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An approach based in MBSE to the GARATÉA-L mission

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Abstract - The Garatéa-L mission will be the first Brazilian mission in deep space, as well as the first mission to the moon. The Garatéa-L will be placed in a lunar orbit by the Pathfinder spacecraft, which in turn will be launched into space by the Indian launch vehicle PSLV-C11, pioneering in the commercial exploitation of deep space, through a partnership between British private companies the British Space Agency and the European Space Agency ESA. The objective of the mission is to carry out tests that will evaluate the effects of exposure to space radiation in bacterial colonies in order to investigate the behavior of these microorganisms in this environment, contributing to the advancement in the area of astrobiology and space medicine. The other experiment to be carried out in the Garatéa-L mission is the collection of multispectral images of the Aitken basin at the south pole of the Moon. The main objective of this work was present the results of the application of the Agile System Engineering methodology in the study of case of the Garatéa-L mission, using the Model-Based System Engineering (MBSE) and SysML language tools. Within the principles of the agile methods, Loop's of design, requirements elicitation process, Lab Meetings, dynamic interaction with stakeholders. From the application of these concepts and methods it was possible to develop the Concept of Operations, covering information essential to the understanding of stakeholder needs, and to perform the modeling through the SysML language, the diagrams created were: Use Cases, System Functions, Sequence Diagram and Requirements Diagram, Reliability Analysis, and Trade Studies. The results demonstrate that the application of the agile approach enables in advance the necessary analysis for the success of the mission and traceability of requirements in response to the needs of the stakeholders. Within the principles of Agile Engineering the use of SysML as a language to generate the diagram was adequate and brought the convergence of understanding to all stakeholders, reducing the time of analysis, mitigating doubts and increasing the probability of mission success. The work is not exhaustive in this article, but rather it evolves gradually as the Loop's of projects happen until converging to the final study, meeting the expectations of the stakeholders.

INTRODUCTION

Agile methods or agile processes often promote a disciplined project management process that encourages frequent inspection and adaptation, a leadership philosophy that encourages teamwork, self-organization and accountability, a set of best engineering practices designed to enable fast delivery of high quality products and a business approach that aligns development with customer needs and company goals.

The International Council on Systems Engineering (INCOSE) and the Space Systems Working Group (SSWG) began investigating the applicability of Model-Based Systems Engineering (MBSE) to design CubeSats in 2011 [1].

SysML (Systems Modeling Language) is commonly used in MBSE, and is a graphical modeling language developed by the Object Management Group (OMG) for the purpose of being used in modeling a wide range of engineering problems [2].

MBSE is the formal application of modeling to support system requirements, design, analysis, verification and validation activities, where a model is a representation of something, and it does not capture all the attributes of the represented thing, but only those that seem relevant [3].

The Garatéa-L mission was modeled according to the engineering concepts of agile systems, using MBSE and the SysML language.

RESULTS

A. Concept of Operation

The Concept of Operations is a document used to translate stakeholder expectations into system requirements. It is intended to describe the characteristics of the system in an operational environment, helping users, customers and managers to understand the objectives of the system and its operation. In Fig. 1 is presented the context diagram for the Garatéa-L mission.

