DEVELOPMENT OF MYSat (1U CUBESAT): MISSION ANALYSIS AND DESIGN

AHMAD SHAQEER MOHAMED THAHEER

UNIVERSITI SAINS MALAYSIA

2017

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by

AHMAD SHAQEER MOHAMED THAHEER

Thesis submitted in fulfillment of the requirements for the degree of Master of Science

November 2017

ACKNOWLEDGEMENT

First and foremost, my most profound gratitude to Allah SWT for giving me the life and the opportunity to write this report. He gave me the power to believe in myself, and without His guidance, it will be a hard time for me to complete this report and may not finish within time.

I offer my sincere thankfulness to Dr. Norilmi Amilia Ismail as my supervisor for her sustained enthusiasm and efforts in helping me to understand the fundamental knowledge in Space Engineering as well as in life. Through her broad knowledge and experience, she has brought great values to me. She has the willingness in motivating me as well as sacrificing her time to explain any uncertainties and giving constructive comments.

I take immense pleasure to express my sincere and deep sense of appreciation to my co-supervisor, Dr. Norizham Abdul Razak, for his exemplary guidance throughout the project. I learned a lot from him about the structural analysis and analyzing the structural behavior, which I am sure, will be useful in the near future. I solemnly submit my honest and humble appreciation to him. I would like to include a special note of thanks to Mr. Mohd. Izmir Yamin from Independence-X Aerospace Sdn. Bhd. as he has been my utmost respect and role-model for sharing his knowledge, resources, and time.

Finally, yet importantly, I am eternally grateful to my beloved family, lecturers and friends for their unconditional love, encouragement, from both physical and emotional, and respects toward my decision in choosing aerospace engineering as my field of study. Although, they know the difficulties in the field in Malaysia, yet they are selfless and continue to support me.

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LIST OF SYMBOLS

a	Semi-major axis
A	Cross-sectional area
A_0	Total radiating surface area
A_{FP}	Footprint area
A_{sa}	Solar array area
β	Beta angle
$B*$	Adjusted value of BC
BC, BN	Ballistic coefficient
$BW_{Helical}$	Helical antenna beamwidth
c	Speed of light in a vacuum, i.e., 3×10^8 ms^{-1}
C_D	Drag coefficient
C_r	Battery capacity
δ	Minimum communication elevation
d	Magnitude of center of gravity
DOD	Percentage of depth-of-discharge
ε_0	Surface emissivity of the satellite
e	Eccentricity
E	Material modulus of elasticity
$EIRP$	Effective isotropic radiated power
$\frac{E_b}{N_0}$	Ratio of received energy-per-bit to noise-density
f	Transmitter or receiver frequency
g	Gravitational load, i.e., 9.81 ms^{-2}

G_R	Receiver Gain
G_T	Transmitted Gain
G_{Dipole}	Antenna Gain
$G_{Helical}$	Helical antenna gain
$\frac{G}{T}$	Figure-of-Merit
h	Satellite's altitude
i	Inclination
I_d	Inherent degradation of a solar array
I_{COG}	Inertia Tensor
ISL	Isotropic signal level
λ	Nadir angle between satellite and ground station
λ	Wavelength
l	Helical structure turns spacing
L	Helical circumference
L_a	Atmospheric loss
L_i	Ionospheric loss
L_l	Line loss
L_{FP}	Footprint length
L_P	Path loss
L_R	Rain loss
$L_{\mathrm{Implementation}}$	Implementation loss
$L_{Pointing}$	Pointing loss
$L_{Polarization}$	Polarization loss
m	Structural mass
η_0	Satellite's material absorptivity

