Design Analysis of a New On-Board Computer for the LAICAnSat Platform

DE MELO, Ana Carolina Cabral Pimentel, GUIMARAES, Fernando Cardoso, HONDA, Yago Henrique Melo, BORGES, Renato Alves, HADDAD, Sandro Augusto Pavlik, BATTISTINI, Simone <http://orcid.org/0000-0002-0491-0226> and CAPPELLETTI, Chantal

Design Analysis of a New On-Board Computer for the LAICAnSat Platform

Ana C. C. P. de Melo, Fernando C. Guimarães, Yago H. M. Honda, Renato A. Borges
Department of Electrical Engineering
University of Brasília
Brasília, DF - Brazil 70310-900
+55 61 31071040
ana.cpmelo95@gmail.com, fernando3guimaraes@gmail.com,
yagohonda11@gmail.com, raborges@ene.unb.br

Sandro A. P. Haddad, Simone Battistini
Faculdade Gama
University of Brasília
Gama, DF - Brazil 72444-240
+55 61 31078901
sandrohaddad@unb.br
simone.battistini@aerospace.unb.br

Chantal Cappelletti
Department of Mechanical Materials and Manufacturing Engineering
The University of Nottingham
University Park, Nottingham - NG7 2RD
+44 01157486848
chantal.cappelletti@nottingham.ac.uk *

September 6, 2019

Abstract

The present work describes the new requirements for LAICAnSat project, a high altitude platform (HAP) developed at University of Brasilia (UnB). An analysis of previous missions and a detailed comparison with respect to the previous OBC version is presented to assist with the design decision making. More specifically, a study of mission lifecycle is conducted to evaluate power consumption and a survey is carried out in order to estimate new power demands.

Contents

1 Introduction

Over the past few years, the Laboratory of Simulation and Control of Aerospace Systems at Univer-

*

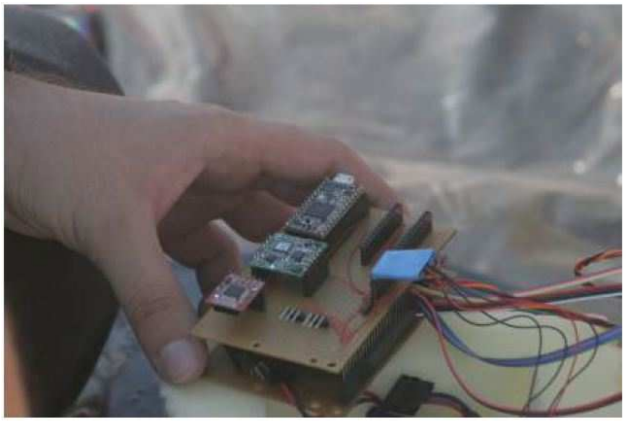

Figure 1: **First data acquisition system.**

Figure 2: **Total solar eclipse image obtained from stratosphere - NASA APOD on August 27th, 2018.**

sity of Brasilia (UnB), has been developing a project aimed at integrating students from several engineering fields, such as mechatronic, aerospace, electric and electronic. The main goal is to develop a low cost modular platform for high and low altitude applications such as remote sensing, telecommunications, scientific studies, and others. This platform, named LAICAnSat, is fabricated in accordance with the CubeSat standard [**?**] using rapid prototype technologies.

Preliminary project efforts originated a fairly unsophisticated electronic system, with components connected to a protoboard, arranged inside a styrofoam box [**?**], as can be seen in Fig. **??**. This system provided the realization of two successful first missions (LAICAnSat-1 and LAICAnSat-2), which leveraged researches and future developments in the project, including researches on trajectory control [**?**, **?**] and a restructuring to the CubeSat standard [**?**].

Evolution came with a printed circuit board [**?**], with the purpose of satisfying the minimum electronic system necessary for the accomplishment of the further four launches in 2017 (LAICAnSat-3, LAICAnSat-4, LAICAnSat-5 and LAICAnSat-5.1). The first ones were carried out to validate the system for the latter ones, which was concerned with the recording of the total solar eclipse from the stratosphere in 2017 by the NASA Space Grant Eclipse Ballooning Project [**?**]. Fig. **??** shows a picture of the shadow of the moon on the Earth surface obtained during the Kuaray mission.

The first LAICAnSat on-board computer consists of a GNSS module, pressure and humidity sensors that also provide temperature measurements, a MEMS Motion sensor and a 3D accelerometer and magnetometer. Data is stored on an SD card and a XBee transmitter assures communication with ground station. Its flowchart can be seen in Fig. **??**.

Based on the analyses of these previous missions, several aspects related with the system development and integration were identified in order to be improved. Although inspired by the PC104 standard, the board does not provide connections for external devices, making it impossible to connect necessary components, as well as to integrate other subsystems.

