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Requirements elicitation for the Bazooka CanSat used in the Second CubeDesign

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Abstract: *Space projects requires a high organizational level for its success. The assertiveness level comes from the choosing of the most suitable engineering methods to propose, develop, verify, validate, operate and discard the systems. Among the methods applied by engineers from INPE (National Institute for Space Research), there are the Requirements Engineering and the Systems Engineering. This work analyses, ranks and organizes the Stakeholders for the Bazooka CanSat system, used in the Second CubeDesign. Then, the people interested on the system where interviewed and the necessities gathered, analyzed and turned into System Requirements. The requirements were weighted according to the need of the people interviewed and proved to be effective for the subsequent steps.*

Palavras-chave: System Engineering; Requirement; CanSat.

1. Introduction

CubeDesign is an event focused in divulgating for the world Space Engineering and INPE (National Institute for Space Research). This event has three categories: MockUp, CanSat and CubeSat. On the CanSat category, the competitors must develop satellite prototypes to be launched 32 meters height by a launch system. The requirement elicitation for the launch system is shown in this paper.

Figure 1 shows the flowchart of the engineering methods used in the development of the launch system named Bazooka CanSat.

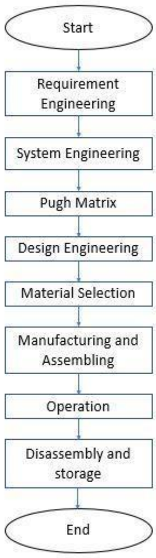

Figure 1 – Bazooka CanSat Flowchart of the Engineering Methods

Requirement Engineering is a method responsible for the deep understanding of the necessities of the stakeholders of a system. In this method, the necessities are interpreted and turned into measurable parameters through iterative processes. The main attributes of a concise requirements are: traceability, verifiability, unambiguity and feasibility [1-3]. Also, the acceptance criteria and validation methods, where the requirements are turned into system specifications, are defined. [1-4]

System Engineering is responsible for proposing one or more solutions, weighted among the stakeholders of the system. This method observes, analyzes and structures the organizational, physical and environmental structures, as well as the people involved, and seeks to meet the requirements of the project, mission, and functions. [1]

The Pugh's Matrix is an engineering method which seeks to choose the more adequate logical solution for the project and the mission fulfillment. It utilizes the output of the possible solutions proposed by the System Engineering. [2]

System Engineering is a method to design a system. It is interdisciplinary and involves the development of the structural calculations, electronics, material selection, product dimensions, product design, and the manufacturing and assembly sequence. [3]

Material selection analyzes and determines the materials which must be employed to make the physical parts of the system, considering cost, geometry, environment, system scenarios, and to increase the lifespan of the system. [1, 2]

The parts manufacturing and assembly is the step where the pieces are made, and the systems are assembled and integrated. After the integration, the final verification and validation by the clients/stakeholders occurs.

2. Methodology

The steps for the gathering and treatment of the necessities, generation, verification and validation of the requirements are presented as a flowchart in the Figure 2.

Figure 2 - Steps for the development and validation of Requirements

The methods for requirement elicitation applied were: interview, activities analysis, and Brainstorming.

For the interview, the following questions were used: What are the essential necessities of the system? What is use intended use for the system? How long the system will be in use? Is there any restriction to the system? What are the fundamental physical characteristics of the system? What are the fundamental chemical characteristics of the system? What is the ideal geometry of the system? What is the deadline to deliver the system? What is the cost limit of the system?

3. Results and discussions

3.1 - Workflow Diagram

The first step was to elaborate the life cycle of the product, focusing in the workflow. Then, the stakeholder groups were identified through the activity analysis, which is shown in Figure 3.

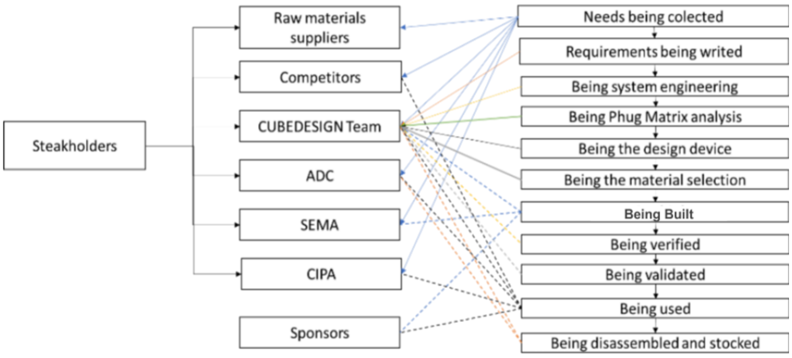

Figure 3 - Organizational stakeholder map in activities function

3.2. Organizational Stakeholders

Figure 4 shows the detailed analysis of the subgroup CUBEDESIGN / CanSat Team. The other subgroups are not shown.

