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Strategic Aeronautical Procurement: Case Study of Supplier Selection in the Colombian Air Force

Bayron Steve Ruiz Niño
Captain, Mechanical Engineer
Aeronautical Logistics Directorate
Colombian Air Force
Bogotá D.C., Colombia
Bayron.ruiz@fac.mil.co

William Javier Guerrero Rueda
Professor, IT and Process Optimization Department
Engineering School
Universidad de la Sabana
Bogotá D.C., Colombia
william.guerrero1@unisabana.edu.co

Abstract

This paper presents a comprehensive strategy designed to support decision-making processes for the procurement of aeronautical products and the selection of suppliers, as required by the National Military Aviation Service in Colombia. The objectives of this study are threefold: (1) to characterize the relevant actors, characteristics of aeronautical products, applicable contractual processes, and external factors within the defense aeronautical ecosystem and its internal management systems; (2) to devise a systematic method for selecting aeronautical products for the Colombian Air Force, focusing on the potential development within the aeronautical industry; and (3) to establish principles for the selection of potential suppliers that aligns with the technical and operational requirements of state aviation. The results and discussions highlight the importance of prioritizing aeronautical products for aircraft with extended service periods, considering factors such as active production lines, operational performance indicators, and availability. Additionally, insights from interviews with technical experts underscore the importance of promoting growth within the Colombian aeronautical industry, particularly in the defence sector, by prioritizing less critical aeronautical products for local acquisition. Integrating feedback mechanisms, transparency, and long-term planning into procurement processes can enhance supplier relationships, promote strategic alignment, and drive sustainable development within the departmental aeronautical ecosystem.

Keywords
Aeronautical products, public procurement, Military aviation, selection supplier and decision making.

1. Introduction
The aviation sector is not only crucial for regional socioeconomic development but also plays a pivotal role in ensuring national air superiority, thereby safeguarding a nation's sovereignty and independence. Aligned with Target 9.2 of the United Nations Sustainable Development Goals, fostering inclusive and sustainable industrialization includes enhancing the aerospace industry's contribution to employment and GDP growth. Colombia, with a strategic vision for 2030, has ambitious plans to bolster its aeronautical sector. However, its heavy reliance on aviation parts sourced from foreign countries poses significant risks to both the supply chain and the country's sovereignty. This article addresses the urgent need for a tailored methodology to strategically select aerospace products and suppliers on a

national scale in Colombia. The dependence on foreign supplies extends beyond economic implications, compromising the nation's response and defense capabilities during critical scenarios. The absence of a dedicated methodology for this context underscores a gap in existing academic literature, highlighting an opportunity to reinforce national sovereignty through informed decision-making in the aerospace domain. Thus, the study delves into the importance of a methodology that not only promotes import substitution and optimal resource utilization but also considers strategic and national defense imperatives. The multifaceted challenge of aeronautical product selection within the defense sector necessitates careful consideration of various factors. Before delving into the proposed methodology, it is essential to define key concepts and contextualize the overarching problem. The Defense Departmental Aeronautical Ecosystem encompasses a network of organizations, companies, academic institutions, and government agencies involved in producing, developing, and maintaining aeronautical products for national defense purposes. Aeronautical products encompass a broad spectrum of equipment and systems vital for military aviation operations. Moreover, the supplier selection process involves identifying and selecting national manufacturers that best fulfill the operational and strategic needs of state aviation.

This study seeks to characterize the attributes, capabilities, and limitations of actors within the defense departmental aeronautical ecosystem, alongside its internal management systems. Additionally, it aims to devise a systematic method for selecting aeronautical products for the Colombian Air Force, focusing on potential development within the departmental aeronautical industry. Furthermore, it endeavors to establish a model for selecting potential departmental suppliers aligned with the technical and operational requirements of state aviation. Interviews with technical experts serve as a vital component in analyzing both facilitators and barriers within the process, ultimately contributing to informed decision-making in the aerospace sector.

The structure of the article consists of an analytical review of the literature on the actors of the Colombian aeronautical market related to defense aviation (section 2), secondly, the general methodology is established based on the diagnosis of the specific sector, the form of prioritize the aeronautical products required by the Colombian Air Force, and finally the criteria and principles for choosing the Colombian supplier manufacturer (section 3). Section 4 describes the method of collecting direct information from technical experts from the perspective of supplier (national industrial) and buyer (state aviation), from which later, in section 5, the prioritization of products and supplier selection criteria with their weights. as well as proposals for improvement and validation of the information collected by the judges.