The microcontroller is an ARM Core M-4 replicated on a Teensy platform for educational purposes and it is going to be replaced for a processor with a more suitable development environment.

The transmitter used presented limitations in view of the new real-time control demands for the platform, so it was decided to make the communication system separate from the command and data acqui-

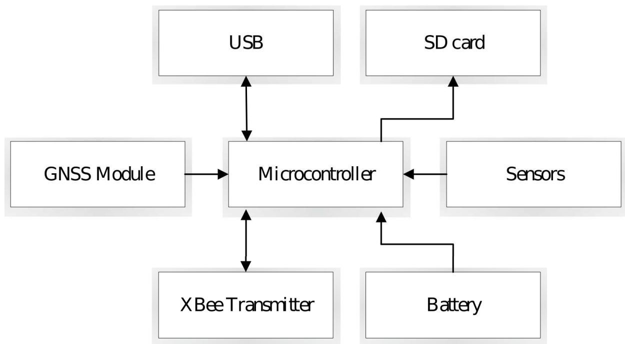

Figure 3: **OBC Flowchart.**

sition system.

A recurring problem during assembly of the system was the weight restriction, where the battery is largely responsible and its oversizing compromises full potential of the platform. In addition, the power supply was not well conditioned, including poor battery protections and lack of health monitoring.

In this context, given the limitations of the PCB board, one of the next steps is to redesign the on-board computer (OBC), aiming to improve its performance and meet the additional demands, such as image processing, flotation control and attitude stabilization.

During past missions, there was a need for a better definition of the requirements, since the lack of management and traceability had negative effects on the project schedule and budget. Within this context, a system engineering approach based on NASA Systems Engineering Handbook [**?**] and similar works [**?**, **?**, **?**] served as a guide to assign well-established requirements, in order to unfold the user needs elicitation into components and interfaces.

The methodology consists in a top-down description of the system, allowing mission needs, goals and objectives to be mapped correctly and facilitating a bottom-up development process. Primarily, the mission is defined in terms of objectives and external constraints are considered, such as size and weight, delimiting the boundary conditions. Thereafter, the concepts of operations (CONOPS) are defined, providing a better understanding of the behavior expected. Lastly, system requirements are defined and unraveled into components and interfaces.

Simultaneous to LAICAnSat activities, the team has been developing a nanosatellite three-axis simulator facility. The simulator main components are an air-bearing table and a Helmholtz cage [**?**]. The facility purpose consists in replicating the frictionless conditions encountered by satellites in space, besides the low gravitational torque and the Earth magnetic field perceived by them while in orbit. Therefore, the nanosatellite simulator allows the simulation, testing and validation of attitude determination and control algorithms, in addition to other spacecraft technologies.

At this facility, a commercial OBC provided by the Italian company Gauss Srl, named ABACUS, is used to test algorithms and CubeSat hardware, such as magnetorquers, reaction wheels and communication modules. It is of interest to design the new OBC capable of attending simulator demands to complement the use of the commercial one. Therefore, in this work a few tests were conducted with ABACUS and the air-bearing table to analyze the performance and power consumption of the microcontroller while running known attitude determination algorithms proposed in [**?**].

This paper is organized as follows, Section 2 describes the system as whole and its concepts of operations, used to raise the components required to accomplish the mission and its interfaces. Section 3 discusses tests conducted in the simulator to estimate some parameters of resolution and sampling rate of the sensors, as well as the analysis of the performance of the microcontroller. Section 4 presents the requirements summary and the last section concludes discussion and presents future works.

2 System Definition

The proposal is the development of a generic, modular and fully recoverable platform, to serve as technology demonstration in atmospheric balloon flights. To be generic and modular, the platform must adopt a CubeSat standard and be PC104 compatible, which establishes external constraints regarding to size (Units of 10cm cube), weight (1.33kg/Unit) and electrical connections. A flotation stage is being planned to ensure scientific operations at high altitude. Therefore, it is necessary to ensure the operation of electronic systems at extreme temperature and pressure variations. A pressure valve prototype is being developed in-house for this purpose and will be tested in the next mission. Furthermore, the platform is designed to autonomously land in safe areas by performing a landing control.

The platform requirements are summarized below:

(1) A Command and Data Handling Subsystem (CDH) to monitor health conditions, store data and manage communications;

(2) A Control Subsystem to perform flotation and landing control;

(3) A Navigation Subsystem to track location and determine orientation;

(5) A Telemetry and Telecommand System (TTS) to communicate with ground stations;

(6) A satellite bus to accommodate and communicate with other subsystems;

(7) A flight software to manage operations and communication between subsystems and ground station;

(8) A format to store data packages acquired from sensors and log informations;

(9) Ground station to receive data and transmit commands;

(10) The platform must be multiple of 10cm cube units (1U), with a mass budget of 1.33kg per unit.

