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Filipe José Oliveira Sabóia

STAKEHOLDER CATEGORIZATION AND ANALYSIS APPLIED TO AN AEROSPACE MISSION

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Filipe José Oliveira Sabóia

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Advisor

Christopher Cerqueira, Adjunct Professor (ITA)

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Filipe José Oliveira Sabóia
Rua Capimirim, 165
04558-090 – São Paulo–SP

STAKEHOLDER CATEGORIZATION AND ANALYSIS APPLIED TO AN AEROSPACE MISSION

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Filipe José Oliveira Saboia

Autor

Prof. Dr. Christopher Shneider Cerqueira (ITA)

Orientador

Prof. Dr. Maurício André Varela Morales

Coordenador do Curso de Engenharia Aeronáutica

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I am grateful to my parents and to family, who supported me since I was born, to my friends and professors and, finally, to God who gave me a life.

"Eu não estou interessado em nenhuma teoria, em nenhuma fantasia, nem no algo mais. A minha alucinação é suportar o dia-a-dia e meu delírio é a experiência com coisas reais." — Belchior

Resumo

O presente relatório tem por objetivo desenvolver métodos capazes de identificar stakeholders, seus objetivos e interesses em um projeto de engenharia.

O projeto em questão visa a desenvolver um pequeno satélite nacional capaz de coletar informações sobre o clima espacial brasileiro de forma a melhorar a capacidade científica do país.

O projeto é uma iniciativa do Instituto Tecnológico de Aeronáutica(ITA) em parceria com o Instituto Nacional de Pesquisas Espaciais(INPE) e outras organizações parceiras.

Palavras-chave: Partes interessadas; Missões espaciais; Microssatélites; Engenharia de sistemas; Engenharia aeronáutica.

Abstract

The ITASAT2 is a small satellite that is being developed by the Technological Institute of Aeronautics in agreement with the National Institute of Aerospace Researches.

The objective of this project is to improve the technological capacity of the Brazilian Institutes by developing a satellite capable to measure and analyze many aerospace phenomena such as the Equatorial plasma bubbles. This phenomenon affect the radio waves degrading the performance of the GPS as well as the capacity of the take-off and the landing in airports located close to the Earth's geomagnetic equator.

The purpose of this report is to develop a system-engineering project that will help the system engineering group to identify the stakeholders, their roles and their influence and their interest in the project.

Keywords: Stakeholders; Concept of Operation; Interest; Influence.

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List of Abbreviations and Acronyms

ITA	Insituto Tecnológico de Aeronáutica
INPE	Instituto Nacional de Pesquisas Espacias
CONOPS	Concept of Operations
NASA	National Aeronautics and Space Administration
MCTIC	Ministério da Ciência, Tecnologia, Inovações e Comunicações
CEI	National Aeronautics and Space Administration
AEB	Agência Espacial Brasileira
USAF	United States Air Force
DCTA	Departamento de Ciência e Tecnologia Aeroespacial
ITU	International Telecommunication Union
ANATEL	Agência Nacional de Telecomunicações
ION	Interorganizational Network
ITASAT-2	Intituto Tecnológico de Aeronáutica Satélite
SmallSat	Small Satellite

Contents

1 Introduction

1.1 Objective

The objective of this work is to make a study of a system engineering project called ITASAT2 that aims to create a small satellite capable of study the aerospace weather.

1.2 Motivation

The ITASAT-2 project adds to the recent technological-scientific efforts in the development of miniaturized satellites offering the opportunity of considerable scientific advance in the understanding of spatial plasma phenomenology.

The Brazilian region presents several unique characteristics in its air space, such as the distinct configuration of the lines of the geomagnetic field, which present a marked declination (difference between the geographic and the geomagnetic axes), the intense decrease in its magnitude (Magnetic Anomaly of the South Atlantic) and the frequent occurrence of large scale depletion in ionospheric plasma density (plasma bubbles).

The development of scientific knowledge in this area is extremely desirable because an immense amount of technological applications is impaired by plasma bubbles and, in fact, by the scintillation. In the case of aeronautics, for example, scintillation is an obstacle to obtaining certification approvals and the implementation of precision augmentation systems for landings and take-offs. Also, the ITASAT-2 project has some prerogatives on other similar missions, due to the instruments that will take with it shipped and the start date of its useful life.

2 Context

2.1 Definition of SmallSats

The Collins English Dictionary describes a satellite as an artificial body launched into the space in order to collect and to transmit information. In this way, a SmallSat could be described as satellite that has a limited size and a limited weight.

To define the range of size and weight that limit a SmallSat a Unit(U) was developed. The unit(U) means a satellite with dimensions equal to 10 cm x 10 cm x 10 cm and a weight less than 1.33 kg.

To compare with other types of satellites, the table below shows the different dimensions of each type:

TABLE 2.1 – SmallSats classifications.(WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017)

SmallSats	Wet Mass
Pico-Satellite	$\leq 1kg$
Nano-Satellite	1 – 10 kg
Micro-Satellite	11 – 100 kg
Mini-Satellite	101 – 500 kg

2.2 Data Analysis

In order to better understand the use of SmallSats, it is necessary to analyze the amount of data that describes its use.

First of all, it is very interesting to analyze the amount of SmallSats launched over the last 25 years. According to (WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017) there was three main periods in the recent history of the SmallSats. The first phase had happened from 1995 until 2000. The Orbcomm and Globalstar constellations were developed for communication use. These two companies were responsible for the launching of 65 satellites.

In 2006, 20 satellites were launched at the same time by the same launcher. However, this mission failed and all objects were destroyed.

Finally, the third phase, that started in 2013, is supported by the growth of scientific SmallSats as well as by growth of military payload launched. In the next figure, it is possible to summarize the number of SmallSats launched by year.

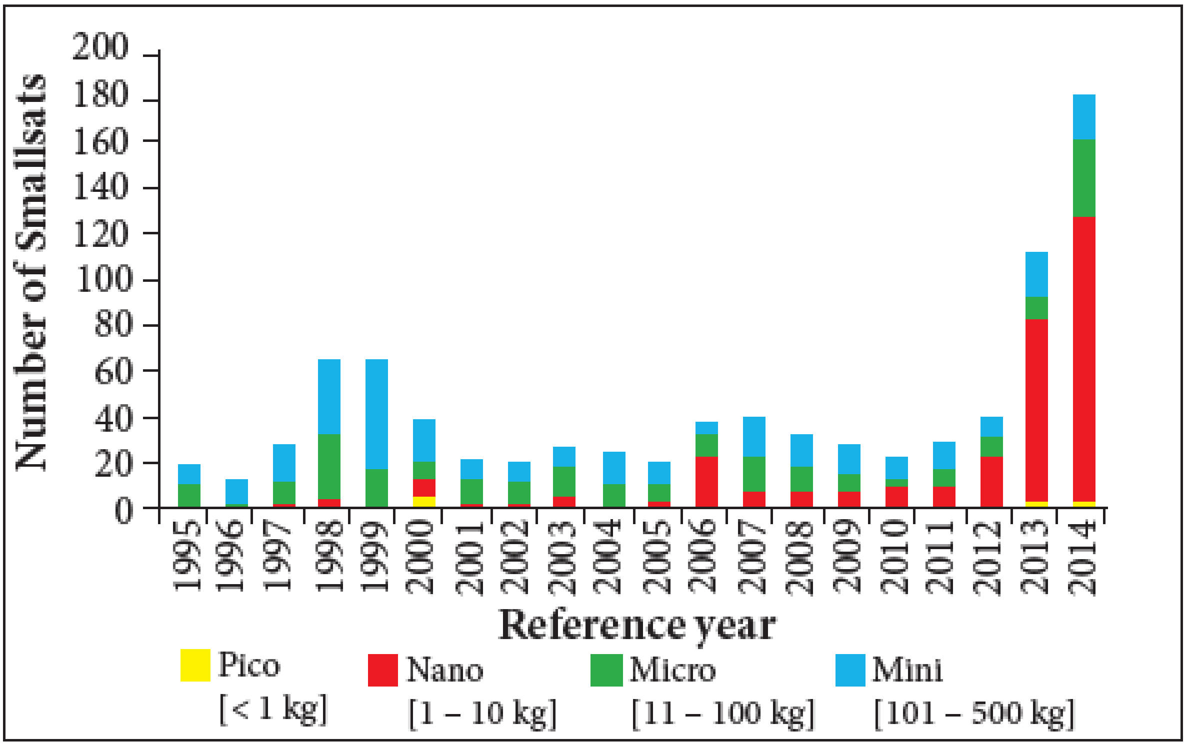

FIGURE 2.1 – Number of Smallsats launched by year. (WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017)

2.2.1 Mission Type

According to (WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017) it is possible to divide the type of mission in five clusters. The first of all is the educational type. That means a mission that is focused to develop the students knowledge or, maybe, to understand a specific process in the system engineering field.

The second type is known as a mission used to validate a new technology as well as to validate the technological capacity of a given institution. This kind of mission could be used, for example, to test a new kind of engine or a new electronic system. After that, there are the science missions focused on the gathering of weather space data.

In the fourth place, the there are the imaging missions that aim to collect earth data like atmospheric weather, geographic data, magnetic field and others physical phenomena.

Finally, there is the main kind of mission. The communication missions aim to cover almost all earth surface, with signals to provide internet access, GPS support as well as the radio signals.

Besides that, there are the military missions that can be developed to survey other countries, to provide a system of self-defense or just to demonstrate military capacity. Below, there is graph that shows the number of satellites launched in accord to their application.

