STK Task: A Trade Study to Choose an Orbit for a 6U CubeSat with a Camera as Payload

by: Sana Valappil

Table of Contents

Part 1

Settings

Altitude: 600km

Propagator: HPOP

Step size: 30 sec

Start time: 1 Sep 2024, 8:00:00

Stop time: 30 Sep 2024, 8:00:00

Step size: 10 sec

Satellites:

Model: 6U CubeSat

1. Circular20
   Orbit: circular
   Inclination: 20 degrees
   Camera1: Rectangular 15*10

2. Circular50
   Orbit: Circular
   Inclination: 50 degrees
   Camera2: Rectangular 15*10

3. SSO
   Orbit: Sun-synchronous with LTAN of 12:00am
   Camera3: Rectangular 15*10

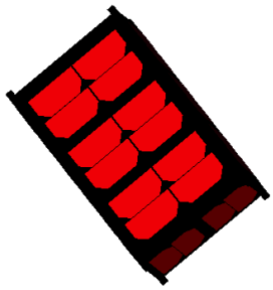

Figure 1: 6U CubeSat

Ground Station (GS): Sharjah, UAE

Area of Interest (AOI): Madagascar

Contact Between Satellite and Ground Station

1. Circular20

Passes in 1 day

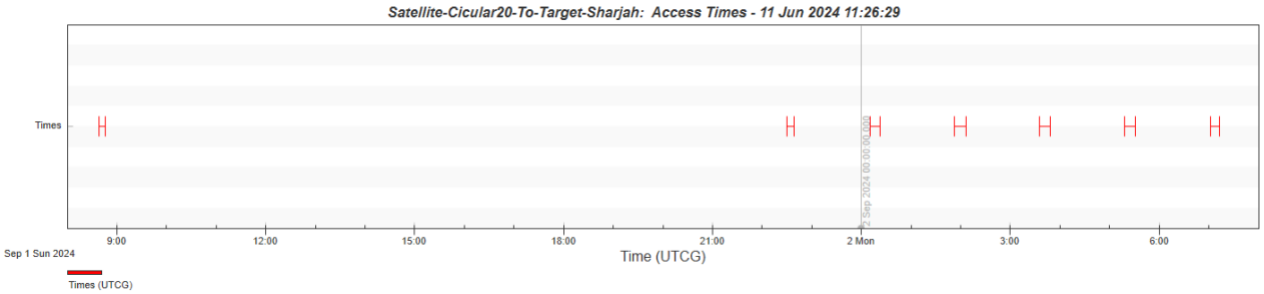

Figure 2: Passes of Circular20 over the GS in 1 day

No. of passes: 7

Mean duration: 683.112 sec (approx. 11 mins)

Passes in 1 week

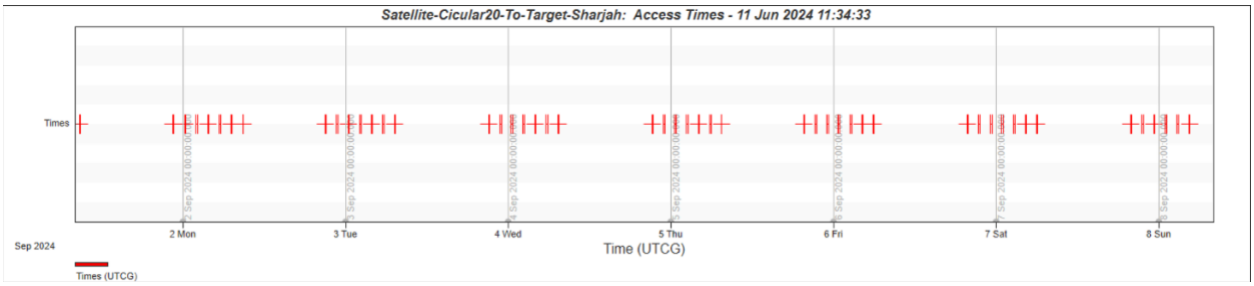

Figure 3: Passes of Circular20 over the GS in 1 week

No. of passes: 35

Mean duration: 660.112 sec (approx. 11 mins)

