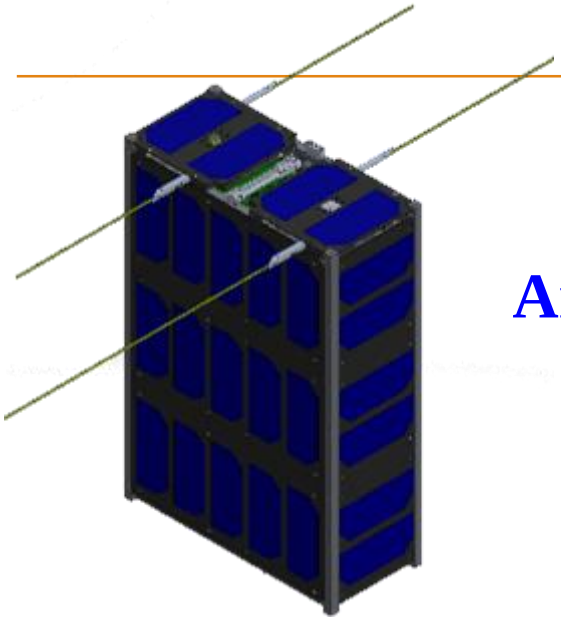

An approach for Assembly, Integration and Verification of a 6U CubeSat and the achievements of the ITASAT Project

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OUTLINE

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- The ITASAT Cubesat
  - Platform
  - Payload
- ITASAT Assembly and Integration
- ITASAT Verification and Validation
- Lessons Learned
- Conclusions

