Interdisciplinary Space Master, ISM20

GNSS reflectometry using a 1.5U CubeSat

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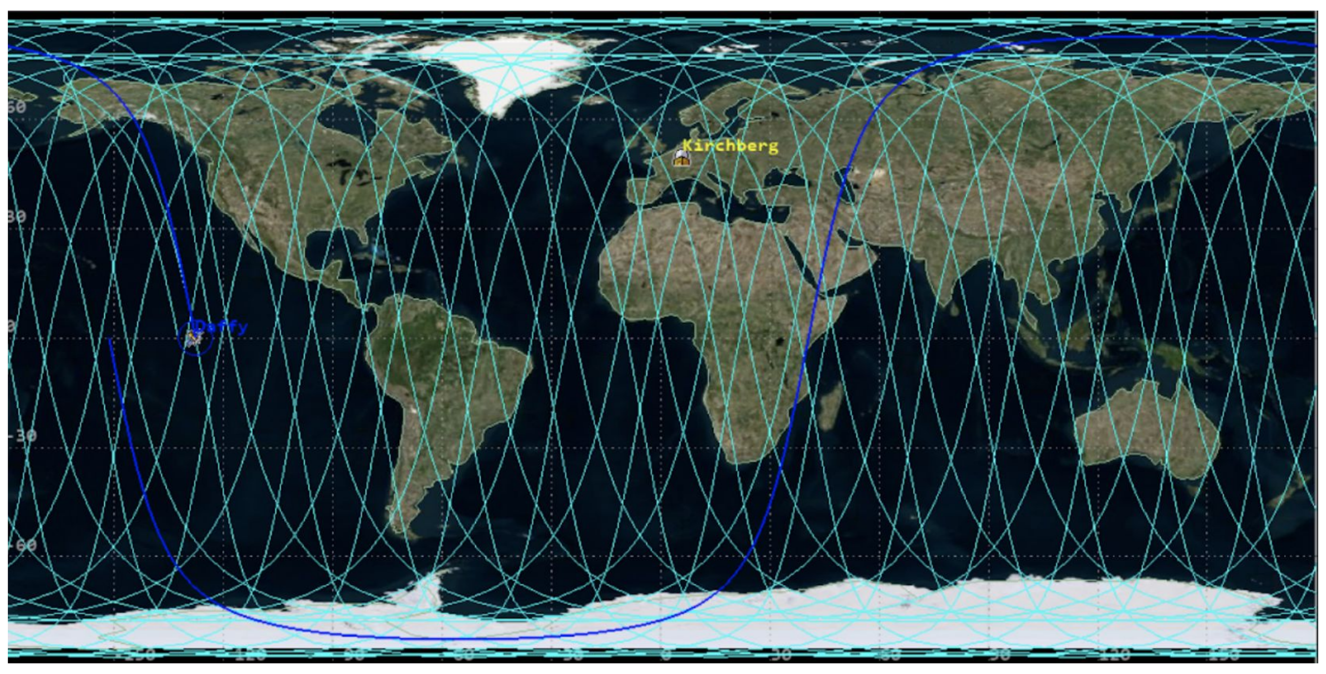
Introduction

- The DAFFODIL mission was conceived as a follow-up to the GOLDCREST GNSS reflectometry (GNSS-R) mission. The mission was to map landlocked water bodies greater than 300 km^2 between latitudes 23.3° N and 66.3° N, using a GNSS-R payload from Low Earth Orbit (LEO) with a CubeSat.
- The purpose was to demonstrate the feasibility of such a mission.

Mission requirements

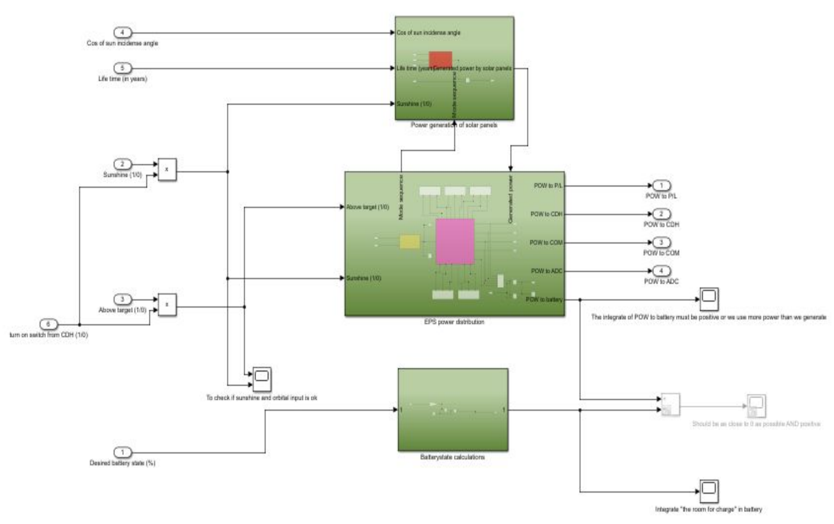
- The maximum size of the CubeSat is 1.5U.
- The payload is a GNSS-R solution.
- Orbit is 10:30 LTAN/LTDN in LEO (400-600 km).
- Mission control and ground station is based in Luxembourg (uni.lu SnT Kirchberg campus, Luxembourg City).
- AGI STK simulation tool was used to define the exact parameters of the mission regarding power generation capabilities and communications.



