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Defining Evaluation Criteria for Strategic Project Portfolio Selection in Brazilian Air Force

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Abstract— **This paper presented an example of a qualitative value model approach for Project Portfolio Selection (PPS) regarding Brazilian Air Force (FAB) projects. First, we present a brief literature review about PPS and Value Focused Thinking (VFT). Then we depict some objectives extracted from FAB's strategic planning to enable the generation of a qualitative value model for PPS. Next, we present the model generation for a subportfolio in the context of Anti-Aircraft Systems within FAB. Lastly, we discuss some approaches to execute a PPS process using the VFT model. This approach is innovative since it allows the elicitation of the value-model according to the specific decision frames of each subportfolio, thus enabling an effective elicitation of the consequences of each process. Additionally, it proposes some procedures to aggregate the results of PPS for each subportfolio by considering the influences of the interdependencies between projects from different subportfolios.**

Palavras-Chave— **Value-Focused Thinking (VFT); Project Portfolio Selection(PPS); Optimization.**

I. Introduction

Decision-making is a significant part of our lives, and are the only way to influence our lives purposefully [1]. Nevertheless, despite the need to deal daily with decisions, some people do not adopt a systematic approach to identify the values associated with the decision, for they identify values based on readily available alternatives, which tends to generate limited solutions in achieving the decision maker's objectives.

Despite the importance of decisions, few people receive any training in decision-making throughout their lives [2]. Therefore, individuals depend on their personal experiences to learn how to make decisions, which can yield bad decision-making habits and shallow thinking about decisions. Additionally, lessons learned from previous experiences are not always beneficial since decisions might vary significantly in different contexts and situations.

Decisions tend to be even more complex when dealing with project portfolios since many concerns related to each project are sometimes conflicting, and some transversal issues overlap the context of individual projects. These topics require management initiatives that embrace and influence multiple items simultaneously.

This paper presents a VFT approach to support a decision-making process regarding project portfolios. We present a brief overview of our proposal and depict an example focused on the strategic project portfolio of the Brazilian Air Force (BAF)

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II. Literature Review

A. Project Portfolio

In many firms and public organizations, activities that seek the achievement of strategic and tactical objectives are organized as follows [3]:

- First, a large number of alternatives within the organization are identified;
- Then, those alternatives that can better contribute to achieve the relevant objectives are chosen. This process is subject to constraints related to time and available resources;

Many problems in multiple domains are tackled in this way. For instance, high tech companies choose the R&D projects that fit best in their growth goals; military planners choose cost-efficient combinations of weapon systems to build capabilities; healthcare organizations seek to maximize patients' health benefits by investing in services and facilities, among others [3].

Hence, a *"Project Portfolio"* (PP) is a collection of various components such as projects, programs, sub-portfolios and other tasks like maintenance and ongoing operations. These components are grouped in order to enable the coordinated management of efforts towards the effective achievement of the strategic business objectives [4]. A PP is also defined as "*a set of projects that share and compete for limited resources*"[5].

B. Project Portfolio Selection

Our main interest in this work is on Project Portfolio Selection (PPS), which is known as a periodic and continuous effort to select and fund portfolios of projects that support organizations stated goals and objectives [4].

PPS is a periodic activity to select a portfolio from available project proposals and ongoing projects. This activity must be adherent to organization's objectives and should not exceed available resources or violate other relevant constraints [6].

The available resources and other constraints are critical to this type of decision-making [7]. In other words, one of the main reasons for PPS is that the financing needs of all project applicants far outweigh the resources available for investment.

Therefore, the decision-making process requires the definition of evaluation criteria that apply to one or more decision-making methods that will guide the choice of the best set of projects to achieve the established objectives. The following subsection presents some concepts regarding the definition of evaluation criteria.

C. Value-Focused Thinking (VFT)

Value-Focused Thinking (VFT) was originally proposed by Ralph Keeney in 1992 whose purpose is "the creation of values. Stakeholders' values are converted to objectives that guide the creation of better alternatives and the identification of better decision situations"[8].

