## Different Possible Antenna Types:

This year, we are trying to make the Avionics bay out of carbon fiber which causes some issues when dealing with transmitting and receiving data. Thus we will be designing external antennas that will be flush with the tubing to send and receive all of these signals. There are many different types of antennas that we can use to transmit our telemetry data from the rocket to the ground. However, each of them will have their pros and cons. Below are just some of the different antenna types that we will explore:

| **Name** | **Description** | **Pros** | **Cons** |
| --- | --- | --- | --- |
| Dipole Antennas | We would place two dipole antennas on opposite sides of the rocket that are both connected together by a wire and a signal input port. This means that in an ideal situation we would be able to transmit all data from 360 degrees around the rocket. This should also have a relatively small gain which would make it more uniform. | * Easy to build * Easy to test * ~360 degree radiation pattern | * Only linearly polarized (aka not circularly polarized) * Will waste some power by transmitting inside the rocket (may be able to fix) |
| Monopole Antenna | The same general design as the dipole but we would use the carbon fiber as a ground plane. | * Easy to build * Easy to test * ~360 degree radiation pattern * Should have a slightly higher gain than dipole | * Only linearly polarized (aka not circularly polarized) |
| Clover Leaf Antenna | A clover leaf antenna has either 3 or 4 leaves and so what we would do is place the curvy part of the leaf (the most external part along the circumference of the tubing. This again will produce a radiation pattern which is completely surrounding the rocket, and it will be flush with the rocket. | * Circularly polarized * Easy to test * ~360 degree radiation pattern | * Will waste some power by transmitting inside the rocket (may be able to fix) * May not be able to get the exact dimensions right (due to the limitation of the tubing) * Hard as fuck to design in HFSS |
| Slot Anatnna | A conductive layer will be added to the outside of the rocket separated by a dielectric layer. This conductive layer will have small slots cut out of it which will act as the radiating element. | * Easy to build * Easy to test * High gain | * May not have ~360 degree radiation * May need to be very thick |

## Gain Measurements:

All antennas are simulated in HFSS in order to verify a desired gain of roughly 1dB (or higher). Due to the interference of the carbon fiber, the gain values for these antennas may be drastically less than the desired value. Thus, the table below documents all possible combinations of different antennas and the slight changes between the variations. At the moment the impedance of the antenna does not really matter, thus this will be neglected.

### Baseline Antennas:

| **File Name** | **Description** | **Peek Gain (dB)** | **Notes** |
| --- | --- | --- | --- |
| ExternalTX-MonopoleAntennaV5 | This is a base antenna where we use the carbon fiber tubing as the antenna. This will 100% not work but I figured that I should at least try it. | -10.22 | This did not work, as expected. This did make a kinda cool radiation pattern though. |
| ExternalTX-MonopoleAntennaV1 | This is the base template for a monopole design. The design consists of a coax cable in the center of the tubbing which then splits into 2 directions (opposite sides). The core of the coax is wrapped around the tubing with some offset to ensure the tubing does not make direct contact with the core. Then the outer section of the coax is connected to the carbon fiber tubing to act as a ground plane. (I now know how stupid this is but this was past Ian). This setup is on both sides of the tubing which means that we basically have two identical antennas.   * Radiating Element Length: λ/2 * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing | -2.77 | This has a very strange radiation pattern. It seems to only extend out in one direction with additional lobs on the top and bottom. This may mean that the current is only going through one of the antennas. Is this due to the fact that the wave length is too long? |
| ExternalTX-SlotAntennaV1 |  |  |  |