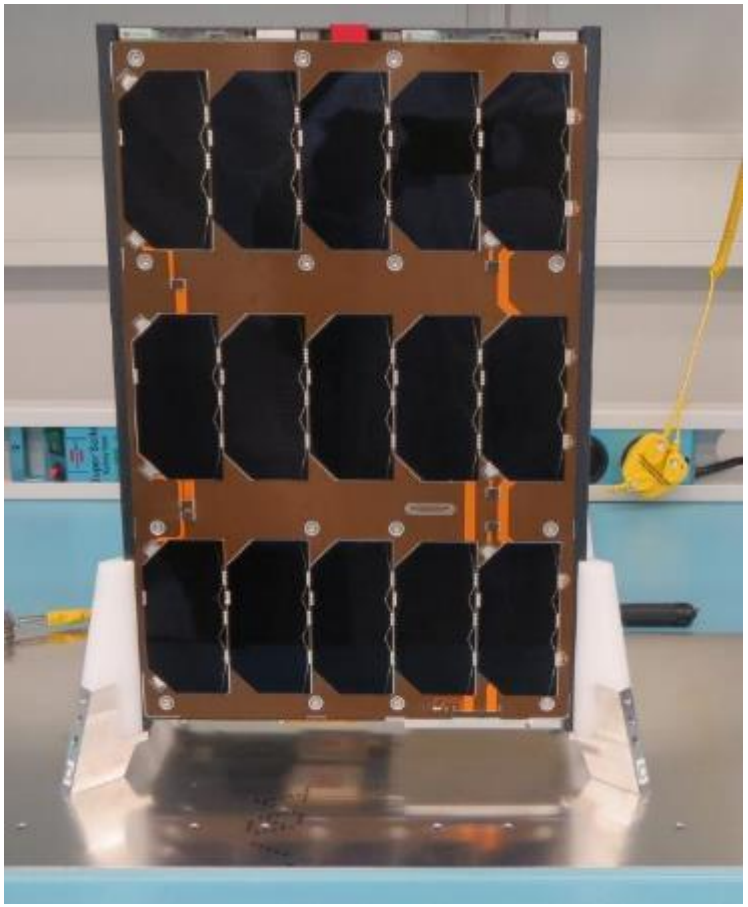
INTRODUCTION

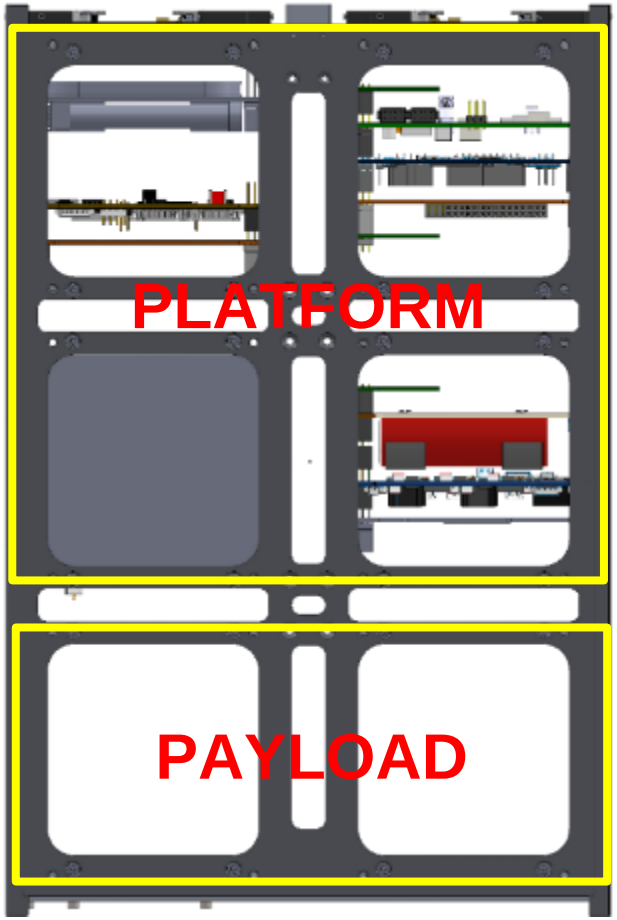
- The ITASAT project is an effort of the Brazilian Space Agency to promote space related projects inside the universities;
- The purpose of the paper is to present the AIV philosophy adopted to the project;
- The Model philosophy of the project considers an Engineering Model and a Protoflight Model.