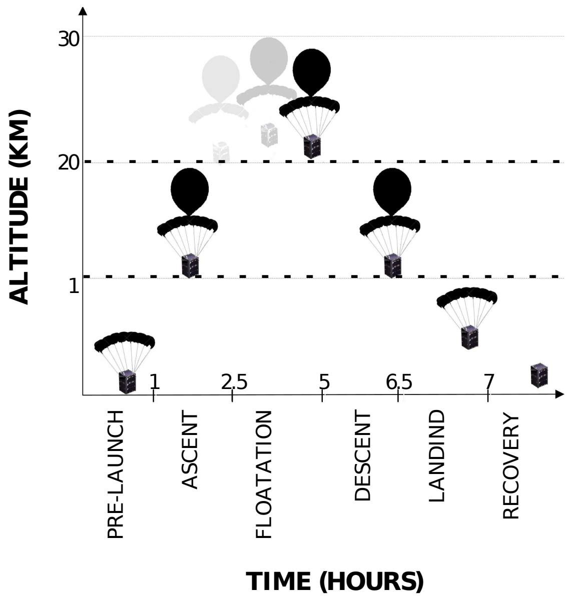

Figure 4: **Mission lifecycle**

2.1 Concepts of Operation

The life-cycle of the mission consists of six phases, as can be seen graphically in Fig. 4, named pre-launch phase, ascent and descent phases, floating, landing and recovery phases. The concepts of operation describe the behavior of the system and helps to characterize the life-cycle of the mission and its operations as a sequence of events, shown in flowchart of Fig. 5.

2.1.1 Pre-launch preparation phase

The ground station is constructed, and vehicles are prepared. The latter step of this stage is to initiate electronic systems and validate its operation.

Upon power-up, in the last step of first phase, all components are initiated, sensors are calibrated, interfaces are checked and storage starts. Communication with the ground station is tested by transmitting initialization data and a response request. When everything works properly, the platform is ready to be launched.

2.1.2 Ascent phase

During this phase, the balloon flies freely, without control of any kind. In this mode, nominal operations, which consists of characterizing internal environment and monitor health conditions, such as temperature, pressure and power consumption take place. These data are properly formatted and stored to be sent to ground station by request at any time or in case of emergency situations to warn operators. The location is constantly monitored and transmitted at different rates, depending on the phase of the mission. It is important to note that this task of monitoring health conditions, as well as capacity to respond to ground station commands, both shaded in gray in Fig. **??**, continuously run throughout the mission.

2.1.3 Flotation phase

Upon reaching 20 km, the operational phase starts, where the majority of missions are intended to be realized. The balloon is intended to float for approximately two and a half hours, performing altitude control through the pressure valve. The location must be transmitted at lower rates, housekeeping tasks are continuously running and images can be taken and stored;

2.1.4 Descent phase

After the float period, the pressure valve is now responsible for deflating the balloon to a safe altitude in order to the landing control to be performed. The location must be transmitted at high rates and normal operations are still running.

If at any time a state of emergency is detected, or if requested by the ground station, the platform with the parachute is released from the balloon and it will try to safely land on ground with using the parachute.

2.1.5 Landing phase

After reaching 1 km, the parachute is controlled towards a safe landing area within a set of possible areas. The location must be transmitted at high rates.

2.1.6 Recovery phase

Recovering the platform is often complicated, so the energy must be saved given that conditions may not be favorable and reaching the platform may take some time. Therefore, as the platform hits the ground, storage is closed and all unessential subsystems are power-down and the location is transmitted at lower rates.

3 Simulator Requirements

This section describes the results of the tests conducted on the air-bearing testbed in order to evaluate the table dynamics and microcontroller performance while running recognized attitude determination algorithms. At a minimum, at least an inertial measurement unit (IMU) is required for the attitude determination applications in the simulator.

In Fig. 6 the on-board computer used as a reference is mounted on the air-bearing table. This facility is described in more details in [**?**, **?**]. The computer is the ABACUS OBC and Fig. **??** shows the board in details. This device has been tested in several missions, including the Brazilian mission Serpens-1 [**?**].

Fig. **??** shows ABACUS mounted on the air-bearing table. Over ABACUS is placed a marker from the ArUco third party extension of OpenCV library [**?**]. Using a web camera and the marker, the attitude of the table was determined by computer vision software using the Euler angles representation. With the results it is possible to obtain boundaries for sensors resolution and sampling time.

Fig. **??** depicts the yaw angle *versus* time obtained in the first test. In this first experiment, the table was put into motion mainly about the Z axis and at the maximum speed allowable, considering the equipment safety. Since the X and Y axes have angular and velocity limitations compared to Z axis, the results obtained are sufficient to affer boundaries for sensors parameters.

