1.5 Target Summary

Propulsion

Considering the top speed that the design is aiming to achieve, a target was created for the Acceleration function. In modern performance cars, larger automotive manufacturers perform an acceleration test from 0 – 60 mph, which is a third of the top speed of the vehicle. The design will be estimated to be performed at 1/3 of the expected top speed in a similar time frame of 4 seconds.

As for the deceleration function, data collected from sports cars that performed a stopping distance test in competitions showed that most were able to stop 7-8 times the length of the car's body. The length of the design is 52 inches or 1.32 meters. Based on the tests performed by the automotive manufacturers, the stopping distance should be approximately 10.6 meters.

Table 3: Propulsion Targets & Metrics

System	Function	Metric	Target
Acceleration	Generate Force	Time	0 - ($\frac{1}{3}$ top speed) in 4 seconds
Deceleration	Remove Force	Distance	10.6 m

Support

Power wheel sized vehicles are designed to be used by children between the ages of one to seven years old. Therefore, the design should be able to accommodate children between the ages of four to eight years old. The impression is that children above the age of four should be knowledgeable enough to safely navigate the design. The Radio Flyer Tesla Model S was selected as a basis for the design. The Center for Disease Control and Prevention gathers data to produce growth charts that depict the height and weight of male and female children. Additional targets used to define the targeted heights and weights include the ages of children that are expected to operate the design.

After researching the 95th percentile and the 5th percentile of both boys and girls ages four and eight, extremes of potential users were identified. These values will represent the maximum and minimum weight of a payload the vehicle will have to carry, and the maximum and minimum amount of room allotted for the payload. The targets are defined in table 4.

Table 4: Support Targets & Metrics

System	Function	Metric	Target
Carries Load	Generate Equal & Opposite Force	Force (Weight)	≤ 36 kg (95th percentile 8-year-old girls)
Carries Load	Generate Equal & Opposite Force	Force (Weight)	≥12 kg (5th percentile 4-year-old girls)
Fits Load	Compensate stature	Height	137 cm (95th percentile 8-year-old boys)
Fits Load	Compensate stature	Height	88 cm (5th Percentile 4-year-girls)

To achieve the requirements outlined in the scope of the project, the chassis of the Radio Flyer Tesla Model S components will be altered to include the removal and replacement of components and compensation for the tracking payload provided by team 504. The curb weight of the original design was measured to be 18.37 kilograms, but with alterations to the chassis, the targeted weight for the design is estimated to be 22.68 kilograms.

Signal

Autonomy is an essential goal of design. It is important that the design has exteroceptive and proprioceptive sensors that are constantly feeding information to the vehicle about its current internal state and surrounding environment. The sensors will be selected to detect the current position, target, and optimal path. From this information, inverse kinematics can be applied to find the velocities of the wheels individually and the design. Knowing the vehicle's desired velocity will help find the desired wheel velocities where the tire speed can be measured.

Based on the general knowledge of robotics, IMU's can read data at a rate of 74 Hz. I The target the design is intended to hit is at least 80 readings a second, or 80 Hz.

Collection and testing of the object sensing will be done using "Simultaneous Localization and Mapping" or SLAM sensing. Visual SLAM uses multiple cameras to give the robot "eyes" and update what is in front of it, and LiDAR SLAM uses light detection and ranging to build a map of what is surrounding the robot. While the type of SLAM remains unknown, the robot surroundings should be updated at a rate of 15 Hertz to generate accurate decisions on obstacle detection and avoidance.

Table 5: Signal Targets & Metrics

System	Function	Metric	Target
Sense Velocity	Measure Tire Speed	Frequency	300 Pulses Per Revolution (PPR)
Sense Position	Gather & Update Position Data	Frequency	80 Hz
Sense Obstacles	Measure Light Reflections	Frequency	15 Hz

