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THE ROLE OF ENGINEERING IN THE ASSET MANAGEMENT OF AN INDUSTRIAL UNIT

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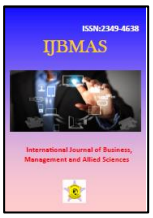

ABSTRACT

Globally, society faces significant challenges in managing its resources, particularly in industrial engineering, which is discussed in this paper. This work aims to develop a comprehensive and cohesive model of how engineering contributes to asset management in an industrial unit. The goal is to use a Delphi panel to better understand the engineering role in this new framework as applied to an industrial organization. This is particularly important because it is an ambitious goal that takes into account the complexity of the topic being studied, the time constraints associated with its implementation, and the pursuit of a more specific goal, namely the development of physical asset management based on a holistic, systematic, systemic, integrated vision and based on risk management, which can unify the various areas of an organization in the search for sustainability, optimization, The time distribution of submissions and complete answers began on April 22, 2023, and ended on May 25, 2024. and The Delphi panel seeks consensus among a group of experts with extensive knowledge in this emerging field by presenting a comprehensive and integrated model for industrial asset management. In summary, it can be concluded that the objective of applying the Delphi methodology was, essentially, to carry out the empirical validation of the MAIGAI, an objective that was successfully achieved; nevertheless, the panel improved the MAIGAI.

Keywords: Engineering Management, Delphi panel, engineering role, industrial asset management

1 Introduction

Engineering, due to its dimension and transversality, has sought, throughout its history, to apply knowledge in the service of transforming and adapting nature to optimize the quality of life, developing methodologies that, evolutionarily, adapted to each historical moment, ensure the

satisfaction of the needs of current generations, without compromising the possibility of future generations to satisfy their own needs [1]. With the development of the new asset management concept came a new technical focus for engineering and the need to engage across disciplines. Asset management is increasingly understood by the business community as a strategic and business discipline where the value of assets contributes decisively. Asset management now emerges like any other management discipline [2].

The physical assets of organizations represent the most important component of the investments made and are usually not easily tradable. In this context, industrial organizations of all types and sizes, but especially those that are capital-intensive, have to face levels of uncertainty about whether or not they are capable of achieving their economic and financial objectives [3]. According to Löffel, et al (2024) [4], the effect of this uncertainty on the objectives of organizations represents "risk". To ensure that this risk is controlled and that ROI – Return on Investments and ROA – Return on Assets ratios are ensured sustainably, it is necessary to manage equipment taking into account its entire life cycle. The performance of organizations is not only the responsibility of maintenance; however, its contribution has an impact on all areas of business.

According to Wang, Yumei. (2002) [5] the history of engineering somehow portrays the trajectory of countries' development. Modernization, progress, well-being and quality of life in society, are tributaries of the contribution of school and academia in the wide range of disciplines and skills that engineering and the activity of engineers touches, requires and requires from offices of studies and projects, private companies and associations, which, as first-line economic agents, have been the drivers of change. The essential aspect of engineering training is, precisely, the development of the ability to solve problems, sometimes quite complex ones. Engineers, in a way, have the privilege of occupying the interface between science and reality, as it is up to them to find technical and technological solutions. They lie equally on the border between fundamental science and applied science. Societies need a civic culture increasingly based on rationality, empirical verification and rigour. According to Hodgson, et al (2011) [6], problem-solving has to be seen differently, that is, training the engineer to solve problems formulated by third parties can be dangerous. Dictating a problem with a battery of data to solve it, usually tailored, as the data provided is only what is necessary and sufficient to solve the problem, is a bad habit. According to Pimentel, et al (2022) [7], the fundamental role of this engineer is now recognized by many companies, which is favourable in terms of the job market. The industrial engineer usually starts working in one of the areas of his speciality, but as everything is interconnected, as he begins to acquire more knowledge, he can progress to management positions. For an engineer, sustainable development is practically intrinsic to the role since he conceives, designs, creates and innovates in different segments, always with a long-term vision. Ultimately, for industries and other organizations that employ engineers, sustainable development is a fundamental objective to be pursued, given the new demands of the global market. Certainly, the opportunity for organizations to prosper is increasingly smaller, that is, if they do not take into account sustainable aspects in their organization, and in these aspects, social, environmental and economic issues must be very clear, and it is up to engineers interpret innovations and ensure the correct application of what concerns their areas of activity [8-10].

The development of the initial BSI PAS 55-1/2 was led by the Institute of Asset Management in collaboration with the BSI - British Standards Institute [11]. The specifications and guidelines were first developed in 2004 in response to the need for a common standard for asset management. According to BSI PAS 55-1 (2008), the organizational strategic plan is an overall long-term plan for the organization, which is derived from and incorporates its vision, mission, values, business policies, stakeholder requirements, objectives and risk management. The BSI PAS 55-1/2 (2008) specifications and guidance provide a comprehensive approach and standard for the management of physical assets. This, in turn, provides asset management professionals with the system tools to be able to explain their organization's asset management strategy at all levels and also provides shareholders and managers with an

understandable framework for asset management [12]. According to BSI PAS 55-1 (2008), this is specifically intended to cover the life cycle management of assets and, in particular, assets that are fundamental to the purpose of an organization, such as utility networks, power stations, rail or road systems, oil and gas installations, manufacturing and process, buildings and airports. Truly optimized management over the entire life cycle of the asset includes risk exposures and performance attributes, considering the economic life of the asset as the result of an optimization process, depending on design, use, maintenance, and obsolescence among other factors [13].