2. Circular50

Passes in 1 day

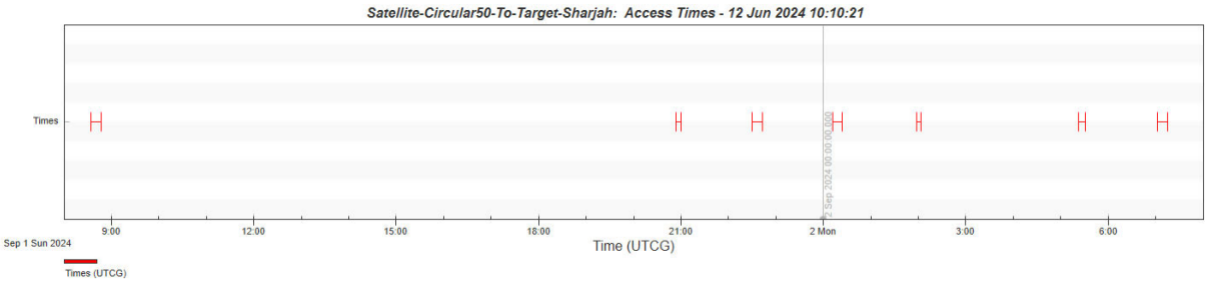

Figure 4: Passes of Circular50 over the GS in 1 day

No. of passes: 7

Mean duration: 620.505 (approx. 10 mins)

Passes in 1 week

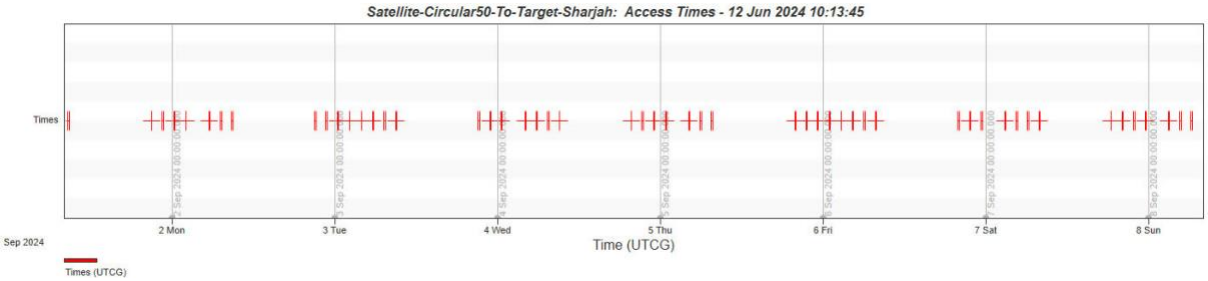

Figure 5: Passes of Circular50 over the GS in 1 week

No. of passes: 52

Mean duration: 582.768 (approx. 10 mins)

3. SSO

Passes in 1 day

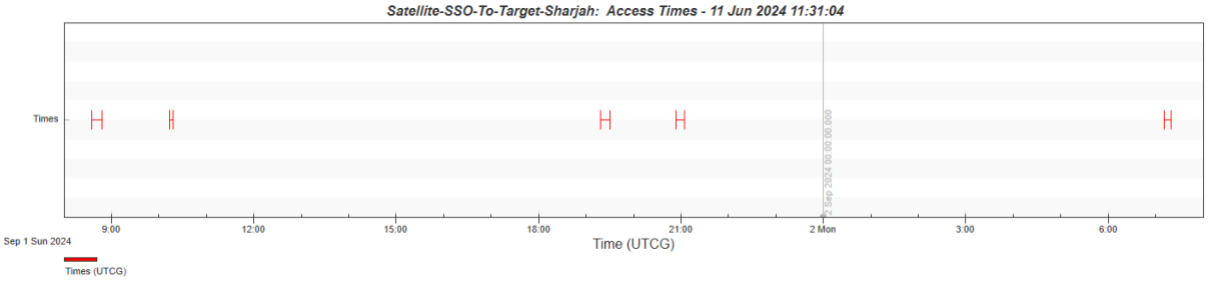

Figure 6: Passes of SSO over the GS in 1 day

No. of passes: 5

Mean duration: 582.687 sec (approx. 10 mins)