VFT enables the identification of the fundamental issues of organizations through the identification of different levels of objectives. These levels range from those that can be measured and influenced by the decisions made within the organization to the more conceptual and mission-oriented levels related to its overall mission. VFT goes beyond other Problem Structuring Methods (PSMs) by linking objectives to specific actions with potentially measurable outputs [9].

Values are fundamental to everything we do. Hence, participants in decision-making processes should dedicate significant time and effort when thinking about the values of the decisions that lie ahead [8]. VFT's primary goal is to describe stakeholders' values regarding a decision problem and identify opportunities to maximize the achievement of their objectives.

Briefly, VFT consists of applying some procedures for Identifying Objectives, Structuring Objectives, Creation of Alternatives, and Decision Opportunities. The objectives are identified through a list of structured questions (VFT Devices). Then, analysts elicit the cause-effect relationships between the objectives through the WITI Test (Why Is This Important?)[8].

Then the objectives are structured in a means-ends objectives network and are classified into three specific types [10]:

- Strategic objectives: guide the entire decision-making process and the choices regarding decisions and opportunities within the context;
- Fundamental objectives: these objectives are the basis for all interest in the decision and qualitatively define all concerns in the context of the decision. Furthermore, these objectives guide quantitative modeling activities or quantitative analysis of the alternatives considered in the decision-making process;
- Means-objectives: these are important for their implications regarding other (more fundamental) objectives in the decision context.

The decision context and the fundamental objectives constitute the decision frame [8], [10]. The decision context defines the set of appropriate alternatives in a specific decision situation. The fundamental objectives present the values the decision maker is concerned with and the classes of consequences associated with these values in the decision. It is essential that the decision context and the fundamental objectives are compatible since they are interdependent concepts [10].

VFT approach applied to PPS has some specific details. Organizations usually split their projects in different subportfolios according to the strategic objectives that are pursued. Therefore, there might be several decision frames within the context of the organizations. Each of these particular frames comprise specific objectives and alternatives. But these frames are subject to resource constraints that might surpass their boundaries. Thus, when conducting a PPS process, a possible approach is to elicit the decision frames for each subportfolio and also identify the influences among them regarding resource constraints and value sharing.

In section III we present a VFT Model with evaluation criteria for strategic portfolio selection in Brazilian Air Force (BAF).

III. VFT Model for Portfolio Selection - Brazilian Air Force

According to the Brazilian Air Force Command Manual - MCA 16-2/2018 (Project Prioritization Process), institutional planning is a process of formulating strategies to establish a holistic view of the organization and, in this way, enable the fulfillment of its mission, considering the scenarios for which it must prepare. This manual recommends integrating all existing plans at all levels to achieve the desired goals.

The following plans guide the Brazilian Air Force (FAB) in the aforementioned institutional planning: Strategic Concept - Air Force 100 (DCA 11-45); Brazilian Air Force Military Strategic Plan (PCA 11-47 - PEMAER) and Complementary Plans; Air Force Multi-Year Work Plan (PCA 11-110); Air Force Command Action Plan (PCA 11-44), ODSA Sectoral Plans and the Annual Work Programs of their Military Organizations.

FAB has undertaken several projects to achieve the strategic objectives of these plans. These projects have different levels of complexity and relevance, ranging from internal ones undertaken within individual military organizations to large-scale projects, such as the development of new combat aircraft and related systems, adequacy of support infrastructure for their operation at their maximum performance, adaptation of human support facilities, weapons for use in conflict situations, improvement of airspace control, development of tactical data links, development of the cyber defense area, among others.

Companies generally apply portfolio balancing methodologies successfully since profit maximization is a fundamental goal that helps to select the best suitable solution. However, this is quite different in public organizations (and in the particular case of FAB) since managers distribute the available resources according to their experience and perception of the organization's needs. Therefore, there is no overarching solution to maximize the chances of achieving the organization's future vision through its projects since the success depends upon many factors regarding the interest of the Brazilian State and the Brazilian Society.