Mission Objectives

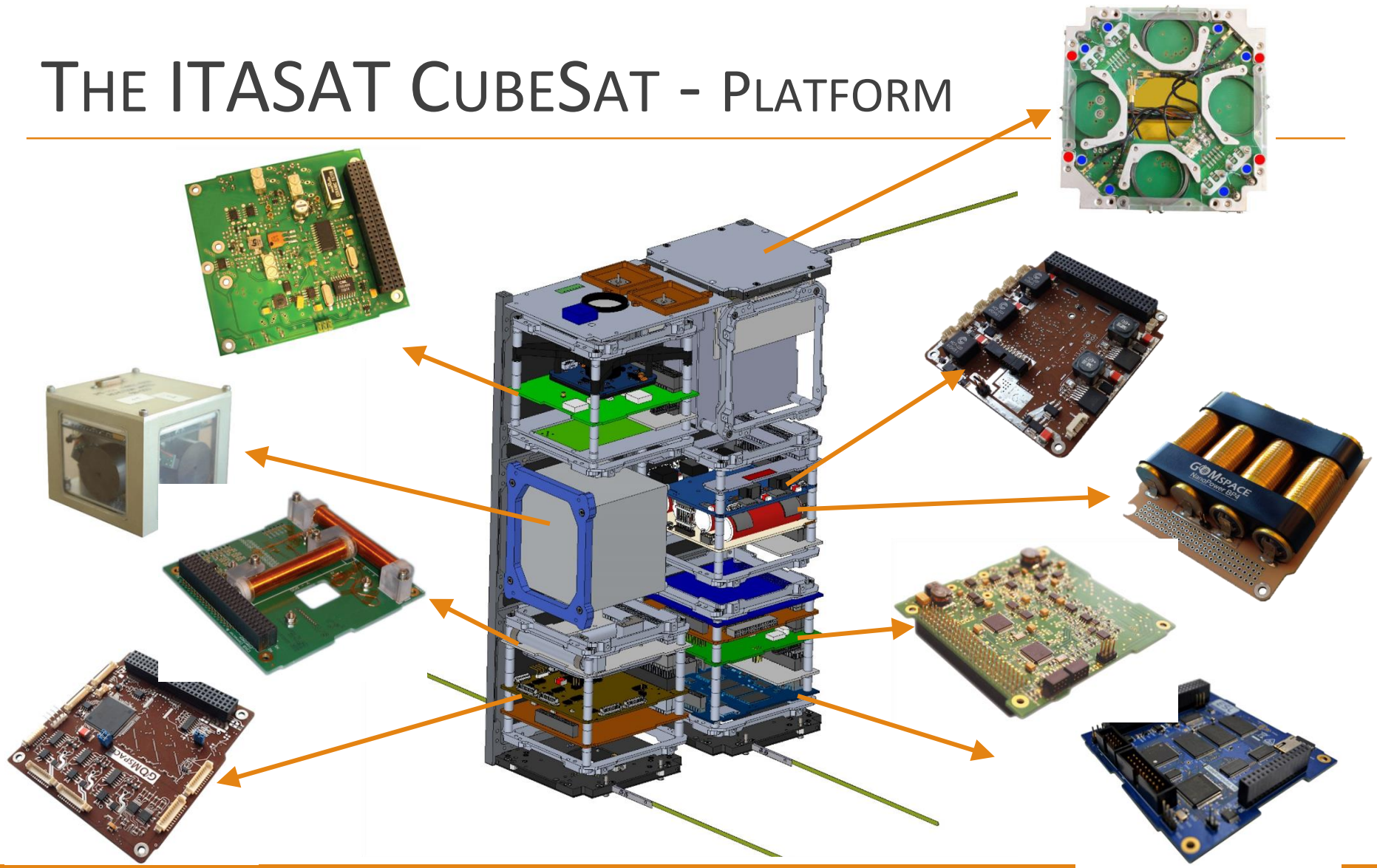
- To promote space projects in universities and to train students (AEB).
- To work in a hands-on way in mission analysis, system design, satellite integration and verification and satellite operation.
- To operate with a System Engineering and AIV Methodology.
- To create a platform to test experiments in orbit .