Passes in 1 week

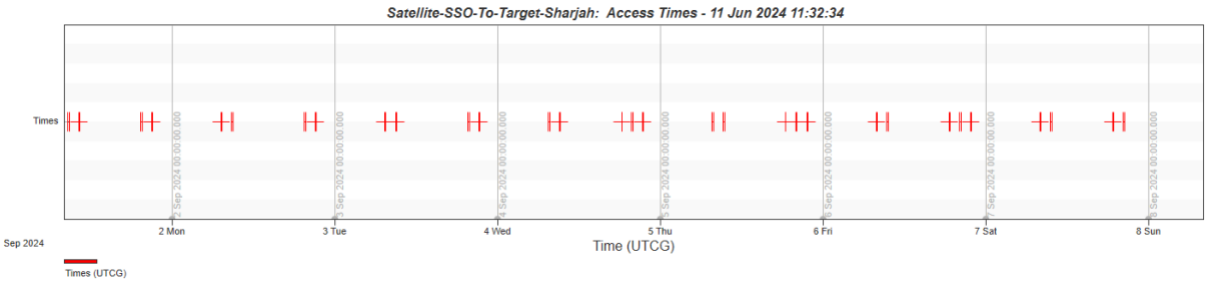

Figure 7: Passes of SSO over the GS in 1 week

No. of passes: 31

Mean duration: 603.987 sec (approx. 10 mins)

Contact Between Camera and Area of Interest

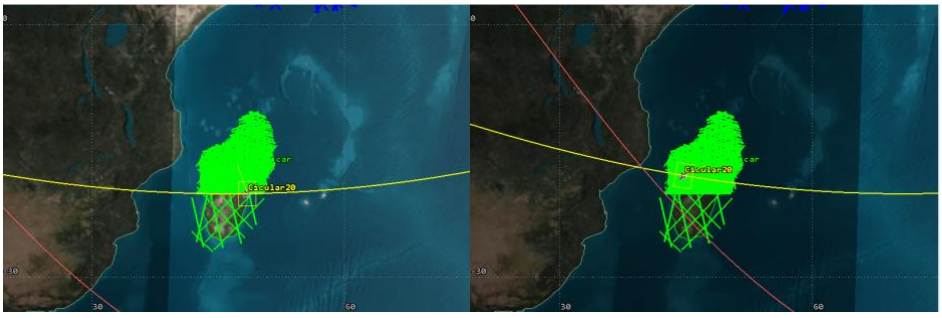

Figure 8: a) Image captured in daylight *b) Image captured in eclipse*

1. Circular20

Passes in 1 week

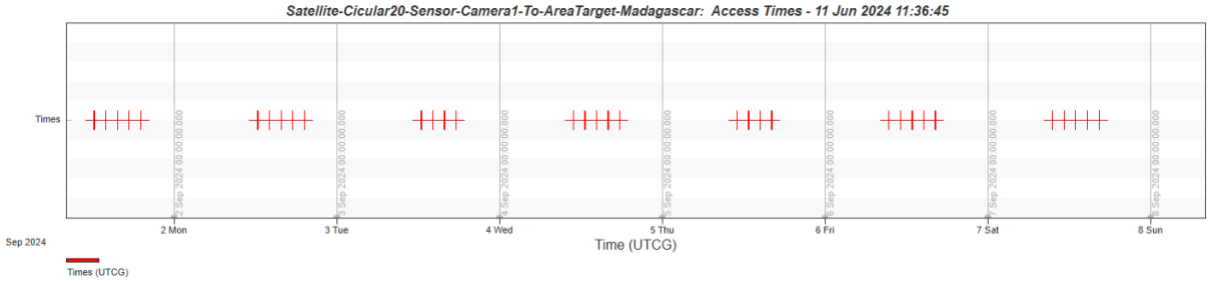

Figure 9: Passes of Circular20 over the AOI in 1 week

No. of passes: 33

No. of passes in light: 20

Mean duration: 108.8439 sec (approx. 2 mins)

