LATIN AMERICAN CUBESAT WORKSHOP
SALVADOR, BR
OCTOBER 2024

Management Theory and Documentation Standards Integrated with Graph-Based Project Organization: A Case Study for PdQSat CubeSat Project

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Abstract

This study explores the application of management theory and graph-based information traceability in the PdQSat project, currently in progress at Federal University of Minas Gerais (UFMG). Project management standards, such as PMBOK® and ECSS, and NASA's System Engineering guidelines provide a strong foundation for development, yet each project demands a tailored approach. The goal of this research is to streamline PdQSat's documentation by focusing on essential templates, improving administrative processes and enhancing efficiency. The authors employ a graph-based method to visualize dependencies between requirements, stakeholders, subsystems and other project artifacts, facilitating better communication and agility. By integrating management theory and graph-based tools, this approach aims to improve project outcomes and inspire similar aerospace engineering projects, highlighting the value of management in technical development. Additionally, the study seeks to support the formation of skilled workforce in the aerospace industry through academic projects.

1 Introduction

As technology continues to evolve, the inherent complexity of engineering projects inevitably increases, presenting a myriad of challenges and opportunities for innovation. In response, a variety of methods and tools to deal with such complexity increase have been created and are widely used. Large-scale projects, such as satellites, exemplify the need for robust management strategies more than ever before, as they are composed of a variety of study fields and technical requirements, need-

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ing to be also reliable, efficient and capable of delivering the project's needs.

Even so, projects in the same domain tend to differ a lot, which brings the need to develop and apply more tailored approaches that can contribute to their advancement. Regarding these tools, management theory and information traceability show up to be extremely helpful during the earlier stages of projects, and also facilitate the later stages by retaining useful information in a organized and traceable way. That being said, this work focuses on the application of the mentioned tools in a real academic engineering project: The development and construction of the PdQSat CubeSat.

The proposal behind the target project of this study [1] is to enhance the Brazilian aerospace sector and scientific production through the project, planning and construction of a CubeSat named "PdQSat". The project involves several areas of the School of Engineering at UFMG, such as Aerospace, Mechanical, Electrical, Control and Systems Engineering, and is coordinated by LISA (*Laboratório Integrado de Sistemas Aeroespaciais*). The proposed mission for the satellite involves testing a lithium-sulfur (Li-S) battery and a supercapacitor developed at UFMG during flight in order to enable it's use in future missions.

The landscape of management theory has undergone significant evolution, with extensive documentation available not only within the realm of project management standards but also tailored to specific applications. Key references such as PMBOK® have emerged as guiding principles for a multitude of projects, spanning technical and non-technical domains alike. Meanwhile, standards such as ECSS stand out for their specialized focus on space-related endeavors.

Despite the richness of these standards, it is evident that the unique characteristics of different projects, even within the same domain, necessitate tailored approaches to documentation and management tools. Against this backdrop, this study endeavors to navigate the array of options for an academic CubeSat, with a clear objective: to distill only the essential documentation required for advancing the project. Through careful selection and integration of management documentation into a refined subset of templates, the study seeks to streamline the project's administrative processes, thereby enhancing operational efficiency.

Central to the investigation is the concept of traceability – the capacity to track and trace crucial project information such as requirements, stakeholders and subsystems. Employing a graph-based approach, the aim is to unravel the web of dependencies inherent within the project's framework. By visually representing these relationships, the intention of this research is to facilitate easy access to critical information, fostering a more agile and responsive project environment. It is anticipated that this approach will yield tangible improvements in project efficiency and communication, two fundamental pillars for successful project outcomes.

Therefore, the approach combines management theory, standard documents and new project organization methods. By using the knowledge from these different areas, the goal is to improve the management of aerospace engineering projects, which could benefit similar researches worldwide. Exploring the intersection of management theory and graph-based information traceability within the context of the PdQSat project aims to provide valuable insights for future endeavors in aerospace engineering and beyond.

In order to further develop the concepts introduced in this section, section 2 will deal with the methods and important definitions for the understanding of the current work, while section 3 addresses the results obtained with the application of the Systems Engineering tools in the PdQSat project, followed by the conclusions regarding the work in section 4.

2 Methods

Since its start, the PdQSat project has been developed with the usage of systems engineering tools to assist in the organization, planning and execution steps. Currently, systems engineering makes itself more needed and crucial than ever on the execution of large-scale projects, and is applied in a variety of fields, ever so contributing to the success of such projects.

As defined by the [2], a system consists of an arrangement of parts that together exhibit behaviour that the individual constituents do not. This definition aptly applies to satellite projects of any scale or purpose, making systems engineering tools ideal for guiding development from the project's earliest stages.

