Risk Analysis Comparison between the Mission NANOSATC-BR1 and NANOSATC-BR2

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Abstract: The goal of this work is to perform the risks analysis of the mission NANOSATC-BR1 and NANOSATC-BR2 and then compare them linearly. The NANOSATC-BR1 and NANOSATC-BR2 are the first and the second satellite, respectively. They belonged to the project NANOSATC-BR—development of CubeSats, which is performed in the facilities built by the partnership between the National Institute of Space Research and the Technological Center from Federal University of Santa Maria. The project focuses on the development of a scientific instrumentation and, simultaneously, the design development, construction, qualification and launch of a national scientific nanosatellite, in a cube shape with 100 mm of edge and near to 1.33 kg of mass, per unit (U). The risk analysis was held to identify and minimize the project’s risks of failure, due to its complexity, assuring the mission success, preventing extra pays and rework. The software, CubeSat Mission Design Software Tool for Risk Estimating, which uses statistical regression methods, was used. So, we were capable to measure the project’s most critical steps assuring its success. The NANOSATC-BR1 was launched in June 19 and it is orbiting the Earth in a nominal regime and the NANOSATC-BR2 has been scheduled to be launched in 2016.

Key words: Analysis, risk, CubeSat.

1. Introduction

The program NANOSATC-BR—development of CubeSats has the NCBR1 and the NCBR2 as its very first nanosatellites, both on the CubeSat standard. This nanosatellite class has, per unit (U), a cube shape with 100 mm of edge and near 1.33 kg of mass, as minimum specifications. Both are composed by:

- mechanical structure;
- systems;
- subsystems;
- payload (scientific and technological).

The NANOSATC-BR1 in Fig. 1 is the first Brazilian scientific university nanosatellite, and thus meets all specifications of the CubeSat (1 U) class. The NCBR1 has the scientific mission of collecting data through a magnetometer (XEN-1210 model, with resolution 15nT) of the terrestrial magnetic field, mainly on the South American Magnetic Anomaly. However, the technologic mission is to test, during the flight, the radiation resistance of ICs (integrated
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circuits) designed in Brazil, being one FPGA (Field Programmable Gate Array) chip developed by UFRGS (Federal University of Rio Grande do Sul) and a drive chip developed by SMDH (Santa Maria Design House), validating it for future use in Brazilian space missions with larger satellites. The 1 U CubeSat—NANOSATC-BR1, was launched into a LEO (Low Earth Orbits) orbit from the Russian Yasny Launch Base by a DNEPR (DNEPR is the rocket baptized name as the Ukrainian river in Dnepropetrovsk) launch vehicle on June 19, 2014, and it is orbiting the Earth in nominal and safe modes.

The NANOSATC-BR2 in Fig. 2 is the second Brazilian scientific nanosatellite from the program and fits the CubeSat (2 U) class, thus meeting all specifications of the CubeSat class. The NCBR2’s scientific mission focuses on using a Langmuir probe to capture data from the ionosphere region, referring to the amount of plasma material present in this region. However, the technologic mission aims to validate the first national system for attitude determination (triple redundancy). The NANOSATC-BR2 is on a very advanced development stage and its launching date is schedule for the end of 2015.

Even when dealing with low-cost space missions, it does not dispense conducting a risk analysis to minimize the subjectivity of the risk evaluation of each stage of the project. The comparison is made linearly between NCBR1 and NCBR2 after conducting the risk analysis of the two nanosatellites.

The paper is organized as follows: Section 2 discusses the methodology used to develop this studies; Section 3 presents results and discussions; and Section 4 gives conclusions.

2. Methodology

For the realization of the NCBR1 and NCBR2 mission’s risk analysis, we used the software CubeSat Mission Design Software Tool for Risk Estimating Relationships, which provide us, numerically and graphically, through the “Likelihood X Consequence” relation, data of several risks involving each missions. This software is based on several historical source of risks association to smaller space projects (CubeSats), and, using statistical regression methods, it is capable to identify the risks involving each project.

By using this software, we reduce the subjectivity of the project’s risk evaluation, thus, being able to recover resources and develop techniques to mitigate the project’s threats.

The sectors evaluated are divided into:
- schedule;
- payload;
- SpaceCraft-1—communication;
- SpaceCraft-2—service subsystem and mechanic structure;
- SpaceCraft-3—mission and orbit;
- personnel—work group (information);
- Cost.

First, we raise several temporal nature data from
both missions; therefore, we can fill out the software input (Fig. 3).

Related to temporal data used in the software, we could choose whether it would be “actual” for data that had already occurred, or “predicted” for data that were only expected to occur.

In Fig. 4, the “months S/C is in operations” is the only item classified as “predicted” for the NCBR1, since the operational period of the nanosatellite is estimated for 36 months. The same happens to the NCBR2.