In this context, the possibility of improving the existing methodology for balancing investment in strategic projects was identified, with a focus applicable to the development and acquisition of products of national defense interest, which integrates the strategic importance of the project and enables simulation of scenarios of chances of success of projects for balancing the project portfolio. According to DCA 11-45, this topic constitutes one of the main challenges for the Brazilian Air Force, as discussed in a previous work [11].

The following subsections present the results of a VFT approach to identify values for PPS within FAB. We applied a *"Gold Standard"* Qualitative Value Modeling Technique [12] from Brazilian Air Force Military Strategic Plan (PCA 11-47 - PEMAER) and identified a set of objectives from to drive resource allocation among FAB's projects. These objectives are adherent with other plans within FAB, including Strategic Concept - Air Force 100 (DCA 11-45).

A. Identifying values from Brazilian Air Force Military Strategic Plan (PCA 11-47 - PEMAER)

We identified 74 objectives from the analysis of the Brazilian Air Force Military Strategic Plan (PCA 11-47 - PEMAER). We focused on objectives related to the following topics: (i)Air Force Operations; (ii) Air Force Preparation; (iii) Air Traffic Management; (iv) Science, Technology and Innovation; (v) Command and Control (C^2); (vi) Air Defense. There are some other objectives regarding other areas (such as logistics, IT, etc.) that were not included in the scope of this work. The objectives are listed below:

i **Air Force Operations** (10 objectives): (a) Maximize operational readiness levels; (b) Maximize deterrence of threats to national sovereignty through aerospace power; (c) Maximize the capabilities of long-range anti-aircraft equipment; (d) Minimize the use of air assets in operations where their presence is dispensable; (e)Maximize military mobilization capability; (f) Maximize quality in civil air traffic management; (g) Maximize efficiency of the Aerospace Defense System through solutions for air traffic management (h) Maximize adequacy of airspace control for unmanned aircraft traffic management (i) Maximize the integration between military operational circulation and the operation of medium and long-range surface-to-air missiles by the Single Forces; (j) Increase the use of space platforms instead of aircraft to increase the quality, safety, efficiency and availability of information;

ii **Air Force Preparation** (20 objectives): (a) Maximize the preparation of crews for the use of Aerospace Power (in response to Capability Based Planning-PBC demands); (b) Elaborate operations concepts for Air Force operation scenarios (including environments with the presence of medium and long-range anti-aircraft equipment); (c) Develop doctrine for Air Force operation scenarios (including environments with the presence of medium and long-range anti-aircraft assets); (d) Improve the operations concept for Remotely Piloted Aircraft Systems (SARP) in Air Force Operations; (e) Improve the concept of operation for Remotely Piloted Aircraft Systems (SARP) in actions with other Armed Forces and Government Agencies; (f) Maximize aircrew readiness to employ Aerospace Power through interaction with other Air Forces; (g) Develop doctrine for the employment of Aerospace Power through interaction with other Air Forces; (h) Maximize availability of Air Force assets to build ready-to-deploy forces in any operational environment; (i) Maximize interoperability capability in joint operations; (j) Maximize interoperability capability in combined and interagency operations; (k) Improve human resource training with simulation; (l) Improve human resource training through operational exercises (joint, combined and interagency); (m) Maximize Air Force capability for protective measures regarding the electromagnetic spectrum; (n) Maximize Air Force capability for attack measures within the electromagnetic spectrum domain; (o) Maximize Air Force capability for support measures within the electromagnetic spectrum domain; (p) Develop doctrine related to the concept of Network-Centric Combat; (q) Develop doctrine for the use of Air Force Assets in Counterterrorism missions regarding Force Protection Capacity and the interests of Brazilian Air Force; (r) Maximize logistical preparation for the use of Air Force Assets in Counterterrorism missions regarding Force Protection Capacity and the interests of Brazilian Air Force; (s) Develop doctrine for the use of Air Force Assets in Chemical, Biological, Radiological and Nuclear Defense (DQBRN) missions regarding Force Protection Capacity and the interests of Brazilian Air Force; (t) Maximize logistical preparation for the use of Air Force Assets in Chemical, Biological, Radiological and Nuclear Defense (DQBRN) missions regarding Force Protection Capacity and the interests of Brazilian Air Force;