The first tool applied to the project was the adaptation of management guides to the context of the project, aiming to create general templates and define its scope. Following these definitions, it is proposed the usage of graphs to view and organize relevant information relative to any stage and of easy usage and adaptability. As a starting point, a revision of the PdQSat project is contained in subsection 2.1, while subsection 2.2 will deal with the details regarding the conception and development of documentation used throughout the project, and subsection 2.3 will approach the usage of graphs as a facilitating mechanism for traceability.

2.1 The PdQSat Project

As mentioned in section 1, the current work is inserted in the context of the nanosatellite named PdQSat-1, currently being developed at Federal University of Minas Gerais (UFMG) and sponsored by the Brazilian Space Agency (AEB). The project started in 2020 [1] having four main objectives, as follows:

1. Testing a lithium-sulfur (Li-S) battery in space environment;
2. Testing a super microcapacitor, developed and manufactured at UFMG, in space environment;
3. Qualify Brazilian workforce in high-tech engineering at the university;
4. Strengthen the state of Minas Gerais in the national aerospace sector.

In order to achieve such goals, a platform should be designed and manufactured in order to meet the payload requirements. As for the workforce qualification, students and professors of the university have been involved in every step of the project, following a problem based learning (PBL) approach.

Regarding the solution itself, the satellite contains eight subsystems that include platform and payload subsystems. The latter, for instance, consists of the electronic components to be tested and an additional circuit for each one, in order to run the tests. These subsystems are:

1. ADCS - Attitude Determination and Control System;

2. EPS - Electrical Power System;
3. S&M - Structure and Mechanisms;
4. OBDH - On-Board Data Handling;
5. TCS - Thermal Control System;
6. TT&C - Telemetry, Tracking and Command;
7. Payloads:
   (a) Lithium-Sulfur (Li-S) Battery + Battery Characterization Circuits;
   (b) Supercapacitor + Supercapacitor Characterization Circuit.

Due to the participation of students and professors from various academic areas, the PdQSat project stands out as a highly multidisciplinary endeavor, engaging multiple generations of students over time. For instance, as of the writing of this work, 12 undergraduate theses related to the project have been completed, with additional ones currently in progress.

In order to enable the integration of new students and teachers, and ensure the continued progression of the project, effective management tools are essential. Motivated by these factors, this work aims to present methodologies and research in this areas of project management and information traceability, as detailed in the subsequent sections.

2.2 Management Theory

Project management in high-complexity sectors, such as aerospace, is crucial to ensure the success of missions that involve multiple technical disciplines, tight deadlines, strict quality standards and the need to efficiently allocate resources. In the context of the PdQSat project, it became essential to develop management practices to ensure that all of these challenges were addressed in a structured and efficient manner. To do so, a careful adaptation of the following management theories was carried out.

The PMBOK® (Guide to the Project Management Body of Knowledge) [3], developed by the Project Management Institute (PMI), is a consolidated reference that brings together a set of ideal practices for project management. PMBOK® methodology organizes this management in five groups: *Initiating*, *Planning*, *Executing*, *Monitoring & Controlling* and *Closing*. These groups embrace the whole project life cycle, ensuring that each individual phase is approached in a systematical and predictable way. Beyond that, PMBOK® defines ten knowledge areas such as *Integration*, *Scope*, *Time*, *Costs*, *Quality*, *Resources*, *Communications*, *Risk*, *Procurement* and *Stakeholders*, which can be customized according to the needs of different projects.

On the other hand, the management challenges faced specifically in space systems projects, from design to launch, have led the European Cooperation for Space Standardization (ECSS), an initiative supported by the European Space Agency (ESA) and other space organizations, to offer a set of detailed standards for planning, monitoring and control of space projects. These standards are divided in four main segments: *Management*, *Engineering*, *Product Assurance* and *Sustainability*. Within the management scope, the ECSS-M-ST-10C standard [4] details the best practices for planning and execution of space projects, focusing on critical aspects such as requirements definition, risk management and quality assurance.

In addition, the space systems project processes established by NASA [5] were also analyzed, since they occur repeatedly in the project life cycle until the desired objectives are achieved. Based on the definition of stakeholder expectations, taking into account objectives, constraints and success criteria for the mission, the high-level requirements survey serves as a reference for establishing a logical and functional decomposition for the project. This is followed by an iterative cycle of project design and trade studies to define the breakdown of the product structure, associated requirements and concept of operation. Finally, a series of questions are addressed to evaluate whether this proposal is fit to continue as a project solution and, if not, it is sent for reformulation.