Passes in 1 month

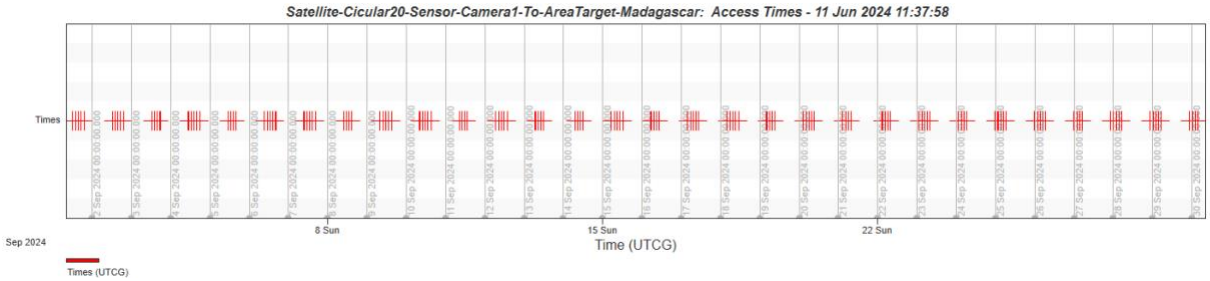

Figure 10: Passes of Circular20 over the AOI in 1 month

No. of passes: 137

No. of passes in light: 104

Mean duration: 115.695 sec (approx. 2 mins)

2. Circular50

Passes in 1 week

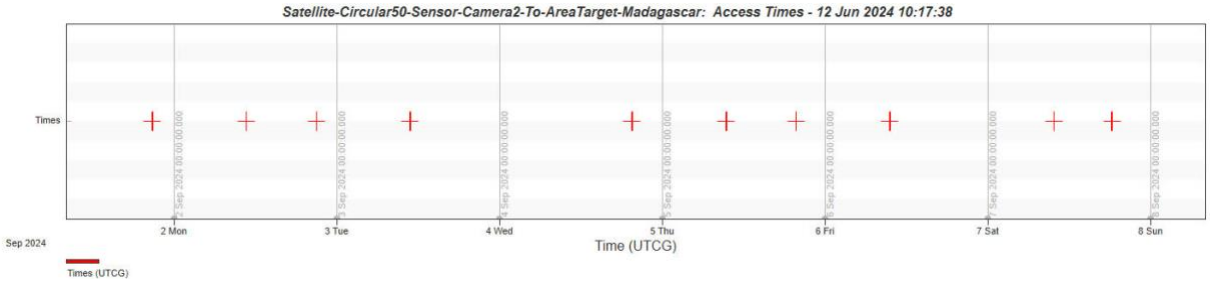

Figure 11: Passes of Circular50 over the AOI in 1 week

No. of passes: 10

No. of passes in light: 5

Mean duration: 115.6298 sec (approx. 2 mins)

Passes in 1 month

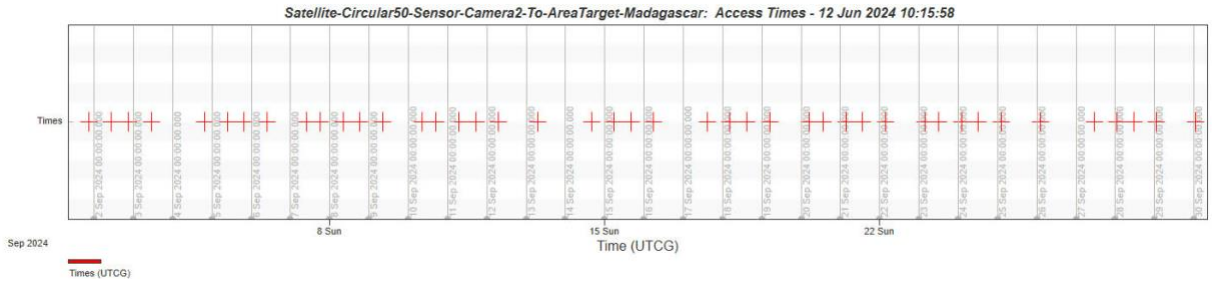

Figure 12: Passes of Circular50 over the AOI in 1 month

No. of passes: 43

No. of passes in light: 21

Mean duration: 127.2785 sec (approx. 2 mins)