This work aims to design a comprehensive and integrated model that explains the role of engineering in the asset management of an industrial unit.

2. Methodology

2.1 Proposal for a Comprehensive and Integrated Industrial Asset Management Model

2.1.1 Characterization of the Comprehensive and Integrated Industrial Asset Management Model

The importance of having a model with these characteristics arose because it could contribute to a better understanding of the role of engineering, and its surroundings, in the context of asset management in an industrial organization. Observing the graphic model will allow a visual interpretation of its elements, its geometric and intuitive shape, its colour and its constituent data that influence its interpretation, creating a feeling or an idea in the person viewing the image. The MAIGAI - Comprehensive and Integrated Industrial Asset Management Model [14], is represented in a slightly abstract image, and in this sense, it allows for better understanding, presenting the same meaning to a significant number of people, considering the visual communication process as a training method that provides information, through its graphic elements and relevant data from its surroundings. On the other hand, the literature review did not find a model with the characteristics of MAIGAI, thus fostering the need and importance of characterizing the role of engineering in an integrated asset management process.

Based on all the elements collected in the literature review, the conceptual model, called MAIGAI, was designed for asset management, which encompasses the functional integration between the areas with the most important role in an industrial unit, where the role of engineering is included and centralized.

This model was empirically validated through a Delphi panel [15] and discussed by professionals in the area, followed by the preparation of the final questionnaire that aimed to validate this model.

A relevant feature, which constitutes Support Activities, was introduced in MAIGAI, however, it was not submitted for evaluation by the experts in the Delphi questionnaire. It was considered that this evolution did not compromise the Delphi panel and improved the essence of the model (and also its possible functionality), which may be the subject of future case studies. Support Activities are considered to be all those activities that encompass the rest of the organizational structure, such as other technicians and specialists from different areas of the organization.

The quadrilateral is represented by a closed polygonal line, which limits the internal and external envelope of the asset management of an industrial organization. The structure with circles in a hierarchical deployment mode represents, in the symbology of shapes, supreme signs of perfection, union and plenitude. The circle is also synonymous with movement, expansion and time. The four circles of equal size, without disproportion, are due to the attribution of the same degree of relevance to the areas of knowledge at each of their levels, except the hierarchical level represented by the asset manager, which is oval in shape, i.e., with geometry with different characteristics from the other circles, which introduces a key element in the integration between engineering and business management, different from a knowledge area represented by circles. The asset manager's role function should present, among other characteristics, the function of moderator and manager of the interfunctional

relationship between engineering and business management, resulting in its shape of a flattened circle, in an oval. In MAIGAI, the geometric elements that present varying degrees of overlap are intended to illustrate the different relationships between the levels of integration and knowledge required. The similarity between these elements is represented in their overlapping parts, while the differences are represented in the non-overlapping parts; the variation in color in the circles and the oval represents an element of differentiation between the different hierarchical levels.

The contribution of MAIGAI compared to the models [16-17] was mainly due to the change in the pyramid shape, whether inverted or with the lower base in a horizontal position, to a set of overlapping circles, which allow for better integration and overlapping of the most relevant areas of the hierarchy. From the point of view of its representation, the inverted position of the triangle is a metaphor used by journalists and other writers, a common method for writing news. The widest part at the top of the triangle represents the most important and interesting information.

The aforementioned elements, which translate into new competitive advantages, were integrated into the improved MAIGAI as follows:

- Communication power added to the role of business management;
- Leadership, engineering knowledge, communication and persuasion power, and technical capacity added to the role of asset manager;
- Concepts of effectiveness and efficiency, reliability, chain knowledge and safety added to the role of engineering;
- Know-how and reliability added to the role of operation and maintenance;
- Customers and the market were incorporated into the topic stakeholders;
- Brand awareness is an integral part of the type of intangible assets and is part of the topic investment;
- Lobbying and the organization's environment were incorporated into the external environment. According to Shreyaskar, et al (2021) [21], lobbying is a pressure group that can influence decision-making in favor of certain interests.

2.2 The Delphi method

According to Wright and Giovinazzo (2000) [19], the Delphi method began to be disseminated in the early 1960s by researchers at the Rand Corporation. The original objective was to develop a method to improve the use of expert opinion in technological forecasting. The authors consider that consensus in the Delphi method represents a consolidation of the intuitive judgment of the participating group. It is assumed that collective judgment, when well organized, is better than the opinion of a single individual. The anonymity of respondents and feedback on group responses for reassessment in subsequent rounds of questions are the main characteristics of this method. The operating principle of the method is the regular and systematic presentation of questions about a given problem to a group of experts. This involves the formation of a group of experts in a given area of knowledge, who respond to a series of questions related to a clearly defined research problem. The summary of the results of the previous rounds of questionnaires is communicated to the experts, who, after further analysis, return with their critical opinions on the content. At each stage, new questions can be introduced as a way of stimulating the experts' reflection. Interactions continue in this manner until a consensus, or near consensus, is reached. The stages with questions are called "rounds" in this dissertation.

Another important factor for the proper conduct of the Delphi method, according to Wright and Giovinazzo, is the anonymity between the participants. This is a way of reducing the influence of one over the other, since they do not communicate directly during the expert panel. The main positive

aspect of this anonymity is that it is impossible for a given expert to be influenced by the reputation of another, more experienced one. Another advantage is the possibility of changing one's opinion without causing embarrassment to the expert. The expert can defend his or her opinions with peace of mind, even if they differ from others, knowing that his or her difference of opinion will not be known by the other experts.