Regarding the PdQSat, the PMBOK® methodological structure was essential to organize the activities and establish a management reference for the team, ensuring that the main aspects of the project were conducted properly and aligning stakeholders' expectations with planned deliverables. Besides, the study of ECSS's Project Planning and Implementation standard and NASA's System Engineering Handbook was important to evolve the PdQSat project from a perspective of risk mitigation and quality assurance for the final product, so that processes can be executed with higher precision and safety, as demanded by the aerospace sector.

Thus, by integrating the best practices from these methodologies, a customized management model was created for the PdQSat project. This model, structured through documentation templates, balances the need for rigorous control with the flexibility required to accommodate the particularities of an academic environment throughout the project's development.

2.3 Use of Graphs in Information Traceability

Regarding the field of systems engineering, traceability is defined by [6, Pages 201 – 202] as a relationship established between two or more entities, thus enabling the tracking of changes of such entities throughout the project. By tracking the evolution of these entities, it becomes possible to evaluate changes in the project and mitigate negative effects that may arise of such changes, like impacts on financial budget or project timeline. The concept of traceability itself can be decomposed into *Bidirectional Traceability*, *Horizontal Traceability* and *Vertical Traceability*, as defined below [6]:

- *Bidirectional Traceability*: This type of traceability enables navigation in both directions across the relationships between entities, allowing for a comprehensive view of how requirements and related elements are interconnected;
- *Horizontal Traceability*: This type of traceability is present in relationships between entities of the same type in the project, thus enabling the connection of artifacts that may be in different life cycles;
- *Vertical Traceability*: Lastly, vertical traceability involves the connection between entities of different types, which makes possible to track the evolution of artifacts in the project from high level to low level concepts.

Traceability is a major topic regarding managing projects, especially large ones, since the scale of the connecting elements can become overwhelming and if not properly handled can cause the failing of the project or at least avoid it's full completion. Concerning a satellite project, traceability surely becomes fundamental for the success of the proposed task when considering the final product as an arrangement of complex individual subsystems that also communicate and depend on one another to achieve the desired behavior. In this way, the most basic information to be traced on the project are the satellite subsystems, which are eight in total (including two payloads), as defined in subsection 2.1.

Another data of interest is the stakeholders, which are the interested and/or affected parts involved in the project, being divided in two categories in this case: organizational entities and development groups [7]. Each stakeholder has its own set of interests, or needs, regarding the project and its execution. These needs, in the case of organizational entities, are sets of documents and norms to be followed, such as presented by [8]. After mapping the needs of the stakeholders, the next step is to generate the appropriate requirements, thus capturing the information in a more technical and non-ambiguous way.

Previous works on the project, such as the ones by [9] and [10], have already mapped several needs and requirements related to each subsystem and to the participating stakeholders, and the current proposal is to organize and connect such topics through the use of a graph, aiming to guarantee easy access to critical information as well as link important topics.

According to [11], a graph, also known as a network, is a set of items (i.e., vertices) inter-

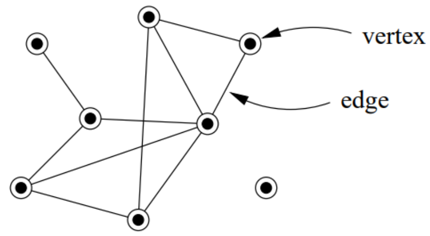


Figure 1: Example of graph structure highlighting the difference between vertex and edge [11]

connected by edges, as illustrated in Figure 1, that can vary in type and have weights if necessary, as well as the vertices. Networks have been a subject of study for a long time but gained substantial force in recent years due to its application in several areas, not only limited to mathematics, but present also in fields like biology and social sciences.

More focused on software projects, [12] identify a set of activities related to traceability and the importance of each one to the correctly achieving of so. Although similar, the focus of the work is more specific to tracing changes on information, and not just information itself, revealing the wide range of applications for graph theory in this field.

Due to its usefulness, graph-based traceability has also been applied as a tool on project management. [13], on the one hand, combine the usage of PMBOK® concepts with graph theory aiming to trace an sequence of documents to be executed in a project management plan, pointing metrics to evaluate the nodes (documents) of the achieved graph and analyze the ideal pipeline.

Additionally, [14] highlight the importance of projects early stages as well as for the design. For such, the authors define the steps involving the information, from conception to technical definition, passing through a high to low level of abstraction through the use of graphs. One particular interesting aspect of this application is the quantification of requirements on the lower level and it's integration in project related equations, which definitely facilitates the evaluation of parameter and variable changes all throughout the project, like temperature, frequency or even financial budget.

To create the graph and manage the desired information, the Obsidian software has been used due to its versatility and ease of use. Obsidian is a note-taking platform that works based on markdown files that can be interconnected and viewed in a graph display on the software. This application is primarily used for daily note-taking and other productivity tasks, but fits perfectly for the task of managing project information, due to it's feature of linking (citing) other notes.