3. SSO

Passes in 1 week

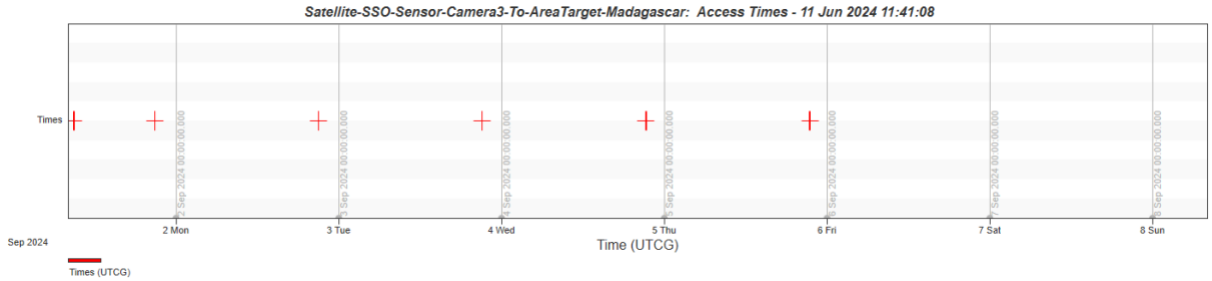

Figure 13: Passes of SSO over the AOI in 1 week

No. of passes: 6

No. of passes in light: 2

Mean duration: 181.5095sec (approx. 3 mins)

Passes in 1 month

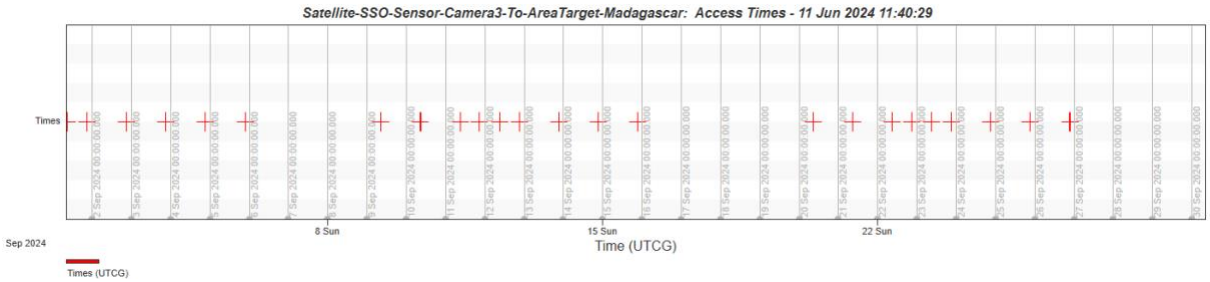

Figure 14: Passes of SSO over the AOI in 1 month

No. of passes: 25

No. of passes in light: 11

Mean duration: 182.4603 sec (approx. 3 mins)

Power Generation

Start time: 1 Sep 2024, 08:00:00

Stop time: 30 Sep 2024, 08:00:00

Time step: 60 sec

Satellite	Average Power
Circular20	11.30713 W
Circular50	12.23939 W
SSO	10.29409 W