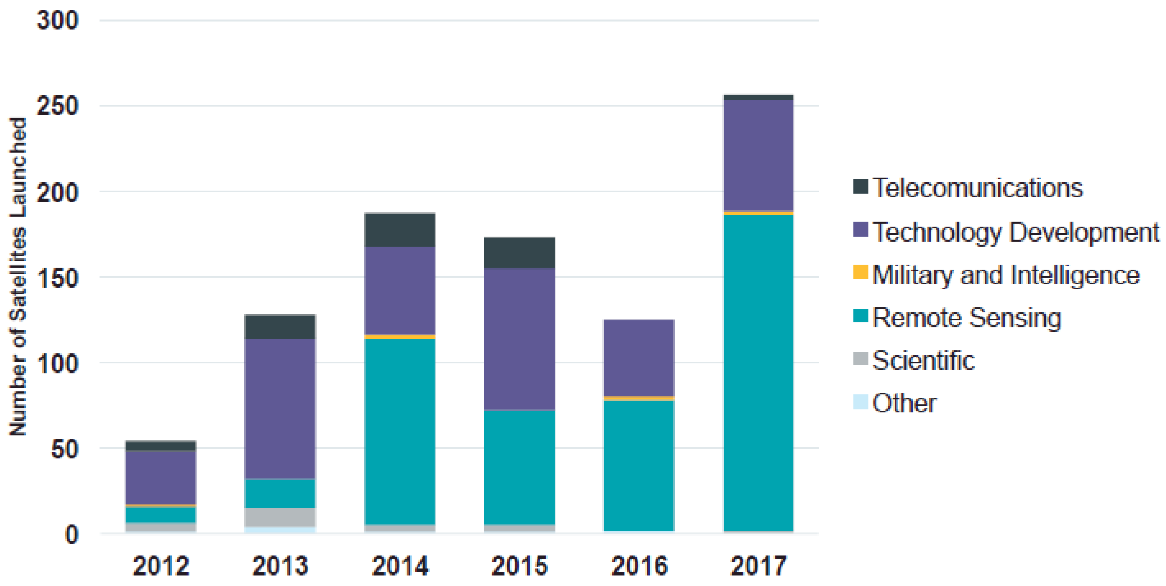

FIGURE 2.2 – Number of SmallSats launched by the specific application.(WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017)

2.2.2 Evolution and Market for SmallSats

According to (WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017) there are several advantages of the use of SmallSats comparing to conventional technologies. The first of all, and maybe the principal advantage, is the possibility to test and to validate new technologies in a faster and cheaper way. This advantage is related to another one: The reduced life cycle.

As mentioned in the previous section, the development time is usually less than 2 years. This factor reduces the life cycle and helps to develop different configurations, using different technologies, in a small time space.

Talking about costs, the size of this kind of satellite reduces the problems related to the standardization of the development process. It is easier to produce the components in large scale as well as to higher the number satellites produced.

Finally, it is possible to say that it is easier to access this kind of technology.As mentioned by (RICHARDSON *et al.*, 2015), from 2009 to 2013, 51% of all small satellites were produced by universities. In addition, 40% were built by commercial and civil entities and only 9% by military institutions.

Talking about to the market, a recent study conducted by the company (EUROCONSULT, 2018) says that over 2018-2019 almost 7000 SmallSats will be launched. This market will generate about USD 38 billion for satellite manufacturing including USD 16 billion to the launch operators.

Another study (PRASAD, 2018) says that it could be generated about USD 62 billion by 2030. According to the author: " The upsurge in demand is the result of small satellites evolving from being simply technology demonstrator platforms to becoming affordable downstream services across the industry. More than 30 commercial operators are building SmallSat capabilities and plan on installing large constellations in the Low-Earth Orbit (LEO) to offer low-cost imagery and affordable global connectivity solutions"

The currently market in shared by different countries with a major contribution from United States.

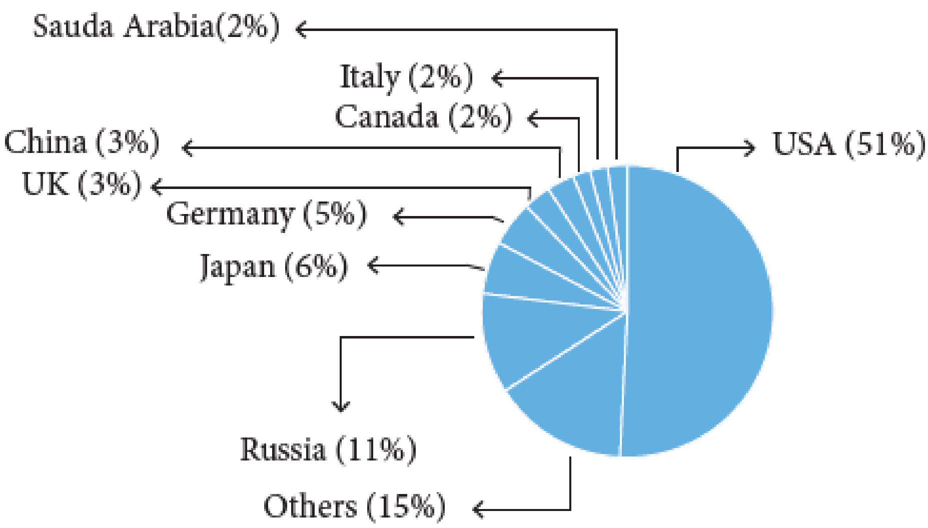

FIGURE 2.3 – Manufacturing market share.(WEKERLE TIMO; PESSOA FILHO; TRABASSO, 2017)

2.3 Definition of Stakeholder

The term "Stakeholders" can be defined as an individual or organization that have any kind of interest in a specific project (SMITH, 2000). The term also can be used to refer to any external entity that could be affect by the project. We can cite as examples of stakeholders the project manager, the sponsor, the suppliers, the customers and the regulatory agencies.

Identify the stakeholders as well as their goals and needs is the first step of a successful project. When dealing with a complex or expensive project, an powerful stakeholder, like the sponsor, can block the project's development. So, in order to deliver a project that attends the expectations is very important to understand all interfaces, attributes and relations between the stakeholders.

After that, the second step consists of aligning the expectations and the commitment in order to define what are the most important tasks to be accomplished by the project.

In order to follow these two steps, it is necessary to create a document that summarize all information. This document is very useful to servile the project's deployment, to check if the development direction is right and to avoid that the final project does not attend the expectations.

The following chapter presents two methods that can be used together in order to list phases of development, to identify stakeholders, to describe roles and tasks and, finally, to rank stakeholders according to their influence and interest.

3 Methods

3.1 Methods Definition

In order to describe a engineering project, it is necessary to identify the stakeholders as well as to create the CONOPS. First of all, a generic CONOPS will be created ,after that a method to identify the stakeholders will be described. Finally, the methods will be used to the real case mixed with a method of analysis of interest and influence as presented in the diagram below.

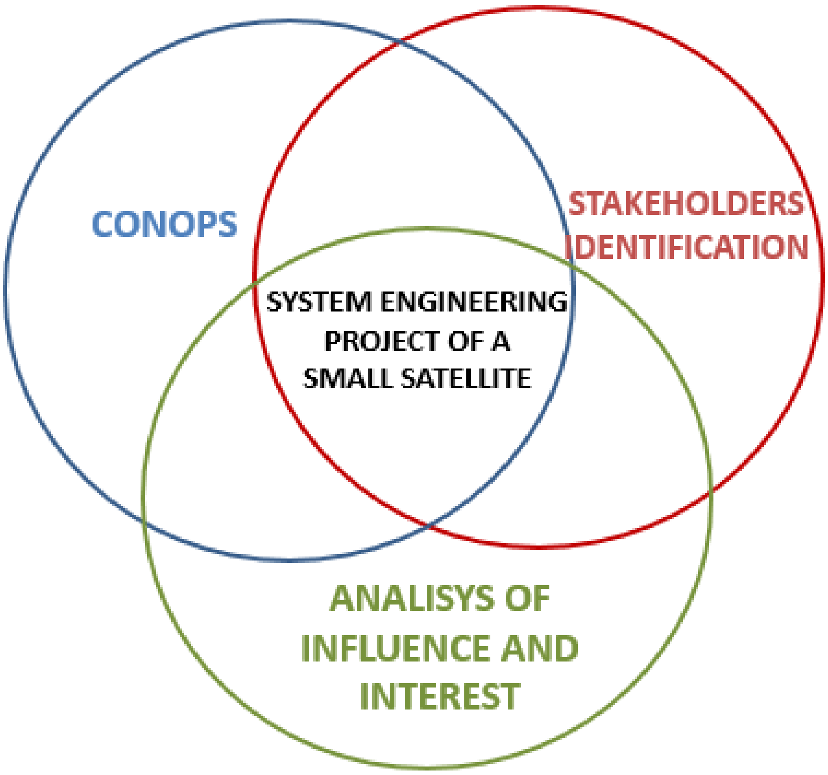

FIGURE 3.1 – Diagram of the three methods.

3.2 Conops

The concept of operations is a document describing the characteristics of a system from the viewpoint of the user. Normally, the CONOPS can be developed in many ways. According to the (HALL PHIL;HICKS,) the CONOPS can be created following six steps:

1. Understand the purpose of the project.
2. Identify the stakeholder's expectations.
3. Define assumptions and constraints.
4. Determine the project boundaries.
5. Define the operational phases and scenarios.
6. Illustrate the conops.