Fig. **??** shows that yaw angle oscillates continuously from -180^o to 180^o while the table rotates about the Z axis; the movement period is about 1 second. The mean value of the angular velocity was

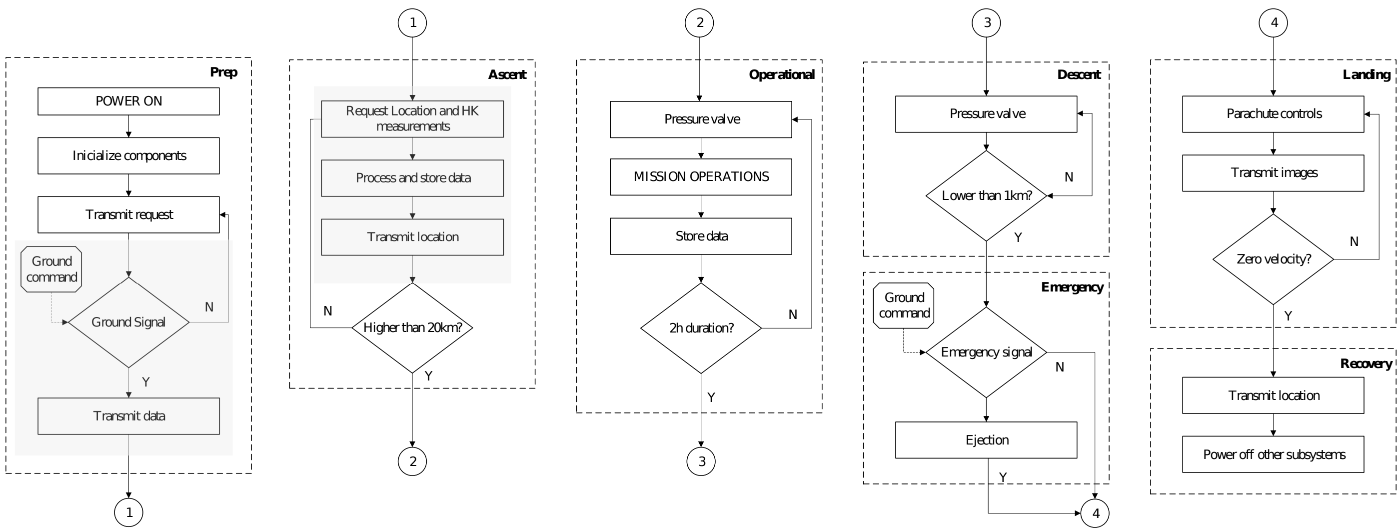

Figure 5: **Mission flowchart**

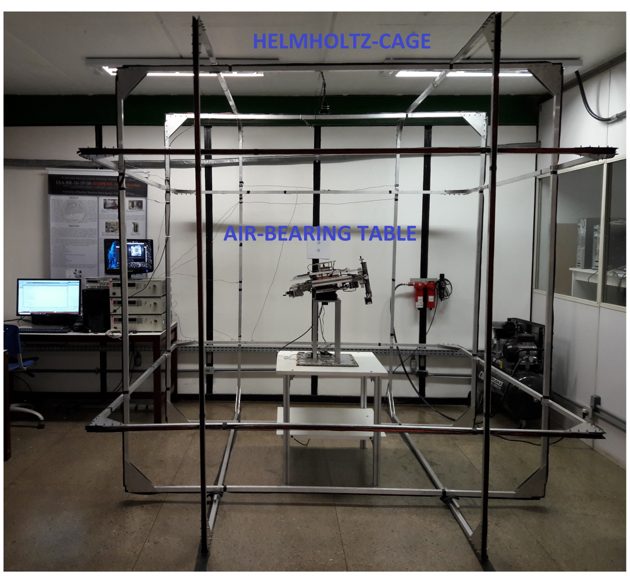

Figure 6: **Nanosatellite simulator overview.**

Figure 7: **ABACUS onboard computer.**

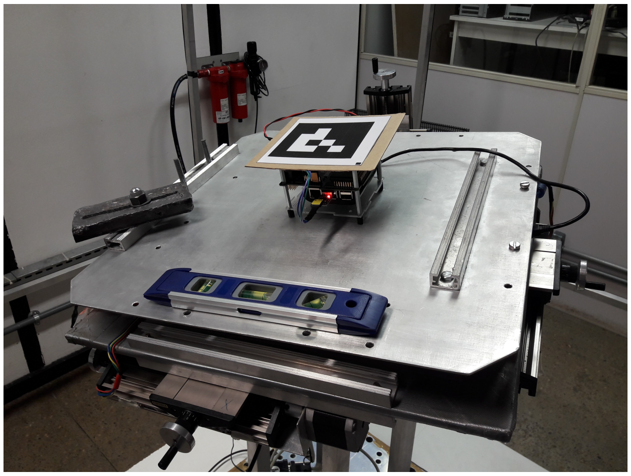

Figure 8: **ABACUS and an ArUco marker mounted on the testbed.**

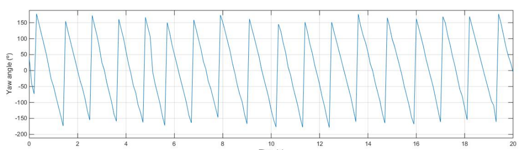

Figure 9: **Yaw angle of the table.**

about $-235^o/s$.

Considering a sampling time quite below the Nyquist limit, for example, ten times lower than the smallest period, a sampling interval of 100ms would be appropriate for the simulator. The angular velocity value of $-235^o/s$ implies in a range of about $\pm 235^o/s$ for the rate gyro. Furthermore, in several algorithms the angular velocity is integrated over time in order to estimate the attitude angles. Thus, since the attitude determination system accuracy is smaller than 1^o, a desirable maximum resolution value for the rate gyro would be $10^o/s$ because $10^o/s \times 0.1s = 1^o$.

The maximum resolution values for the other IMU sensors can not be easily evaluated considering that they do not directly estimate the attitude. Therefore, the relationship between these sensors characteristics and the attitude estimation accuracy depends on the algorithms.

Table 1: **Summary of boundaries for IMU**

Parameter	**Boundaries**
Interface	I2C/SPI
Sampling rate	100ms
Rate gyro range	$\pm 235^o/s$
Rate gyro maximum resolution value	$10^o/s$

Table 2: **Current consumption and execution time**

Test	**Current (mA)**	**Exec. time (ms)**
TRIAD	18.4	1.91
USQUE	18.5	64.62

The resulting requirements obtained for IMU are summarized in Table **??**.