iii **Air Traffic Management** (5 objectives): (a) Maximize automatic procedures in the Brazilian Airspace Control System (SISCEAB) and related systems; (b)Maximize efficiency in the collection of air navigation fees; (c) Ensure integration of Airspace Control with Air Defense and Anti-Air Defense by updating legislation, and observing standards and practices recommended by the International Civil Aviation Organization (ICAO); (d) Promote strengthening of the support structure for Airspace Control through Public-Private Partnerships (PPP) (e) Ensure adequate performance of the Operational Safety Surveillance Program of the Air Navigation Service;

iv **Science, Technology and Innovation** (31 objectives): (a) Maximize technological autonomy in critical areas through the use of offset contractual clauses when importing defense products; (b) Maximize knowledge and technological internalization regarding areas of interest through strategic partnerships and cooperation agreements with international, national and governmental institutions; (c) Maximize available resources to subsidize activities in the space area through an appropriate strategy that fits the Strategic Program for Space Systems (PESE) to the National Program for Space Activities (PNAE); (d) Develop launch vehicles for space platforms, meeting the operational requirements of PESE and PNAE; (e) Develop support infrastructure for launching space platforms, meeting the operational requirements of PESE and PNAE; (f) Develop control and monitoring infrastructure for space platforms, meeting the operational requirements of PESE and PNAE; (g) Maximize efficiency in the exploration of launch centers for space platforms through partnerships with national and foreign companies; (h) Maximize efficiency in operating space platform launch monitoring centers through partnerships with national and foreign companies; (i) Maximize development of the Defense Industrial Base (BID) through projects for the supply and maintenance of aerospace products; (j) Maximize nationalization of sensitive aerospace products with high added value; (k) Increase CT&I projects with a focus on developing FAB's military capacity; (l)Increase CT&I projects focused on the development of medium and long range anti-aircraft systems; (m) Foster research and development in the aeronautics area; (n) Foster research and development of unmanned aerial platforms; (o) Foster research and development in the space area; Foster research and development in cybernetics; (p) Foster research and development in electronic warfare; (q) Foster IT research and development; (r) Foster research and development in operational analysis; (s) Foster research and development in air weapons; (t) Foster research and development of anti-aircraft systems; (u) Foster research and development in remote sensing; (v) Foster research and development of positioning and location sensors; (w) Foster research and development in decision support; (x) Foster research and development in alternative energy; (y) Foster research and development in direct energy; (z) Foster research and development in ionizing radiation; (aa) Foster research and development in data link; (ab)Foster research and development in intelligence; (ac) Maximize partnerships with public and private institutions for prospecting new technologies by sharing FAB's facilities, laboratories and equipment; (ad) Maximize the applicability of research in the area of biotechnology as a driver of Aerospace Power;

v **Command and Control (C^2)** (6 objectives): (a) Maximize integration between the FAB and other Armed Forces in Aerospace Defense activities (Air and Anti-Aircraft); (b) Maximize integration between the FAB and other Armed Forces in Cyber Defense activities; (c) Maximize integration between the FAB and other Armed Forces in Electronic Warfare activities; (d) Maximize integration between the FAB and other Armed Forces in Operational Intelligence activities; (e) Maximize integration between the FAB and other Armed Forces in Data Link Systems activities; (f) Develop and deploy efficient Command and Control systems that support the operational needs of the Force;

vi **Anti-Aircraft Defense** (2 objectives): (a) Maximize security of installations at FAB's military organizations; (b) Maximize self-protection of Air Force Assets with equipment compatible with use in Law and Order Assurance Operations (*"Operações de Garantia da Lei e da Ordem - GLO"*).

