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*Editorial*

# CubeSats and Small Satellites

**Jeremy Straub ,[1] Michael Swartwout,[2] Miguel Nunes,[3] and Vaios Lappas[4]**

[1]*Department of Computer Science, North Dakota State University, Fargo, ND 58108, USA*
[2]*School of Engineering, Saint Louis University, Saint Louis, MO 63103, USA*
[3]*Hawaii Space Flight Laboratory, University of Hawaii at Manoa, Honolulu, HI 96822, USA*
[4]*Department of Mechanical Engineering and Aeronautics, University of Patras, Patras 26504, Greece*

Correspondence should be addressed to Jeremy Straub; jeremy.straub@ndsu.edu

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## 1. Introduction

CubeSats and other small satellites have advanced from being perceived as toys and only suitable for educational purposes to robust platforms for conducting space missions. They have been used for commercial [1, 2] and government and military [3, 4] purposes, in addition to bona fide science [5, 6] and educational purposes [7, 8]. Constellations of small satellites are currently being deployed for imaging and other data collection purposes. Small satellites have also served as testbeds for numerous innovative concepts, mitigating risk and preparing them for prospective use in other space missions.

With the incredible growth in a small spacecraft—and the proximal launch of the 1,000th CubeSat [9], there are still numerous logistical and technical considerations that need to be explored. The discipline is still quite young as well: questions of nomenclature [10], licensing, deorbiting, and producing orbital debris abound. Some look at small satellites as harbingers of a new space age; others—perhaps—are more concerned with the potential that they may harm a more expensive spacecraft.

## 2. The Special Issue

In this environment, we are excited to present the journal's first special issue devoted to CubeSats and small spacecraft. With 18 papers, this special issue is the largest to date for the journal and approximately double the size of the next largest special issue. These papers are, of course, only a fraction of the total number of papers actually submitted for consideration.

We thank all of the authors who submitted their work for consideration. Also absolutely critical in this process are the reviewers who provided their feedback to editors on acceptance decisions and, more importantly, to the authors on how to improve their work.

Herein, we have papers spanning the small satellite ecosystem. They come from all over the world, including Italy, Greece, the United States, Pakistan, Ukraine, South Korea, Finland, Spain, Brazil, and China, showing the truly global enterprise that "small space" now is. They range from a review of the growing number of small satellites to mission design articles to articles on particular subsystems. We even have an article on forensic analysis of the failure of a small satellite mission.

## 3. Articles

The article "High-Resolution Image and Video CubeSat (HiREV): Development of Space Technology Test Platform Using a Low-Cost CubeSat Platform" discusses a spacecraft developed by the Korea Aerospace Research Institute to help grow the local small satellite ecosystem. This 6-U spacecraft will collect videos and still images and demonstrate technical capabilities.

The article "Satellite Forensics: Analysing Sparse Beacon Data to Reveal the Fate of DTUsat-2" discusses what to do when things go wrong with a satellite. The satellite was initially created to track birds; however, the team that developed it ended up having to track down the faults that caused it to operate abnormally. Their work provides a prospective model for others who may experience a similar situation in the future.

The article “Attitude Analysis of Small Satellites Using Model-Based Simulation” discusses the creation of a software tool for simulating forces acting on a satellite in low-Earth orbit. This tool is designed to help those trying to create attitude determination and control systems.

The article “Modular Design of RF Front End for a Nanosatellite Communication Subsystem Tile Using Low-Cost Commercial Components” describes a modular radio for satellite communications and the technical innovations that were required to enable it. Based on lower-cost commercial components, the concept may have the potential to reduce mission costs for other future missions.

The article “Thermal Design of Large-Power Focal Plane Components for a Microsatellite Based on Pyrolytic Graphite Sheet” presents work on solving a heat dissipation problem that is faced by small satellites trying to collect high-resolution visual sensing data. It proposes the use of a Pyrolytic Graphite Sheet and associated design to aid in thermal control.