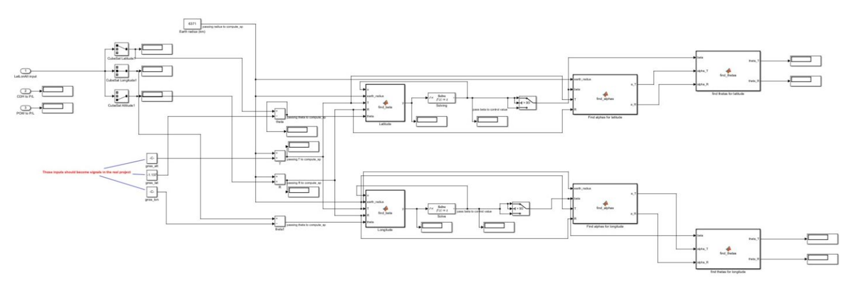
Mission design with a CubeSat Simulator

- Subsystems were designed separately using Matlab Simulink.
- Simulink's CubeSat Simulator was used as the frame to integrate all subsystems into a single mission simulator.
- DAFFODIL is to position itself for ideal power generation when nadir-pointing is not necessary. This allows a battery surcharge, used up during payload functions in eclipse.
- Communications are to occur during daytime to ensure a balanced power budget. [2]
- Specular point location calculated based on [1].
- Downlink trade-off in favor of: S-band instead of UHF (with additional GS in Quebec, Canada) due to optimal data/energy ratio [3] :
  - UHF : 3x10^8 $bits$ / 8203 s x 4.3W = 8.5 bit/J
  - S-Band : 3x10^8 $bits$/80 s x 5.5W = 681 bit/J