Further tests evaluated the current consumption and the execution time of ABACUS while running two attitude determination algorithms. The first is the TRIAD algorithm and the second is the Unscented Quaternion Estimator (USQUE) proposed in [**?**]. Both methods were implemented in C language for MSP430 in the context of the work presented in [**?**]. The execution time for the algorithms shown in Table **??** correspond to one sample time, therefore, the value defined earlier of 100ms for the sampling interval is suitable for TRIAD and even USQUE execution. For TRIAD, the sampling interval can be much smaller.

It is worth mentioning that the ABACUS microcontroller, MSP430, was extremely efficient, although it presents inferior characteristics to the one currently used, ARM Cortex-M4, concerning to bit width and clock frequency. Both microcontrollers characteristics are exposed in Table **??**. The microcontroller specifications listed in the table are sufficient for the design, since MSP430 complied with both attitude determination algorithms tests performed described above.

Table 3: **Microcontroller comparison**

Board	**OBC LAICAnSat**	**ABACUS**
Architecture	ARM Cortex M4	MSP430
Bit width	32	16
Frequency Clock	72MHz	25MHz
Memory size	256kB flash	256kB flash
Price	$8.70	$5.20

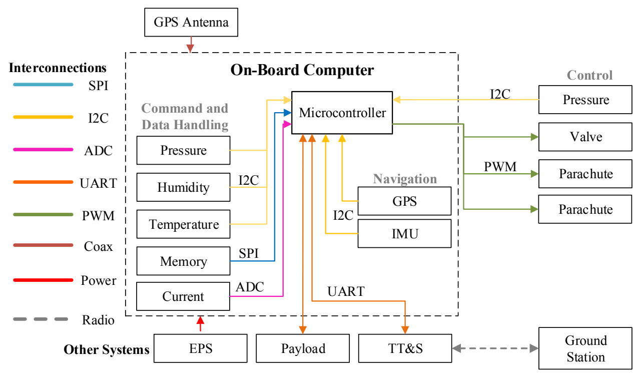

Figure 10: **System description**

4 On-board computer Requirements

Considering requirements presented in section 2, the platform subsystems are translate as commercial off-the-shelf (COTS) components and interfaces, shown in Fig. ??. According to flowchart of Fig. ??, the OBC shall:

- Transmit its location throughout the flight at different rates depending on the phase of the mission, as well as store it for later reconstruction of the trajectory;
- Monitor the internal environment conditions and be able to evaluate integrity of the system;
- Manage data and communication with subsystems that are integrated with it;
- Perform floatation and landing control;
- Be capable of responding to ground station commands at any time, to transmit data, to perform maneuvers or to abort mission if requested;
- Be able to validate attitude determination and control algorithms simulated on air-bearing table.

