|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Function**: | **Metric:** | **Target:** | **Validation Method:** | **Validation Tools:** |
| **Accelerate** | | | | |
| Generate Thrust | Take-off  Distance | Less than 100 ft.  Time Limit: 120 sec. | Test Flight | Measuring tape to find take-off distance of each test flight |
| Thrust Force | Greater than 10 pounds | Thrust Test | Custom built thrust test stand |
| Maneuver Down Runway | Turn Radius | Less than 5 ft | Physical Measurement | Measuring tape |
| **Enable Lift** | | | | |
| Provides Lift | Planform Area | Greater than 6 ft2 | CAD | Creo |
| Wingspan | Less than 120 in. | CAD | Creo |
| Overcoming Drag | Drag Coefficient | Less than 0.15 for the aircraft | Computational Fluid Dynamics | Ansys |
| **Carry Payload** | | | | |
| Load/Unload Cargo | Time to Unload | Less than 1 minute | Timing | Stopwatch and/or video recording |
| **Flight Controls** | | | | |
| Motor – Provide Thrust | Thrust Curve | Maximum thrust within 4 seconds | Thrust Test | Custom built thrust test stand combined with video footage for timing |
| Rudder – Control Yaw | Angle of deflection | ±25° | Physical Measurement | Protractor |
| Elevator – Control Pitch | Angle of deflection | ±25° | Physical Measurement | Protractor |
| Aileron – Control Roll | Angle of deflection | ±25° | Physical Measurement | Protractor |
| Longitudinal Stability | Static Margin | Greater than 5%, less than 30% | Manual Computation | MATLAB, Creo |
| Resist Effects of Stress | Airspeed at maximum deflection | 50ft/s | Experimental testing | Moving test rig with manometer |

The first section of the major functions is to accelerate, the plane must be able to generate thrust. One of the most crucial functions and end goals of the airplane will be to take off and land within 100 feet as per SAE guidelines. Although simulating the dynamics will help get an estimate of our takeoff distance, the best way to see if we’ve met our target is to fly the aircraft and utilize video recordings and measuring tape.

According to our rough estimations of drag, lift, and total weight, the airplane will need achieve a minimum airspeed of 34 ft/s to counteract gravity in level flight. This is assuming a minimum wing planform area of 6 ft2. In MATLAB simulation, this speed was reached with 10 pounds of thrust. To test this thrust, our team has already assembled a thrust test stand capable of monitoring thrust, power draw, and motor RPMs. Given that our team has a variety of motors and propellers available to us, we will be testing different combinations to determine what’s best for our limitations.

The plane must be able to taxi and maneuver about the runway which will be accomplished by using a servo motor to steer the tail wheel. For this reason, we have decided on a minimum turn radius of 5 ft that could be computed theoretically or tested and measured physically.

When creating our wing, we need to consider how large it needs to be to generate an appropriate amount of lift. Our calculations for level flight called for a 6 square foot planform area given 10 pounds of motor thrust. This area can be computed by hand or by using a projection in CAD. Our wing will also be limited to a 120-inch span for the competition which can easily be measured physically. Finally, our airplane will need a low enough drag coefficient to achieve lift. This parameter is considered in the wing section because most of the drag will come from the wing rather than the fuselage. Once again going off of our rough simulation in MATLAB, a total drag coefficient less than 0.15 should allow us to get up to speed. This can be verified using CFD or wind tunnel testing with a force balance.

Another requirement from SAE is that the payload (soccer ball) must be unloaded within one minute after landing. This unloading time can be tested experimentally using either a stopwatch or video recording.

Once the airplane is in the air, there must be a function to control the roll, yaw, pitch, and throttle. In the accelerate function, we defined a maximum thrust, but never gave any time specifications for the motor. Competition rules state that one team member can hold the airplane until max thrust is achieved before takeoff, but in the air, we need to make sure that the throttle response time is low enough to provide the pilot with decent control. To begin, we have defined a desired step rise time of 3 seconds to reach maximum throttle from a dead stop. This can be validated using the custom thrust stand along with video recording.

With certain aircraft configurations, only a rudder or ailerons are required to obtain usable control over the aircraft, however, most pilots are accustomed to having all four control inputs. Removing one of the control inputs may affect the pilot's ability to make quick and instinctive adjustments to the flight path. For this reason, we have decided to include all standard airplane controls. According to our research, the maximum usable deflection for a control surface is approximately 20° for a surface that is 20% of the chord length. Our team has decided that each of these control surfaces need to be able to deflect to a minimum angle of 25°. With this minimum we can always adjust the maximum deflection from the airplane transmitter.

Another need that has been added to our targets and metrics is the longitudinal stability of the airplane. Without simulating every aspect of the aircraft, the static margin provides a good estimate of stability from an aerodynamic perspective. In general, lower static margins yield more maneuverable aircraft, higher static margins yield more stable aircraft, and a negative static margin results in instability. We will be using dimensions and center of gravity estimations taken from Creo, combined with a MATLAB program to predict this metric. The upper and lower limits we chose for static margin are based off single prop planes with similar desired flight characteristics.

Finally, each control surface needs to withstand some minimum airspeed at their maximum deflection. To avoid mathematical complexity and possible inaccuracy, this is to be tested using an actual wing segment and high-speed winds. These high airspeeds can be emulated using a moving platform, high powered fan, or wind tunnel. A handheld manometer attached to a pitot probe can be used to measure this airspeed. The minimum airspeed target is based on our simple MATLAB simulation, with a safety factor of 1.4.