Fig. 3 Software input’s interface.

| Parameter                  | Description                                                                 |
|----------------------------|-----------------------------------------------------------------------------|
| Form factor                | Enter numeric value corresponding to the number of U's your spacecraft design uses (e.g. 1U would be entered as “1”)) |
| Mass                       | Enter numeric value of the mass (kg).                                       |
| Launched?                  | Yes, the S/C has been launched.                                             |
| Launch Date                | Yes, the S/C has been launched.                                             |
| Months in Development      | Enter numeric value corresponding to the number of months in full design and development, including everything up to flight integration, indicate whether this value is actual or predicted. |
| Months in Integration      | Enter numeric value corresponding to the number of months spent on integration, indicate whether this value is actual or predicted. |
| Months in S/C Testing      | Enter numeric value corresponding to the number of months spent on testing. Indicate whether this value is actual or predicted. |
| Months S/C is in operations| Enter numeric value corresponding to the number of months spent on testing. Indicate whether this value is actual or predicted. |

In Fig. 5, it has all items classified as “predicted” because the NCBR2 project is still in early development.

The inputs of both missions are relatively equal in the category AIT (assemble, integration and tests). This similarity in periods of AIT is because this process is relatively the same for both nanosatellites; thereby, we have a greater linearity on risk analysis comparison.

Through numerical results (probability/consequence) after the first step, we compared the risks of both missions. The software also provided a graphic “Probability X Consequence”, helping visual comparison.

After thoroughly analyzing each sector evaluated by the software, we classify the most critical risks for each project. These results will be presented later.

3. Results and Discussions

The analysis has begun with NANOSATC-BR1, CubeSat 1 U, which is already on space.

First, the “Probability X Consequence” graphic is shown in Fig. 6.

Analysis of NANOSATC-BR2, nano-satellite 2 U CubeSat, is scheduled for release in 2015.
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Fig. 6 “Probability X Consequence” NANOSATC-BR1’s graphic. “Schedule” shows the same position as “cost”.

Fig. 7 Numerical risk value of “schedule” and “payload” for the NCBR1.

Fig. 11 shows the “Probability X Consequence” of the NCBR2.

The following numerical results follow with a straight comparison between the two missions.

By making the results analysis frameworks of NCBR1 in Fig. 7 and NCBR2 in Fig. 12, it is attested that the probability that an anomaly has occurred with the schedule NANOSATC-BR1 is higher, especially regarding to design of software (basic functionality of components or programming problems) delay.

Nevertheless, the consequence of an error in this...
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Fig. 10  Numerical risk value of “cost” for the NCBR1.

Fig. 11  “Probability X Consequence” NANOSAT-C BR2’s graphic.

Fig. 12  Numerical risk value of “schedule” and “payload” for the NCBR2.

sector, especially concerning delays due to delayed documentation, is higher in NANOSAT-C BR2, since it is still under development.

According to the graphic generated by the software, both the nanosatellites payloads have relatively the same risk. However, after evaluating the numerical results, we found that the probability of an error in the interface between the payload and the spacecraft or the electrical part of the payload occurs, was higher in NCBR1. The probability of an abnormality in the payload due to the mechanical (structural) or software failures is greater in NCBR2. The consequence for a failure in this sector was considered equal for both nanosatellites.

The analysis is done by comparing Figs. 8 and 13.

In relation to “SC-1”, it has been concluded that NCBR1 has “Probability X Consequence” higher than any other failure in this sector. A risk towards maximum probability was found (grade: 5), referred to lacking of nanosatellite internal systems communication frequency and as conclusion it has shown higher risk on Consequence.

NCBR1 has presented higher probability of error on the mechanical structure and services models sector, which the critical case is the failure on data collects sensors. In case of any NCBR2 anomaly, its consequence would be higher, mainly in battery/energy failure system sector.

Fig. 13  Numerical risk value of “SpaceCraft-1” and “SpaceCraft-2” for the NCBR2.
Considering the numerical values of Figs. 9 and 14, we conclude that the NCBR1 risk related to the orbit and mechanics has “Probability” is mainly related to “Spacecraft that will not get out of orbits within 25 years”, and “Consequence”, especially in the area “It not meet the requirements in Mechanical during its Orbit”, is greater than the risk of NCBR2.

The NCBR1 also has higher “Probability”, mainly in the lack of training of the working group, and “Consequence”, especially in the area of lack of information management, than NCBR2 in working group sector.

Regarding “mission costs” in Figs. 10 and 15, the NCBR2 is much more vulnerable, since the “Probability” mainly in “components cost increasing” and the “Consequence”, especially in “delay in the receiving of financial resources for the project” are the greatest risks for NCBR1.

In Fig. 16, it follows the comparison done through the software between NANOSATC-BR1 (Milestone 2) and NANOSATC-BR2 (Milestone 3).

After analyzing all missions sectors, the Probability and Consequence items were processed. These two items are shown in Table 1.

We have defined and analyzed that the Probability of risk for NCBR1 is greater than NCBR2, nevertheless, the Consequences of these risks for NCBR2 is greater.

4. Conclusions

It is concluded from the risk analyses of NANOSATC-BR missions that the “SCH”, schedule, was identified as the greatest risk sector for both projects, thus, an extra attention must be required, regarding the current NCBR1 step and future NCBR2 step. Furthermore, for NCBR1, the lower risky sector is “cost” and for NCBR2 is “SC-3” (mechanics and orbit).

Therefore, the risk analyses are attested as mandatory for CubeSat missions, since the missions complexity is increasing with the time.

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