THE ITASAT CUBESAT





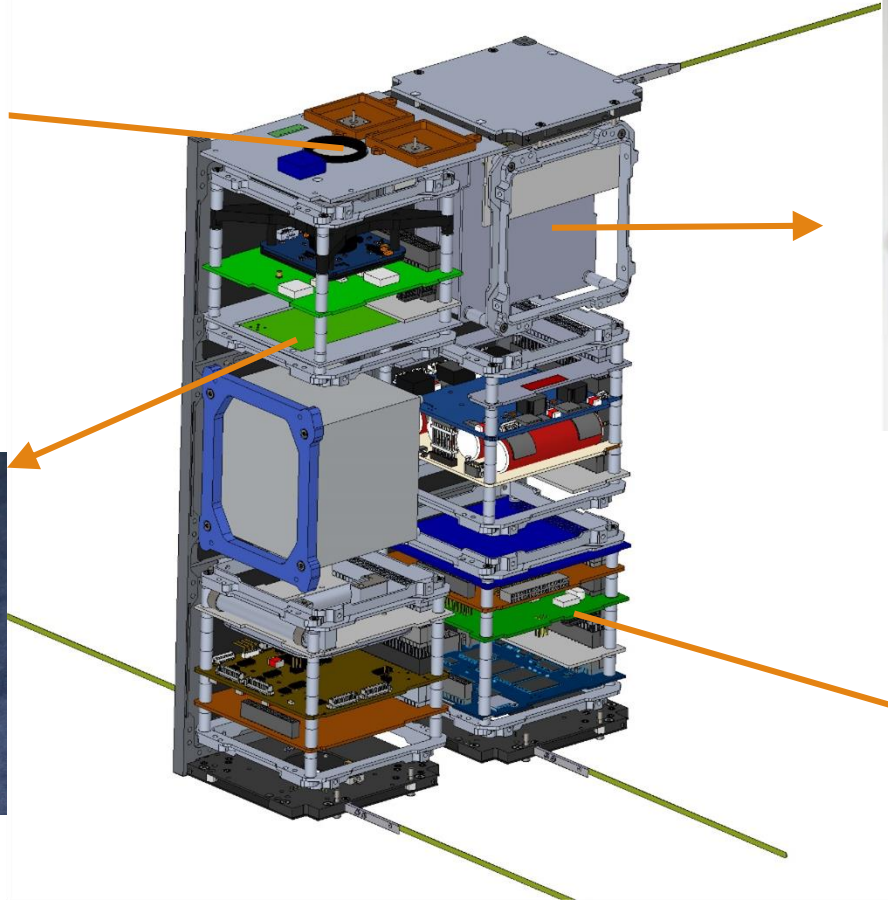
THE ITASAT CUBESAT - PLATFORM



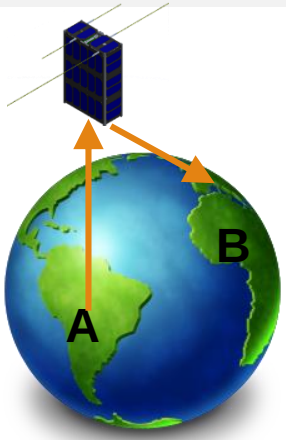
THE ITASAT CUBESAT - PAYLOADS

DCS Transponder

Camera



GPS Receiver



Communication Exp.