In order to refer to another note, one just needs to write it's name inside two brackets (i.e., `[[Note Name]]`) thus making possible to access the cited note through the file and also creating a visual connection between them on the graph. Beyond that, it is possible to associate tags with each note in the software by simply creating a name for the desired tag and writing it after a hash (#) symbol.

3 Results and Discussion

The purpose of this section is to highlight and discuss the results achieved by further developing the methods proposed in section 2. These methods are the application of management theory to develop custom documentation associated with the project, as well as a graph-based approach to interconnect and track relevant artifacts and information from the PdQSat project.

Results regarding the study of management theory are contained in subsection 3.1 and the results derived from the application of graphs in the project are discussed in subsection 3.2.

3.1 Documentation Templates

The creation of management documentation templates for the PdQSat was motivated by the need to ensure that each phase of the project is managed efficiently and with technical rigor, providing a solid framework adapted to the project's particularities. Considering the project's early stage, the necessity to establish a set of standard documents and guide management activities was identified, thus ensuring that the project progressed in a structured and organized manner, as documented by [15].

Given the academic nature of PdQSat, which aims to train qualified professionals, the project extends over several months, with a natural rotation of collaborators. This dynamic requires standardized and robust management to ensure continuity and consistent use of the initial planning as a reference aligned to the satellite mission's final objectives, while maintaining the ability to adapt to changes that may arise throughout its development.

The creation of these templates involved a detailed analysis of demands specific to the PdQSat, based on the recommended metrics from PMBOK®, the guidelines from NASA and the norms from ECSS. From this analysis, ten main documents were created, each one tailored to a specific and critical role in the project management:

1. **Project Charter** (*Termo de Abertura do Projeto* - TAP): PdQ-M-01 - Formalizes the start of the project by detailing

it's main objectives, scope, deliveries and the main stakeholders. It is essential to guarantee a strategic alignment of all the stakeholders within the project.

2. **Work Breakdown Structure** (*Estrutura Analítica do Projeto* - WBS): PdQ-M-02 - Decomposes the project in manageable work packages, facilitating planning, execution and monitoring of the activities. It guarantees that all of the necessary tasks are identified and structured in a logical and efficient way.
3. **Team Breakdown Structure** (*Estrutura Analítica da Equipe* - TBS): PdQ-M-03 - Defines the organization of the team work groups, specifying clearly the responsibilities of each member related to the work packages defined in the WBS. It is crucial to ensure that the functions and responsibilities are distributed coherently.
4. **Execution Schedule** (*Cronograma de Execução*): PdQ-M-04 - Organizes the project activities in a detailed timeline, allowing for precise tracking of progress and identification of possible delays. It is vital to to ensure that the project remains within the established schedule.
5. **Cost Schedule** (*Cronograma de Custos*): PdQ-M-05 - Estimates and plans the costs associated with each activity from the project, ensuring that the budget is strictly followed and financial resources are optimally used.
6. **Mission Definition Review** (*Revisão de Definição de Missão* - MDR): PdQ-M-06 - Evaluates and validates the mission definition, including early technical requirements. It is fundamental to ensure that all critical aspects from the mission are approached in a appropriate way from the start.
7. **Preliminary Design Review** (*Revisão Preliminar de Projeto* - PDR): PdQ-M-07 - Performs an analysis of the preliminary design, verifying its compliance with technical requirements, budget and schedule. It is essential to ensure that the project is ready to move to the detailed development phases.
8. **Critical Design Review** (*Revisão Crítica de Projeto* - CDR): PdQ-M-08 - Conducts an in-depth analysis of the final project design, ensuring it is ready for the production and testing phase. It is critical to identifying and mitigating any remaining risks before satellite construction.
9. **Flight Readiness Review** (*Revisão de Prontidão de Voo* - FRR): PdQ-M-09 - Assesses the satellite's readiness for launch, including verification of all technical, operational and safety aspects. The FRR is essential to ensure the satellite is fully prepared for the mission.
10. **Project Closure Document** (*Documento de Encerramento do Projeto* - DEP): PdQ-M-10 - Formalizes the project's closure, documenting the achievement of objectives and the project's performance in relation to the planned schedule and budget. It is crucial for post-project analysis and capturing lessons learned, specially in an academic environment.

3.2 Obsidian Graph

The flow of information between the different types of notes created is shown in Figure 2. Basically, a Stakeholder has a Need that generates an Requirement associated with a Subsystem managed by a Team Member. The reference is made backwards, with the notes referring to other notes that generated or are responsible for them.