3. Results and Discussion

3.1 The Delphi Method Rounds

The First Round: According to Custer et al. (1999) [20], in the first round, the Delphi process traditionally begins with an open-ended questionnaire. The open-ended questionnaire serves as the cornerstone for the case of requesting specific information on a given content area. After receiving the responses from the expert panel, the researcher needs to convert the collected information into a well-structured questionnaire. This questionnaire is used as a research instrument for the second round of data collection.

The Second Round: In the second round, according to Ludwing (1994) [21], each participant receives a second Delphi questionnaire and is asked to review the items summarized by the survey requester, based on the information provided in the first round. Thus, the Delphi panel of experts may be required to evaluate or establish preliminary priorities among items. As a result of the second round, areas of disagreement and agreement are identified. According to Jacobs (1996) [22], in some cases, the Delphi panel of experts is asked to state the rationale for ranking priorities among the items. In this round, consensus begins to form and the actual results can be presented among the participants' responses.

According to Delbecq, et al. (1975) [23], if the second round is considered the last round, it provides a final opportunity for the participants to review their responses. It should be remembered that the number of Delphi iterations depends largely on the degree of consensus sought by the researchers, however, it can typically range from three to five.

3.2 Sequence and number of rounds performed

Theoretically, the Delphi process can be continuously iterated until a consensus is reached. However, Ludwing (1994) [20]and Custer et al. (1999) [21] point out that three iterations are often sufficient to collect the necessary information and, in most cases, reach consensus. The definition of the number of rounds to be performed in this dissertation depended fundamentally on obtaining an acceptable level of consensus for its purpose. The iterative scheme was established as shown in Figure 1.

In this study, only two rounds were carried out using the Delphi method, a number that made it possible to reach consensus, in the first round in 83% of the responses, that is, in 24 of the 29 closed questions, and in the 2nd round in approximately 97% of the 29 responses with closed questions, that is, in the 2nd and last round there was only 1 question in which 1 of the respondents answered unfavorably for a reason that will be explained later. The average time between each round was 15 days, however, it took 26 days for the 1st round and only 4 days for the second round, as it contained a significantly smaller number of questions to answer.

The questionnaire was originally developed based on a literature review, and 29 closed questions and 5 semi-open questions were presented, totalling 34 questions that constituted the survey in the 1st round, divided into 8 groups. Having confirmed the idea that some of the experts had difficulty in assessing the questions, with some scattered responses, a second round was carried out, with only the same questions already asked and in which there were divergent responses, intending to reach consensus on only 5 of the 29 questions addressed to the respondents who disagreed in the 1st round. The reason why, in the 2nd round, the 5 questions were addressed to only 5 respondents was because the trend was clearly unfavourable to this minority group of respondents. Google Drive was used to

consult the experts. This computer tool made it possible to carry out the survey in its 2 rounds simply and effectively. Respondents were contacted by email with a presentation of the questionnaire, which included a direct access link to the questionnaire. However, it was necessary to develop a table with the questions and a field to mark the answers (see Appendix V), which was made available to respondents who did not have access to the Google Drive platform. According to the recommendation of Marconi and Lakatos (1999), an explanatory note on the nature of the research, its importance and the need to obtain answers should be sent along with the questionnaire, in an attempt to arouse the interest of the recipient, so that he/she fills out and returns the completed questionnaire within a reasonable time frame.