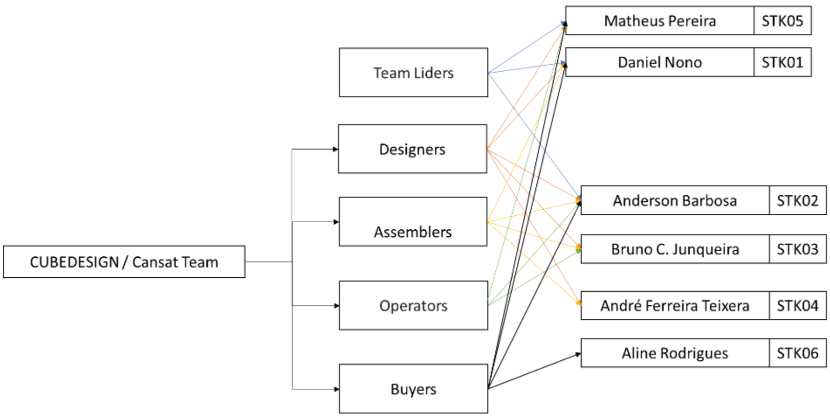

Figure 4 - Stakeholders for the Subgroup CanSat Team.

3.3 Interviews and analyzes

The interviews were effective to elicit the requirements. The experience showed that most of the stakeholders have confusing ideas, which reflect in greater time expending to sort the types of requirements. The results are shown in the columns one and two of the Table 1

3.4 Document Verification

The documentation was verified through the internet. The information was uploaded to a drive on the data cloud and the stakeholders verified if the requirements were acceptable.

This step was burdensome due to fact that the necessities weighting was discussed several times, until a solution that moderately satisfied the stakeholders was found.

3.5 Documents Validation

This step was less disturbed because the stakeholders had already verified the requirements and agreed with it. The work employed on the detailed verification was responsible for the fast validation of the requirements.

3.6 Requirements Results

The results of the requirement analysis and of the requirements obtained are shown in simplified version in the Table 1.

Table 1 – Results of the requirement analysis

Number	Author	Type	Necessity	Author of the Necessity	Requirement	Verification Method	Validation Method	Verification Text	Rationale
RQT01	Daniel Nono	Performance	"Basically, it is necessary to verify the flight height and the CanSat dimension"	Eduardo Burguer	The system must be capable to throw CanSat at a height of 32±1 meter.	Experimental and Modeling	Field Test	The verification must be done through the recording of the launch with 20±0.3cm. A standard of 1±0,05m must be placed in the vertical, away 10±0,3 meters of the launching system, below and parallel to the flight trajectory. The recording must be analyzed and a geometric comparation between the flight apogee and the standard. The prototypes must follow the established criteria in the RQT05. Five launches must be done. The requirement will be considered verified if the flight height is of 32±1m.	The group decided that the launch must reach the center of the soccer field of ADC/INPE. Therefore, for a launch at 45°, it is necessary to reach this height.
RQT02	Daniel Nono	Performance	"Basically, it is necessary to verify the flight height and the CanSat dimension"	Eduardo Burguer	The system must be capable to throw CanSat at a height of 32±1 meter.	Experimental and Modeling	Field Test	The verification must be done through the recording of the launch with 20±0.3cm. A standard of 1±0,05m must be placed in the vertical, away 10±0,3 meters of the launching system, below and parallel to the flight trajectory. The recording must be analyzed and a geometric comparation between the flight apogee and the standard. The prototypes must follow the established criteria in the RQT05. Five launches must be done. The requirement will be considered verified if the flight height is of 32±1m.	The group decided that the launch must reach the center of the soccer field of ADC/INPE. The greater distance from the side to the center of the soccer field is, approximately, 32m.
RQT03	Daniel Nono	Performance	"Basically, it is necessary to verify the flight height and the CanSat dimension"	Eduardo Burguer	The system must be capable to throw a CanSat with radius of 3.0±0.05cm.	Experimental	Field Test	The verification must be done through the measuring of the distance of the launching system, with the help a calibrated caliper with a precision of 0.01mm. The requirement is verified if the diameter is bigger than 3±0.05cm	The competitions rules say that the official measures of a CanSat is of a diameter of 60±0.1mm, so it is necessary to verify if the CanSat will fit in the launcher.

4. Conclusion

The requirements elicitation for the system Bazooka CanSat was inspired on the method applied by INPE in Satellites projects. The results were weighted among the stakeholders through arduous negotiations. Among the main problems found, the meeting between the expected launch height and the height that was possible to accomplish with the time and resources available was the hardest. The results accomplished were satisfying, even though some of the requirements could not be met. In fact, this sequence of methods to generate requirements helped the designers, assemblers, and operators of the system to accomplish the mission and to satisfy the stakeholders

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