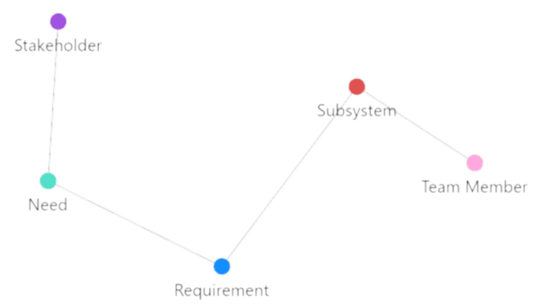


Figure 2: Example of connections between types of nodes

It is important to note, however, that there are cases where intermediate connections can be made, for example the Departments where Team Members work, that are Stakeholders as well, and, in this case, a connection between Member and Stakeholder is made. Also, regarding the PdQSat project and the determination of needs made by [7], it is quite common that the needs themselves refer to the subsystems as well as the requirements.

By evaluating the flow of information generated by this logic, it appears that the graph resembles more with an Information Network, once the nodes refer to each other in a directed and informative way, like requirements being originated from a need or a need belonging to a stakeholder. Also, once the information represented follows some kind of order, the graph is mostly acyclic, meaning that there are almost none closed loops occurring.

Beyond linking the notes on the software, Obsidian allows customization by changing the color of the graph's nodes, making it easier to find and visualize information. The color change is made through the use of the tags created in the software, such as `#Requirement` or `#Stakeholder`, which can be divided into sub-tags, like `#Requirement/Functional` to disguise notes from the same group. With that in mind, nine major tags were created, some of them containing sub-groups of tags:

- `#Requirement`: Project requirements, derived from established needs.
  - `#Requirement/Functional`: Requirements that describe functions of the system.
  - `#Requirement/Non_Functional`: Requirements related to restrictions, security, performance, reliability, and others.

`#Level`: Relative to the level of each requirement within the project.

  - `#Level/Mission`: The highest level of the project, relative to requirements regarding the project as a whole.
  - `#Level/System`: Applied to requirements that involve the CubeSat or the Ground Segment systems.
  - `#Level/Subsystem`: Relative to each subsystem in the project.
  - `#Level/Component`: Requirements in the lowest form in the project, normally making reference

to properties or parts of a subsystem.

#Criticality: Represents the importance of an requirement.

- #Criticality/Low
- #Criticality/Medium
- #Criticality/High

#Status: Indicates the completeness of requirements.

- #Status/OK
- #Status/NOK

- #Need: Project needs, normally associated with a Stakeholder.
  - #Need/System: Needs from a system as a whole.
  - #Need/Battery: Needs from the battery.
  - #Need/Supercapacitor: Needs from the supercapacitor.
  - #Need/Platform: Needs from the platform.
- #Subsystem: The major systems that compose the satellite.
  - #Subsystem/Platform
  - #Subsystem/Payload
- #Members: The people involved in the project.
  - #Members/Management
  - #Members/Systems_Engineering
  - #Members/Space_Segment
- #Stakeholder: Parties that are interested and/or affected by the project.
- #Document: The documents created following the developed templates.

Based on previous work made on the project, the templates for some categories of artifacts, such as needs and requirements, were already available and were adapted to be used in Obsidian, as shown below on File 1 and File 2, respectively. Beyond these, an additional template was created for the team members, shown on File 3. As for documents, stakeholders and subsystems, the templates contain only the field for the tag, with the rest of the file being initially empty.

In File 1, the need's type is identified by the {type} field in the tag, with its name or ID, being automatically filled with the name of the file. The Origin field references the associated stakeholder that originated the need, written in the Need section, and the Characteristic field highlights an associated subsystem or another characteristic, such as Test or Mission.

File 1: Need Template

```
Type: #Need/{type}

---
- **ID**: {{title}}

- **Origin**:

- **Characteristic**:

- **Need**:
---
```

Regarding File 2, the fields {type}, {level} and {criticality} establish the three different tags for each requirement, identified by its ID and written explicitly in the Description field. As for the Origin, it references the parent need or requirement, with Allocation being analogous to the Characteristic filed for the needs, thus referencing the context of the requirement, such as a subsystem. Finally, there was also created the Verification field to write down what is necessary to verify the completeness of each requirement. Note that the Status tag in the template is started as NOK, but can be changed whenever the requirement is satisfied.