### Antenna Modifications:

| **File Name** | **Changes** | **Peek Gain (dB)** | **Notes** |
| --- | --- | --- | --- |
| ExternalTX-MonopoleAntennaV1.1 | Due to the imaging effect, the antenna should either have a smaller radiating element (λ/4) or not have a ground plane. Thus, in this version the ground plan was removed.   * Radiating Element Length: λ/2 * Antenna Tubing Space: 2mm * Outer Coax **NOT** Connected to Tubing | -1.04 | The radiation pattern is kinda weird. It seems to be radiating towards only one of the antennas and not both. This still implies that only one of the antennas has current. |
| ExternalTX-MonopoleAntennaV2 | Due to the imaging effect, the antenna should either have a smaller radiating element (λ/4) or not have a ground plane. Thus, in this version the radiating element was reduced.   * Radiating Element Length: **λ/4** * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing | -1.92 | This has a very normal radiation pattern, which is very good. However, based on the results from this and V1.1 we can probably conclude that the ground plan does not create a very good imaging effect. V1.1 and V2 both solve the imaging effect issue from the base antenna but one of them seems to be much more effective. This may be due to the fact that the plane is curved. |
| ExternalTX-MonopoleAntennaV2.1 | To confirm that the imaging effect is still in place on V2. The ground plan was removed. This should result in a very poor gain.   * Radiating Element Length: **λ/4** * Antenna Tubing Space: 2mm * Outer Coax **NOT** Connected to Tubing | -12.92 | This is exactly as we would expect from this antenna. Thus, this proves that the imaging effect is still a major aspect of V2’s antenna. |
| ExternalTX-MonopoleAntennaV3 | One possible source of error is that the two antennas are interfering with each other and causing a net loss in gain. This is unlikely due to the fact that the conductive tubing should isolate the two antennas relatively well. This is also unlikely since by using the right hand rule the fields produced by the radiating elements should be in addition and should in fact add to the overall gain. However, we might as well try it.   * Radiating Element Length: **λ/4** * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing\ * **Separate sources for each antenna with a 180 degree phase shift** | -2.24 | This did not seem to affect the value of gain too much. This is kinda as expected as this might mean that the antennas have almost 0 effect on each other. However, this does produce a very cool radiation pattern. This pattern may be circular? |
| ExternalTX-MonopoleAntennaV4 | To determine what is happening with the weird radiation pattern in the base antenna, the second antenna was removed so that we can directly compare the two radiation patterns.   * Radiating Element Length: λ/2 * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing * **Only one antenna (aka no coax split)** | -2.64 | This is almost the exact same gain as the base antenna. This antenna also has a very similar radiation pattern. The only difference is that the 2 upper and lower lobes are gone. I think this basically proves that in the base antenna (and V1.1) the current was only going through 1 antenna. |
| ExternalTX-MonopoleAntennaV4.1 | To doubly confirm that the current is only going to one of the antennas in the base and V1.1. The same setup as V1.1 is used but with only one antenna.   * Radiating Element Length: λ/2 * Antenna Tubing Space: 2mm * Outer Coax **NOT** Connected to Tubing * **Only one antenna (aka no coax split)** |  |  |
| ExternalTX-MonopoleAntennaV2.2 | Since we know from V2 and V2.1 that the imaging effect is a major player in the gain, in this setup we will imagine that the tubing is a perfect conductor. Thus, instead of having carbon fiber tubing it will be tubing made from a perfect conductor.   * Radiating Element Length: **λ/4** * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing * **Tubing made from perfect conductor** | 1.58 | This is a really good gain (exactly what we want). This also has a nearly perfect radiation pattern. The only bad thing about this is that the tubing is in fact not a perfect conductor. |
| ExternalTX-MonopoleAntennaV2.3 | Continuing on the work from V2.2, tis version has a thin dielectric layer (vacuum) covering the tubing followed by another layer made of a perfect conductor. A gap is added around the coax and the tubing to ensure that they are not in contact with each other. However,. The outer layer (the conductor) is still touching the outer coax. This will hopefully make a perfect ground plan just like in V2.2   * Radiating Element Length: **λ/4** * Antenna Tubing Space: 2mm * Outer Coax Connected to Tubing * Outer Coax **NOT** Connected to Tubing * **Outer coax touch an isolated conducting layer overtop of the tubing (Layer thickness: 0.5mm\*2)** | -12.92 | So i was very confused as to why this didn’t work but I think now that it has to do with the fact that the ground plan is too close to the radiating element. This is something that we may be able to fix a bit but probably not too much as that would stick out too far. |