These objectives are the initial source for the elicitation of the criteria for PPS within FAB. The next step is to define the initial decision frame for PPS and select the suitable objectives among this list. The following subsection presents an example of a hypothetical decision frame and its implications for the PPS model.

B. Qualitative Value Model- PPS example for Anti-Aircraft Defense

In this section we depict a qualitative value model for a subportfolio for Anti-Aircraft Defense in FAB by selecting a set of objectives from the list presented in Section III-A. Figure 1 presents the objectives that were selected for this subportfolio. We grouped the objectives according to the topics extracted from PCA 11-47 (PEMAER).

After the WITI Test, we generated the Means-Ends Network presented in Figure 2.

The fundamental objectives presented in Figure 2 are the source for defining attributes (or criteria) for PPS decision process regarding the subportfolio of anti-aircraft related projects. Figure 3 presents an example of Fundamental Objectives Hierarchy that considers these objectives and depict hypothetical attributes (or criteria) to be used in a PPS process.

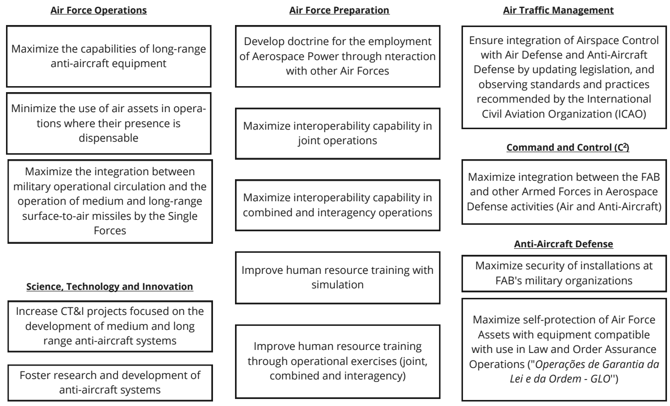

Fig. 1. Objectives for Anti-Aircraft Defense Subportfolio

The models presented in Figure 2 and 3 correspond to a subporfolio within the organization. The PPS process in an organization might comprise multiple subportfolios such as these. Section IV discusses how to approach each subportfolio, programs or group of projects to develop a model for PPS within the organization.

IV. Discussions and Further Developments

As mentioned in Section II, PPS requires a quite different modeling approach when applying VFT. Some organizations develop a single model for PPS and uses it to evaluate all projects. The evaluation using this kind of approach can be somehow cumbersome due to the difficulties to compare projects with totally different characteristics and with distinct purposes.

Hence, in the following subsections we propose some possible paths to develop VFT models for PPS.

A. Divide the portfolio in standalone subportfolios

This option divides the overall portfolio in independent standalone subportfolios. Each portfolio has its own decision frame, thus requiring a specific value model and specific resource constraints. Objectives are considered separately in each subporfolio model and the attributes have measurement scales according to the characteristics of the alternatives contained in the decision frame of the subportfolio. Resources are divided in separate slots ("buckets") according to the decision-maker's preferences. Figure 4 illustrates this option.

For the example explored in Section III, one possible initial decision frame for a subportfolio would be "Anti-Aircraft Systems". Other possible subportfolios "Combat Aircrafts and related Devices", "Air Traffic Management Systems", among others. The decision makers should decide about a suitable division according to the strategic objectives and the areas of interest of the organization.

This approach simplifies the optimization procedures by limiting the number of options in each subportfolio. Nevertheless, this option presents a relevant drawback: it limits the opportunity for increasing overall portfolio value by considering the influences between projects from different subportfolios, for instance: less resource consumption when two projects (from different subportfolios) are selected in the final solution.