2. Literature Review

With the objective of establishing a general theoretical framework, the literature review was developed based on milestones ordered for the development of the project, identifying an initial base in the document Study of the technological industrial focus on military publications mainly in the Library Information System Colombian Public Force (SIBFuP by its acronym in Spanish) identifying diagnosis of the Colombian aeronautical sector (SECAD, 2018), Analysis of aeronautical clusters referring to the development of the Colombian aerospace cluster (Bello Zapata, 2017), a characterization of national civil aviation (Aerocivil, 2020) and an update regarding aeronautical clusters (Morante Granobles et al., 2021) which will begin with the characterization of the aeronautical ecosystem based on cluster-type organizations, as they are currently associated companies in the Colombian aeronautical sector, summarized in illustration 1. State aviation aeronautical industry ecosystem graph. Where ecosystem actors and their relationships can be identified, establishing different exchanges of services and goods (Figure 1).

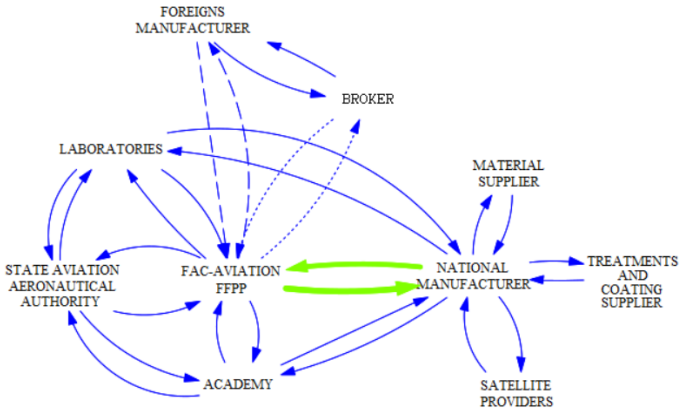

Figure 1. State aviation aeronautical industry ecosystem graph.

The literature exploration yielded documented cases of success with developing Latin American countries, as a framework to establish characteristics that may be relevant in the development of the model (Burgos & Johnson, 2018) such as the general location of the cluster, the distance between companies in the same sector, availability of qualified labor, existence of support networks, public research and universities, tradition, industrial structure and technology parks, among other characteristics that must be evaluated to sufficiently understand the Cundinamarca aeronautical ecosystem. Once a case of the aeronautical organization ecosystem and its analysis were known, a description of the national aeronautical clusters and a more detailed analysis were identified as explained by Morante Granobles et al. (2021) with the aim of determining similarity and purifying the characteristics that are considered less explanatory, in order to counteract these with external conditions, such as the action of the state and its policies for successful development (Chavarría et al., 2020).

In this way, the possible explanatory variables of the national or regional aerospace ecosystem will be selected, focusing efforts on determining a rational and informed decision method for the selection of potentially developable products, which will be based on the technical and operational characteristics that coincide with capabilities established in the clusters, with sufficient development time, with a high turnover to make each project profitable, evaluating obsolescence or competition in the market, and thus being able to execute a complexity analysis (Peschiera et al., 2020). It is necessary to highlight that there is a lack of focus in entrepreneurship ecosystems, especially in the evaluation of alternative policies and their corresponding intervention (Carayannis et al., 2022), or in this case the selection of aeronautical products from local companies in an ecosystem of aeronautical undertaking for regional defense, one of the tools of the state to intervene in the country's economy, fulfilling the essential purposes of the state, particularly in the promotion of general prosperity, this relationship between the State - Aeronautical Sector, can be visualized from the Figure 2., where it is explicitly indicated that there must be an intersection of interests, condensed in the selection of projects that align state social policies and interests of profitability or utility for entrepreneur-investors, as follows in Figure 2.

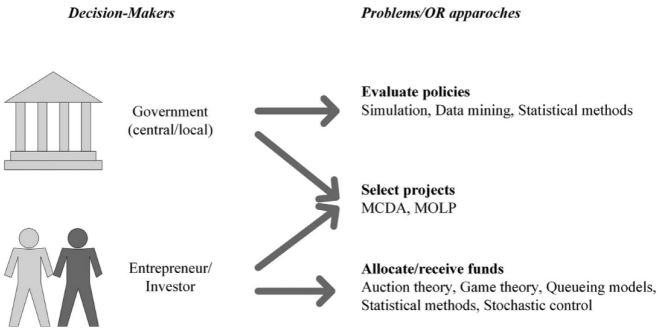

Figure 2. Examples of alternative approaches for the policy and interventions problem (Carayannis et al., 2022).