File 2: Requirement Template

```
Type: #Requirement/{type}
Level: #Level/{level}
Status: #Status/NOK

---
- **ID**: {{title}}

- **Description**:

- **Origin**:

- **Allocation**:

- **Criticality**:
    #Criticality/{criticality}

- **Verification**:
---
```

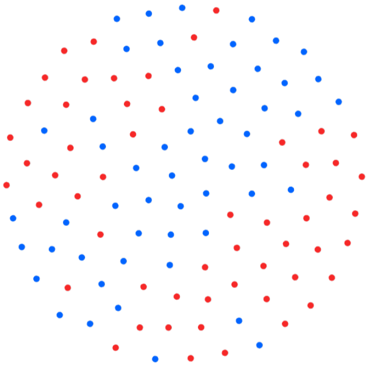
The final file template created in Obsidian is shown in File 3, in which the working team is delimited by the {team} tag for each member identified by Name. Field is used to identify the role of expertise of each member, as well as Location identifies a working location, such as a laboratory from the university. Finally, there is also contact information, such as E-mail and Phone.

File 3: Member Template

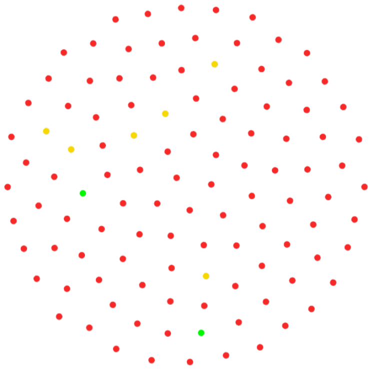
```
Allocation: #Members/{team}

---
- **Name**: {{title}}

- **Field**:

- **Location**:

- **E-mail**:

- **Phone**:
---
```

On Figure 3, the requirements are shown divided by its respective four group highlights: Requirement Type on Figure 3a, Criticality on Figure 3b, Status on Figure 3c and Level on Figure 3d. Also, the needs, subsystems and crew members are displayed coloured by type on Figure 4a, Figure 4b and Figure 4c, respectively. Note that, for now, there are only three payload subsystems on Figure 4b, them being the battery, the supercapacitor and the circuit responsible for the characterization of the supercapacitor. Also, work packages like orbit, propulsion and ground segment were considered subsystems on the graph view.

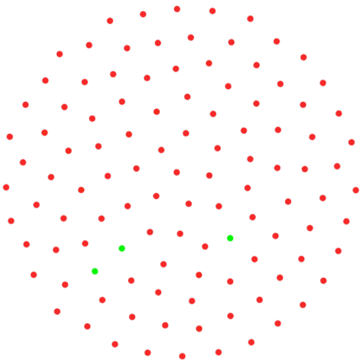
Figure 5 shows the complete graph for the current state of the project. From the figure, it is possible to notice that some of the notes have a substantially higher number of connections, thus highlighting that they consist of key elements for the project, such as the two payload subsystems, on the top of the graph, or the TBS document created for the project, which interconnects all of the team members and subsystems.