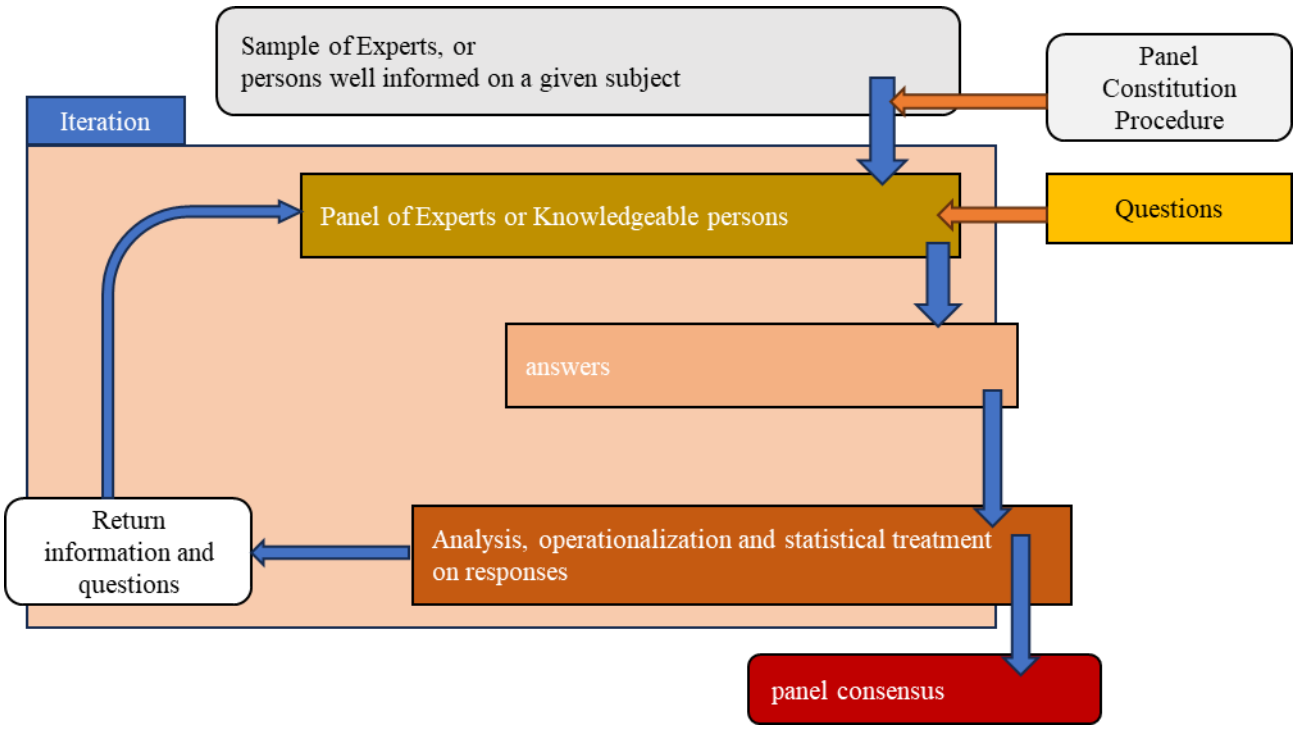

Figure 1 – Iterative scheme of the Delphi methodology [24].

The time distribution of submissions and complete answers began on April 22, 2023, and ended on May 25, 2024.

The 29 closed questions were mandatory; however, the 5 semi-open questions were optional. The optional response was used by only 3 of the 18 respondents, i.e. 17% of respondents.

The majority's lack of response to the semi-open question was interpreted as agreement regarding the topic addressed in the group of questions.

The responses received via Google Drive were analysed to verify the points of consensus. After this analysis, a second round was carried out (Appendix III) and subsequently, after the final analysis, it was decided to close the survey to all experts, the results of which are presented in Appendix IV. While Hsu and Stanford (2007) [25] recommend a minimum of 45 days for the various possible rounds, on the other hand, the same authors also state that after fifteen responses, the reliability and accuracy achieved with the addition of each new respondent becomes irrelevant.

A median obtained of 4.5 was considered adequate. Which, according to Hsu and Stanford (2007) [25], recommend only a value of 3.25 for a Likert 1 scale. Although none of the questions had a median lower than this value, it was decided to carry out the 2nd round.

In the competitive advantages described in the semi-open responses, those were considered that justified, after interpretation, the adequacy of some details for the constitution of the MAIGAI - improved Comprehensive and Integrated Industrial Asset Management Model [26]

Table 1 - Summary of the empirical MAIGAI validation process.

Qualitative Research	Validation of the Model	Panel Dimension	Questionnaires	Unit Analysis
Dashboard Delphi	Internal	Specialists Contacted - 24	1st Round - Mandatory	MAIGAI
		Specialists Responded - 18	2nd Round - Held	
			3rd Round - Not Necessary	

Table 1 summarizes the above. Therefore, and under these conditions, the expert panel was closed and the empirical process began with the internal validation of MAIGAI using the Delphi panel.

Although anonymity is one of the characteristics of the Delphi method, according to Kayo and Securato (1997), in this research the names of the respondents could have been revealed from the 2nd round onwards, and the disclosure of the answers, that is, this reason given could function as a source of motivation for the participation of experts, a situation that was not necessary to use, given that all responses were obtained after 4 days, in the 2nd round.

3.3 Impact of the application of the Delphi method

The questionnaire, which used the Delphi method, had as its main objective the empirical validation of the MAIGAI. Fachin (2003) [27 emphasizes the fact that the questionnaire, when completed without the presence of the person requesting the survey, guarantees anonymity.

There was only one question in the survey that did not achieve total consensus. There was significant divergence in only 1 expert, who considered another interpretation in relation to the applicability of the PDCA concept to the asset life cycle, and in this sense there was no important point that gave significant room to give rise to a certain amount of divergence among the experts. The panellist disagreed because he presented a neutral answer, possibly he did not know how to answer and preferred not to commit himself. Given that he did not justify the reason for his neutral answer. Therefore, this question received a majority of favorable answers, but 1 less favorable answer, which is not significant for the devaluation of the model, and therefore there was no justification for carrying out a 3rd round.

3.4 Expert Selection Criteria

The ideal population for this study would be all experts linked to universities and also to the industrial sector. As this objective could not be achieved, an effort was made to reach a certain consensual number of experts, without any distinction between industry or university. Dias (2015) cites Hsu and Stanford (2007) regarding the size of the panel. According to these authors, it is common for the number of experts to be less than fifty. In this study, the first round was contacted by 24 experts, following recommended practice.

Since the Delphi technique focuses on eliciting expert opinions over a short period, the selection of Delphi panellists is generally dependent on the areas of expertise required by the specific question. All experts consulted have a basic education in engineering and relevant experience in the industrial sector, which is considered a key criterion for their selection.

To select the experts, several sources were used, and the selected panel was considered to be able to participate through a survey with questions (sometimes of high difficulty), even for those who currently deal with the emerging topic of asset management. In any case, it was understood that, although they came from different engineering specialties, in general, each of them would have more

knowledge of some subjects than others, but would be able to answer all the questions. Even so, it is necessary to acknowledge the great difficulty involved in the surveys and the great demands placed on the responding experts. Of the experts consulted, around 42% were academics and the remaining 58% were industrialists, as shown in Figure 2.