n	Load factor
n	Load transmission efficiency
n	Number of turns of the helical structure
N	Number of batteries
ρ_0	Atmospheric referenced density
P	Applied load
P	Total orbital period
P_0	Ideal solar cell output
P_e	Power required during an eclipse
P_d	Power required during a daylight
P_i	Solar illumination intensity, i.e., 1368 W/m^2
P_T	Transmitted power
P_{BOL}	Power at beginning-of-life
P_{EOL}	Power at end-of-life
Q_{Abs}	Portion of absorbed incoming radiation by the material, independent of the incident angle of the radiation
Q_{Dis}	Radiation converted into heat energy because of some electrical or mechanical operations
Q_{Emit}	Fraction of energy emitted relative to an ideal blackbody at the same temperature
Q_{ER}	Power due to sunlight reflected from the earth
Q_i	Power from the heat produced inside the satellite
Q_{IR}	Radiant infrared power emitted from the earth due to its temperature
Q_{Sun}	Direct thermal power from the sun
R_E	Earth radius
$R_{Available}$	Available downlink rate

$R_{Transmitted}$	Transmitted downlink rate
σ	Boltzmann constant, i.e., -228.6 dBW/K Hz^{-1}
σ_{Avg}	Average stress
σ_B	Stefan-Boltzmann constant, i.e., 5.67×10^{-8} Wm^{-2}K^{-4}
S	Path length or slant range
SF	Safety factor
$\frac{S}{N_0}$	Signal-to-noise ratio
θ	Angle measured between satellite-sun vector and a vector normal to the solar array
θ	Cone angle
θ	True anomaly
Ω	Right ascension of the ascending node (RAAN)
T_0	Average external temperature
T_d	Daylight period
T_e	Eclipse period
T_S	System noise temperature
$T_{BetweenContacts}$	Time between access
$T_{Contacts}$	Contact time
ω	Argument of perigee
$x_{COG}, y_{COG}, z_{COG}$	Centre of gravity on all three axes
X_d	Power regulation efficiency during a daylight
X_e	Power regulation efficiency during an eclipse

LIST OF ABBREVIATIONS

AdvCAT	Advanced Conjunction Analysis Toolkit
AGI	Analytical Graphics, Inc.
AMSAT	Radio Amateur Satellite Corporation
BOL	Beginning-of-Life
CAD	Computer-aided Design
CMOS	Complementary metal–oxide–semiconductor
COG	Center of Gravity
COTS	Commercial-off-the-shelf
CRRES	Combined Release and Radiation Effects Satellite
CSS	CUTE Separation System
CSSI	Center for Space Standards and Innovation
DAS	Debris Assessment Software
DET	Direct Energy Transfer
DC	Direct Current
DOD	Depth-of-Discharge
DSS	Dassault Systèmes
EOL	End-of-Life
FE	Finite Element
FOV	Field of view
GaAs	Gallium-Arsenide
GEO	Geostationary Orbit
GEVS	General Environmental Verification Standard

GMAT	General Mission Analysis Tool
GMSK	Gaussian Minimum Shift Keying
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HPOP	High-Precision Orbit Propagator
IARU	International Amateur Radio Union
InP	Indium Phosphide
IR	Infrared
ISIPOD	ISIS Payload Orbital Dispenser
ISIS	Innovative Solutions in Space, BV
ITU	International Telecommunication Union
JEM	Japanese Experimental Module
J-POD	JAXA-Picosatellite Orbital Deployer
J-SSOD	JEM Small Satellite Orbital Deployer
LEO	Low Earth Orbit
MJ	Multi-Junction
MSC	MacNeal-Schwendler Corporation
NOAA	National Oceanic and Atmospheric Administration
NPS	Naval Postgraduate School
NRCSD	NanoRacks CubeSat Deployer
NRLMSISE	US Naval Research Laboratory Mass Spectrometer and Scatter - Exosphere
OPAL	Orbiting Automated Picosat Launcher
PCB	Printed Circuit Board
P-POD	Poly Picosatellite Orbital Deployer