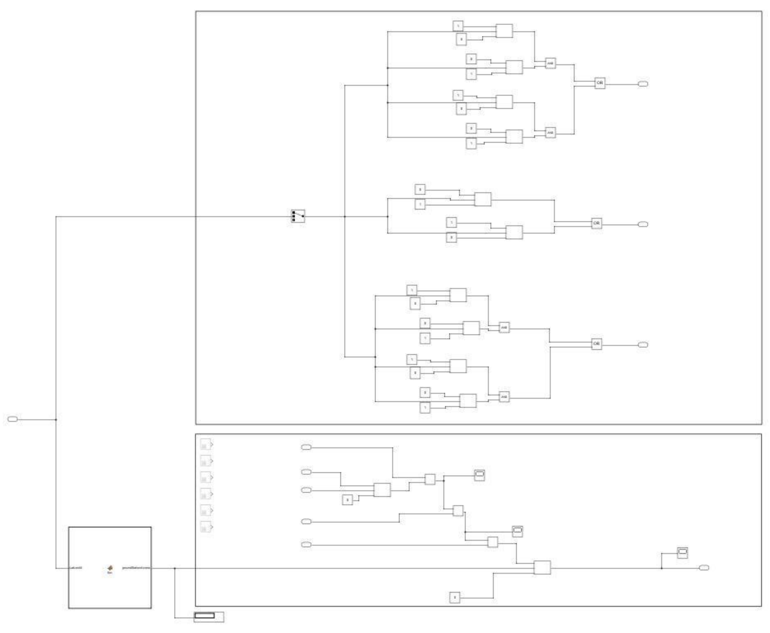
Power



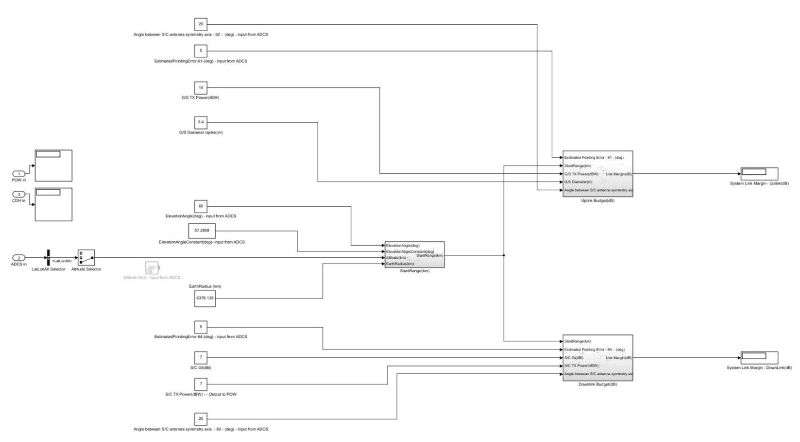
Payload



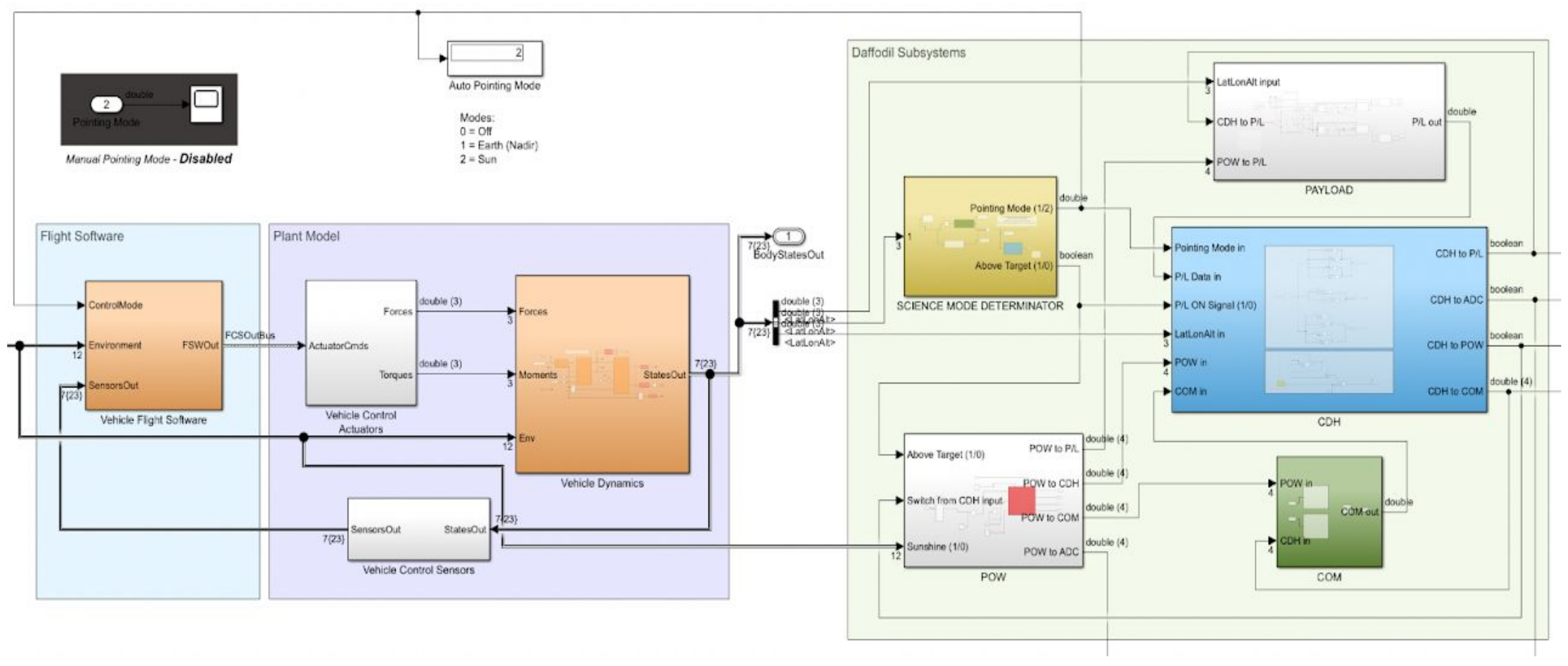
Data handling



Communications

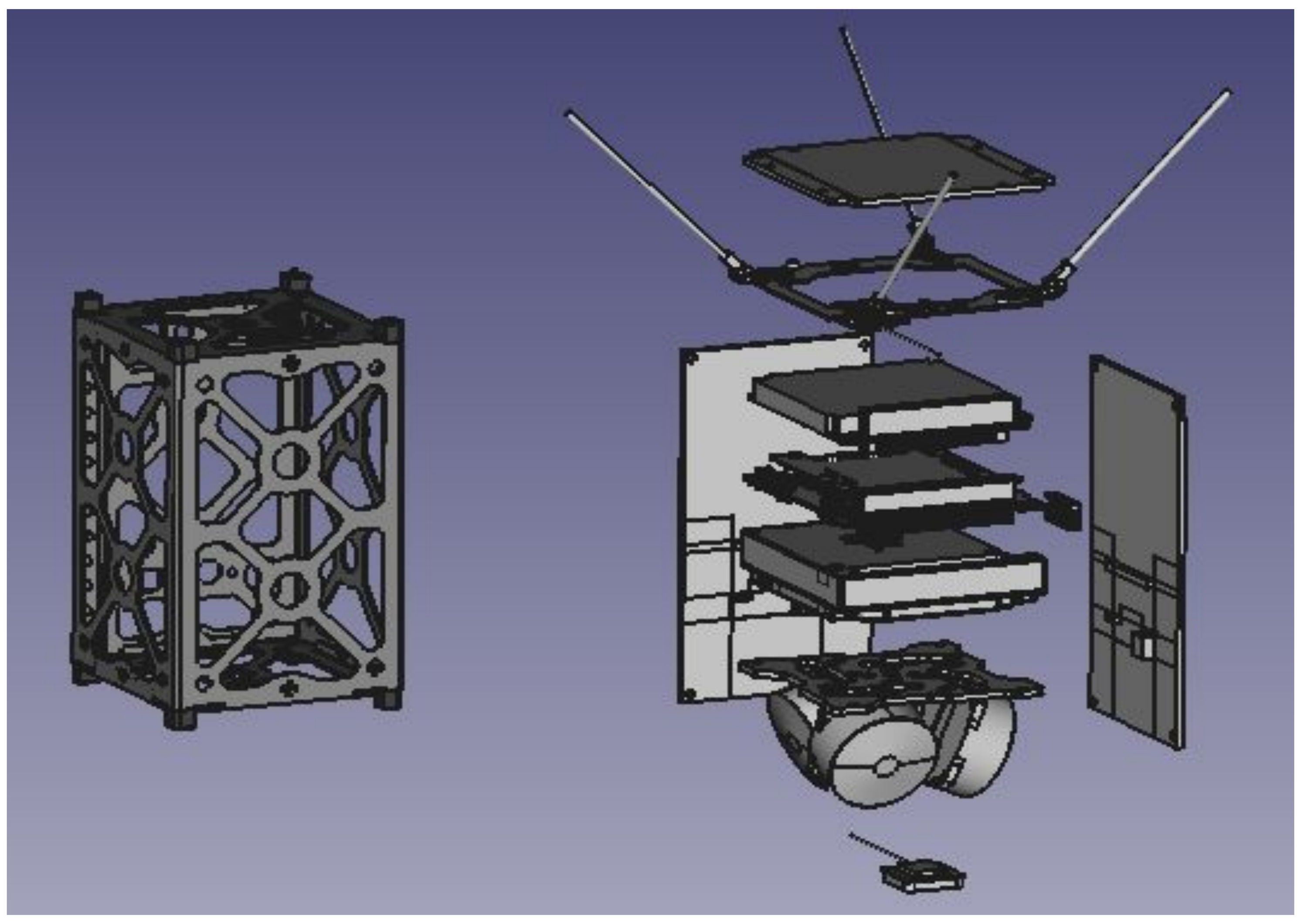


INTEGRATED SIMULATOR



Hardware design with CAD

- Multiple hardware options were considered to conduct a trade-off evaluation of possible sub-system designs.
- Hardware and design optimization were conducted using concurrent engineering approaches.
- CubeSat hardware design was verified using the official CAD data for off-the-shelf components.
- Final design was verified using the tool FreeCAD.



References

[1] Southwell, Benjamin & Dempster, Andrew. (2018). A New Approach to Determine the Specular Point of Forward Reflected GNSS Signals. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. PP. 1-8. 10.1109/JSTARS.2017.2775647

[2] Cappelletti Ch., Battistini S., Malphrus B. K. (Editors) (2020), "Cubesat Handbook: From mission design to operations", Academic Press (Elsevier)

[3] Wertz J. R., Larson W. J. (Editors) (1999), "Space Mission Analysis and Design (SMAD)", 3rd Ed.

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