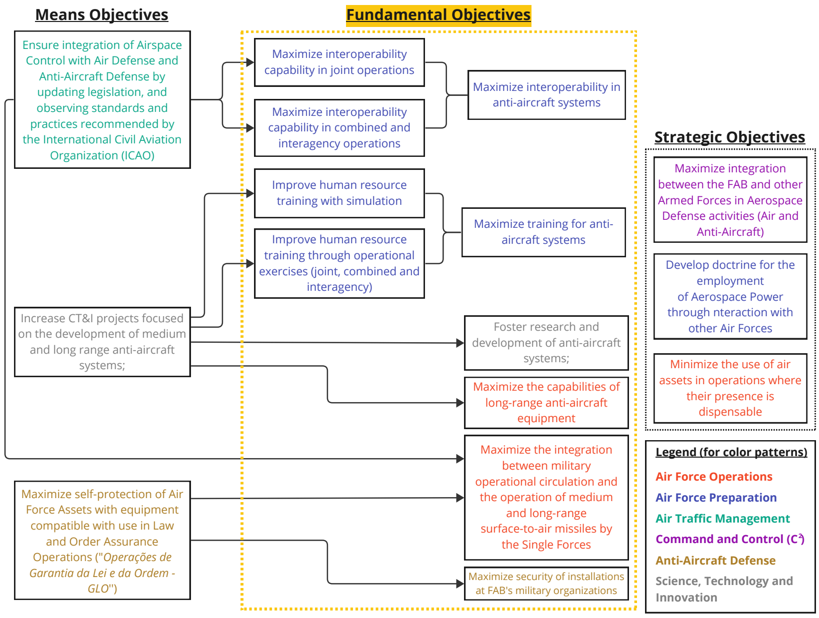

Fig. 2. Means-Ends Objectives Network for Anti-Aircraft Defense Subportfolio

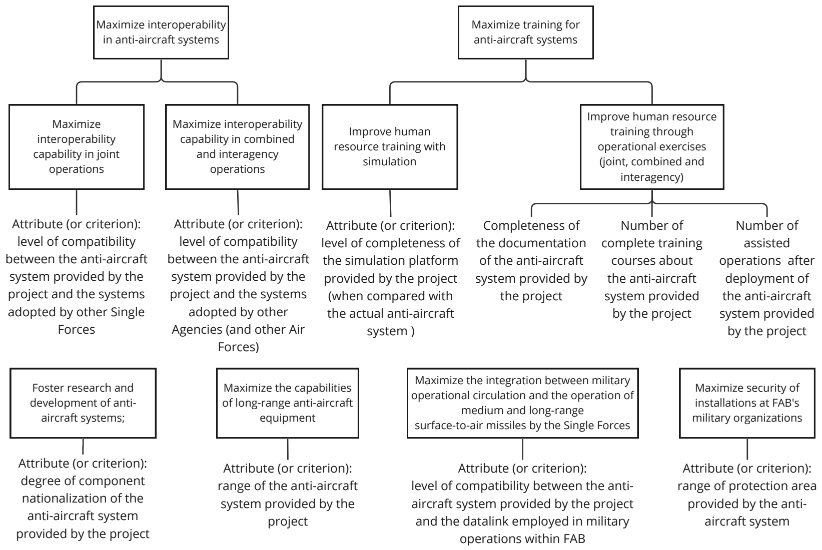

Fig. 3. Example of Fundamental Objectives Hierarchy for Anti-Aircraft Defense Subportfolio

