3.2.4.3 GPS Coordinates Calculated

Depending on the outcome of the design choices listed in section 3.3.1.1, it will be necessary to gain the GPS coordinates of the sampled area in one of two ways:

1) Using the 3DR's DroneKit SDK and inbuilt functions, poll the flight controller for the UAV's GPS coordinates and use this as the approximate location of the sample area (assumes spectrometer is pointing perfectly down and does not account for roll, pitch, and yaw of the aircraft if spectrometer is statically mounted to UAV)
2) Using the 3DR's DroneKit SDK and inbuilt functions, poll the flight controller for the UAV's GPS coordinates, roll, pitch, yaw, and altitude and use this data to calculate the actual coordinates of the sample area with respect to the UAV's position and the angle between the spectrometer and the UAV's chord plane. The chord plane identifies the geometrical plane the UAV has when in perfectly horizontal (hovering) flight.

3.2.4.4 GIS point cloud developed

Phase 3 of the scope of the thesis requires the processing of the GPS tagged data into a GIS ready format. Ideally this would be completed with the intention to insert as a layer into Google Earth software. Standard data formats for Google earth are Keyhole Mark-up Language (Kml) or its compressed version known as KMZ. The purpose of this phase of the processing chain is to generate KML files for loading into Google Earth or similar software. This can be achieved using Python libraries for KML such as pyKML, simpleKML and fastKML.

3.2.4.5 Final Product

The final product will see phase 4 of the scope of this thesis implemented. This phase will make use of the GIS-ready format with embedded NDVI data. Ideally this data will be displayed in a graphically non-technical way.

3.3 Testing and Success Criteria

3.3.1 Procedure for testing

3.3.1.1 Mounting the TSU

The TSU will be initially statically mounted to the accessory bay of the 3DR Solo for testing purposes. However, due to the pitch and roll of the aircraft, this is expected to give a high percentage in error when calculating the GPS coordinates of the target sample area with respect to the UAV. There are number of solutions to this including:

1) Hardware Solution: Mount the TSU to the gimbal of the 3DR Solo and test for gimbals ability to maintain direction and heading.
2) Software Solution: Using the UAV's pitch, roll, yaw and altitude data, calculate the coordinates of the sample area with simple geometric algorithms.

During the fabrication stage of this thesis, these solutions will be tested for accuracy, robustness, and completeness.

3.3.1.2 Analysis of the effects of altitude and FOV on the sample area

This thesis aims to have the smallest sample area possible however, higher flight altitude is preferred for the UAV to avoid collision and aid mission profiling. Further, the size of the sample area will impact the validity of the results. Therefore, a trial will be conducted to test the effects the FOV angle of the spectrometer and the altitude of the UAV have on the accuracy of the measurements and the sample area.

Assuming the FOV centreline is perfectly vertical, the sample area can be calculated using the following formula shown in Equation 3 below:

$$Sample\ Area = \pi A^2 \tan^2 \frac{FOV°}{2}$$

EQUATION 3 - SAMPLE AREA

The trial will include the following data sets shown in Table 7.

TABLE 7 - SAMPLE AREA TRIALS

Trial ID	FOV (°)	Altitude (m)	Radius (m)	Sample Area (m^2)
1	1	10	0.087	0.024
2	1	20	0.175	0.096
3	1	30	0.262	0.216
4	1	40	0.349	0.383
5	1	50	0.436	0.597
6	2	10	0.175	0.096
7	2	20	0.349	0.383
8	2	30	0.524	0.863
9	2	40	0.698	1.531
10	2	50	0.873	2.394
11	3	10	0.262	0.216
12	3	20	0.524	0.863
13	3	30	0.786	1.941
14	3	40	1.047	3.444
15	4	10	0.349	0.383
16	4	20	0.698	1.531
17	4	30	1.048	3.45
18	5	10	0.437	0.6
19	5	20	0.873	2.394

These values were chosen to consider trialling the effect the FOV angle has on increasing the accuracy of the spectrometer measurements whilst keeping the sample area as small as possible. The FOV of the spectrometer has a direct effect on the integration sampling time. The larger the FOV, the fast the integration time. However, the smaller the FOV, the more accurate the measurements. FOV and altitude data sets causing a sample area larger than four square meters were not included due to the area being too large to be of any use.