A recurring problem exposed in previous sections was the oversizing of the battery that negatively influenced the weight budget. In fact, it was found that given current system consumption (80mA), the battery would be able to supply power for approximately 30 hours, while the mission lasts only seven. Thus, an estimation of the consumption of the new system was carried out, considering the new components to be added.

The Command and Data Handling and the Navigation Subsystems are inherited from previous proposals, maintaining same pressure sensor (Bosch BMP180) and GNSS module (uBlox LEA M8T). Humidity sensor (Sensirion SHT15) must be changed since the line used will be discontinued. The IMU considered in this analysis is InvenSense MPU-9250, which meets the requirements listed in Table ??. A current monitor should be added to analyze battery behavior and evaluate power consumption throughout the mission.

As for the Control Subsystem, the solution under analysis requires wireless LAN and USB interfaces, at least 1GB RAM memory, a graphical processor unit (GPU) and a 1.2GHz clock. Platform actuators have also been considered, a digital servomotor 6221MG, which consumes approximately 20mA for actuation of the valve and two continuous servos HS755MG for control of the parachute, that consume 150mA each. However, their operations will not be performed throughout the mission, being considered

Table 4: **Power Budget and Interfaces**

Subsystem	Power (mW)	Interface
OBC	600	6xI2C 2xSPI UART
Control	1000	3xPWM I2C SPI/UART
TTS	400	UART
Payload	To be determinated	UART

only in their specific moments. With this solution, a power consumption of approximately 600mW is estimated for OBC, with additional 1W for sensor and actuators.

An exclusive module for the Telemetry and Telecommand System (TTS) system will be designed, and it is one that consumes more power, being able to vary from 400mW to 2W. [?]

Table ?? exposes systems power budget and interfaces required. With this survey, OBC consumption is estimated as approximately 600mW. With the additional subsystems, the consumption increases to 2W, without considering payload. Thus, the currently used battery (Nanotech 6.6V / 2100mAh Transmitter Pack) is suitably sized for the seven-hour mission of validating new systems, as it provides 1.98Wh. However, consumption should be better evaluated after their development and validation.

Regarding the sensors, the microcontroller must have four to six I2C inputs and at least two SPI. The current monitor uses analog input and is converted by the microcontroller ADC. It is also necessary to secure the interface with the valve pressure sensor, through an I2C output and with the GPS antenna, through a coax connector.

In addition, it is desired that it has a development environment that allows high and low level programming, in order to optimize firmware. It needs to have a built-in non-volatile memory to store the firmware and a boot mechanism that allows remote updating of the firmware.

The microcontroller used in previous tests is able to satisfy these demands of both interfaces and power consumption.

5 Summary

The new HAP embedded system has been described in terms of user requirements and unraveled into components and interfaces. Considering the testbed applications, the OBC should have six PWM outputs, three for reaction wheels and three for magnetorquers. During the missions, three PWM outputs are necessary for control systems. For communication with the payload and the transmission system, at least two UART outputs are required. Upcoming developments include designing a printed circuit board, as well as its assembly, test and integration with other subsystems.

The minimum specifications required for the microcontroller were shown in table ??. It is interesting to note that the microcontroller MSP430, besides having presented satisfactory performance in the determination of attitude, it presents additional interesting characteristics that brings benefits to the platform balloon missions. It consumes approximately ten times less than the current microcontroller and has additional 16kB SRAM. Also, a Direct Memory Access controller allows movement of data without CPU intervention and a dedicated peripheral module supports 32-bit multiplication operations. Moreover, it also presents configurations of low power modes that would allow the power management in case of missions of longer duration.

Also, the development of the firmware is an extremely important next step. To guarantee the reliability of the data, it is necessary to develop calibration techniques for the sensors, as well as filtering algorithms. The pressure and humidity sensors also provide temperature measurements which can be used in fusion data techniques. In the last mission, the lack of such refinement resulted in some cases in unreliable measurements.

As the transmitter will be removed from the OBC, it will be necessary to design a dedicated module for communication with the ground station. As well as a power subsystem, with its proper protections and balancing, capable of providing outputs of 5V and 3.3V to power all subsystems.

For the time being, the current battery specifications meet initial planning of a seven-hour mission to validate the subsystems described. However, there is an interest in carrying out missions of longer durations depending on the performance of the pressure valve. In this case, a study on power generation and power management should be carried out if needed.

6 Acknowledgements

The authors thank the Brazilian agencies CAPES, CNPq and FAPDF for supporting this work.