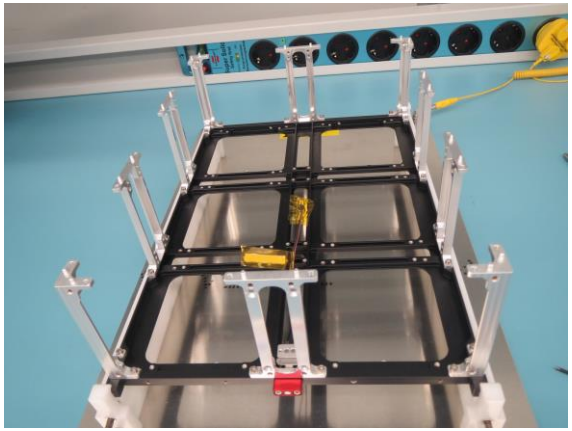
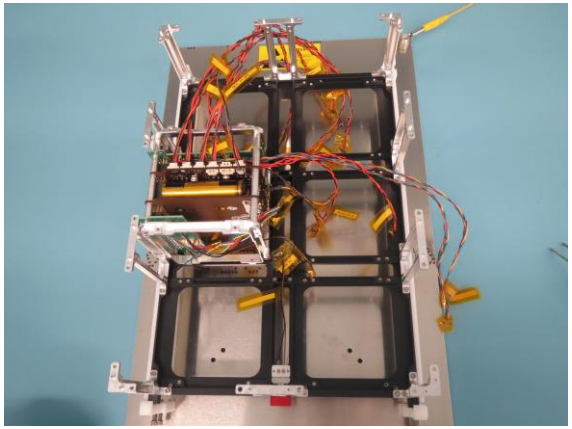
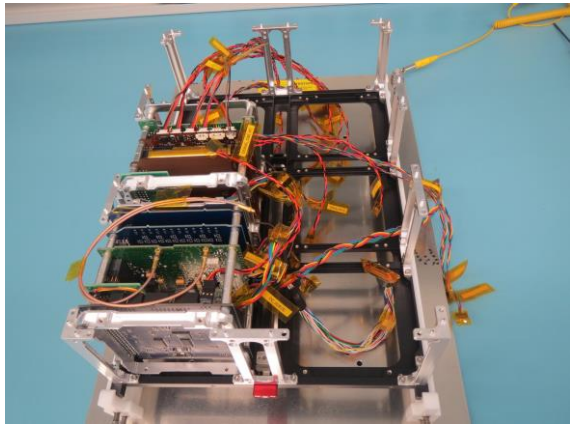
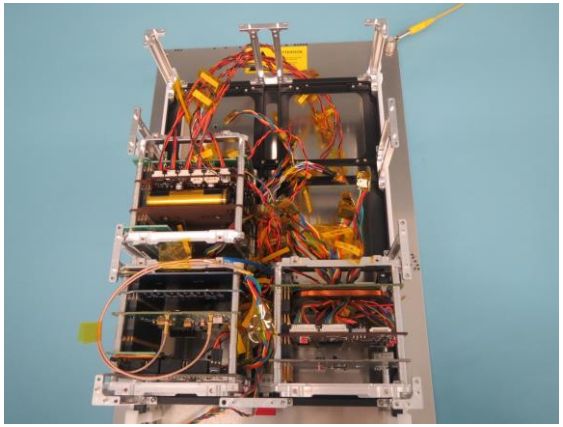
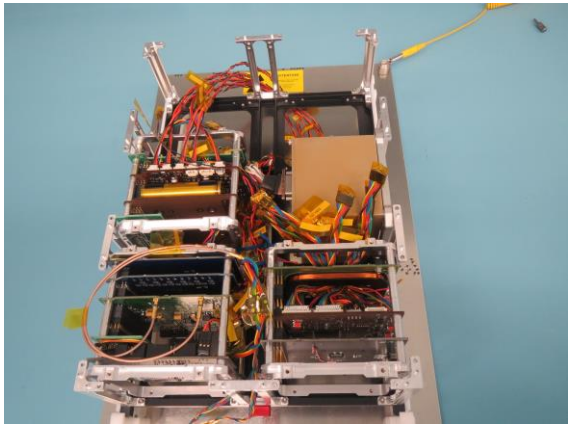
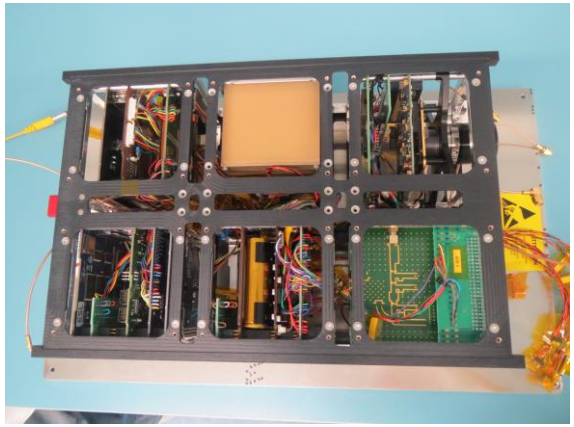
Assembly and Integration