Navigation

For the design to be successful, the vehicle must be able to take corners with accuracy. If cornering is done with too much speed or an uneven ground, this may cause the vehicle to tip or roll over. Through analysis of energy and velocities, the rate of change for roll that will make the vehicle roll over was anything larger than 2π rad/sec. This number was calculated using the track length and a situation where, after hitting uneven ground, one side of the car had an induced roll rate and the other side remained completely on the floor. The number calculated using this model is not extremely accurate, however, as more information is learned about the vehicle geometry, a threshold will be created through mechanical design that will allow for this target to be met. This parameter will be tested using one of the sensors that is within the vehicle. Using a gyroscope and accelerometer in the design, the roll rate can be easily calculated in the vehicles software.
As for Yaw Rate, the idea is to make a target based on how fast the design should make a full 360° turn. The desired period that was selected was 4 seconds. By doing some quick math, a 360° turn in 4 seconds, results in a yaw rate of $\frac{d\psi}{dt} = \frac{2\pi}{4} = \frac{\pi}{2}\frac{rad}{sec}$. This is the current target that

was set; however, the yaw rate is a complex target to fully comprehend and will be adjusted in the coming weeks.

Table 6: Navigation Targets & Metrics

System	Function	Metric	Target
Navigation	**Resist Roll Motion**	Angular Velocity	$\leq 2\pi \ \frac{rad}{sec}$
Navigation	**Induced Yaw Rate**	Angular Velocity	$\approx \ \frac{\pi}{2} \ \frac{rad}{sec}$

Additional Targets and Metrics

The Tesla Model S Radio Flyer tops out at a maximum speed of about 2.68 m/s. After further insight, a top speed target of 4.47 m/s was devised as an optimization for the design. The test distance that the vehicle will take begins at the bus stop outside of the FAMU-FSU college of engineering and ends at the AME building. This distance is approximately 644 meters (about 2112.86 ft) and the requirement provided by the sponsors is to get from point A to point B in 5 minutes (300 seconds). By dividing the total distance by the time limit to get there a maintained velocity of about 2.17 m/s was calculated. These targets will be tested using the velocity sensor in the vehicle.

To determine the turn radius, comparisons were made based on cars in the current automotive market. Using the Tesla Model S, the Toyota Corolla, and the Volkswagen Jetta, the equation for steering angle was used $\delta = \frac{L}{R}$, using L as the length from front wheel to back wheel and R the turn radius to create a length to turn radius ratio. After using the equation for all three cars and taking the average of the values yielded, that data was set equal to the length of the project design vehicle over the turn radius of the project design vehicle, resulting in a 1.59 m turn radius. The turn radius can be tested by using simple mathematics, geometry, and physics.

After doing energy calculations, for a 22.8 kg vehicle going 4.47 m/s, it was deduced that roughly 226 Joules of energy is needed for the trip. To provide a buffer for the project, a battery that outputs around 350 Joules of energy to our system is desired, to power motors, sensors, and the microcomputer.

For this project simulations will be run before the start of the mechanical build of the vehicle. While simulations can be run until everything is "perfect," the simulations will never be able to fully represent what will happen in the real world. Since this is the case, a rough estimate of the number of simulations is desired to present a promising idea of what will happen, but without wasting too much time trying to perfect it. The number that was set was 50 simulations with different parameters.

Table 7: Additional Targets and Metrics

System	Function	Metric	Target
Additional	**Top Speed**	Velocity	4.47 m/s
Additional	Maintained Velocity	Velocity	2.17 m/s
Additional	Turning Radius	Distance	1.59 m
Additional	Battery Size	Energy	350 Joules
Additional	Simulation Runs	Iterations	50 Simulations

Critical Targets

The targets that were bolded in each individual table are critical targets to the project's success. The ones bolded were, Carries Load (Max), Resisting Roll Motion, Inducing Yaw Rate, and Top Speed.

Carries Load (Max) was considered a critical target as it sets limits on how heavy a load can be and still be carried by our design. In this case we went with 36 kg, which was the weight of a 95th percentile 8-year-old girl, which was the top end of the target demographic.

Next was to resist a roll motion, which was marked as critical because avoiding rollover is extremely important as a rollover would lead to failure in a time limit aspect. As stated by the sponsor, the design should reach the specified end point in 5 minutes or less which would not be achievable if rollover occurs.

Inducing a yaw rate is important because the car must be able to take tight corners. By reducing the amount of time spent on each mission of the vehicle, the inertial forces are then in turn reduced.

Lastly was the top speed, the top speed was marked as mission critical as there are a few other targets that were created based on the top speed target. Being able to achieve the top speed target will allow the design to be validated in other targets such as the acceleration target and the deceleration target.