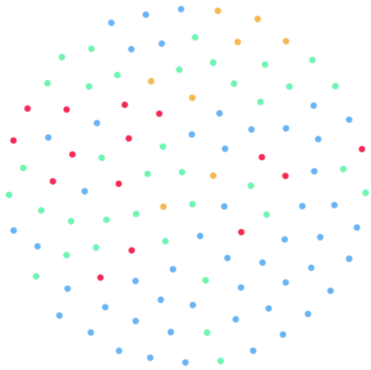
(a) Requirement type



(b) Requirement criticality

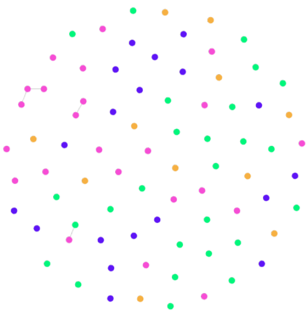


(c) Requirement status



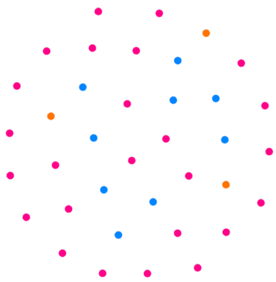
(d) Requirement level

Figure 3: Current documented requirements distinguished by groups



(a) Project needs distinguished by type

(b) Subsystems distinguished by type



(c) Project members distinguished by team

Figure 4: Needs, subsystems and team members grouped by type

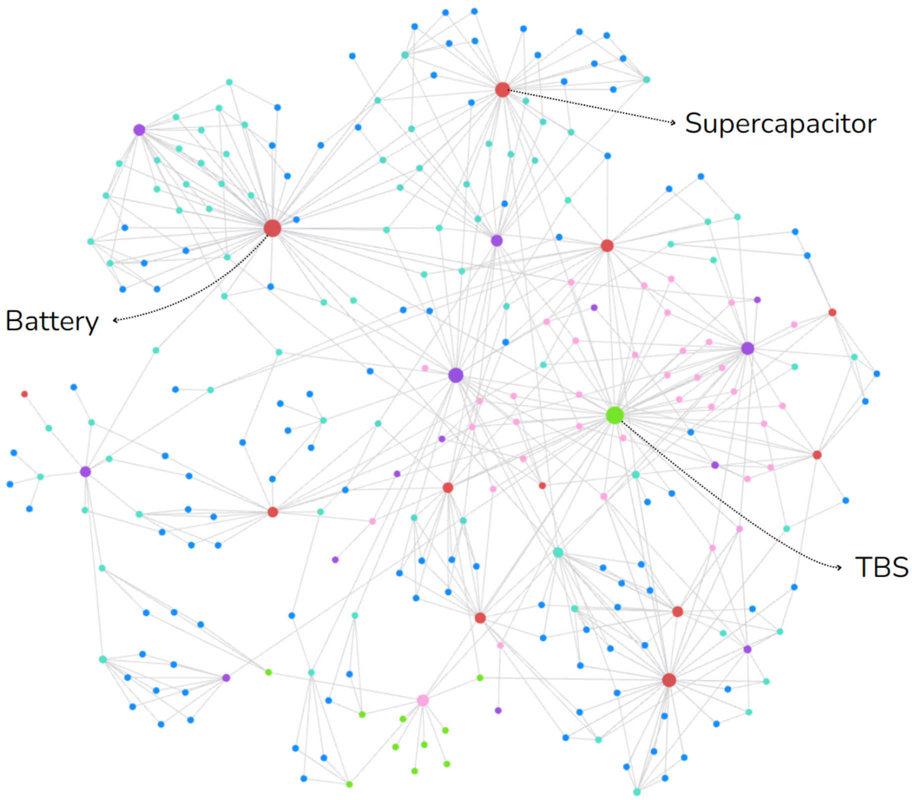


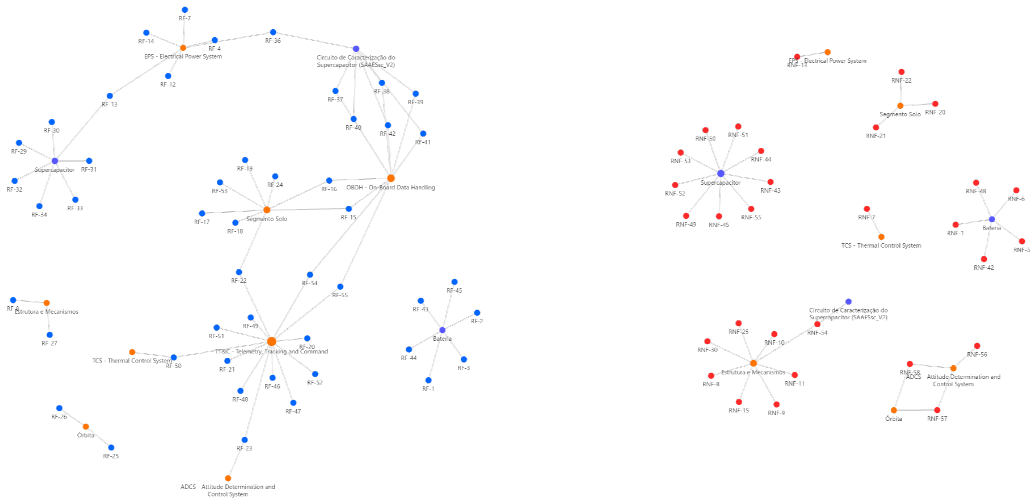
Figure 5: Complete graph for the current state of the project, with highlights on the payloads and TBS nodes

By taking advantage of the tags system inside the Obsidian software, several analyses can be performed, like viewing the subsystems and it's respective Functional or Non-Functional Requirements, as in Figure 6 or even with the requirements divided by level, as shown in Figure 7. From these two analyses, it is possible to note that Functional Requirements and Requirements in the Subsystem level are responsible for most of the interconnections between the different subsystems.

4 Conclusion

Throughout the review of well known practices and guides, such as PMBOK®, NASA or ECSS, and with the study of similar applications of graphs within traceability in real projects, this work presented unique and tailored approaches concerning the use of such tools in the context of a real project: the development and construction of a real academic CubeSat, the PdQSat.