The purpose of the project was explained in the first chapter. However, to better understand the needs, the goals and the objectives, a generic view of project must be created. The following topics explains the project overview by showing possible scenarios.

3.3 Generic CONOPS

3.3.1 The Study of Project Viability

The first step to create a engineering project is to create a study of viability. In this phase, the developers and the sponsors make efforts to identify and understand the project from a generic view in order to estimate the necessity of money, the development time and the technological capacity.

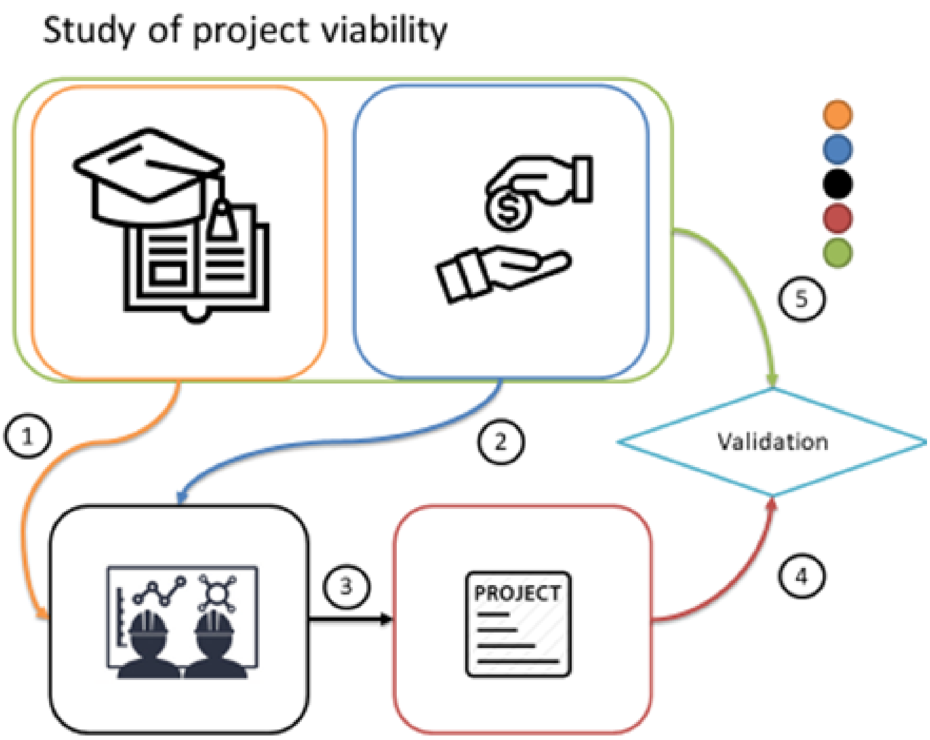

FIGURE 3.2 – Project Viability.

The figure above shows how the stakeholders are correlated in this phase. It is possible to notice that there are five different groups. In the orange square it is represented the technological group that will feed the project with the theoretical analysis. Besides that, in blue, the sponsor team will analyze the financial viability. These two groups have the function to support the system engineering team (the black group). Finally, the project viability must be validate by all stakeholders.

3.3.2 Development Phase

The second phase of the project is the development phase. In this step, it is already known that the project is financial and technological viable. The project manager must divide the work in different groups according to the project's specificity.

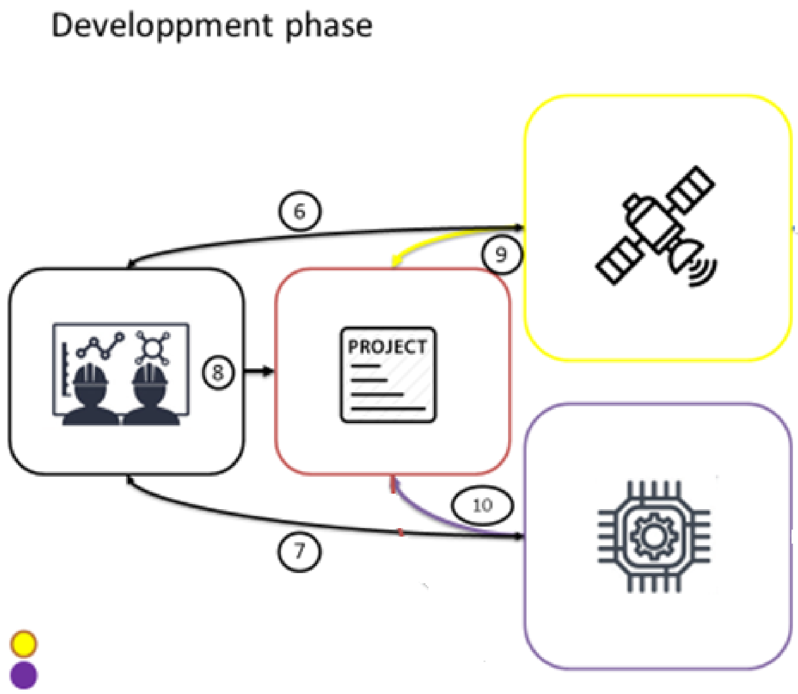

FIGURE 3.3 – Development Phase.

Looking at the development phase representation we can notice that there are two main different groups working at it. The yellow group represents the enterprise responsible for the physical architecture, besides that, the purple team is responsible for the electrical development.

It is important to say that the system engineering team must coordinate the flow of information.

3.3.3 Project Validation

This phase is probably the most crucial step. This phase includes the integration and the validation. At this time, two groups appear as the principal stakeholders. The launch enterprise and the government group. Without the validation of these groups the project can not continue.

The validation process is a loop of analysis. Each stakeholder gives its opinion about what is necessary to change. After a period of discussions, the project finally is validated.

In the figure below, each number represents the conclusion of each stakeholder about the project. For example, the number 14 represents the feedback answer from the launch enterprise. If the project obeys the requirements, the launcher gives a positive feedback. On the other hand, if the project does not meet the requirements, the launcher asks for project changing.

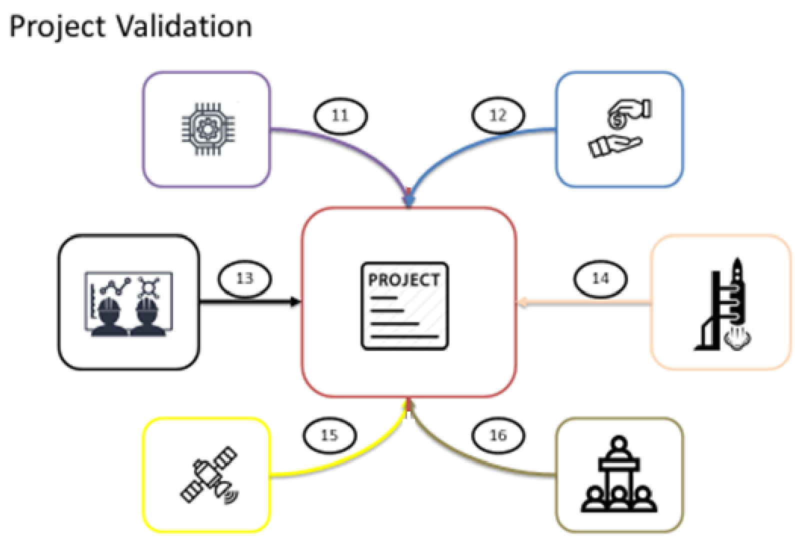

FIGURE 3.4 – Project Validation Phase.

3.3.4 The Service

During the service, besides the stakeholders that was listed, two other groups take place. The ground station group (the red group) that communicates with the satellite and the scientific society that uses the data provided by satellite to study the spacial weather.

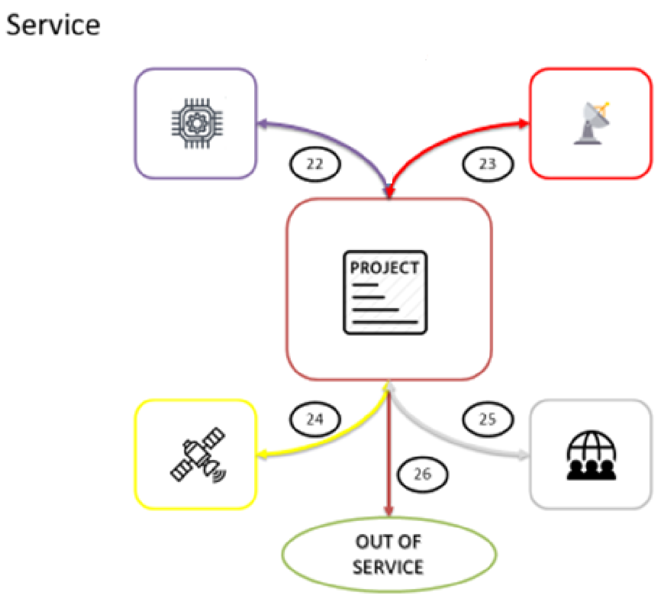

FIGURE 3.5 – Service Phase.

3.4 Method for the Stakeholders Identification

According to (BALLEJOS; MONTAGNA, 2008) requirement engineering is a process that aims to study all requirements, goals and objectives by the stakeholders identification. In order to make this process easier, many methods have been studied. For this project, it will be used the method developed by the mentioned authors.

First of all, it is important to define the stakeholder concept. (BALLEJOS; MONTAGNA, 2008) states that "a stakeholder of an interorganizational information system is any individual, group, or organization that can affect or be affected (positively or negatively) by the system under study and that have direct or indirect influence on its requirements."