The approach adopted in the ITASAT CubeSat aims to take advantage of the modularity of the system in such a way that each U of the 6U represents a subsystem.

Assembled and integrated independently. The functional tests of the subsystem were performed at this stage.

At each stage, minimum checks were performed to guarantee the electrical connections.

Assembly and Integration

Assembly and Integration

Onboard software Architecture:

- designed following the concepts of modularity - isolation of the software in small modules, thus helping in the execution and validation of the tests.
- reuse of the software and develop the software in a parallel.

Example: the Attitude Determination and Control System (ADCS), algorithm were developed using MATLAB, and due to the modularity the only rework needed was to convert some utility functions used in MATLAB that C does not support to a pattern that is compatible with the embedded processor.

VERIFICATION AND VALIDATION

For ITASAT the verification and validation process considered the "end-to-end" methodology test.

verification and validation of the satellite functions was based on blackbox tests of the satellite, which means the functionalities of the satellite were validated considering the sequence of operations expected to be executed in orbit

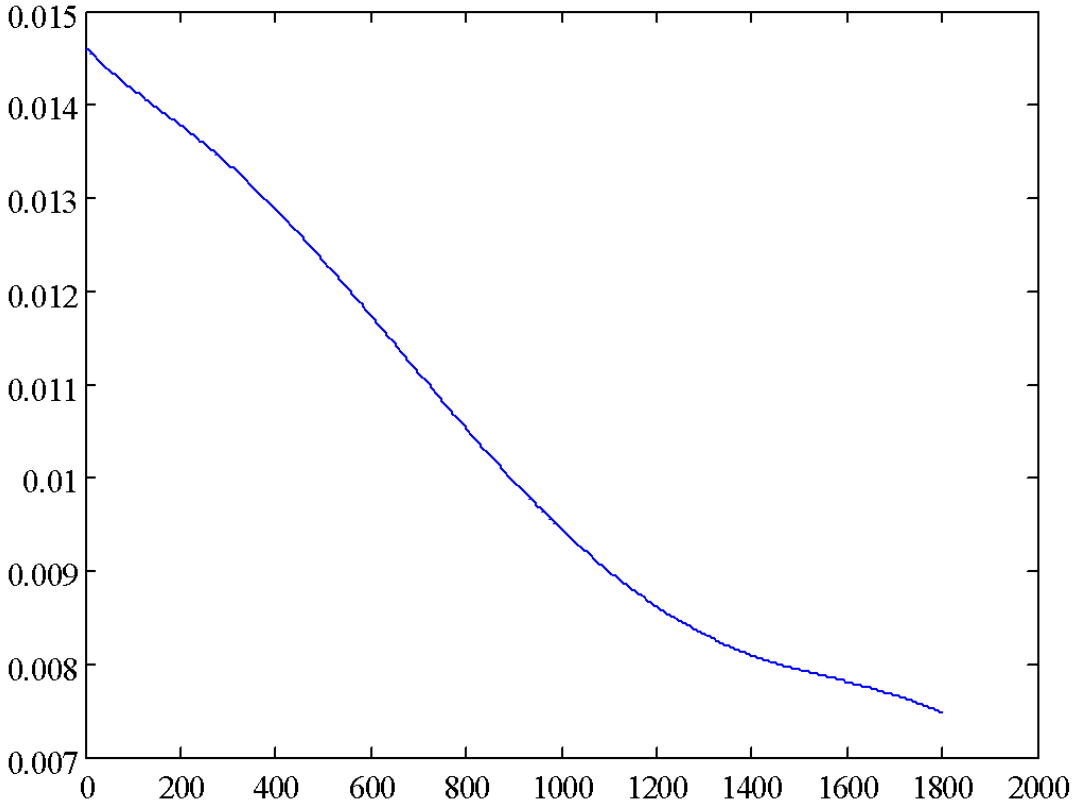
the sequence of commands and corresponding telemetries simulating the environmental conditions and operational modes were used as **main parameters** to assure the validity of the test sequences and satellite validation.

VERIFICATION AND VALIDATION

To validate the ITASAT attitude control software a set of tests were carried out, consisting of:

- Characterization of sensors and actuators
- Open-loop tests for validation of readout interfaces with sensors and actuators
- Closed-loop tests with simulation of attitude dynamics and sensor measurements performed in Matlab

VERIFICATION AND VALIDATION



(time in seconds)

Kinetic Energy of ITASAT during hardware in the loop testing, with the B-dot method.

LESSONS LEARNED

Definitely equipment applied to Cubesat's are not plug and play.

We experienced that there is a considerable effort to be done in System Engineering level and on subsystem level to have everything working as expected.

A fully understanding of each equipment to be used and its interfaces and peculiarities is essential to have a good result.

LESSONS LEARNED

The quality **of I2C signal matters.**

I2C bus is widely used to provide data communication in cubesats, but its utilization demands a good adjustment of the signal waveform (low and high levels), which implies in a good characterization or knowledge of the characteristics of each equipment.

LESSONS LEARNED

Technical documentation, procedures and reports shall be customized.

Customize the amount of project document is important.

For ITASAT project it was possible to create a set of project documents and configuration control philosophy.

LESSONS LEARNED

Test cycles shall be greater than development, Assembly and integration.

“Everything that is not tested is a potential item of failure.”

The “end-to-end” methodology used on ITASAT is one approach of test that worked well for the purpose of this first mission but depending on the purpose of the mission, other types of verification and tests shall be applied.