References

[1] A. Mehrparvar, D. Pignatelli, J. Carnahan, R. Munakata, W. Lan, A. Toorian, A. Hutputanasin, and S. Lee, "CubeSat Design Specification - Rev. 13," The CubeSat Program - Cal Poly SLO, February 2014. [Online]. Available: http://www.cubesat.org/s/cds_rev13_final2.pdf

[2] P. H. D. Nehme, R. A. Borges, C. Cappelletti, and S. Battistini, "Development of a meteorology and remote sensing experimental platform: The LAICAnSat-1," in *Proceedings of the 35th IEEE Aerospace Conference*, 2014, pp. 1–7.

[3] B. H. A. Noronha, A. V. S. Silva, R. A. Borges, and S. Battistini, "System identification of a square parachute and payload for the LAICAnSat," in *Proceedings of the 36th IEEE Aerospace Conference*, 2015, pp. 1–7.

[4] M. A. L. Holanda, R. A. Borges, Y. M. Honda and S. Battistini, "Trajectory control system for the LAICAnSat-3 mission," in *Proceedings of the 38th IEEE Aerospace Conference*, 2017, pp. 1–7.

[5] M. F. S. Alves, A. P. Wernke, F. C. Pereira, D. H. Gomes, G. S. Lionço, C. H. F. L. Domingos, D. B. da Trindade, C. Cappelletti, M. N. D. B. Júnior, S. Battistini, and R. A. Borges, "Design of the structure and reentry system for the LAICAnSat-3 platform," in *II Latin American CubeSat Workshop*, 2016, pp. 1–15.

[6] R. R. Dias, A. K. de Castro, S. Battistini, R. A. Borges, and C. Cappelletti, "LAICAnSat-3: A mission for testing a new electronic and telemetry and tracking system," in *Proceedings of the 2nd Latin American IAA CubeSat Workshop*, 2016, pp. 1–9.

[7] R. A. Borges, L. T. de M. Corrêa, S. C. Guimaraes, A. C. dos Santos, S. Battistini, and C. Cappelletti, "LAICAnSat-5: A mission for recording the total solar eclipse from the stratosphere," in *Proceedings of the 39th IEEE Aerospace Conference*, 2018, pp. 1–7.

[8] R. Shishko and R. Aster, "Nasa systems engineering handbook," *NASA Special Publication*, vol. 6105, 1995.

[9] S. A. Asundi and N. G. Fitz-Coy, "Cubesat mission design based on a systems engineering approach," in *IEEE Aerospace Conference,*, 2013, pp. 1–9.

[10] T. E. O'Brien, "Space situational awareness CubeSat concept of operations," Master's thesis, Naval Postgraduate School, Monterey, California., Dec. 2011.

[11] J. Straub, C. Korvald, A. Nervold, A. Mohammad, N. Root, N. Long, and D. Torgerson, "Openorbiter: A low-cost, educational prototype cubesat mission architecture," *Machines*, vol. 1, no. 1, pp. 1–32, 2013.

[12] R. C. da Silva, U. A. Rodrigues, R. A. Borges, M. Sampaio, P. Beghelli, S. G. P. da Costa, B. T. Popov, S. Battistini, and C. Cappelletti, "A testbed for attitude and determination control of spacecrafts," in *II Latin American IAA CubeSat workshop, Florianopolis, Brazil*, vol. 18, 2016.

[13] J. L. Crassidis, “Unscented Filtering for Spacecraft Attitude Estimation,” *Journal of Guidance, Control, and Dynamics*, vol. 26, no. 4, pp. 536–542, Jul. 2003.

[14] R. C. Silva, F. C. Guimarães, J. V. L. Loiola, R. A. Borges, S. Battistini, and C. Cappelletti, “Tabletop testbed for attitude determination and control of nanosatellites,” *Journal of Aerospace Engineering*, 2018.

[15] J. V. L. Loiola, L. C. van der Ploeg, R. C. Silva, F. C. Guimarães, R. A. Borges, G. A. Borges, S. Battistini, and C. Cappelletti, “3 axis simulator of the Earth magnetic field,” *IEEE Aerospace Conference*, Mar. 2018.

[16] G. F. de Oliveira, P. D. Nehme, and C. Cappelletti, “Analysis and simulation of attitude determination and control for the serpens nanosatellite,” in *Proceedings of the 2nd IAA Conference on Dynamics and Control of Space Systems, International Academy of Astronautics, Roma, Italy*, 2014.

[17] S. Garrid-Jurado, R. Muñoz-Salinas, F. J. Madrid-Cuevas, and M. J. Marín-Jiménez, “Automatic generation and detection of highly reliable fiducial markers under occlusion,” *Pattern Recognition*, vol. 47, no. 6, pp. 2280–2292, 2014.

[18] F. C. Guimaraes, “Implementation of Attitude Determination Techiques for a Small Satellite Three-axis Simulator,” Master’s thesis, Universidade de Brasília/PPGENE.DM - 703/2018, Jul. 2018.