The supplier selection relationship in public bidding has been traditionally widely studied from the perspective of the default decision maker (expenditure authorizer/buyer), however, when talking about a commutative relationship, it must be evaluated from both the perspective of the buyer and the seller (bidder/entrepreneur), focusing on generating the greatest amount of value for money possible, as concluded in the article Rethinking Government Supplier Decisions: The Economic Evaluation of Alternatives (EEoA) (Melese & Fan, 2022), where the invitation to review public procurement is accepted as a relationship of two perspectives that can benefit the collaborating parties in a significant way, considering each of their interests.

Preliminarily, some variables that buyers consider when making any product acquisition can be identified, such as cost reduction, delivery improvement, quality, sustainability, strategic competitive advantage, innovation and compliance (the latter adapted variable) based on the necessary and sufficient skills of a good buyer (Stek & Schiele, 2021). However, we should not ignore the perspective of the entrepreneur and his perception of state aviation as a customer, given that variables must be included (profit, loyalty, potential growth, potential cross-selling) that allow us to determine the degree of relevance of state aviation. state or the Colombian Air Force, as a client for the national aeronautical product manufacturer and its degree of priority within its marketing and sales strategy (Khorramshahgol & Al-Husain, 2021).

Additionally, the type of Multicriteria Decision Method (MCDM) that is most convenient must be evaluated for its conceptual, logical, experimental and operational validity, as it is significant for the analyst as well as for the decision maker and the degree of legitimacy, which consists of complying with condition of effectiveness and veracity, and that satisfies the support for making a decision (Meinard Yvesand Tsoukiàs, 2022), the above, in line with what is proposed to solve the problem of sustainable supplier selection through an integrated MCDM model in purchasing public using DEMATEL (Decision-Making Trial and Evaluation Laboratory) and BWM (Best Worst Method) methods for a Spanish public hospital, where it was also confirmed that, based on a literature review in a supply chain management context, without import the good or service, the MCDM application with consistency in the weight matrix is necessary and pertinent and that for the particular case study, the results in the positioning of the bidders were the same, except for the number of operations to reach the result. where the AHP was the one that required the most computational capacity (Yazdani et al., 2020). Meanwhile, it is essential to review similar processes for an application where, due to the similarity of the product to be acquired, it is possible to standardize base criteria to begin the bidding process for local aeronautical products. In this sense, the way of selecting a method for support the selection of a weather radar in Brazil, in which unstructured interviews for a limited number of specialists were considered, to identify relevant criteria for the acquisition of a weather radar system, such as: Human resources, Observation Network meteorological, Numerical Modeling and Meteorological Communication System and where it was considered to use the Multi-Attribute Value Theory method (Caruzzo et al., 2020).

3. Methods

This article aims to provide a solid and effective methodology for the selection of aeronautical products in the defense sector. Given the critical importance of this industry for national security and defense, choosing the appropriate products is essential to guarantee the efficient and effective operation of the Air Force or the aviation areas of Public Force of a country with an emerging economy like Colombia. This methodology is developed in the context of the department of Cundinamarca, Colombia, but can be adapted and applied in other regions with similar needs. Despite

the existence of previous research in this field, a lack was identified in the literature and in local practices, regarding the selection of aeronautical products specifically adapted to the needs and capabilities at the national level (Colombia). A comprehensive methodology has not been developed that considers all the dimensions of this process in the regional context. To fill the identified gap, is it proposed a methodology in three interconnected phases:

Phase 1: Characterization of the Departmental Aeronautical Ecosystem of Defense. This phase involves an exhaustive analysis of the aeronautical ecosystem in Cundinamarca. Descriptive research methods, consultation of public statistics and semi-structured interviews with key actors in the industry (technical experts) will be used until the saturation point where the survey using this instrument would conclude (Hernández Sampieri, 2016). The goal is to understand the capabilities, limitations, and relationships within the ecosystem.