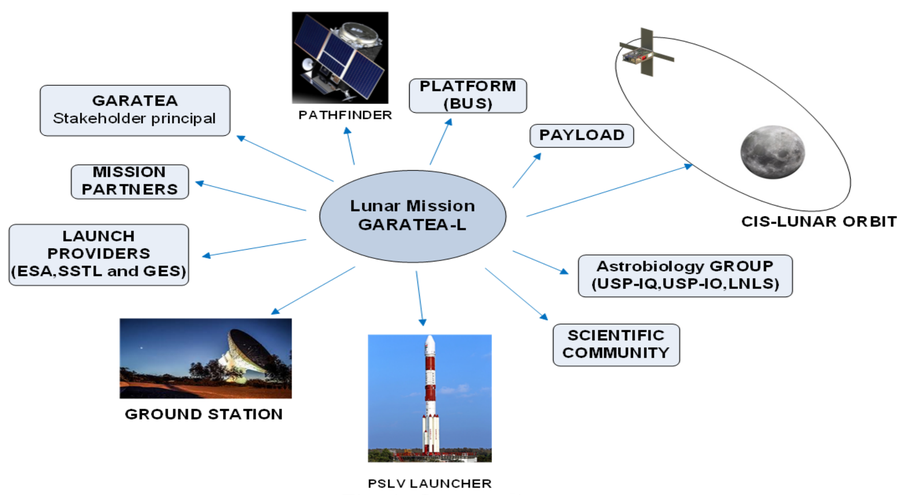

Fig. 1. Context diagram

B. System & Subsystem Functions

System functions are statements of what the system does, these functions must be related to the requirements of stakeholders, more specifically, they can be derived from these requirements, and are generally more qualitative. In Fig. 2 the system functions were modeled using the Use Cases diagram.

There are two feasible approaches to system deployments in subsystems. The first approach is the "Bottom up" where the system is composed from the definition of the components. And the second, which was used to perform the modeling of this work is the "Top down". In this approach the Use Cases of the system are decomposed with the "include" relationship together with the relevant functions of the system, so that each of them are assigned to a subsystem as in Fig.3.

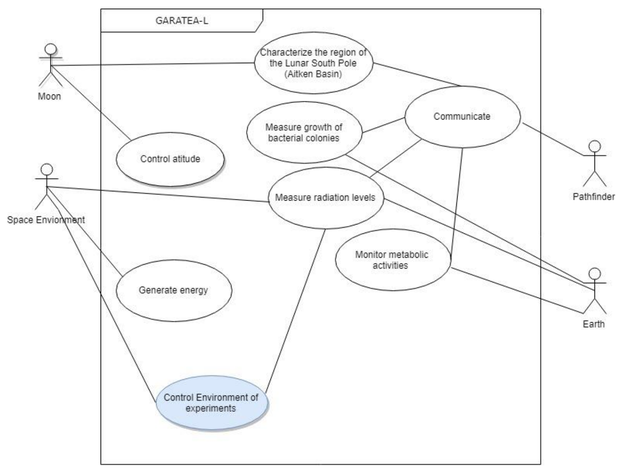

Fig. 2. System Function

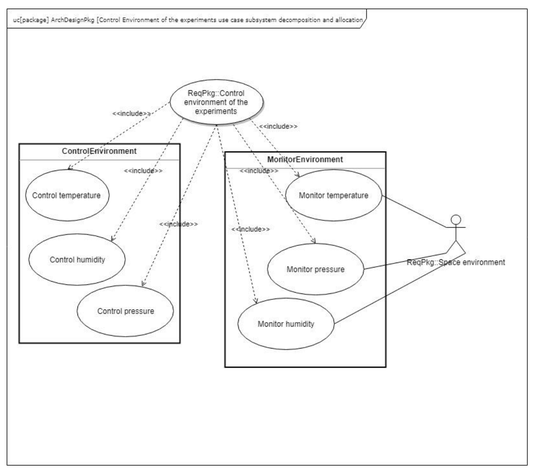

Fig. 3. Subsystem Function

After defining the subsystems that are included in the system, an "Environment Monitor" subsystem was developed and represented using Use Cases (Fig. 4), in order to understand the relations between the actors and the functions of that subsystem. The purpose was to make clear these interactions for the creation of the sequence diagram of a "White Box" scenario. Which make possible to see internal parts at the subsystem level, and map the interactions between the subsystems that perform these interactions (Fig.5), each time a flow of information or an event in the sequence diagram is generated, the functions for these subsystems are being created and allocated, refining their interfaces, and indirectly allocating requirements.