After that, another aspect to be studied is the environment where the stakeholder is involved. A organizational context can be defined as a fixed relation between the company and its stakeholders. Normally, in this kind of environment it is easy to identify suppliers, customers and competitors, so each entity has a specific objective. On the other hand, in an interorganizational network (ION), which means a structure involving all stakeholders, all internal and external entities share goals and objectives 3.6. The hierarchic levels are not clear and the network between the companies is very complex.

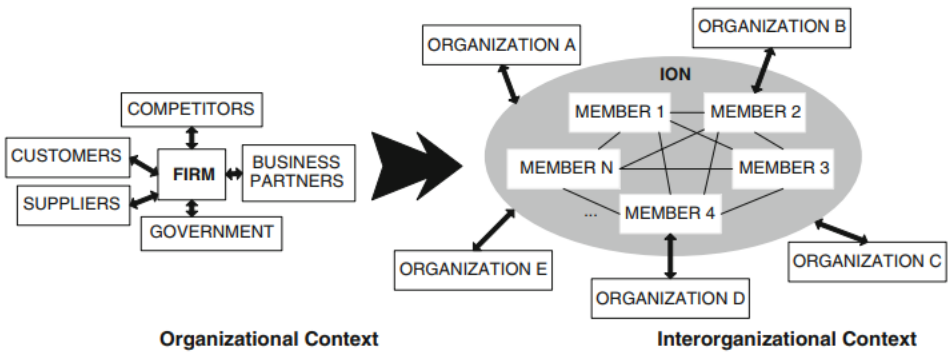

FIGURE 3.6 – Comparing a single organizational context with an interorganizational context. (BALLEJOS; MONTAGNA, 2008)

Finally, it is possible to divide the stakeholders in two types: Internal stakeholders and external stakeholders. Talking about the internal context, the stakeholders can be analyzed as individual entities, that have specifics objectives, but also as part of a big structure that has different objectives from those of the members. Thinking about the present study, it can be inferred that each institution has a different perspective from the global network.

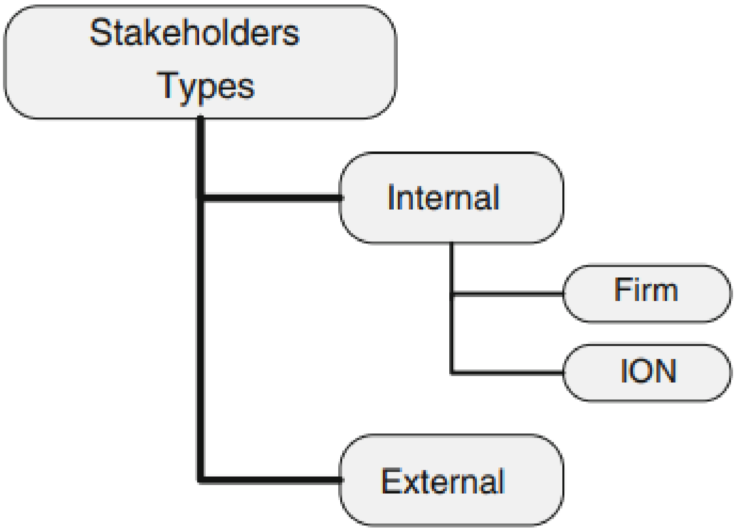

FIGURE 3.7 – Types of stakeholders. (BALLEJOS; MONTAGNA, 2008)

3.4.1 The Identification Method.

The identification method is divided in 5 steps. The first is used to analyze the skills and abilities that each stakeholder must have. In this phase, it is analyzed attributes like industrial capacity and technological development.

In the second step, the roles of the project are associated to each stakeholder during the project life-cycle. Both steps, the first and the second must be built in parallel to the concept of operations which purpose is to describe the characteristics of a given system including information like goals, objectives, activities and schedule associated to the participants.

In the third phase, each concrete stakeholder is selected and, in the next step, each role is associated to a specific stakeholder. Finally, the influence and the importance of each stakeholder are analyzed by considering its role in the project.

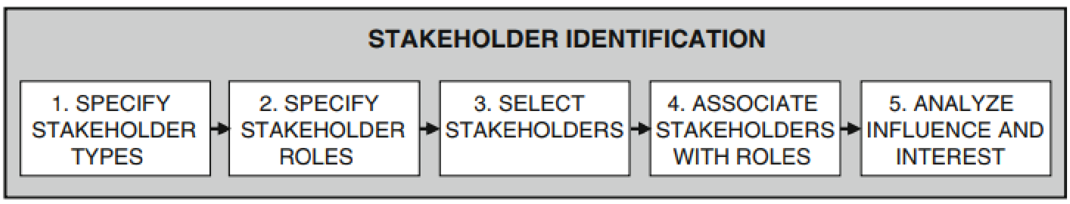

FIGURE 3.8 – Stakeholders identification. (BALLEJOS; MONTAGNA, 2008)

As a result, the method will provide a table that summarize the association between stakeholders and their roles as well as to identify aspects of the system like influence and interest.

As it mentioned before, this method must be developed in parallel to the concept of operations. The two documents work close to each other. For example, to specify stakeholders roles, in the second step, is necessary to define the system characteristics described by the Conops. On the other hand, to create a schedule, or even to describe the interactions among the participants, is necessary to identify the stakeholders.

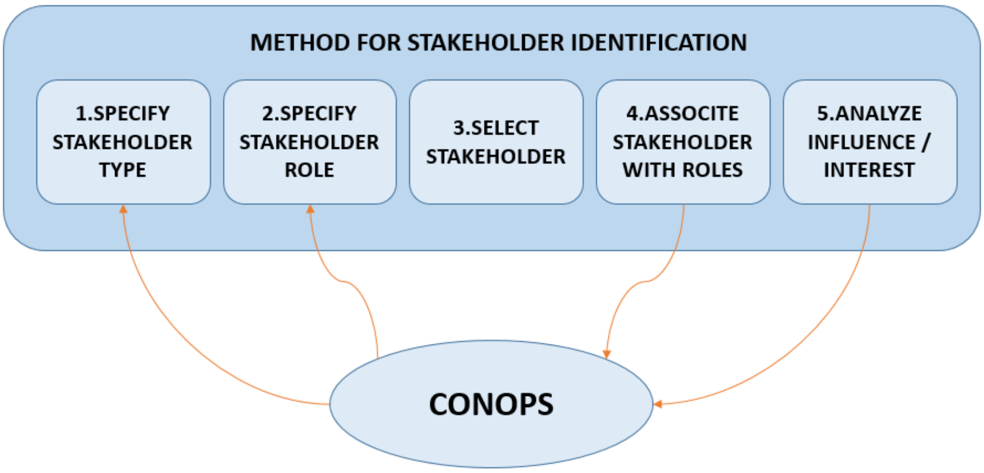

FIGURE 3.9 – Loop describing the relation between the stakeholders identification method and the CONOPS.

3.4.1.1 Specify Stakeholder Types

This phase begins with the analysis of all requirements and the needs by dividing them in different criteria. Besides that, it is made an environment analyze to define if the stakeholder must be an internal or external entity. The following table 3.1 shows that the stakeholders can be analyzed by considering its geographical location, its technological knowledge as well as its hierarchic level.

TABLE 3.1 – How to define the stakeholder types. (BALLEJOS; MONTAGNA, 2008)

Selection criterion	Specify stakeholder types		
Functional	Internal		External
Geographical location	Individual	ION	
Hierarchical level			
Knowledge/abilities			

3.4.1.2 Specify Stakeholder's Roles

In this phase the roles of the project are defined. This step is indispensable since it will define the schedule, the scope and the financial dependency. To help the development of this step, two tables were created in order to guide the stakeholders' roles definition. The first table aims to summarize maximum number of roles associated to the project. It will help, also, in the development phase.

TABLE 3.2 – Stakeholder's roles. (BALLEJOS; MONTAGNA, 2008)

Regulators:	They are generally appointed by government or industry to act as regulators of quality, security, costs or other aspects of the system. They generate guidelines and outlines that will affect the system development and/or operation.
Developers:	They are directly involved in IOS development (requirements engineer, analyst, designer, programmer, tester, project manager, etc.).
Beneficiaries:	Those that benefit from the system implementation.
Functional:	They benefit directly from the functions performed by the system and its products or results. Other information systems that interact with the new one can be included in this role, since the functionalities to be implemented would be beneficial to this exchange.
Financial:	They benefit indirectly from the system, obtaining financial rewards.
Negatives:	Those that undergo some kind of damage as a consequence of the system implementation or are adversely impacted by its development (for example, losing their jobs, physical damage, financial damages, etc.)
Political:	They benefit indirectly from the system, obtaining political gains in terms of power, influence and/or prestige.
Operators:	They are also called "users" by many authors, since they operate the system to be developed. They interact with the system and use its results (information, products, etc.).

After that, a second table, that describes and presents the details, is created.

TABLE 3.3 – Stakeholder role name description.(BALLEJOS; MONTAGNA, 2008)

Name:	**Stakeholder role name:**
Brief description:	Briefly describe the role and what it represents for the project. Generally, a stakeholder playing a particular role represents a group of stakeholders, some aspect of participating organizations, or some other affected business areas.
Responsibilities:	Summarize key responsibilities in relation to the project and the system to be developed. Specify the value the role will provide to the project team. For example, some responsibilities may be monitoring project progress, specifying expenditure levels and approving funds spending, etc.
Participation:	Briefly describe how they will be involved in the project and in which stages they will have greater influence.