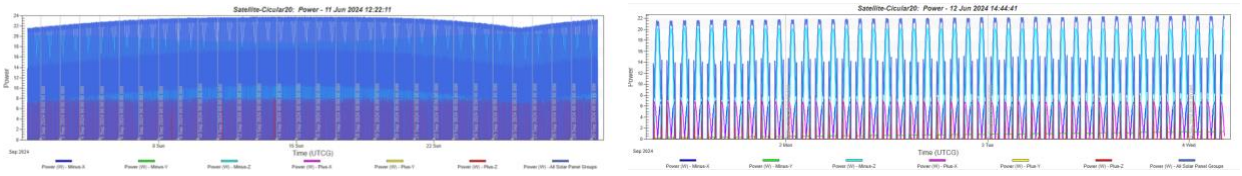

Figure 15: Power generation of Circular20

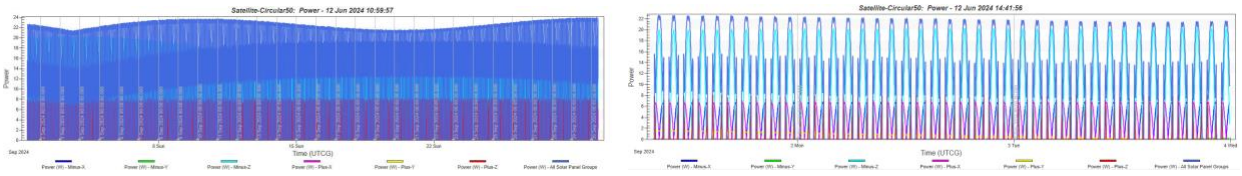

Figure 16: Power generation of Circular50

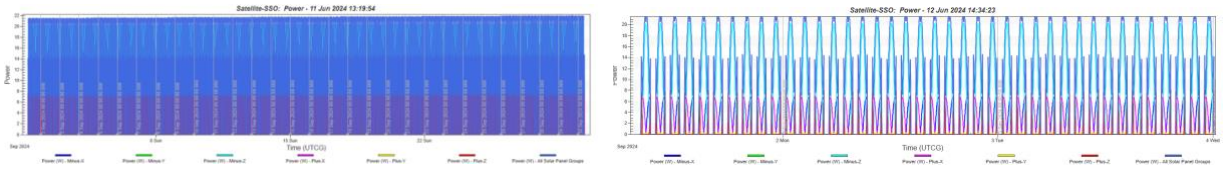

Figure 17: Power generation of SSO

Conclusion

The best orbit for the mission is the circular orbit with 20 degrees inclination, Circular20. Circular20 passes over the GS 35 times per week and stays in contact for approximately 11 minutes, providing sufficient time for downloading the captured images. It passes over the AOI 137 times in a month, and can capture the image in daylight conditions 104 times. However, it stays over the AOI for only two minutes. The sun-synchronous orbit, SSO stays over the AOI for the longest with about 3 minutes. However, SSO, passes over the AOI only 25 times in a month, and can only capture images 11 times. It passes over the GS about 31 times a week and stays in contact for approximately 10 minutes. Circular50 crosses the GS a greater number of times in a week than Circular 20 and SSO, with 52 passes a week. However, it passes over the AOI only 43 times and can only capture images 21 times, which is significantly lower than Circular20. Similar to Circular20, it stays over the AOI for 2 minutes. Circular20 will be chosen over Circular50 and SSO because it passes over the AOI the most and stays in contact with the GS for a longer duration compared to Circular50 and SSO. The average power generation of the Circular20 orbit is 11.30713 W, which is close to those of Circular50 (12.23939 W) and SSO (10.29409 W).

Part 2

Satellite chosen: Circular20

Number of Passes Over the New Ground Stations

1. **Bogota, Colombia**

   Passes in 1 day

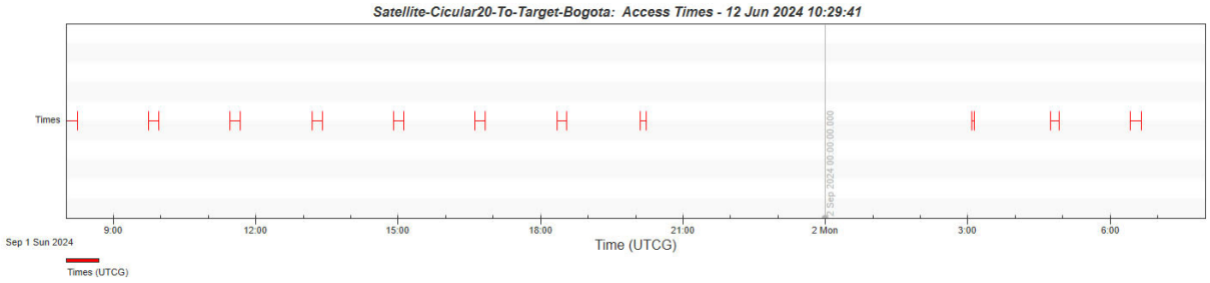

Figure 18: Passes of Circular20 over Bogota in 1 day

No. of passes: 11
Mean duration: 685.279 sec (approx. 11 mins)