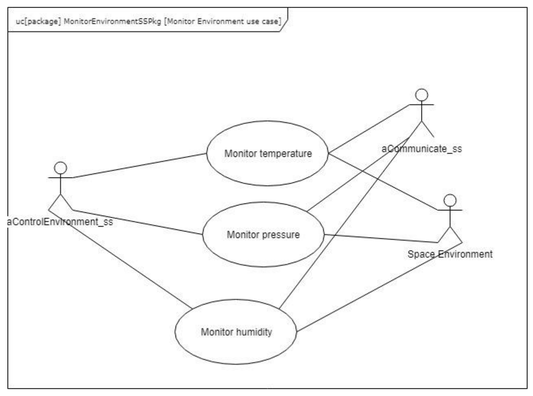

Fig. 4. Environment Monitor subsystem

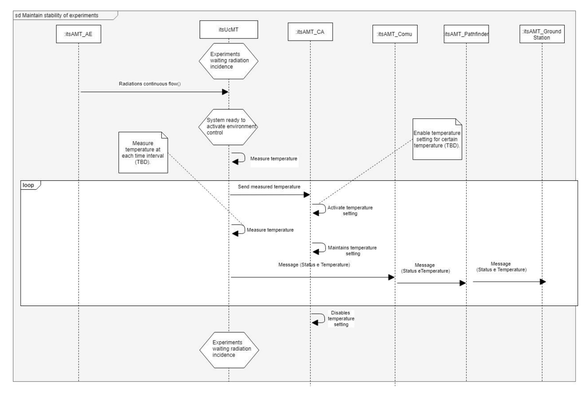

Fig. 5. Sequence diagram “ White Box”

The subsystems are generally composed of elements from various engineering disciplines, including software, hardware, mechanical, thermal, among others. The Fig. 6 illustrates the relationship of system-level requirements with requirements at the subsystem level. This diagram illustrates the relationship between system-level requirements and subsystem-level requirements. With these well-defined requirements it is possible to allocate them to the various engineering areas so that each specialty can continue the project development stage. Through this modeling it is possible to perceive if there are, perhaps, some missing, excess, or duplicated requirements. It also enables traceability, keeping these requirements organized, and improving understanding of the system.

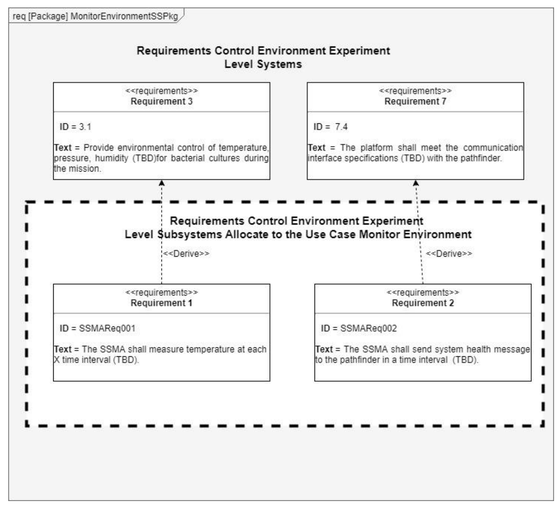

Fig. 6. Requirement diagram

CONCLUSION

The results demonstrate that the application of the agile MBSE approach adds more performance and dynamics to the space system development teams, through the design Loop's, allows to systematize the process through the logical modeling of the analyzes that define the system, and helps in the traceability of requirements in order to maintain alignment with stakeholders needs.

Within the principles of Agile Systems Engineering, the use of SysML as a descriptive language of systems to generate diagrams helped in the convergence of understanding among all stakeholders, reducing the time of analysis commonly oriented to documents, mitigating doubts and increasing the probability of understanding on the functions and requirements of the system.

The work is not exhaustive in this article, but rather it evolves gradually as the Loop's of projects happen until converging to the final study that meets the expectations of the stakeholders.

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