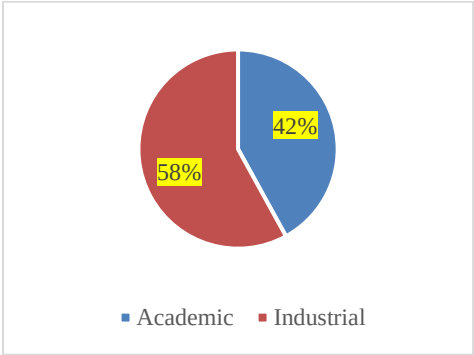

Figure 2– Composition of the Delphi Panel.

Of the 24 experts consulted, 18 responded to the survey, that is, 75% of those interviewed. Of these 18 respondents, 8 are academics and the remaining 10 are industrial, where the vast majority of academics have doctorates and belong to 3 different national universities. Industrialists are engineers who have extensive experience, from business management to engineering and maintenance in the largest national industries.

In the survey header the respondents had to identify themselves, and as previously stated, followed by a total of 8 groups of questions, referring to the different levels that constitute the industrial organization, which represent the basis of MAIGAI.

The first level refers to the "external environment". For this level, 5 questions were asked, one of which is semi-open, thus allowing the respondent to make their contribution, about the most relevant characteristics in this environment, for the management of assets of the industrial organization (e.g.: Legislation and standards).

At the second level, a question was asked about the iterative PDCA management method [28], with a brief introduction to this concept to frame the respondent for its level of importance for asset management.

At the third level, another question was asked about the asset life cycle and its relationship with the PDCA iterative method.

At the fourth level, there is a question about investment, systems and processes and the importance of their inclusion in a management environment.

At the fifth level, 6 questions are presented about the competitive advantages for Operation and Maintenance in the management of assets of an industrial unit (for example, production and data processing).

In the sixth, seventh and eighth levels, 20 questions are presented about the competitive advantages for each of the integral parts: engineering, asset management, business management, and their integration process in an asset management context of an industrial organization.

In short, each of the questions or group of questions sought to obtain from the experts' confirmation (or not) of the relevance of each of the items comprising the MAIGAI.

In addition, the aim was also to obtain a specific opinion from the experts regarding the competitive advantages that were part of the bibliographic review in the different parts of the MAIGAI.

After approximately 30 days to receive responses, which were slowly emerging, and with 18 responses already in hand, the questionnaire was blocked, the results of which are presented in Annex II.

4. Conclusion

Asset management is considered a complex interaction of planning and control of activities related to assets within an industrial organization, and this set of activities related to physical assets has been established. Asset management should be observed from several perspectives, depending on the management levels of the industrial organization: business management, also called top management, engineering with all its surroundings, operation and maintenance, and finally the role of the asset manager. These perspectives can be combined into a single framework that represents the activities, relationships and mechanisms that play a role in asset management and system effectiveness, which is why this framework was named MAIGAI. The model presented by this framework for an industrial organization, through a functional and integrated model, is proposed as a guide for asset management practice, which aims to achieve a competitive strategy for that organization. It is argued that the proposed framework can be used as a reference for asset management and the respective actions that should take place in that organization.

The Delphi technique has and will continue to be an important data collection methodology, with a wide variety of applications and uses for researchers who want to collect information from those who are immersed and embedded in this topic of interest, and thus provide real-time knowledge of the world.

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Annex – I : Delphi Questionnaire – 1st Round Results

External Surroundings

1 – What level of importance do you attribute to the following factors in asset management in an industrial unit:

In addition to these characteristics mentioned, what other would you add as advantages to the external environment of the asset management of an industrial unit?

- Lobby.

- I think that Customers and the Market are part of the Stakeholders.

- Surroundings of the industrial unit.

- Nothing to add.

- Brand awareness.

Interactive PDCA management method

2 - What level of importance do you give to the inclusion of this model, PDCA, in the asset management system of an industrial unit?

Asset lifecycle

3 – In the asset management system of an industrial unit, it is essential to know what is more logical: The PDCA encompasses the life cycle of the asset or the opposite. So, how important is your level of importance to the fact that the PDCA cycle encompasses the life cycle of an asset, or a set of assets?

Systems & Processes

Investment

4 – How important do you give to the fact that the asset management system is part of a management environment that includes: Systems & Processes and Investment.

Operation & Maintenance

5 - What level of importance do you attribute to the following competitive advantages for Operation & Maintenance in asset management in an industrial unit:

– In addition to these characteristics mentioned, what other would you add as competitive advantages for Operation & Maintenance in the asset management of an industrial unit?

- Know how to do it.

- Reliability and, if possible, acquisition of data that may influence Reliability (sensors).

- Nothing to add.

6 – How positive do you consider the integration of Operations with Maintenance in Asset Management in an industrial organization?

Engineering

7 - In asset management in an industrial unit, what level of importance do you attribute to the following competitive advantages for Engineering:

In addition to these characteristics mentioned, another, or others, would add competitive advantages to Engineering in the management of assets of an industrial unit. - Concepts of Effectiveness and Efficiency.

- Reliability.

- Knowledge of the chain.

- Nothing to add.

- Security impact.

8 – In Asset Management in an industrial organization, what level of importance do you attribute to the interfunctional integration of Operation & Maintenance with Engineering?

Asset Manager

9 - What level of importance do you attribute to the following characteristics for the Asset Manager in asset management in an industrial unit:

In addition to these characteristics mentioned, what other would you add as advantages for the Asset Manager in managing the assets of an industrial unit?

-Leadership.

-Nothing to add.

-Engineering knowledge.

- Power of Communication and Persuasion.

- Technical capacity.