3.4.1.3 Select Stakeholders and Theirs Roles

Using the table generated in the section 4.1 as well as the table of stakeholder's role, it is possible to select the stakeholders. In order to define their roles, there exists a specific table that creates the join between the role and the actors. This table is showed below:

TABLE 3.4 – Association between the stakeholder and a specific role. (BALLEJOS; MONTAGNA, 2008)

ID	**Stakeholder**	**Description**	**Stakeholder type**		**Stakeholder role**	**Influence**	**Interest**
			Criterion	**Dimension**			
S1							
S2							

3.4.1.4 Stakeholders Influence and Interest

Finally, the authors describe a matrix responsible for the classification concerning to the interest and the influence of each stakeholder.

TABLE 3.5 – Stakeholders influence and interest matrix. (BALLEJOS; MONTAGNA, 2008)

		Influence	
		Low	**High**
Interest	**High**	These stakeholders will need special initiatives.	These stakeholders constitute the supporting base of the project.
	Low	They are the least important stakeholders for the project	They can influence results, but their priorities are not the same as those of the project. They may constitute a risk or an obstacle for the project

4 Methods Application

4.1 Methods Application for the Small Satellite Project.

In order to understand how the CONOPS and the method of stakeholder identification are correlated the following chart was created.

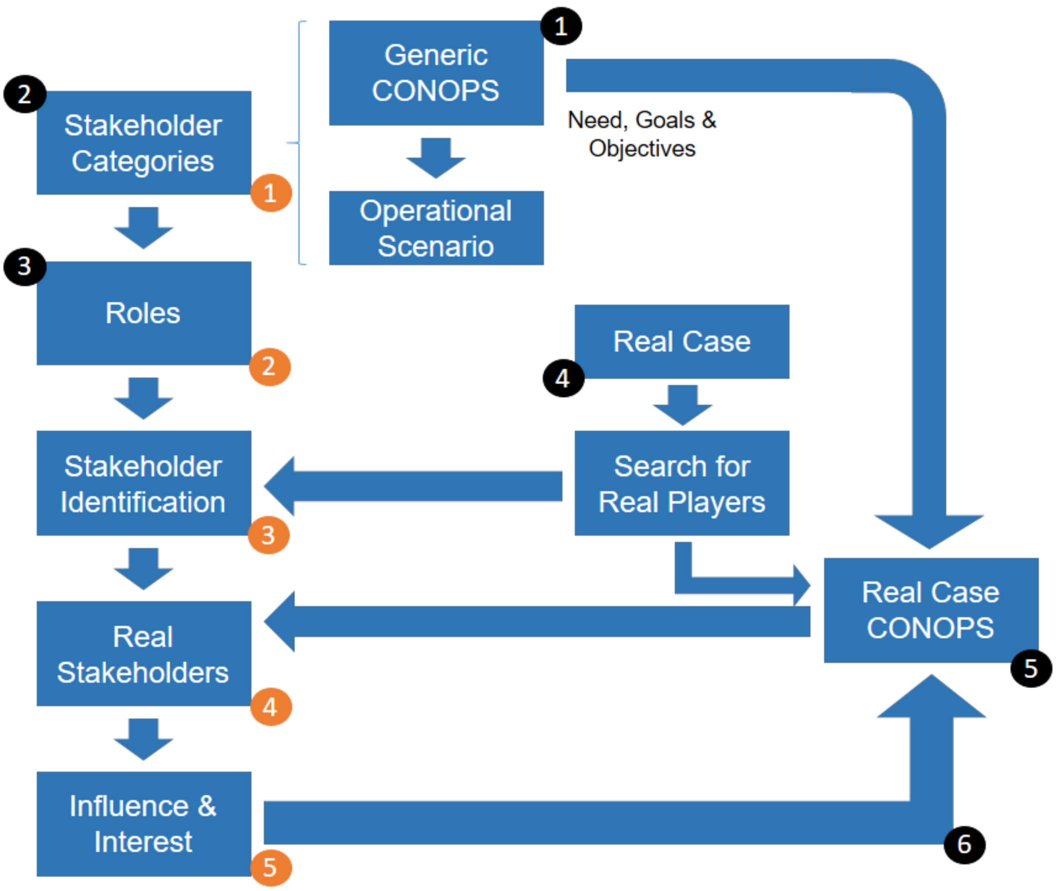

FIGURE 4.1 – Chart flow indicating how the two methods work.

The black numbers represent the six steps that were mentioned is the previous chapter.

1. Understand the purpose of the project.
2. Identify the stakeholder's expectations.

3. Define assumptions and constraints.

4. Determine the project boundaries.

5. Define the operational phases and scenarios.

6. Illustrate the CONOPS.

The orange numbers, on the other hand, represent the steps of stakeholders identification method.

1. Specify stakeholder types.

2. Specify stakeholder roles.

3. Select stakeholders.

4. Associate stakeholders with the roles.

5. Analyze influence and interest.

As the generic CONOPS was already proposed, this chapter will focus on the development of the two methods in order to present a real CONOPS.

4.1.1 Stakeholder Categories

This phase is mix of the specify the stakeholders types and their expectations. To do that, let's focus, first, on determine their types.

4.1.1.1 Specify Stakeholder's Types

As it was explained before, this step is useful to determine the types of stakeholders as well as to define if a stakeholder is external or not.

First of all, it is necessary to define the selection criteria where the stakeholders will be grouped. To do that, let us return to the CONOPS from the chapter 3 and enumerate the list of stakeholders:

1. The system engineering team.

2. The sponsor.

3. The technological study team.

4. The computer and electronic developer.
5. The structural developer.
6. The local authorities.
7. The external authorities.
8. The launcher.
9. The ground base.
10. The scientific society.

From the list above, we can associates each generic stakeholder to a selection criteria. The system engineering team represents a very important criteria that is the management.

The technological study team meets the knowledge criteria, as the computer and electronic developer and the structural developer meet the development criteria.

The sponsor is the related to the financial part. Besides that, the local authorities and the external authorities represent government criteria.

The launcher and the ground base are related to the location criteria. In addition, the ground base is also related to the functional criteria as well as the scientific society is related to it.

TABLE 4.1 – Stakeholder's types.

	SELECTION DIMENSION	
SELECTION CRITERIA	INTERNAL	EXTERNAL
MANAGEMENT	1	
KNOWLEDGE	3	
LOCATION	8, 9	
DEVELOPMENT	4, 5	
GOVERNMENT	6, 7	
FUNCTIONAL	9, 10	
FINANCIAL	2	

Now, it is necessary to define the external stakeholders. The table above just presents the stakeholders who are inside the interorganizational network.

These kind of stakeholder was not discussed in the generic CONOPS, however, they play a significant role during the project.The list below cites the principal eternal stakeholders.

11. The media.
12. The suppliers.
13. The logistical company.
14. The politicians.
15. The transition.

As the launching of a satellite represents scientific advance, the media will act broadcasting news about the project as well as about its development.

The suppliers will be presented during all phases of the project. Thinking about the development phase, they will provide all kind of pieces and tools in order to support the development teams. The logistic company works in different phases. Transporting materials and people during the development phases as well as during the launching.

The politicians, on the other hand, are the main stakeholders during the study of viability and during the project validation as they have the power to stop the project development.

Now, we can list three new selection criteria: The marketing, the logistics and the supply chain capacity.

TABLE 4.2 – Complete stakeholder's types table.

	SELECTION DIMENSION	
SELECTION CRITERIA	INTERNAL	EXTERNAL
MANAGEMENT	1	
KNOWLEDGE	3	
LOCATION	8, 9	
DEVELOPMENT	4, 5	
GOVERNMENT	6, 7	14
FUNCTIONAL	9, 10	
FINANCIAL	2	
MARKETING		11
SUPPLY CHAIN		12
LOGISTICS		13, 15

4.1.1.2 Identify the Stakeholder's Expectations

This phase is complex because the project manager must align the expectations of all stakeholders in order to avoid that the final project do not meet the goals and objectives previously defined.

For each stakeholder listed in the previous section, the following part describes their expectations.

1. The system engineering team: The final product meets the expectations about the system physical characteristics, the product functionalities, the budget expended during the development phase and the development phase.

2. The sponsor: The final product is capable to do whatever was defined during the development phase, the final budget is close to the estimated budget and the development time meets the schedule.

3. The technological study team: The technological requirements, during the development phase, are in accord to what was defined by the technological study.

4. The computer and electronic developer: The satellite, when in an operational phase, works as it was supposed to work respecting factors like: durability, operational capability and life-cycle time.

5. The structural developer: The same expectations as the previous group.

6. The local authorities: The project must respect the local laws like: environmental laws, civil laws and contractual laws.

7. The external authorities: The satellite must obey the international laws.

8. The launcher: The launching must place the satellite in according to the contract and must avoid any damage to the object. Besides that, the final costs and the final schedule must be in according to what was signed by the stakeholders.

9. The ground base: The satellite, when in the operational phase, must be capable to communicate with the ground base, to send required data, to receive and to apply orders received by the ground base.

10. The scientific society: The satellite must be capable to collect and to send data about the aerospace weather.

11. The media: They must be able to be broadcast all relevant news about the project.

12. The suppliers: The components provided by the suppliers must work as they were projected for. The components must not fail during the operational phase it will create additional costs.

13. The logistical company: All logistical phases must be accomplished during a specific interval of time without any damage to physical components and without any additional cost.

14. The politicians: They must be able to take relevant decisions about the project when necessary.

15. The transition: The company must support the project adequately in order to avoid any damage to the system.

4.1.2 Roles

This phase combines the definition of the stakeholder's roles as well as to define assumptions and constraints.

