

Target 7 quantifies the ability of the autonomous vehicle to navigate around corners and obstacles, from a mechanical perspective. The steering angle is the maximum angle that the front wheels are able to flex to when told to steer to the left or right. Typical cars have a maximum steering angle of about 33 degrees so the target angle here is 25 degrees as measured from rest (i.e. the long axis of the vehicle), with an ideal value of 30 degrees. With a small vehicle and a small wheelbase, smaller steering angles can still perform adequately, and this will give us a margin of error when developing the steering system. This metric will be measured using a protractor on the ground to measure the angle of the front wheels when told to steer.

Target 8 is a measure of the vehicle's wheelbase. The wheelbase is the distance from the front axle to the rear axle. In general, a shorter wheelbase is related to improved cornering and quicker changes in direction, but decreased handling at high speeds. For the purposes of an autonomous 1/10th scale vehicle, a shorter wheelbase is ideal in order to have the quickest response when avoiding obstacles. The target here is 35 cm, with 26cm being ideal. This is based on standard dimensions of 1/10th scale vehicles from common RC car manufacturers such as Traxxas. While any wheelbase is technically feasible, a shorter wheelbase will help the vehicle navigate around obstacles, so this target is rated at a 3/5. To measure this metric, a tape measure will be used to measure the distance between front and rear axle.

Target 9 quantifies the maximum weight for the autonomous 1/10th scale vehicle. This weight should be pulled straight from the F1/10 competition rulebook, but the section is incomplete. After numerous attempts to contact the F1/10 team and no response, we were forced to research other common RC cars on the market. Combining these weights with the weight of onboard sensors, processors, and microcontrollers, a target weight of 8 pounds was generated. This metric is rated as a 3/5 because while it is important to be within regulation for competition, the ultimate goal of the project is producing a vehicle that can perform the job of autonomous navigation. This metric will be measured using a scale.

Target 10 quantifies the length, height, and width requirements for the vehicle to abide by the F1/10 competition rules and regulations. Due to the most recent rules not being available and with the team designing the chassis instead of using the chassis supplied by the competition, rough estimations had to be made to set initial targets until a response from the competition is received. 51cmx29cmx32cm (LxWxH) was selected for the maximum vehicle dimensions based on what similar RC cars dimensions were, leaving plenty room for all the required components. For optimal values, 46cmx23cmx28cm was selected in order to provide a more compact design while still taking into account the width containing the width of two tires and the chassis. The target is rated a 3/5 in importance because if the weight and dimensions are off the vehicle will not be eligible for the competition and the performance of the vehicle will be impacted, affecting other targets. This metric will be measured using a tape measure at the extremes of each dimension.

Target 11 quantifies the maximum acceleration for our vehicle this target was chosen to make lap times quicker . The 2.23 m/s^2 was chosen because it would bring the vehicle to it’s target top speed in 2 seconds giving the car a quick transition out of turns. Ideally it should accelerate at 3.5 m/s^2 in order to get to top speed with in a second. This target is only a 2 in importance because accelerating quickly is only important during competition. For the purpose of moving from one office to the other, acceleration is not a top priority. This target will be measured using the onboard accelerometer on the Zed stereoscopic camera, starting from rest until maximum speed is achieved.

Target 12 quantifies the deceleration capabilities of the autonomous vehicle. Deceleration is an important metric as typically the car that wins a race is the one who brakes last going into turns. Thus the ability to decelerate quickly is vital. In order to accommodate rapid stopping to avoid obstacles and make turns, a target of 5.36 m/s^2 was selected. This should bring the vehicle from 10 mph to 0 mph in one second. An ideal value of 6.71 m/s^2 is preferred if possible to have even better stopping power. This metric is rated at a 3/5 because after functionality of the autonomous system itself, the ability to brake last into turns will prove important if trying to win races. This metric will be measured using the onboard accelerometer on the Zed stereoscopic camera when going at full speed and braking to a stop.

Target 13 quantifies the maximum speed to be achieved for our autonomous vehicle . This target was chosen for the facts that 10 mph is the average speed of a wide variety of indoor 1/10 scale vehicle . Also the speed is low enough for the sensor camera to optimally scan its environment. Furthermore most competitions the vehicles are seen only achieving speeds around 10 mph. Ideally the rules want a car that is capable of speeds of over 40mph. This target has an importance rating of 2 because fundamentally the vehicles autonomous operation is more important that it's top speed. Top speed will be directly related to the ability to win competitions. This target will be measured using the onboard accelerometer on the Zed stereoscopic camera during max throttle.

Target 14 will quantify the track width, or distance between tires on the left and right side of the vehicle. In general, a wider track width will be more stable going around corners. The limiting factor of course is the width of the entire vehicle. Therefore the target will be set at 27cm, 2cm less than the target for width of the vehicle. This target is of lower importance than most others, at a 2/5. It will be measured using a tape measure between the left and right hand side tires.

Target 15 deals with quantifying the specifications of the wheels. Typical RC car wheels are about 1 oz in weight, and we will strive for the same weight. Thus the marginal goal for this will be 1.5 oz per tire. The width of the tires should be under 3.5 cm and the diameter should be under 8cm. These tire sizes are relatively standard across the 1/10th scale RC car community. The wheel size will be an important factor when calculating the force required to achieve other metrics such as acceleration and top speed. Metrics will be measured using a tape measure and scale.

Target Catalog

Target No.	Metric	Imp.	Units	Marginal value	Ideal value
1	Ability to navigate course	5	%	50%	80%

2	Autonomous Control Switch	5	Yes/No	Yes	Yes
3	Sensor detection distance	5	m	15.3m	17.3m
4	Run time	4	min	15min	20min
5	Cost	4	USD	3000	2000
6	Battery capacity	4	mAh	5000	6000
7	Steering angle	3	degrees	25	30
8	Wheelbase	3	cm	35	26
9	Weight	3	lbs	8	5
10	Vehicle Dimensions				
	Length	3	cm	51	46
	Width	3	cm	29	23
	Height	3	cm	32	28
11	Maximum acceleration	3	m/s^2	2.23	3.5
12	De-acceleration	3	m/s^2	5.36	6.71
13	Maximum velocity	2	mph	10	40
14	Track Width	2	cm	27	20
15	Wheel Dimensions				
	Weight	2	oz	1.5	1
	Diameter	2	cm	8	7.5
	Width	2	cm	3.5	2.8