Passes in 1 week

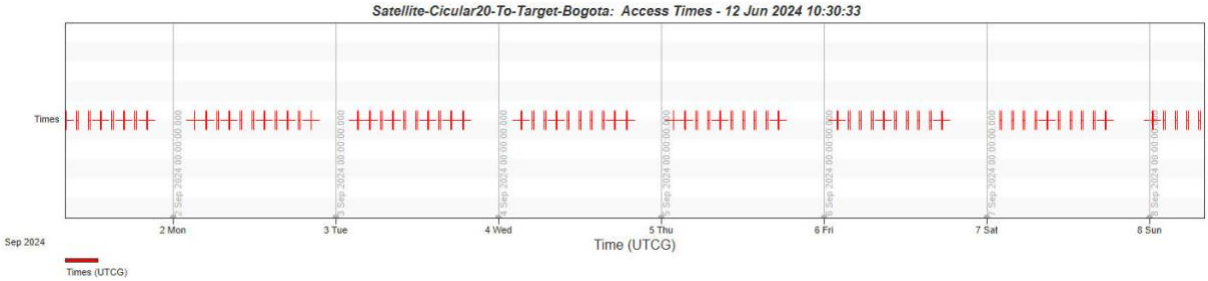

Figure 19: Passes of Circular20 over Bogota in 1 week

No. of passes: 74
Mean duration: 706.869 sec (approx. 12 mins)

2. Parapara, New Zealand

Passes in 1 day

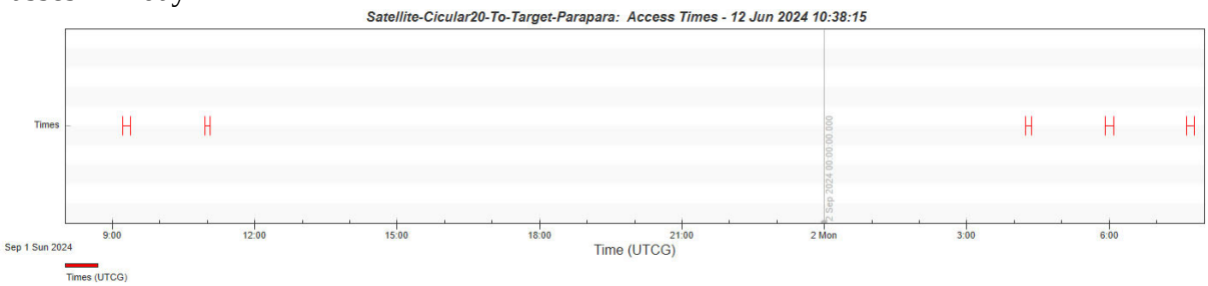

Figure 20: Passes of Circular20 over Parapara in 1 day

No. of passes: 5
Mean duration: 540.618 sec (approx. 9 mins)

Passes in 1 week

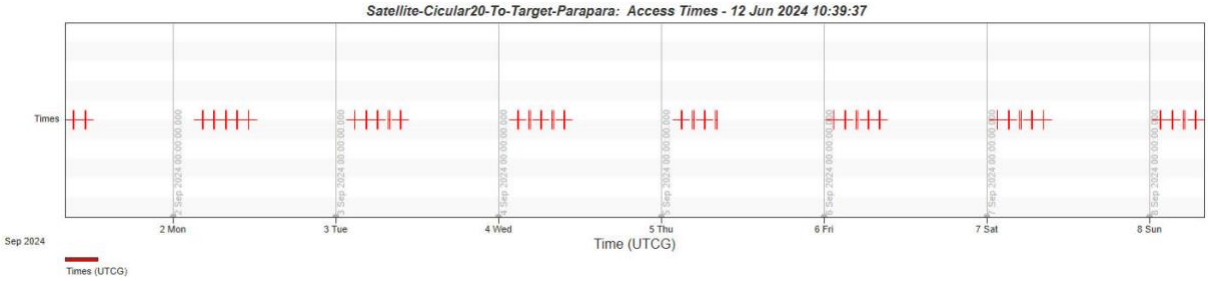

Figure 21: Passes of Circular20 over Parapara in 1 week

No. of passes = 35
Mean duration = 504.401 (approx. 8 mins)