4.1.2.1 Specify Stakeholder's Roles

This step could be as complex as the project manager want. It is possible to describe all roles from the management roles to technical roles. The following table is the method application described by the table 3.2.

TABLE 4.3 – Stakeholder's roles for the real case.

Regulators:	They are generally appointed by government or industry to act as regulators of quality, security, costs or other aspects of the system. They generate guidelines and outlines that will affect the system development and/or operation.
Developers:	They are directly involved in IOS development (requirements engineer, analyst, designer, programmer, tester, project manager, etc.)
Beneficiaries:	Those that benefit from the system implementation.
Functional:	They benefit directly from the functions performed by the system and its products or results.
Financial:	They benefit indirectly or directly from the system. They may play the role of the functional or the beneficiary.
Negatives:	Those that undergo some kind of damage as a consequence of the system implementation or are adversely impacted by its development (for example, losing their jobs, physical damage, financial damages, etc.)
Political:	They benefit indirectly from the system, obtaining political gains in terms of power, influence and/or prestige.
Operators:	They are also called "users" by many authors, since they operate the system to be developed. They interact with the system and use its results (information, products, etc.).
Supporters:	They are involved by feeding the project with information, data, knowledge or physical tools.

Now the following table describes with more information the roles listed above.

TABLE 4.4 – Regulators description.

Name:	**Regulators**
Brief description:	The regulators define aspect of the production and the use of the satellite. Normally, they are public corporations and international institutes.
Responsibilities:	They must guarantee that the project respects national and international laws as well as to servile the satellite use.
Participation:	The regulators have a special importance during the development phase when technological contracts are being made. Also they have a huge importance during the operational phase.

TABLE 4.5 – Developers description.

Name:	**Developers**
Brief description:	The developers take place after the initial phase. They are responsible for the development as well as for the technical support during the operational phase. They must be in contact with the system engineering team during all the project.
Responsibilities:	They must guarantee that the project is in accord to what as defined by contract and the satellite must be capable to perform all its functionalities.
Participation:	The developers are important during the development phase but also during the operational phase as they must support the operators.

TABLE 4.6 – Beneficiaries description.

Name:	**Beneficiaries**
Brief description:	The beneficiaries are not a group with the major interest in the project but they benefit by earning money like the suppliers do or earning knowledge like the developers do.
Responsibilities:	As beneficiaries they do not have any specific responsibility. However, Some beneficiaries play different roles during the project so they may have other tasks to do.
Participation:	They are involved during all phases of the project.

TABLE 4.7 – Functional description.

Name:	**Functional**
Brief description:	The functional group is the group that benefits directly by the project. They use the functions performed by the satellite to study the aerospace weather.
Responsibilities:	They have the responsibility to use the developed system and to create value from the functions provided by the satellite.
Participation:	They are, mainly, involved during the operational phase when the satellite could provide data about the aerospace weather.

TABLE 4.8 – Financial description.

Name:	**Financial**
Brief description:	The functional role is, normally, made by a stakeholder with a great influence and interest in the project.
Responsibilities:	The stakeholder who has this role is responsible for sponsor all phases of project from the study of project viability to the operational phase.
Participation:	They participate during all phases having a key influence in all important decisions.

TABLE 4.9 – Political description.

Name:	**Political**
Brief description:	As this is a military project, the political group is responsible for signing technological agreements as well as for signing international agreements.
Responsibilities:	The have the responsibility of the project deployment surveillance.
Participation:	They participate during all phases having a key influence in all important decisions.

TABLE 4.10 – Operators description.

Name:	**Operators**
Brief description:	During the operational phase, this role will act interacting with the satellite in order to obtain data and information about the aerospace weather.
Responsibilities:	The group must control, send commands, extract data from the system.
Participation:	They participate during the operational phase.

TABLE 4.11 – Supporters description.

Name:	**Supporters**
Brief description:	During the project many different stakeholders can assume this role. There are supporters acting in different steps like administrative supporters, technical supporters as well as logistical supporters.
Responsibilities:	Give support in different areas.
Participation:	During all phases of the project.

4.1.2.2 Assumptions and Constraints

The next step is to identify assumptions and constraints related to the real case. When working in a real case project there are always constraints related to budget, to schedule and to technological capacity. Besides that, it possible to list investments in employees, training and development capacity.

On the other hand, it is possible to list assumptions like: impact of the results for the academic society, financial return due to the project and gain of knowledge. The next section will list all the possible stakeholders and their assumptions and constraints related to the small satellite project.

4.1.3 Select Stakeholders and Project Boundaries

This section aims to select the concrete stakeholders including the description, the constraints as well as the type of each stakeholder.

The table 4.12 describes each institute and, after that, the table 4.14 relates them to each criterion and to each dimension.

TABLE 4.12 – Description of stakeholders.

ID	STAKEHOLDER	DESCRIPTION
S1	ITA	The institute aims to gain knowledge and experience in the aerospace sector, specially in the small satellites area. The organization also aims to continue a precedent project called SPORT which objective was to improve the temporal resolution in order to collect scientific aerospace data. A second objective is to launch not only one but two satellites creating a constellation of satellites. This objective means a real technological advancement to the Brazilian Air Force as well as to the groups of research.

TABLE 4.12 – Description of stakeholders.

ID	STAKEHOLDER	DESCRIPTION
S2	INPE	The first objective of the institute is to validate its knowledge. Besides that, this project is a unique opportunity to develop new technologies. This institute will provide a range of electrical devices capable to measure different phenomena such as a Langmuir probe that is a device used to determine the electron temperature, electron density, and electric potential of a plasma, an Impedance probe, an E-field probe, a Magnetometer which is a device that measures magnetism including direction, strength, or relative change of a magnetic field.
S3	BRAZILIAN AIR FORCE	The Brazilian Air Force aims to dominate a new kind of technology with applications for the military field as well as for the civil field.
S4	BRAZIL	The project is important because it improves the scientific knowledge of the brazillian society. Besides that, the project represents a great opportunity to exchange technological advances and to create international contracts.
S5	CONGRESS	The congress has a interest in the geopolitical influence that the project could afford.
S6	MINISTRY OF DEFENSE	Interested in the defense knowledge that can be extracted from the project. Interested in partnerships to exchange defense knowledge.
S7	DCTA	Coordinates the technological aerospace developments of the FAB. Keep tracks of the contracts, schedule, suppliers and etc.
S8	CEI	Develop projects. Interested in the publicity of the projects. Interested in the evolution of students.
S9	MCTIC	Interested in generation of new projects. Interested in scientific and practical outcomes. Interested in the publicity of the projects.

TABLE 4.12 – Description of stakeholders.

ID	STAKEHOLDER	DESCRIPTION
S10	AEB	Keep tracks of contracts, schedule and the agreements. Wants that the space related scientific discoveries solve society needs.
S11	USA	Negotiate partnerships with other countries. Needs to cooperate with strategic allies. Scientific projects open relations to exchange knowledge.
S12	USAF	Interested in the development of space systems aligned to the strategic view.
S13	LAUNCHER	Interested in products that requires launching. Interested in publicity of the launchers.
S14	BRAZILIAN SUPPLIERS	Interested in sell parts. Interested in participating in the projects Interested in validating their products.
S15	INTERNATIONAL SUPPLIERS	Interested in sell parts. Interested in participating in the projects. Interested in validating their products.
S16	SCIENTIFIC COMMUNITY	Interested in the collected raw data. Interested in publishing papers. Interested in the scientific knowledge.
S17	ITU / ANATEL	Coordinate the use of frequencies.
S18	SOCIETY	Wants the final effect of the science. Wants a better life.
S19	MEDIA	Wants to publish news.
S20	DELIVERY SYSTEMS (mail)	Carries the vendor items, and the final product. Interested in the logistic aspect of the transitions.

TABLE 4.13 – Assumptions and Constraints.

ID	STAKEHOLDER	ASSUMPTIONS AND CONSTRAINTS
S1	ITA	Project knowledge must return knowledge to classes. Project must have students involved. Project must generate scientific publications.
S2	INPE	Requires money to pay professionals. Requires workplaces. Requires budget to operate spacecraft. Requires budget to integrate spacecraft.

TABLE 4.13 – Assumptions and Constraints.

ID	STAKEHOLDER	ASSUMPTIONS AND CONSTRAINTS
S3	BRAZILIAN AIR FORCE	Requires an alignment within the portfolio. Wants trained personnel. Wants to share knowledge.
S4	BRAZIL	Project must have an end. Requires that the project stay in budget, and in time. Requires return to the society. Consider the project as a geopolitical asset.
S5	CONGRESS	Must approve the budget as well as the international agreements.
S6	MINISTRY OF DEFENSE	Requires information to improve strategic knowledge of the Brazilian ionosphere.
S7	DCTA	Requires information to improve strategic knowledge of the Brazilian aerospace sector.
S8	CEI	Requires money to pay the students and to develop new projects. Requires workplaces.
S9	MCTIC	Requires a ROI. Requires the redistribution of gathered knowledge.
S10	AEB	Wants the project deliverable items.
S11	USA	Project must have an end. Requires that the project stay in budget, and in time. Requires return to the society. Consider the project as a geopolitical asset.
S12	USAF	Requires an alignment within the portfolio. Wants trained personnel. Wants to share knowledge.
S13	LAUNCHER	Provides a launch price/window to the project.
S14	BRAZILIAN SUPPLIERS	Sets a configuration item, with its resources and constraints.
S15	INTERNATIONAL SUPPLIERS	Sets a configuration item, with its resources and constraints.
S16	SCIENTIFIC COMMUNITY	Defines the set of instruments. Defines how the data must be generated and delivered. Defines how the data will be distributed.
S17	ITU / ANATEL	Define the slots available for transmission.
S18	SOCIETY	Requires understanding of the mission. Requires the knowledge of the use of its taxes.
S19	MEDIA	Requires information of the project. Requires information of the needs that drove the project. Requires the reasons for the project existence.

