# ISURE Flight Readiness Report

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# Dart:

## Design and Requirements of Component:

The dart is made up of a bottom portion, which houses the electronics, a coupler, and a nose cone. The coupler portion houses a black powder charge which was used as an ejection charge to deploy the parachute. A portion of shock cord ran through the length of the entire dart. To have a successful launch, the dart would need to:

1. Be stable under high velocity.
2. Separate from booster portion.
3. Have a safe recovery.
4. Ensure safe housing of the electronics.

## Results of Test Flight:

On the first test launch, the dart failed to separate from the booster. It also failed to have a safe recovery due to the parachute not deploying. The effect of the failed recovery system were that the shoulder of the nose cone as well as one of the bulkheads inside the dart was damaged. The shock cord was also cut in order to retrieve the parts that got stuck inside of the nose cone. In order to prepare for the second launch, a Styrofoam barrier was installed between the electronics and the black powder charge instead of a bulkhead (to save time). The nose cone shoulder was also repaired.

Bottom of dart after second test launch.

As of the latest test launch, the top portion of the dart was not recoverable. This includes the transition area, nose cone, and parachute. The shoulder for the coupler separated from its original piece and lodged inside the bottom portion of the dart. The fins and bottom shoulder are still intact. In order to recover this bottom portion, the shock cord that ran throughout the length of the dart had to be severed (for a second time). This would cause an added variable for failure if another shock cord had to be tied to the short length that is inside now.

## Analysis of Flight Readiness of Component:

Due to the lack of transition, nose cone, parachute, and the damage done to the shock cord, our group has come to the decision that **<u>the dart is not flight-ready</u>**.

## Dart Conclusion:

In order for the dart to be ready for another test flight, these requirements would have to be fulfilled:

1. Order and receive a:
    a. Coupler
    b. Shoulder
    c. Nose cone
    d. Parachute
2. Cut, sand, and epoxy the coupler to the required length.
3. Cut, sand, and epoxy the shoulder for both the nose cone and transition.
4. Repair or replace the shock cord.
5. Reinstall a safety switch.

# Booster:

## Requirements of Component:

The booster consists of two primary pieces: there is the booster body, and the booster-dart transition. Both pieces are intact and functional. For the purposes of a test flight, the booster would need to meet the following criteria to ensure a stable, reliable, and recoverable flight:

1. Securely holds the rocket motor and casing, and keeps both from moving into or out of the rocket.
2. All components are structurally intact, sound, and undamaged.
3. Parachute is properly sized, packed, and attached to the shock cord.
4. The motor is properly delayed for a successful recovery system deployment.

## Results of Test Flight:

From the initial test flight, a number of interesting pieces of information were gained. For starters, the booster acted almost exactly the way that was predicted by the simulation created through Open Rocket. What that means is that the booster successfully propelled the dart upward and the recovery system deployed perfectly allowing for a successful recovery and no damage to the booster. However, there were a couple additions that needed to be made for the following test flight. The first of which was the addition of a secure motor mount. The motor mount initially installed in the booster did not account for the extra overhang of the motor casing; as such, the team had to determine a temporary fix (using wire wrapped around bolts) to secure the motor. For the second launch, a modification was made to the bolts already installed (they were extended by about a quarter-inch) which would adjust for the overhang and ensure a secure motor mount. This allowed the component to be flight ready for the second test flight.

On the second flight, there were a number of issues that lead to an successful, but a non-optimal recovery. For starters, after making several adjustments to the simulation and to the dart itself, a decision was made to adjust the delay timer of the motor deployment charge by 2.5 seconds. This, coupled with unfavorable weather conditions and a failed separation of the dart and booster, caused the booster recovery system to fail. The motor deployment charge ignited 9.5 seconds after burnout, but by that time had already gained a downward acceleration greater than the installed shock cord could handle which caused the parachute to be ripped away from the booster as it free-fell towards the ground.

## Analysis of Flight Readiness of Component:

After the secondary test flight, the booster was left largely intact with minor cleaning and repairs to be made in order for it to be flight ready. But, since neither of those two have yet to be completed it is the team's decision that, currently, **the booster is not flight-ready**.

## Booster Conclusion:

The booster is likely the most sound and stable piece of the rocket. As such, not much would need to be done to ensure that it is flight ready. Below is a list of things that would need to be completed for the booster to once again fly:

1. Removed all dirt from inside the rocket inner tube and transition.
2. Determine if the shock cord is damaged, and repair if necessary.
3. Revert motor deployment charge to initial conditions.

# Electronics (components):

## Design and Requirements of Components:

The avionics for this rocket must have the capabilities to collect and store data along its flight until it reaches dart apogee. For the purpose of safety and recovery, the avionics control the release of the parachute for the dart. Along with the previously stated, the following are also requirements for the competition:

1. Use a commercially available altimeter to compare data with the altimeter required by the competition.
2. Use a gyroscope to collect rotation data on the x-y-z axes.
3. Record downward facing video to compare the rotation with that recorded by the gyroscope.
4. Detonate a charge to deploy the parachute on the dart.
5. Record our data on an SD card for easy data analysis.
6. Manual on/off switch to control power to the board and charges.