10 - In Asset Management in an industrial organization, what level of importance do you attribute to interfunctional integration:

11 – What level of importance do you give to the fact that the Asset Manager's basic training is in Engineering and complemented with training in the area of Financial Management?

Business Management

12 - What level of importance do you attribute to the following competitive advantages for Business Management in asset management in an industrial unit:

– In addition to these characteristics mentioned, what other would you add as competitive advantages for Business Management in the asset management of an industrial unit?

-Knowledge of the activity.

-Power of Communication and Persuasion.

-Competence.

-Nothing to add.

13 – In Asset Management in an industrial organization, what level of importance do you attribute to the inter-functional integration of Engineering with Business Management?

Annex –II Delphi Questionnaire of the 2nd Round

Full name:

Meaning of the Likert Scale values:

1 – Not at all important

2 – Slightly important

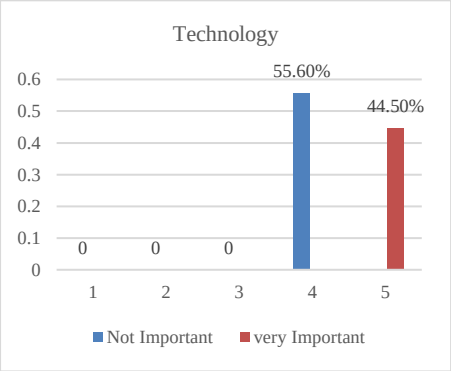
3 – Important

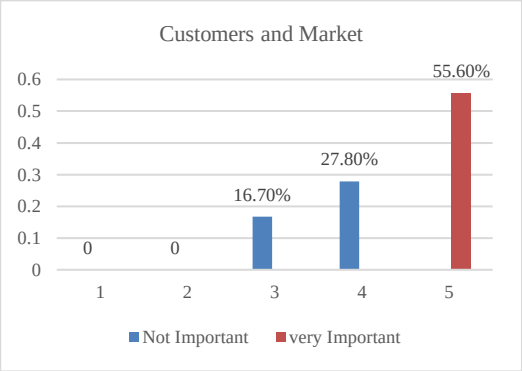
4 – Very important

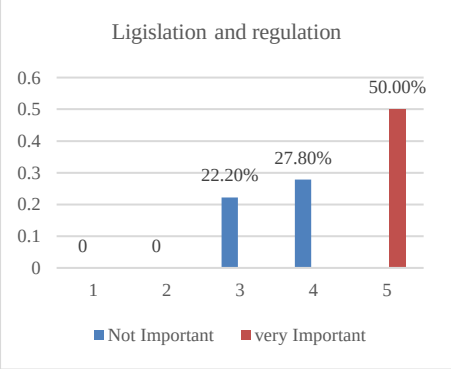
5 – Very Important

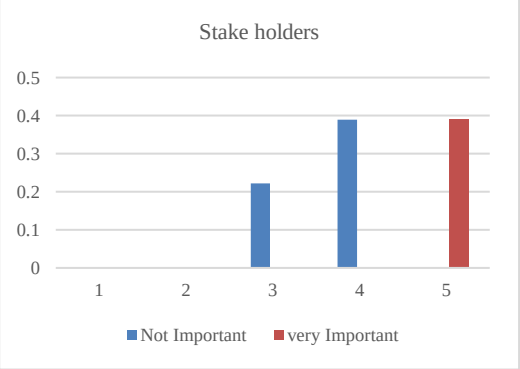
PDCA interactive management method

The Deming circle or PDCA cycle is a systematic four-stage management method, typical in the implementation of a continuous improvement system: Plan, Execute, Check and Act/Correct. Plan: used for planning to achieve objectives, actions to assign risks and opportunities; Do: operational control, change management and outsourcing; Check: Monitoring, analysis and evaluation of results; Act/Plan: Preventive, corrective actions and continuous improvement.



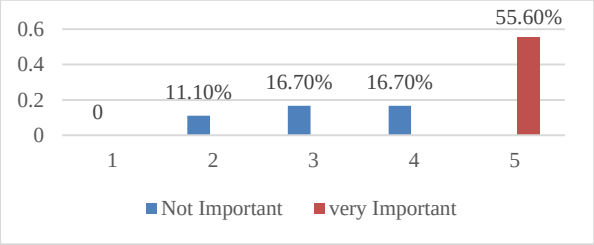






Asset life cycle

The life cycle of an asset comprises all stages of asset management, that is, from the design phase to the decommissioning or disposal phase.



3 – In the asset management system of an industrial unit, it is essential to know what is more logical: PDCA encompassing the life cycle of the asset or vice versa. So, how important is it to you to attribute the PDCA cycle to encompassing the life cycle of an asset, or a set of assets?

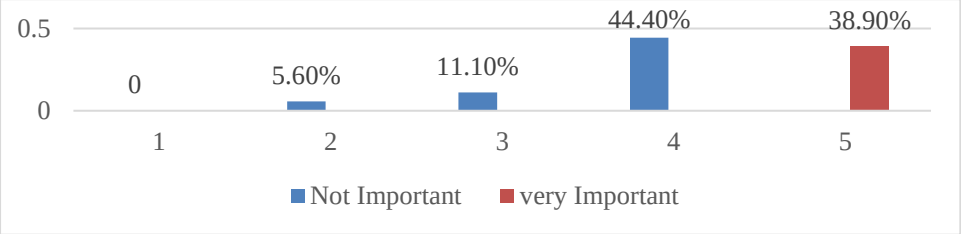
Systems & Processes

Using an integrated management systems approach, this allows an organization's asset management system to be built on elements of other existing systems, such as quality, environment, health, safety and risk management.

