

Calculation of the transfer time of a photo by the CubeSat to the ground station

For this calculation, I will use two scenarios. They correspond to the maximum and minimum time required to transfer a photo to the ground station.

To simplify the calculations, I assume that a satellite cannot transmit data to the ground station until the first satellite has received its data packet.

****Scenario 1: Most favourable situation**

In this case:

- The 6 satellites had time to receive their packet. This step takes 1h55. This time has been calculated previously.
- The first satellite enters the transmission window when it has just received its packet.
- The first satellite has time to transmit its packet to the ground station. Because the transmission of a packet takes 7 min (460 s) and to browse the transmission window it takes 10 minutes.
- As the satellites follow each other by 10 minutes each of the 5 other satellites has time to transmit its single packet: this step takes 50 minutes more.

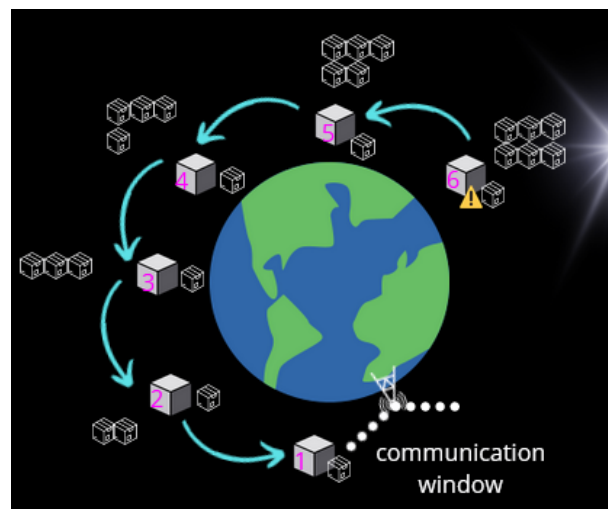


Fig. 1 - Schematic of data packet transfer in scenario n°1

The total time calculation for this scenario is therefore:

Total time = 1 hour and 55 minutes of satellite transfer + 60 minutes for ground transfer: a total of 2 hours and 55 minutes.

In this scenario, I calculated that the satellite network takes 2h45 minutes to take a picture and transmit it to the ground station.

****Scenario 2: Worst case scenario****

The first satellite exits the ground communication window before receiving its data packet.

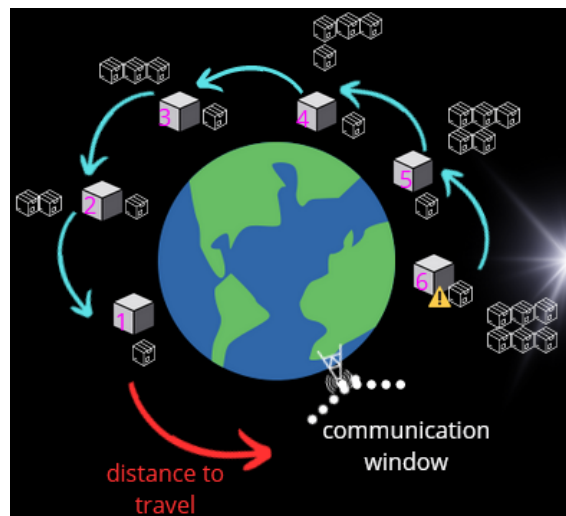


Fig. 2 - Schematic of data packet transfer in scenario n°2

In this case:

- The first satellite exits the ground communication window before receiving its data packet. It is therefore necessary to wait for it to travel through its orbit until it has entered the transmission window again.
- When the first satellite enters the transmission window, it transmits its packet to the ground station in 10 minutes.
- As the 5 satellites follow each other by 10 minutes in 10 minutes. Each satellite has time to transmit its packet: this step takes 50 minutes.

To calculate the transmission time I must first do the following calculations:

a/ As before the packet transfer time between CubeSat is 1 hour and 55 minutes (= 6900s/ 3600s).

b/ Calculation of the orbit of satellites:

Data for this calculation:

- Radius of the Earth 6371 Km
- Height of low orbit from the ground: 160 Km
- Perimeter formula $P = 2 \pi r$ (Earth radius + orbit height)
So $P = 2 \times 3.141593 \times (6371 + 160) = 40107 \text{ Km}$

The perimeter of the orbit of the satellite is 40107 Km.

c/ Calculation of the time taken by the first satellite before entering the transmission window:

Data for this calculation:

- Orbit Perimeter: 40107 Km
- Length of transmission window 4400 Km
- Satellite speed: 7.4 Km/s
- Formula to use: Time = distance / speed

Time to orbit $T = (40107 - 4400) / 7.4 = 4825 \text{ s}$

So 1 h 20 minutes

d/ Calculation of transmission time from photo to ground station:

As in the previous scenario, the transmission time is 60 minutes.

e/ Calculation of the total time between taking the photo and transmitting it to the ground station:

Data for this calculation:

- Packet transfer time between CubeSat: 1 hour and 55 minutes
- Time for the first satellite to enter the transmission window: 0120
- Transmission time to ground station: 1h (=60 minutes).

Total process time = 1h20 + 1h55 + 1h = 4 h 15

So in this second scenario, the time elapsed between taking the photo and transmitting it to the ground, is 4:15 minutes.

So between these two scenarios there is a difference of 1h20 minutes.