## Results:

At the initial test launch, a ground test was conducted to determine the correct amount of black powder need to deploy the parachute. After a few tests the team was able to determine the amount of black powder need was 1 gram. After a successful ground test of the black powder charge, testing of the altimeter was done to ensure that all the electronics worked in their needed fashion. During the launch, the avionics were successful in logging the necessary data, however they failed to deploy the parachute. The result from this was that the dart free fell and was embedded into the ground. After careful excavation of the dart, the entirety of the avionics bay was now conveniently located within the nose cone. Most of the avionics bay was destroyed including the foam housing, the battery, the Arduino and the power cable. Thankfully, the SD shield along with the sensors that were attached to it were still in working condition, albeit damaged, through multiple tests. The conclusion, was that there was not enough amperage coming from the battery to the charge to successfully detonate the charge.

In preparation for the second launch, as much of the electronics were recovered as was possible. A chip kit was used instead of an Arduino and stronger batteries arrived the day following launch. Upon arrival at the second test launch, a ground test was carried out, and was unsuccessful after three attempts. The first test failed due to a wire that became disconnected. After the second test, the timer code was modified to fix a possible error that was found, to no avail. After inspection of the wiring with a voltmeter it was concluded was that the only problem could be with the timer code which was being used to detonate the charge for the ground test, meaning that there was a chance the altimeter-based detonation would still work properly, as it had been demonstrated the night before. With this being the last chance to test launch the rocket (a competition requirement), and understanding that there was a chance at success; the decision was made to go ahead with the launch. This launch ended the same as before but the avionics bay was completely unsalvageable. The avionics team hypothesizes that there was a wiring problem, either occurring during the launch or present beforehand, that led to the failure to deploy the parachute charge.

## Analysis of Flight Readiness:

After the second test launch the avionic were left totally unusable, and thus **not flight ready.**

## Avionic Conclusion:

In order to successfully launch this rocket, there would need to be totally new parts including:

1. an Arduino
2. new sensors to collect needed data
3. SD shield

## Programming:

The program that we designed with the assistance of some very helpful lab monitors was intended to gather gyroscopic and altitude data to then be recorded to an SD card. The program was done in the arduino C/C++ code form. The majority of the code was taken from the example codes for each of the sensors and spliced together and edited for our purposes. The program also had to uses the altitude data to trigger the parachute charge. This was accomplished by using a greater than equal to statement to record the highest altitude value and if a lower value outside of the tolerances was detected it would send a signal to a digital pin which triggered a mosfet for the electric match. All data recorded to the SD card was to then be ported to matlab where it could be graphed and put into a more user friendly format.

## Discussion of Results of Test Flights

While the first two test flights were unsuccessful, a large amount of data was gained and used to make adjustments. Firstly, from the simulation (OpenRocket), the dart and booster apogees were expected to go 510m for the dart and 420m for the booster. What ended up happening, was that the booster and dart did not separate until about 20m from apogee (i.e. there was 20m separation in dart and booster apogee). Furthermore, the dart only reached an apogee of about 400m; this leaves a 110m discrepancy that needed to be accounted for. After returning to the lab at Iowa State, a number of possibilities were found to have caused the discrepancy. Firstly, the simulation was found to have slightly less weight than the actual dart; this was attributed to the fact that a couple additions were added last minute to the dart that were unaccounted for in the simulation. Secondly, the booster and dart fins were not found to be as precisely designed as is shown in the simulation. The combination of the two lead to a lower apogee with more horizontal distance covered due to the fins causing the rocket to take about a 14 degree angle almost instantly after leaving the launch rails.

For video, unfortunately the on-board video camera either encountered data loss due to the ground impact which could have potentially damage the SD card, or, and the what is the most likely option, the camera was improperly handled when being put into the rocket causing it to shut off rather than record. Either way, the team feels very confident in the design of the camera viewing window and the design of the camera mount, and will find more information on the next test launch.

## Planned Changes and Improvements

As stated above, none of the parts are currently flight ready after a very unsuccessful second test flight. However, a number of steps are being taken to ensure the rocket can be rebuilt, recorded, and successfully tested by competition. For starters, a second nose cone has been ordered to replace the one that was unrecoverable. The nose cone ordered has a slightly different design to it which the team hopes will provide better aerodynamics with reduced weight allowing for a higher apogee. Secondly, as both tests failed to an electronics malfunction, the team is enlisting the help of a couple senior students and faculty to look over and assist in the reprogramming and rewiring of the avionics and avionics bay. The goal is to have this done much in advance to the next test flight allowing for several tests of the avionics which should ensure a successful flight. Lastly, along with the reprogramming of the primary ejection of the dart parachute, the electronics team also plans on implementing a fail-safe to hopefully ensure the safe deployment of the dart parachute. Combined, the team hopes these changes will allow for not only a successful flight, but also a better apogee.