Processes are defined as sequences of activities with the ultimate purpose and objective of creating value for the organization, such as integrated decision-making processes for implementing management plans, functional plans, planned plans, among others.

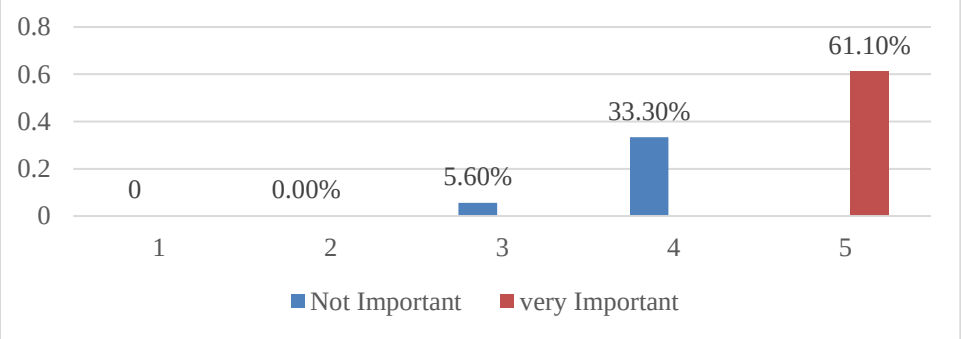
Investment

Investment is of decisive importance in organizations. It is the basis for its creation, growth and modernization, and represents a long-term application of resources to respond to market opportunities and threats, creating or reinforcing its strategic potential in an environment of risk and uncertainty in the assumptions associated with the market and investment. Organizations need to invest in assets, so it is essential to make decisions about investments, improving their return and creating value.



4 – How important is it to the fact that the asset management system is part of a management environment that includes: Systems & Processes and Investment?

Operation& maintenance



Regarding the role of the asset manager in the industrial organization, he or she must be able to contribute positively to: value creation, gains in effectiveness and efficiency, management of assets or asset systems, development of a set of skills and abilities in the area of engineering, and also in the area of management and finance, functional integration with top management and the rest of the structure of the industrial organization. 9 - How important are the following characteristics for the Asset Manager in managing assets in an industrial unit:

9.c – Communication and Negotiation

11 – How important are the Asset Manager's basic training in Engineering and complemented with training in the area of Financial Management?

13 – In Asset Management in an industrial organization, how important are the interfunctional integration of Engineering with Business Management?

Thank you very much!

Annex –III: Delphi Questionnaire of the 2nd Round

Full Name:

Meaning of the Likert Scale values:

1 – Nothing Important

2 – Not very important

3 –Important

4 – Very Important

5 – Very Important

Interactive PDCA management method

The Deming circle or PDCA cycle is a systematic four-step management method, typical in the implementation of a continuous improvement system: Plan, Execute, Check and Act/Correct. Planning: used for planning with a view to meeting objectives, actions to allocate risks and opportunities; Do: operational control, change management and subcontracting; Check: Monitoring, analysis and evaluation of results; Act/Plan: Preventive, corrective and continuous improvement actions.

Asset lifecycle

The life cycle of an asset comprises all stages of asset management, i.e. from the design phase to the decommissioning or disposal phase.

3 – In the asset management system of an industrial unit, it is essential to know what is more logical: The PDCA encompasses the life cycle of the asset or the other way around. So, what level of importance do you attach to the fact that the PDCA cycle encompasses the life cycle of an asset, or a set of assets?

1	2	3	4	5	
Nothing important	○			○	Very Important
Select a value in the range of 0,Irrelevant, up to 4,Voidable,.	○	○	○		

Systems & Processes

Using an integrated management systems approach, it allows an organization's asset management system to be built on elements of other existing systems, such as quality, environment, health, safety and risk management.

Processes are designated as sequences of activities with the greater purpose and objective, the realization of value for the organization, such as processes in decision making, integrated, for the implementation of management plans, functional, planned, among others.

Investment

Investment is of decisive importance in organizations. It is the basis of its creation, growth and modernization, it represents an application of long-term resources to respond to market opportunities and threats, creating or reinforcing its strategic potential in an environment of risk and uncertainty of the assumptions associated with the market and investment. Organizations have investment needs in assets, so it is essential to make decisions about investments, improving their return, creating value.

4 – What importance do you attribute to the fact that the asset management system is part of a management environment that includes: Systems & Processes and Investment.

1	2	3	4	5	
Nothing important					Very Important
Select a value in the range of 0,Irrelevant, up to 4,Voidable,.					

Asset Manager

With regard to the role of the asset manager in the industrial organization, he must be able to contribute positively to: value creation, gains in effectiveness and efficiency, management of assets or asset systems, development of a set of skills and skills in the area of engineering, and also in the area of management and financial area, functional integration with top management and with the rest of the structure of the industrial organization.

9 - What level of importance does it attribute to the following characteristics for the Asset Manager in the management of assets in an industrial unit:

9.c – Communication and Negotiation

1	2	3	4	5	
Nothing important					Very Important
Select a value in the range of 0,Irrelevant, up to 4,Voidable,.					

11 – What is the level of importance you attribute to the fact of the basic training of the Asset Manager be in Engineering and complemented with training in the area of Financial Management?

1	2	3	4	5	
Nothing important					Very Important
Select a value in the range of 0,Irrelevant, up to 4,Voidable,.					