Figure 11 below shows the relationship between the sample size, FOV angle and altitude. As the altitude is increased and the FOV held constant, the sample size increases exponentially. Trial number 10's sample area (FOV 2° at 50m) is equal to trial number 19's (FOV 5° at 20m) and therefore it can be seen that if there is a need to increase or decrease either the altitude or the FOV, a similar sample area can be achieved accordingly.

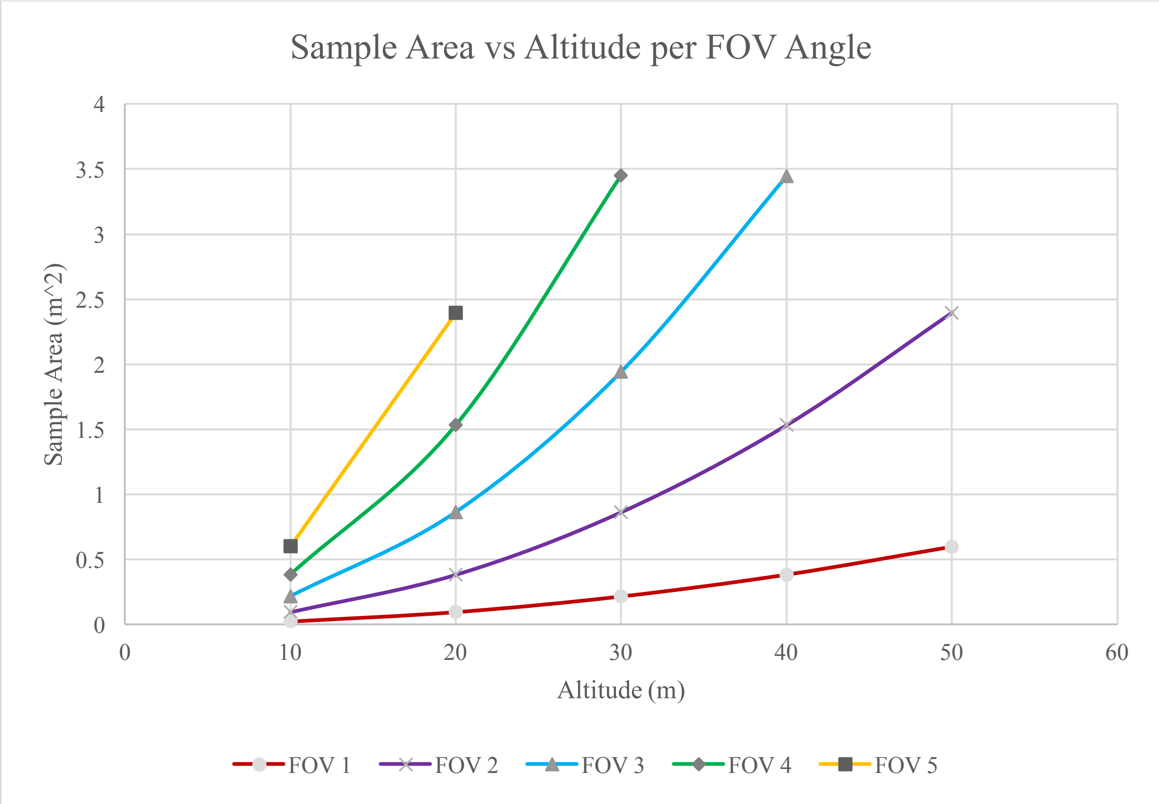

FIGURE 11 - SAMPLE AREA VS ALTITUDE PER FOV ANGLE

3.3.1.3 Accuracy of GPS

Phase two of this thesis will associate the spectrometer data with the GPS coordinates of the sample area. An analysis of the accuracy of these GPS coordinates with respect to what the spectrometer is targeting is necessary to ensure validity of results. The following outlines how this will be achieved.

1) TSU mounted with laser pen pointer and lab testing completed to ensure an equality of both components targets
    a. point spectrometer at red circle on white background (ensure sample area includes only the red circle)
    b. test spectrometer is pointing at red circle by using ocean optics software output (Ocean View 1.5.2) and analysing the spectrum plot as intensity-vs-wavelength (the colour red has a different spectrum shape to the colour white)
    c. mount laser pointer to spectrometer in such a way as to ensure the laser is also targeting the red circle
2) Define a location ‘X’ and (using a Garmin GPS device or surveying equipment) define the locations GPS coordinates.
    a. This could also be achieved by defining the location ‘X’ on a known location and position.