TABLE 4.13 – Assumptions and Constraints.

ID	STAKEHOLDER	ASSUMPTIONS AND CONSTRAINTS
S20	DELIVERY SYSTEMS (mail)	Define the time frame of deliver. Define the method to stock the items. Define the price of the transition between sites.

In order to associate each stakeholder to its dimension and to its criterion, let's return to the table 4.2. That table shows the association between the generic stakeholders and their types. Now, each real stakeholder takes the place of the generic stakeholder.

1. The system engineering team: CEI
2. The sponsor: BRAZILIAN AIR FORCE, USAF
3. The technological study team: ITA, INPE
4. The computer and electronic developer: INPE
5. The structural developer: ITA
6. The local authorities: DCTA, BRAZIL, CONGRESS, MCTIC, AEB ITU/ANATEL, BRAZILIAN AIR FORCE, MINISTRY OF DEFENSE
7. The external authorities: USA
8. The launcher: LAUNCHER
9. The ground base: INPE, CEI
10. The scientific society: AEB, MCTIC, SCIENTIFIC COMMUNITY
11. The media: MEDIA
12. The suppliers: BRAZILIAN SUPPLIERS, INTERNATIONAL SUPPLIERS
13. The politicians: CONGRESS
14. The transition.

Rewriting the table 4.2 the following table associates the stakeholders with their types.

TABLE 4.14 – Real stakeholder's types table.

	SELECTION DIMENSION	
SELECTION CRITERIA	INTERNAL	EXTERNAL
MANAGEMENT	S8	
KNOWLEDGE	S1, S2	
LOCATION	S13 , S2, S8	
DEVELOPMENT	S2, S1	
GOVERNMENT	S3, S4, S5, S6, S7, S9, S10, S11, S17	S20
FUNCTIONAL	S2, S8, S10, S9, S6	
FINANCIAL	S6, S12	
MARKETING		S19
SUPPLY CHAIN		S14, S15
LOGISTICS		S20

4.1.4 Real Stakeholders and Their Roles.

In order to associate each role to one or more stakeholders a table should be constructed. It will be used the table 4.3 and the table 4.12 to create the associations.

TABLE 4.15 – Stakeholder's roles in a concrete case.

ID	STAKEHOLDERS	ROLES								
		REGULATORS	DEVELOPERS	BENEFICIARIES	FUNCTIONAL	FINANCIAL	NEGATIVES	POLITICAL	OPERATORS	SUPPORTERS
S1	ITA				X					X
S2	INPE		X		X				X	X
S3	BRAZILIAN AIR FORCE			X		X				X
S4	BRAZIL	X		X				X		
S5	CONGRESS	X						X		
S6	MINISTRY OF DEFENSE	X		X						X
S7	DCTA	X		X						X
S8	CEI		X		X				X	X
S9	MCTIC	X		X						X
S10	AEB	X		X						
S11	USA	X		X				X		
S12	USAF			X						X
S13	LAUNCHER			X						X
S14	BRAZILIAN SUPPLIERS			X						X
S15	INTERNATIONAL SUPPLIERS			X						X
S16	SCIENTIFIC COMMUNITY				X					
S17	ITU / ANATEL	X								
S18	SOCIETY			X		X				
S19	MEDIA			X						
S20	DELIVERY SYSTEMS (mail)									X

4.1.5 Stakeholder's Influence and Interest

Finally, in order to finish the method application, it is necessary to create a graphic that shows the influence and the interest of each stakeholder in this project.

According to (SMITH, 2000), the influence indicates the stakeholder's power within a Project. A influential stakeholder can control key decisions and can head the project's development. On the other hand, such player can also influence negatively causing delays to the project's schedule. The project's influence is derived from the stakeholder's economic power, political position or even the geographic location. The interest is related to the trade off between the stakeholder's needs and the goals and the objectives of the project. If the project's purpose is aligned with the stakeholder's needs, so the stakeholder will have a high interest in the project. The two measures are independent from each other and could be evaluated by implementing the participation matrix. This matrix is created by analyzing the role of the stakeholder in each stage of the life-cycle.

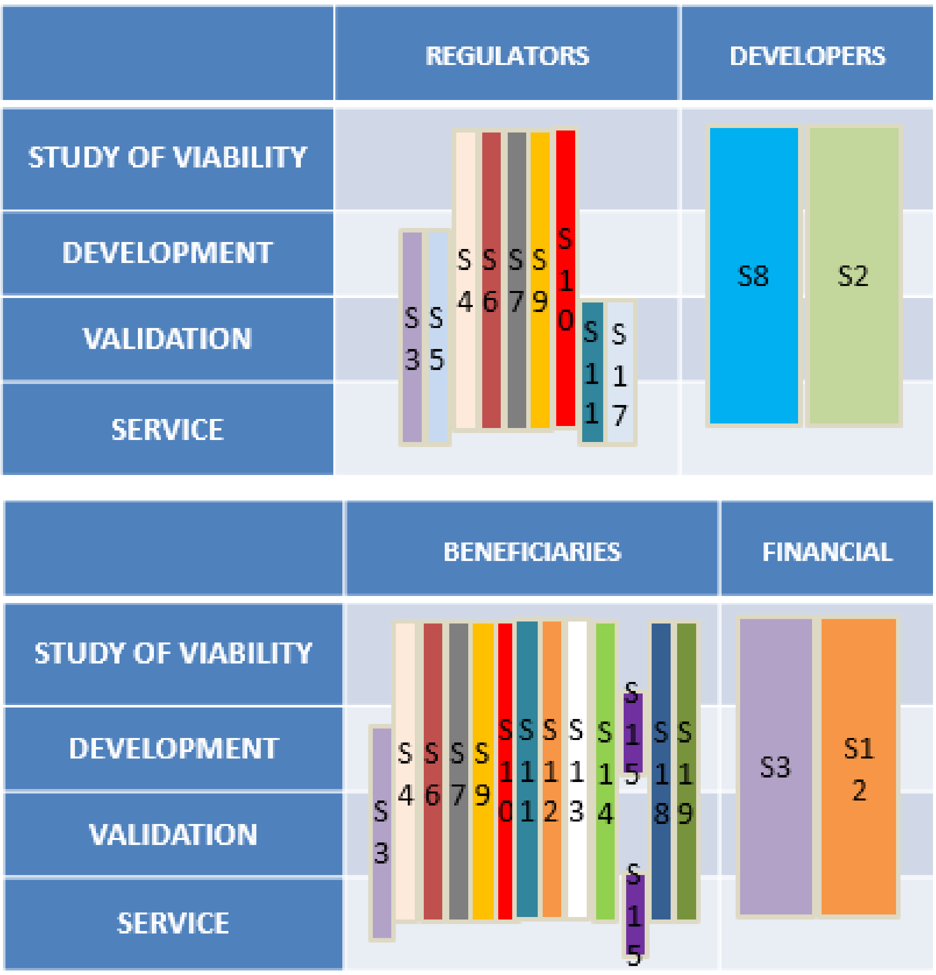

FIGURE 4.2 – First part of the participation matrix.

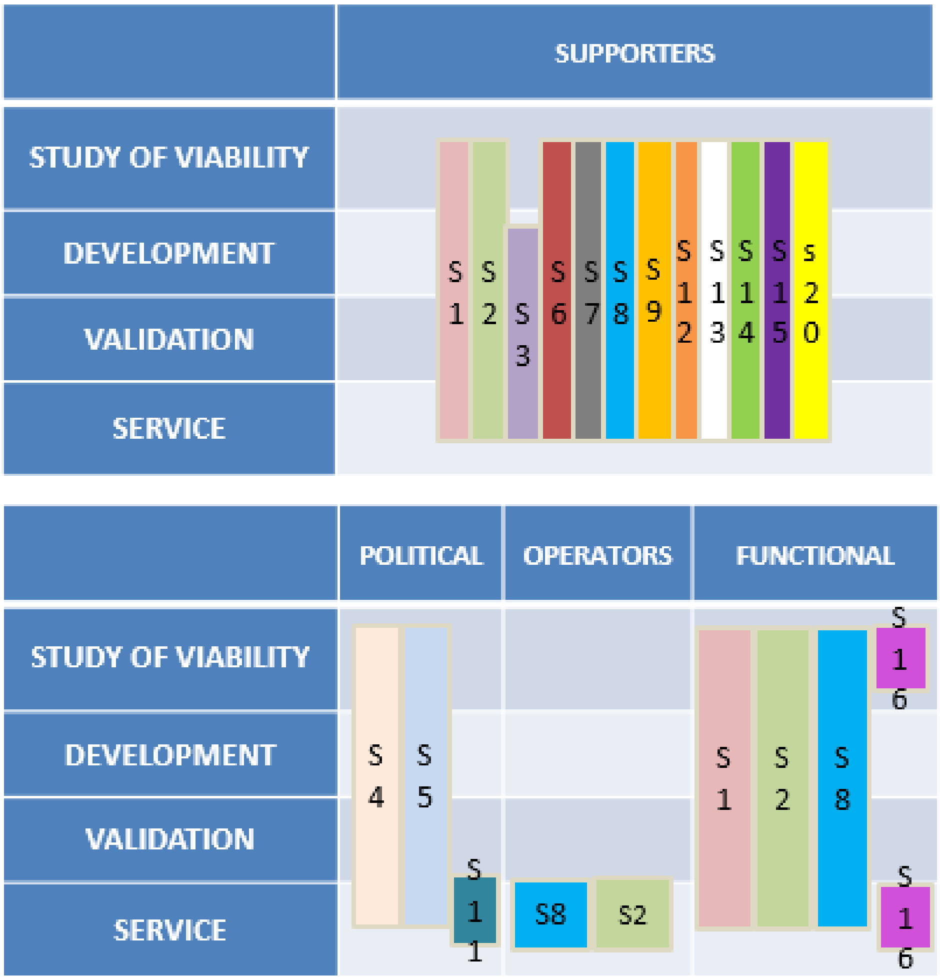

FIGURE 4.3 – Second part of the participation matrix.