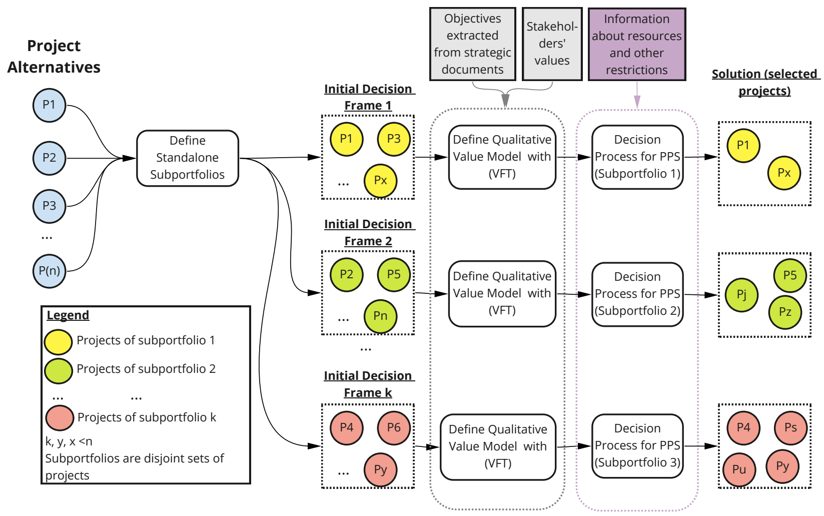

Fig. 4. Conceptual Diagram about PPS with VFT option: standalone subportfolios

B. Divide the portfolio in subportfolios with shared resource restrictions

This option is similar to the one presented in Section IV-A except for the considerations about resource allocations. At a first glance, one could attempt to combine individual value models for each portfolio in a single optimization model (a single objective function) that deals with the same set of restrictions ("single bucket" for each resource). However, it would be cumbersome to define the scale constants for variables that represent each project, since projects from a specific subportfolio might not have mappable consequences in the value model of other subportfolios, thus jeopardizing tradeoff (or swing) procedures. Thus, this approach would possibly violate the axiomatic structure of the multiattribute (or multicriteria method) adopted in the decision process.

Hence, in this case, a possible procedure is: order the subportfolios according to the judgement of the decision-makers regarding their relative importance. Then execute the PPS process individually for each subportfolio as follows:

1) Select the most important subportfolio instance that has not been optimized yet;
2) Apply all resource interdependencies that benefit this subportfolio (reduce resource consumption) and which inclusion was not yet defined in the previous rounds of subportfolio optimization;
3) Optimize the selected subportfolio and save the results;
4) Return to the initial step until all subportfolios were considered.

The proposed procedure is a heuristic that attempts to take into account the influences between subportfolios regarding resource consumption. It is noteworthy that this heuristic will often result in suboptimal PPS. Nevertheless, despite this drawback, it might present some interesting opportunities for PPS when compared to the standalone portfolio option presented in Section IV-A.

C. Optimize individual subportfolios considering all possible combinations of interdependencies

The last proposed approach is to consider the optimization for different scenarios. In each scenario, a feasible combination of interdependencies is defined and each subportfolio is optimized individually (according to the assumptions that result from the set of interdependencies previously defined). For instance, suppose that we have a interdependency that occurs when project P1 and P2 are included together and causes a reduction of 20% of the resource consumption in P1 and 10% in P2. Hence, the scenario that activates this interdependency must include a restriction that activates both projects in their specific subportfolios (i.e., sets the variables corresponding to the project to 1 in binary variable models). On the other hand, the scenarios that do not activate this interdependency must run the optimization of each subportfolio ensuring that P1 and P2 are not activated simultaneously.

This process can also consider interdependencies that affect the consequences for the attributes in each value model. Nevertheless, if this is the case, the elicitation process might require significant effort when there are many interdependencies.

V. Conclusion

In this paper we depicted an example of a qualitative value model approach for PPS regarding Brazilian Air Force (FAB) projects. First, we presented a brief literature review about PPS and VFT. Then we depicted some objectives extracted from the strategic planning of FAB to generate the qualitative value model for a subportfolio regarding Anti-Aircraft Systems within FAB. Lastly, we discussed some approaches to execute a PPS process using the VFT model.

Our work has some limitations. First, we did not validate the model with stakeholders with knowledge about the specific domains identified in the strategic documents. This validation could correct misunderstandings of the analysts regarding some objectives and provide additional objectives to enhance the model. Second, despite discussing some proposals for dealing with interdependencies that surpass the scope of the individual subportfolios, we did not execute a thorough procedure with all the steps proposed to present a complete example.

This approach is innovative since it allows the elicitation of the value-model according to the specific decision frames of each subportfolio, thus enabling an effective elicitation of the consequences of each process. Additionally, it proposes some procedures to aggregate the results of PPS for each subportfolio by considering the influences of the interdependencies between projects from different subportfolios.

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