The article “Self-Compensation for Disturbances in Differential Vibratory Gyroscope for Space Navigation” presents a new concept for a differential mode of gyroscope operation. This approach appears to be more robust to the shocks and forces endemic to space missions during launch and other phases.

The article “AOCS Requirements and Practical Limitations for High-Speed Communications on Small Satellites” discusses the communication limitations and requirements of small spacecraft. In particular, the authors present information that should be helpful to future missions in defining their pointing accuracy and power budget requirements as well as for communication band selection.

The article “Data Analysis and Results of the Radiation-Tolerant Collaborative Computer On-Board OPTOS CubeSat” presents a proposed solution to the need for growing computational capabilities of onboard spacecraft. It presents the “OPTOS On-Board Computer” which implemented techniques designed to increase robustness to radiation, despite the limitations of the hardware utilized. The authors analyse the performance of this computer over the term of a three-year mission.

The article “A Spherical Micro Satellite Design and Detection Method for Upper Atmospheric Density Estimation” proposes a spacecraft which differs from the box-shape design that is common among small spacecraft. The proposed spherical satellite as well as its atmospheric science mission is detailed and analysed in this paper.

The article “A Heuristic Genetic Algorithm for Regional Targets’ Small Satellite Image Downlink Scheduling Problem” also deals with the communication problem, from a software perspective. The authors propose an algorithm to help with downlink scheduling that is based on benefit maximization.

The article “Towards the Thousandth CubeSat: A Statistical Overview” provides a look back at the CubeSat missions that have gone before and analyses their successes and failures. It notes that CubeSat missions have an improving success rate over time and presents some projections about future missions and growth.

The article “Design and Implementation of 3U CubeSat Platform Architecture” presents a satellite bus developed for the KAUSAT-5 mission. An optimized mechanical design as well as electrical subsystems and other components is presented. The authors note that the design has demonstrated suitable vibration test robustness and thermal capabilities to be useful to others for future use.

The article, “Design of Modular Power Management and Attitude Control Subsystems for a Microsatellite” discusses the development of component subsystems for power and attitude control. Analysis related to component modularity, redundancy, efficiency, and suitability for the space radiation environment is included.

The article “Path Formation Time in the Noise-Limited Fractionated Spacecraft Network with FDMA” discusses communications in a “fractionated spacecraft network.” The time required to identify and form paths is considered under a model where frequency division multiple access and binary phase-shift keying modulation are used. The authors discuss the impact of their analysis on orbit design.

The article “Antenna Configuration Method for RF Measurement Based on DOPs in Satellite Formation Flying” considers the navigation and positional awareness needs of formation space missions. Recommendations for antenna design are presented as are suggestions for improving accuracy. A “dilution of precision” metric is also proposed, and the use of a genetic algorithm for design purposes is discussed.

The article “Allocation Optimization Strategy for High-Precision Control of Picosatellites and Nanosatellites” proposes a control approach for spacecraft using “solid propellant microthruster array” hardware. An algorithm for increasing precision and reducing energy use is proposed and analysed.

The article “Design, Analysis, Optimization, Manufacturing, and Testing of a 2U Cubesat” covers the design and testing of Greece’s first CubeSat. The structural rigidity and mass required to achieve it are assessed.

Finally, the article “Design and Numerical Validation of an Algorithm for the Detumbling and Angular Rate Determination of a CubeSat Using Only Three-Axis Magnetometer Data” proposes a detumbling and angular rate calculation algorithm for a spacecraft with only a magnetometer onboard. This algorithm is analysed and demonstrated to work across multiple deployment scenarios and to support multiple different hardware configurations.

## Conflicts of Interest

The guest editors declare that there is no conflict of interest regarding the publication of this special issue.

*Jeremy Straub*
*Michael Swartwout*
*Miguel Nunes*
*Vaios Lappas*

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