Looking at the figure above, it is possible to list the roles that are associated to the stakeholders with a high interest. These roles are the beneficiaries and the functional. Besides that, the roles associated to the stakeholders with a high influence are the regulators, the developers, the political and the financial.

So, analyzing the figures above we can notice that the stakeholders with a high interest in the project are the INPE(S2) , the CEI(S8), the ITA(S1) and the Heliophysics Scientific Community(S16) as they are the main beneficiaries.

On the other hand, the most influential stakeholders are the Brazilian air force(S3), the Anatel(S17) and also the CEI(S8) and the INPE(S3) as these stakeholders have roles related to the project's funding and the project's development.

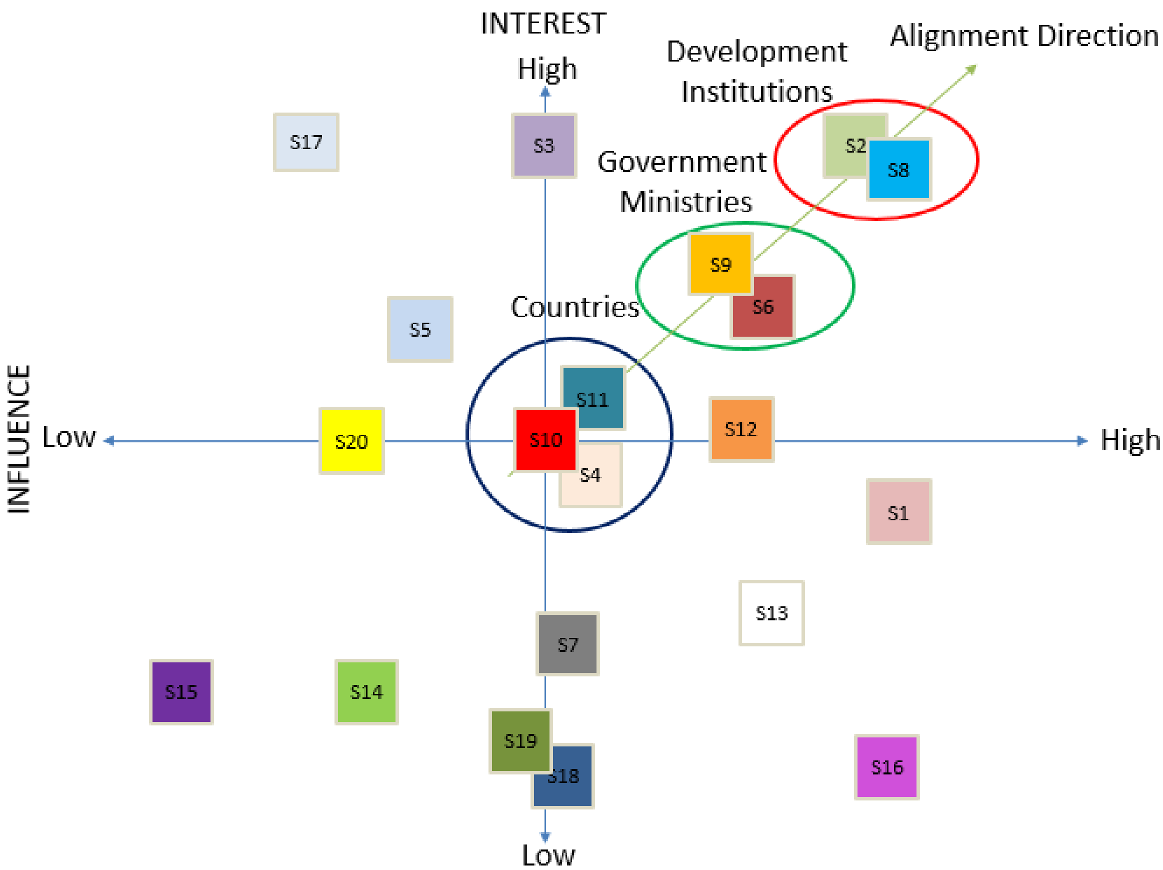

FIGURE 4.4 – Graphic of influence and interest.(SMITH, 2000)

The figure above shows the places of all stakeholders in a graphic of interest versus influence. As it was debated previously, the most interested and influential groups are the INPE and the CEI. It is also possible to notice that some stakeholders can be grouped forming different clusters like countries, government ministries and development institutions. Notice that there is a direction of alignment. This direction represents the order of importance of the stakeholders. The stakeholders that lie on the direction are key group for the project's success.

5 Conclusion

The present report had as objective the application of three different methods in order to analyze an engineering project.

When dealing with a project with a high complexity like a small satellite project, it is always import to understand factors related to the stakeholders before starts the development. First of all, it is necessary to identify and create a generic CONOPS in order to gain a overview of project and to identify different phases of development and different functionalities. In parallel to that, it is also necessary to identify the stakeholders as they have the power to validate or to block the project.

In order to achieve the previous tasks, a method for stakeholders identification was presented in the chapter 3 and it was applied in the chapter 4. Using the generic CONOPS, it was possible to create a list of generic stakeholders and also a list of different criteria to select the real stakeholders.

Finally, analyzing the roles of each stakeholder across the project's phases it was possible to define different levels of influence and interest. The main stakeholders could be grouped in cluster indicating a direction of alignment which the function is to indicate the stakeholders that must be listened to deliver a successful project.

It is also important to cite difficulties that were found in this work. When dealing with a complex project in a first stage it is almost impossible to identify all possible scenarios of operations and to list all organizations involved by the project. Besides that, in a initial stage is only possible to list roles in a generic view without having a depth conscious about the project in its final stage.

Now, thinking about a future work, during the development phase of a engineering project the reference (DRESCH ALINE; LACERDA, 2015) states that the stakeholders influence the objective, the strategy, the criteria and the search sources that conducted the research. In this way, according to (KRUGER, 2016) there are eight main problems when dealing with a stakeholders.

The first one is the resistance to share information.For example, as this is a project related to the military field, the sharing of information could be a problem. There is a fear to share secret information as well as to share technological knowledge. Each stakeholder has its own priorities information like technological patents which means economical and technological power.

Besides that, a stakeholders have the urge to design the end system. It is common that the stakeholder try to give a solution before explain the root cause of the problem. It is a very dangerous attitude because it could create a bias in the development of the system. To solve this problem is very important to pay attention and to follow the procedure developed by the system engineering.

Another common problem is that stakeholders miss-define their real needs. When a stakeholder miss define a real need it conduces the project development to a bad way because it could conduces a miss definition of the operational scenario, the principal functions, the specified requirements and also the final product.

To accept or to ignore requirements when more than one stakeholder is involved with different views is a complex issue. As is already known, the main stakeholders can have different views that can create a conflict inside the project. For example, the requirement to launch a constellation of satellites could be a conflict between the ITA and the Air force. In this way, it is necessary to find a convergence to avoid any disagreement.

Another problem related to the amount of stakeholders is the conflict of interest. When a project involves different kind of institution, it can create conflicts related to project goals and objectives. Also, there are problems that lie to schedule, invested capital and technology properties. In the field of small satellites, it is common to exist agreements with military institutions and universities. Normally, in cases like that, the problems related to schedule and technology properties are the most important.

As presented in the figure 4.4 different organizations have different levels of interest or engagement. Low engagement is a problem that is associated to the lack of involvement. It conduces to higher demand of money and time to finish the project. It also can conduce to a low quality final product and, in extreme cases, to the cancellation of the project.

The figure 4.4 also presented a direction of alignment.Normally big technological projects are divided in small projects related to different fields. The problem happens when it is necessary to integrate all parts. Normally, if there is no integration between the stakeholders, an additional time will be required in order to adjust the final product. It requires more time, more money and creates a conflict between the stakeholders.

Finally, a no long-term thinking impacts the project life-cycle, the delivered quality and also the cost of the project. Thinking in a long-term helps to anticipate risks related to the development phase as well as to protect the project in the running phase.

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11. RESUMO: The objective of this project is to improve the technological capacity of the Brazilian Institutes by developing a satellite capable to measure and analyze many aerospace phenomena such as the Equatorial plasma bubbles. This phenomenon affect the radio waves degrading the performance of the GPS as well as the capacity of the take-off and the landing in airports located close to the Earth's geomagnetic equator. The purpose of this report is to develop a system-engineering project that will help the system engineering group to identify the stakeholders, their roles and their influence and their interest in the project.			
12. GRAU DE SIGILO: (**X**) **OSTENSIVO** ( ) **RESERVADO** ( ) **SECRETO**			