CONCLUSIONS

The ITASAT CubeSat allowed to train and to develop a qualified team inside ITA

The satellite development, assembly, integration and verification was performed by the team composed by undergraduate and graduate students

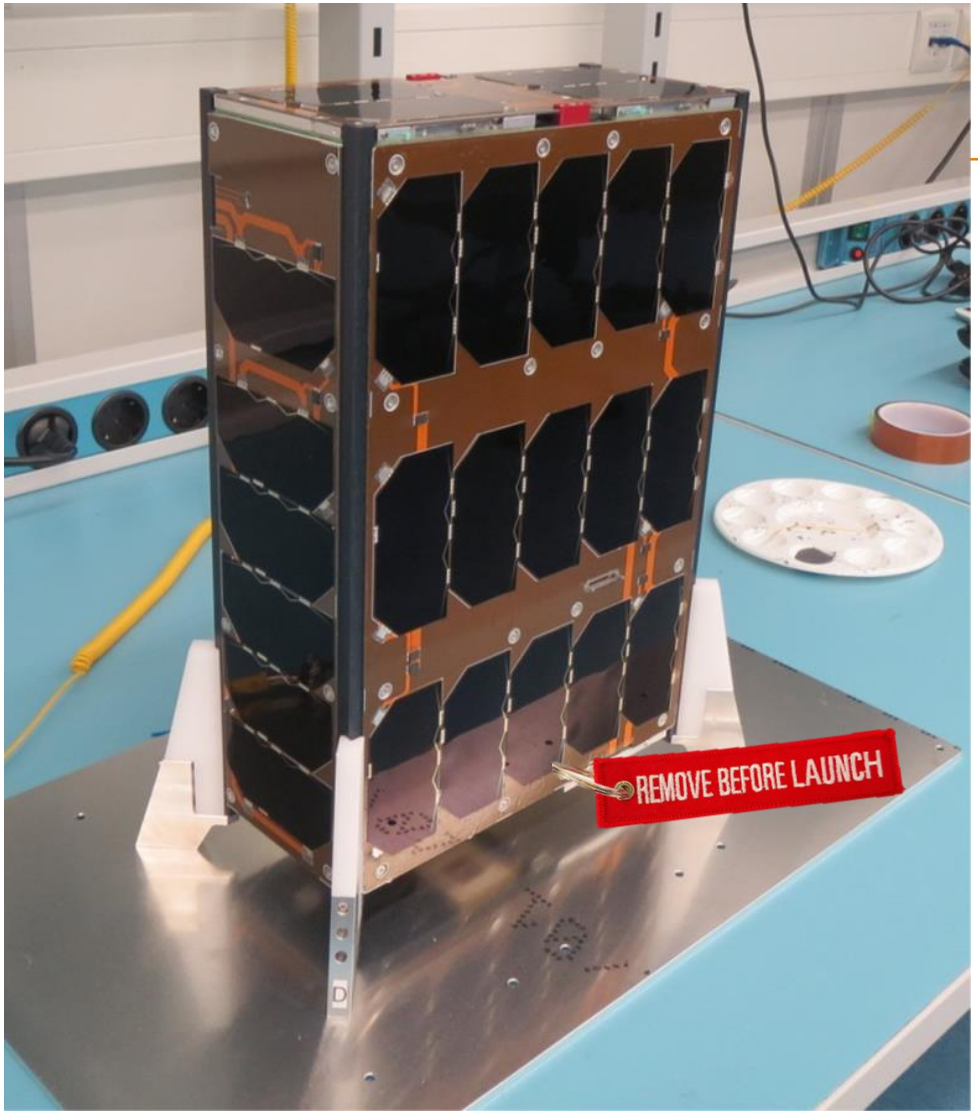
The onboard software was integrally developed by the project software team;

ITASAT is the first satellite to carry onboard a Brazilian attitude control software to be tested in orbit.

CONCLUSIONS

There is a platform that can be adapted for a range of missions and it was created on ITA an expertise to work with embedded systems

The space is our limit.



Muchas Gracias.