[19] P. Muri and J. McNair, “A survey of communication sub-sytems for intersatellite linked systems and CubeSat missions ,” *Journal of Communications*, vol. 7, no. 4, pp. 290–308, 2012.

Ana Carolina Cabral Pimentel de Melo received her B.S. degree in Electrical Engeneering from Universidade Federal do Rio Grande do Norte in 2017. She is currently a M.S degree student of the Postgraduate Program of Electronic Systems and Automation (PGEA) at Universidade de Brasília. Her research interests are related with embedded systems and development of high altitude scientific platforms.

Fernando Cardoso Guimarães received his B.S. degree in Mechatronics Engenieering from University of Brasília in 2014. After working 2 years as an embedded systems development engineer, he obtained his Masters Degree at Universidade de Brasília with focus in aerospace technologies for small satellites in 2018. He is affiliated with the Laboratory of Automation and Robotics (LARA) and with the Laboratory of Aerospace Science and Innovation (LAICA) at the same university. His main research interests are embedded systems applied to aerospace technologies, spacecraft guidance, navigation and control, Lyapunov stability theory, robust control, stochastic modeling and filtering.

Yago Henrique Melo Honda received a B.S. degree in Aerospace Engineering from University of Brasilia (UnB) in 2018. He is currently a M.S degree student of the Postgraduate Program of Electronic Systems and Automation (PGEA) at University of Brasília. His main research interests are related to numerical simulation, control systems and development of high altitude scientific platforms.

Renato Alves Borges received a Master (2004) and Doctoral (2009) degree in Electrical Engineering from the University of Campinas and a PhD degree in Electrical Engineering from the University of New Mexico (USA) (2009). From 2009 to 2011 he held a post-doctoral fellowship from the state of Sao Paulo Research Foundation working at the School of Electrical and Computer Engineering at the University of Campinas. He is currently an assistant professor in the Electrical Engineering Department of the University of Brasília and a control system researcher affiliated with the Laboratory of Automation and Robotics (LARA) and the Executive Coordinator the Laboratory for Application and Innovation in Aerospace Sciences (LAICA) at the University of Brasilia. His main research interests are Lyapunov stability theory, stability analysis of linear and nonlinear systems, modeling and control of rotating body, dynamic system analysis under uncertainty, and development of high altitude scientific platforms.

Sandro Augusto Pavlik Haddad received his BSc degree in Electrical Engineering from the University of Brasilia (UnB) with honors in 2000 and a PhD degree in Microelectronics from Delft University of Technology (Delft University of Technology - TUDelft, Electronics Research Laboratory) in 2006. From 2007 to 2010, he worked for Freescale Semiconductors as an integrated circuit designer engineer (Analog IC Designer). In 2010, he began his activities at the University of Brasília (UnB) as Adjunct Professor. He also participates in the Master's program in Biomedical Engineering of the Faculdade UnB Gama (FGA) and the Graduate Program in Electronic Systems and Automation (PGEA) of the Department of Electrical Engineering of the University of Brasília. In addition, he serves as technical manager of the Design Center for Integrated Circuit projects, DFCHIP. His line of research includes mixed-signal and analog integrated circuits, ultra low-voltage analogue signal processing for implanted biomedical systems and high frequency analog circuits for UWB communication systems.

Simone Battistini received his BSc (2006) and MSc (2009) degrees in Control System Engineering from Sapienza Università di Roma. He got a PhD in Aerospace Engineering (2013) from the Scuola di Ingegneria Aerospaziale della Sapienza Università di Roma. In 2012 he was a visiting student at Technion - Israel Institute of Technology. He is currently an assistant professor at the Faculdade Gama of Universidade de Brasília, Brazil. He is associated with the Laboratory of Aerospace Science and Innovation (LAICA) of Universidade de Brasília. His main research interests are related with guidance, navigation and control of aerospace vehicles.

Chantal Cappelletti received a BSc (2005) in Aerospace Engineering, a MSc (2008) in Astronautical Engineering and a PhD (2012) in Aerospace Engineering all from Sapienza Università di Roma (Italy). She is currently an Assistant Professor at University of Nottingham (UK), where she is affiliated with the Nottingham Geospatial Institute. Previously, she was an Assistant Professor at the University of Brasilia (Brazil) and a visiting researcher at Morehead State University (USA). She is the cofounder of the Italian company GAUSS Srl. She has led 6 satellite projects in Italy (UNISAT program and others) and in Brazil (SERPENS, TuPOD). She was PI of 2 missions concerning cancer cells behaviour in space. She was an Italian Space Agency delegate at the Inter-Agency Space Debris Coordination Committee. Her main research interests are related with small satellites, biomedical research in space, space debris, astrodynamics and attitude control. She is member of the International Academy of Astronautics.