13 – In the Asset Management of an industrial organization, what level of importance do you attribute to the interfunctional integration of Engineering with Business Management?

1	2	3	4	5	
Nothing important					Very Important
Select a value in the range of 0,Irrelevant, up to 4,Voidable,.					

Select a value in the range of 0,Irrelevant, up to 4,Voidable,.

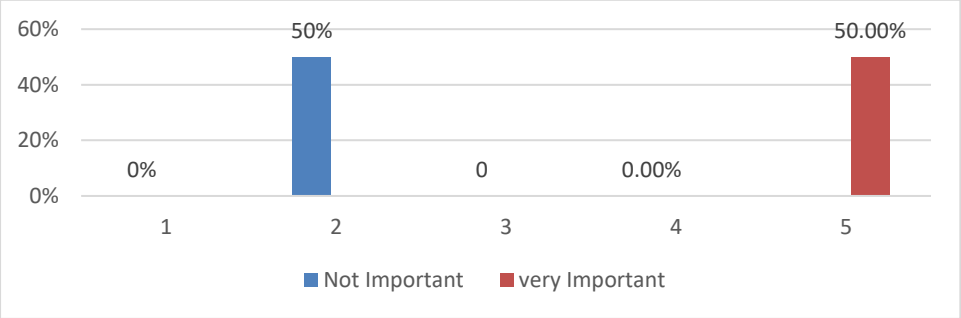
Thank you very much!

Annex –IV: Delphi Questionnaire – Results of the 2nd Round

Interactive PDCA management method

Asset lifecycle

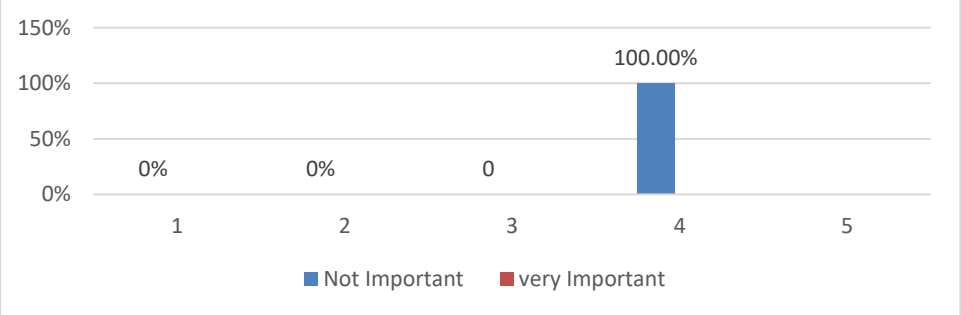
3 – In the asset management system of an industrial unit, it is essential to know what is more logical: The PDCA encompasses the life cycle of the asset or the other way around. So, what level of importance do you attach to the fact that the PDCA cycle encompasses the life cycle of an asset, or a set of assets?



Systems & Processes

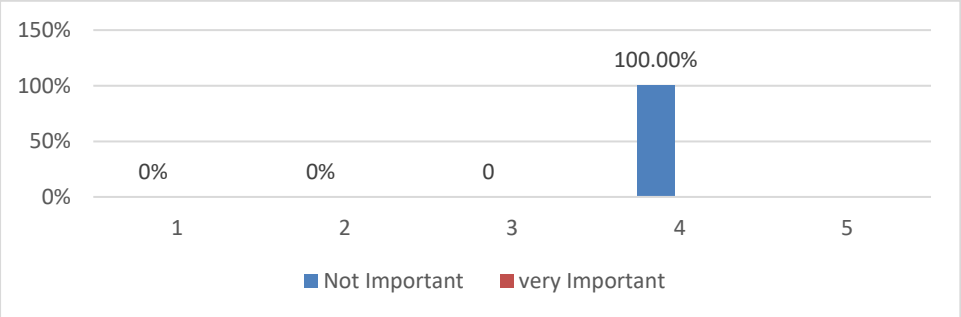
Investment

4 – What importance do you attribute to the fact that the asset management system is part of a management environment that includes: Systems & Processes and Investment.

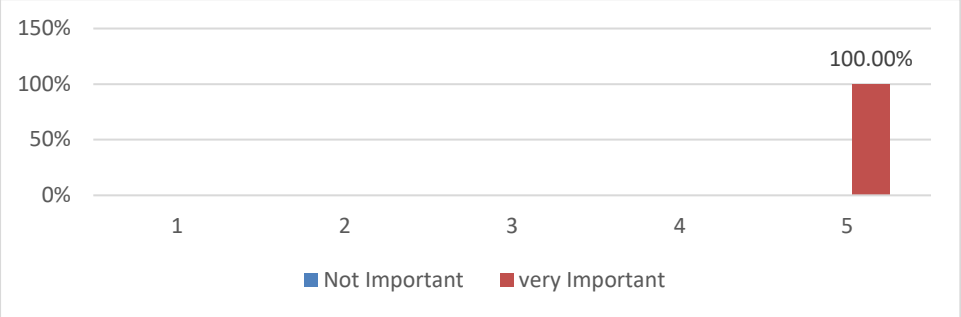


Asset Manager

9 - What level of importance do you attach to the following characteristic for the Asset Manager in the management of assets in an industrial unit:



11 – What level of importance do you attribute to the fact that the basic training of the Asset Manager is in Engineering and complemented with training in the area of Financial Management?



13 – In the Asset Management of an industrial organization, what level of importance do you attribute to the interfunctional integration of Engineering with Business Management?