Motivated by the need to create a customized management structure suitable to the academic and technical nature of the project, and with the guidance of well established stan-



(a) Functional Requirements

(b) Non-Functional Requirements

Figure 6: Subsystems view of requirements divided by type

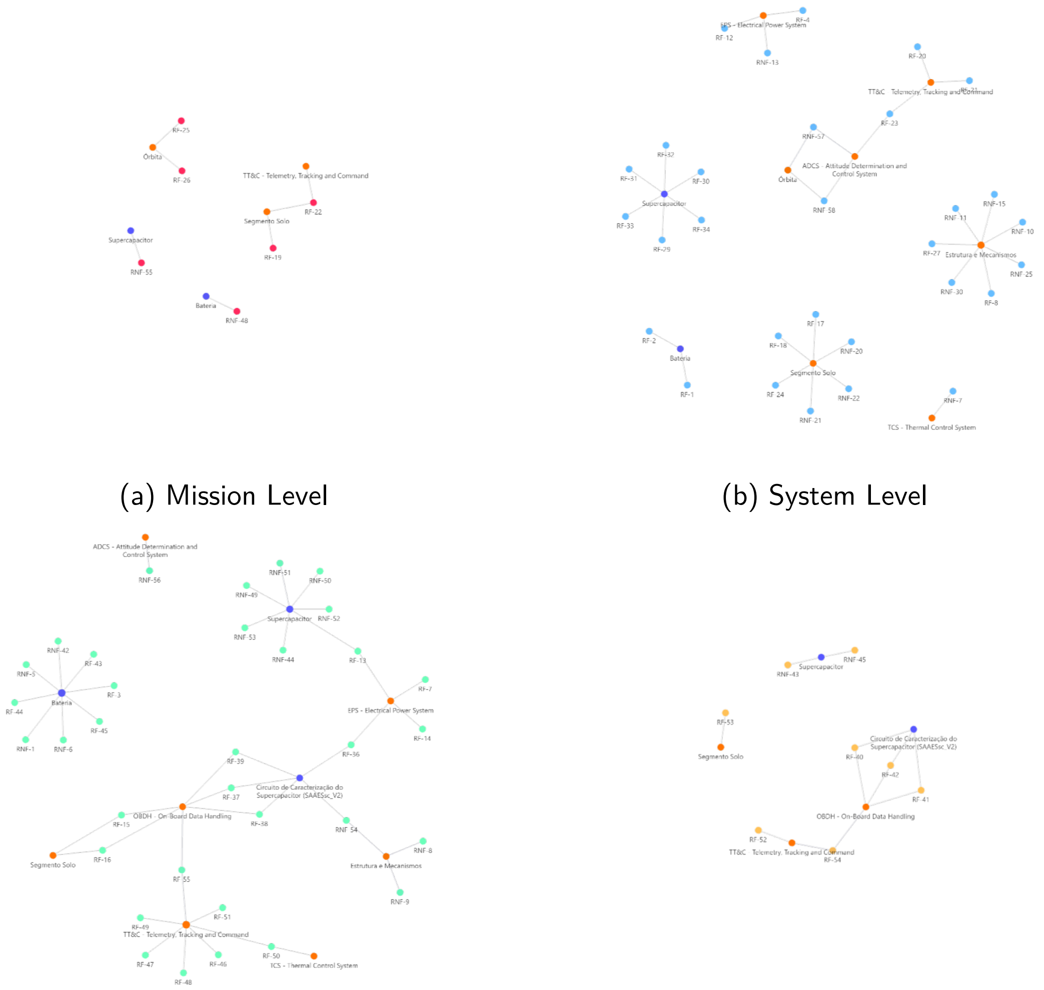
dards for management documentation, a set of ten documents was created, with each one approaching a key aspect or design phase for the project, such as schedules, team divisions, reviews and others. These documents contributed to establish a management model that is suitable for the project, thus allowing it to be carefully developed and to last through multiple generations of students.

Beyond the documentation created, the current work also delved into the study of graphs and their application regarding information traceability within real projects. By analysing the particularities of the PdQSat project and review works made by other students, a division of the most important classes of artifacts became clear, thus allowing to organize key information form the project. Uniting these studies with the selection of a familiar and flexible tool, the Obsidian software, it was possible to validate the proposed structure in the context of the project and establish new paths to trace in order to expand the implementation and aggregate ever so more value to the ongoing work being developed at the university.

5 Acknowledgments

We would like to express our deepest gratitude to everyone who contributed and still contributes to the development of the PdQSat project. First, we thank the Brazilian Space Agency (AEB) for their invaluable support and sponsorship, which made this research and development project possible.

We are also immensely grateful to the Federal University of Minas Gerais (UFMG), whose infrastructure, expertise and high-end professionals provided the foundation for the PdQSat's development. A special thanks to all the students who contributed through their projects and theses, exploring areas such as



(a) Mission Level

(b) System Level

(c) Subsystem Level

(d) Component Level

Figure 7: Subsystems view of requirements divided by level

mission analysis, subsystem design, requirements engineering and more. Your dedication and hard work have been crucial to both the advancement of this research and the PdQSat project, and your contributions continue to shape the future of this academic mission.

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