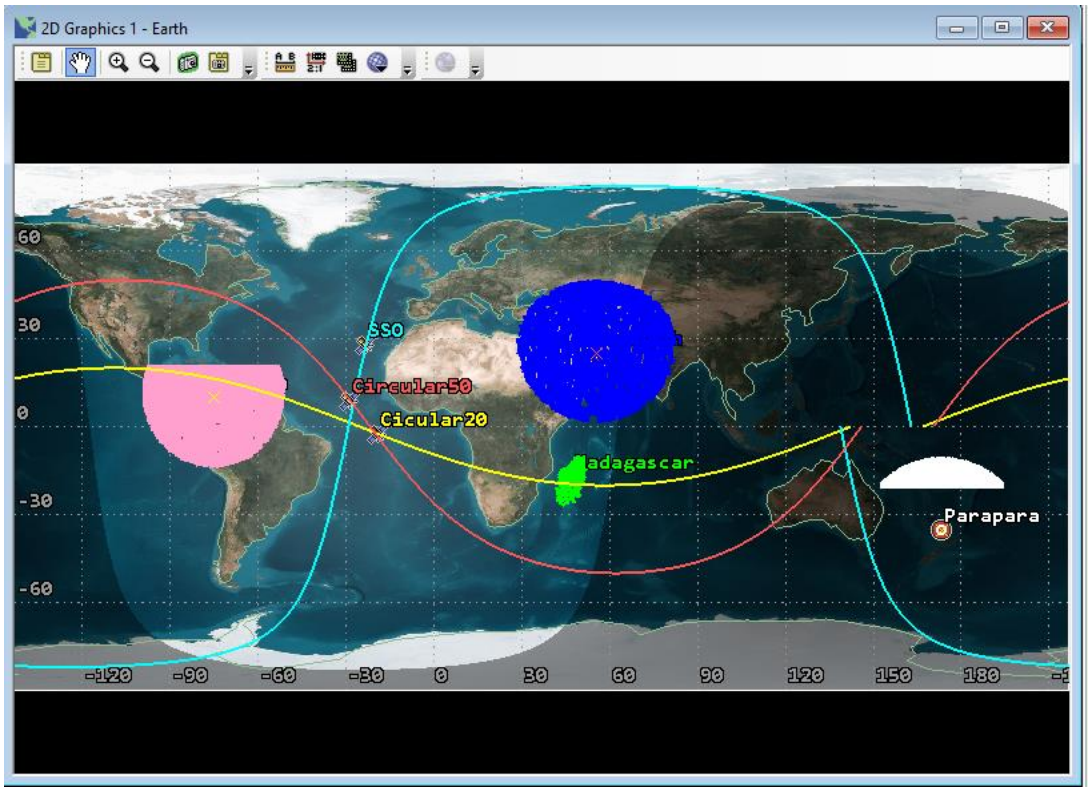

Figure 22: 2D Model of the passes of Circular20 over the ground stations

Conclusion

The GS suitable for the mission is Bogota. Bogota is located at a low latitude, close to the equator, making it suitable for an orbit with low inclination. The satellite passes over this GS 74 times in a week and stays in contact for an average of 12 minutes. The GS at Parapara is similar to the GS in Sharjah. Using multiple ground stations can be more reliable since we can download the images and send commands more frequently. In this case, the satellite is taking 20 pictures in a week and passes over the Sharjah GS 35 times a week. It would be helpful to have an extra GS to download these images. The extra ground station can also act as a backup ground station.