PPT	Peak Power Tracking
PSD	Power Spectral Density
RAAN	Right Ascension of Ascending Node
RIC	Radial, In-Track, and Cross
ROKAFA	Republic of Korea Air Force Academy
SAA	South Atlantic Anomaly
SALT	Semi-Analytical Liu Theory
SEET	Space Environment and Effects Tool
SGP4	Simplified General Perturbations No. 4
Si	Silicon
SJ	Single-Junction
SMAD	Space Mission Analysis and Design
SPL	Single Picosatellite Launcher
SSDL	Space Systems Development Laboratory
STK	Systems Tool Kit
TEC	Total Electron Content
TeNeP	Temperature and Electron Density Probe
TLE	Two-Line Element
T-POD	Tokyo Picosatellite Orbital Deployer
TSA	Thin Sheet Amorphous
TT&C	Telemetry, Tracking, and Command
U	Unit
UTJ	Ultra-Triple Junction
UV	Ultra Violet
XPOD	eXperimental Push Out Deployer

PEMBANGUNAN MYSat (1U CUBESAT):

ANALISIS MISI DAN REKABENTUK

ABSTRAK

Platform angkasa berkos rendah diperlukan untuk mengukur ketumpatan elektron di ruang Ionosfera untuk membuktikan hubungan anomali bumi dan perubahan ketumpatan elektron. Kaedah pengukuran terdahulu dilakukan menggunakan satelit traditional yg sangat mahal dan bersaiz besar. Namun, pembangunan satelit adalah rumit kerana komponen dipilih perlu optimal dan dilaksanakan untuk misi itu. Analisis reka bentuk awal dilakukan untuk menentukan keperluan sesuai untuk misi dan setiap subsistem. Oleh itu, kajian ini membentangkan analisis misi dan reka bentuk struktur dan analisis 1U Satelit Kiub dinamakan MYSat.

MYSat dijangka dilancarkan menggunakan JEM Small Satellite Orbital Deployer (J-SSOD) di Stesen Angkasa Antarabangsa (ISS) dengan misi mengukur ketumpatan elektron di Ionosfera. Kajian bermula dengan definisi misi melalui menyenaraikan objektif dan keperluan misi dan subsistem. Seterusnya, analisis orbit MYSat dilakukan mengunakan perisian Systems Tool Kit (STK) untuk mengira jangka hayat orbit. Simulasi ini juga dilakukan untuk menentukan masa pengcahayaan dan jejak bumi MYSat. Hasil simulasi dan konsep operasi itu dimasukkan ke keperluan subsistem dan bajet awal subsistem dikira. Struktur MYSat juga direka dan analisis struktur dilakukan mengunakan perisian ANSYS.

MYSat akan mengorbit pada altitud 400 km dengan jangkaan hayat 1 ke 1.3 tahun. Ia tidak mempunyai kawalan tingkah laku dan dilengkapi dengan sistem kawalan therma pasif. Jaringan komunikasi menggunakan Penerima Frekuensi Sangat

Tinggi (VHF) (114-146 MHz), dan Pemancar Frekuensi Ultra Tinggi (UHF) (435-438 MHz) dengan kuasa pancaran terhad kepada 1.5 W. Sel solar GaAs (UTJ) digunakan untuk penjanaan kuasa dilengkapi bateri Li-ion. Semua subsistem termasuk unit sains Prob Suhu dan Ketumpatan Elecktron (TeNeP) telah diintegrasikan ke dalam struktur bersaiz 10×10×11.35 cm dengan berat maksimum 1.30 kg. Hasil kajian menunjukan rekaan dibangunkan boleh dilaksanakan dan beroperasi dengan cekap menggunakan kuasa dan berat tersedia. Hasil analisis struktur menunjukkan purata tekanan di alami oleh MYSat adalah di bawah kekuatan akhir bahan itu. Oleh itu, struktur itu mampu menampung keadaan tekanan yang melampau. Analisis itu juga menunjukkan nombor ballistik dan frekuensi semula jadi MYSat mengikut kehendak system pelancaran J-SSOD.

Kaedah yang digunakan adalah berkesan dalam menganggar keputusan awal, tetapi sekumpulan ahli pakar disyorkan untuk projek ini kerana ia melibatkan bidang berlainan; Oleh itu, analisis yang lebih terperinci dapat dilakukan untuk meningkatkan pembangunan MYSat untuk misi untuk berjaya.

Kata Kunci-komponen; satelit kiub; reka bentuk; elektron; MYSat; nanosatelit; kuasa.