INSPIRESat-1: Introduction and Feasibility Study for a CubeSat Mission for Middle and Upper Atmosphere Wind and Temperature Observations

Jih-Chin Lai1, Loren Chang1, Jack C. Wang1, Cornelius Caesar Jude H. Salinas1, Jia-Yu Su1, Joe Hong1, Yi-Chung Chiu1, Cuan-Wen Chen2, Pei-Yun Chi2, Duany Y1, Ya-Chih Mao1, Pei-Ting Kao1, Bing-Hao Tsai1, Tsung-En Beng1, Anmal Chandran1, Michael McGrath2, Larry L. Gordley2, David C. Frizz3, Steven C.R. Chen4

1Institute of Space Science, National Central University, Taoyuan, Taiwan, 2Laboratory for Atmospheric and Space Science, Colorado State University, Colorado, Boulder, USA, 3GATS Inc, Boulder, USA, 4National Space Organization, Hsinchu, Taiwan

Abstract

Spanning from the altitude range from 20 – 1000 km, middle and upper atmosphere is the region that significantly important to understanding the atmosphere as a whole. The winds and temperature in this region have important implications both for the Low Earth Orbit space environment, as well as understanding vertical coupling process. However, existing satellite measurements of this region are limited in terms of their spatial and temporal coverage. Therefore, compact sounding payload that may be deployed using small satellites satisfying the payload requirements are needed.

As part of International Satellite Program in Research and Education (INSPIRE), we present a report over the feasibility of utilizing a CubeSat mission carrying the Doppler Wind and Temperature Sounder (DWTSS) instrument, which is being co-developed by CDH, GATS and Brandwine Photonics. The report highlights on the analysis, preliminary design, and requirements imposed on all the subsystems for the INSPIRE-1 mission, as determined by NCU students and in collaboration with Taiwan’s National Space Organization (NSPO).

INTRODUCTION

INSPIRE is a multinational-cooperative program to develop constellation of small satellites for cutting edge space and earth science research, a supporting global ground station network, as well as research and educational programs covering spacecraft design, space systems engineering, operations, and data analysis.

INSPIRESat-1 and Mission:

INSPIRESat-1 is a 6U CubeSat carrying the Doppler Wind and Temperature Sounder (DWTSS) payload. The mission goal is to demonstrate the capability of measuring winds and temperature in the middle and upper atmosphere, 20 – 200 km.

Object of this study: Determine whether such requirements can be met using COTS – Commercial Off The Shelf components.

Doppler Wind and Temperature Sounder (DWTSS)

DWTSS is a radiometer payload concept developed and patented by the U.S. aerospace firm GATS inc [Gordley and Marshall, 2011; Gordley et al., 2013]. It is capable of providing continuous daytime and nighttime measurements of winds and temperatures across a vertical range of 25-200km. DWTSS utilizes an infrared camera to measure Doppler shifts and widths of N(0, 3µm) and CO2 emission spectra by passing on cell filter.

INSPIRE-SAT SYSTEM DEFINITION, FEASIBILITY, AND PRELIMINARY DESIGN

The subsystem requirements of an 800 km low Earth orbit (LEO) mission can generally be met using COTS – Commercial Off The Shelf components.

Orbit and Navigation (ORB/NAV)

- 24 hours solar local time coverage
- 1207.2 cm² solar panel surface area
- 44 W power for the spacecraft
- Orbit: 350km circular, 65° inclination can survive at least 1 year with solar local time coverage in 45.16days.
- Navigation: continuous measurement of spacecraft position and velocity, GPS

ATTITUDE DETERMINATION AND CONTROL (ADCS)

- Meet the attitude requirement from DWTSS
- Solved FOV and eclipse problem

THERMAL CONTROL (ITC)

- Passive thermal control devices are required for some subsystems.
- Passive thermal control devices are required for some subsystems.

COMMUNICATION (COM)

- Link margin of 6 dB
- Download data rate 225 megabits/day
- VHF / UHF frequency bands

DATA RATE BUDGET

- Estimated : 20panels, 1207.2 cm² per panel
-大道: 12 V
- Batteries (1-sigma) for 2 axes (1-sigma) for 3 axes

PUBLICATION

- 1. Solar panel shall provide 44 W of power for the spacecraft.
- 2. 3.3V, 5V, 12V will be voltage provide to subsystems.
- 3. The EPS battery shall have a required capacity of at least 20 Wh.

SPE

- Power from solar panel
- Total power consumption
- 2019 APR

SUMMARY

Our feasibility study shows:
- The subsystem requirements of an 800 km low Earth orbit (LEO) mission can generally be met using COTS – Commercial Off The Shelf components, utilized with a 6U CubeSat bus.
- Key challenges identified include
- 1. Satisfying the spacecraft power requirements.
- 2. Satisfying the DWTSS operational pointing requirements.
- 3. Achieving proper thermal control to ensure that all components are within their operational temperature margins during the mission.

REFERENCES

4. CDH COTS option with highest power