Phase 2: Determination of Priority Aeronautical Products. In this phase, aeronautical products that are of high priority for state aviation will be identified. Factors such as need, installed capacity and technical knowledge will be considered. Multi-criteria analysis techniques, including the Analytical Hierarchical Process (AHP), will be used to evaluate and prioritize these products, like the way a method was selected to support the selection of a weather radar in Brazil, in which interviews were considered. unstructured for a limited number of specialists, to identify relevant criteria for the acquisition of a meteorological radar system, such as: Human Resources, Meteorological Observation Network, Numerical Modeling and Meteorological Communication System and where it was considered to use the Multi method -Attribute Value Theory (Caruzzo et al., 2020).

Phase 3: Establishment of a Model for the Selection of Departmental Suppliers. The last phase focuses on the selection of local suppliers for the aeronautical products identified in the previous phase. An inductive logical approach will be applied, considering the proposals of local companies and establishing objective criteria for the evaluation of the offers. Strategic decision models will be explored, and multi-criteria methods will be applied to make informed and rational decisions. Additionally, the type of Multicriteria Decision Method that is most convenient must be evaluated for its conceptual, logical, experimental, and operational validity, as it is significant for the analyst as well as for the decision maker and the degree of legitimacy, which consists of complying with condition of effectiveness and veracity, and that satisfies the support for making decision (Meinard Yvesand Tsoukiàs, 2022).

4. Data Collection

Firstly, the information collection design was developed as a semi-structured interview to determine the perspective and perception of representative actors of the aeronautical industry for defense in Colombia. Which was validated based on the content validity criteria and expert judgment according to Lawshe-Tristan (Tristán-López, 2008) obtaining a Content Validity Ratio (CRV) according to Lawshe with Tristan adjustment of 0.92857143 higher than the recommended 0.5823. Once the instrument was defined, it was applied to six technical experts whose main characteristic is knowledge in the purchase and sale of nationally manufactured aeronautical products for the defense sector in Colombia, both on the part of the buyer and on the part of the manufacturer, from different years of experience, with the purpose of knowing various perspectives of this commercial activity. Following the order of the methodology, a data analysis was carried out, primarily inductive, with the purpose of determining the relationship of the responses issued with respect to the topic of interest, which yielded the following cloud of concepts (Figure 3.) presented below in Figure 3:

Figure 3. Cloud of concepts determined under inductive analysis.

Where the relevance of the answers can be evidenced given that it focuses on the concepts of product, industry, process, development, equipment certificate, process, among others. Once the relevance of the responses obtained was reviewed, a free deductive analysis was developed to identify paragraphs in the interview responses that would allow determining the most relevant concepts, from the perspective of the researcher and keeping in mind the purpose of being close to the main ones. actors in the process. purchasing process to identify global themes and their semantic relationships, therefore the Sankey Diagram of Co-occurrence of the Overview Code (Figure 4.) was obtained. Where relationships between concepts can be recognized, generally opposite for the type of experts interviewed. Likewise, the following concepts applicable to the research are identified, confirming that the interviews handled concepts of interest.

Likewise, the following concepts applicable to the research are identified, confirming that the interviews handled concepts of interest:

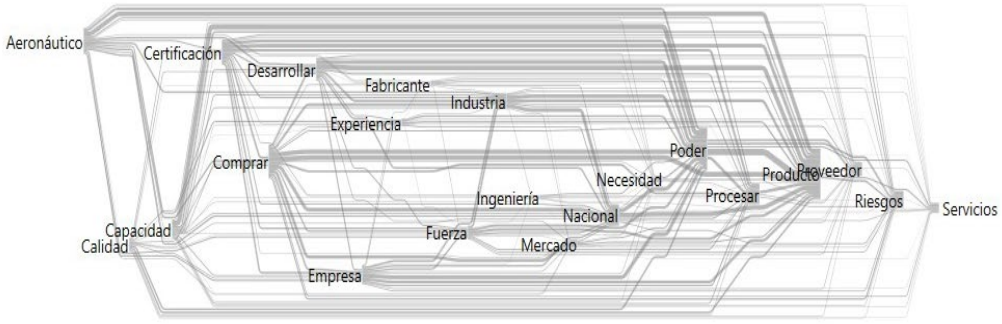

Figure 4. Code Co-occurrence Sankey Diagram of inductive analysis. The previous figures are shown in their original language of analysis to save information due to translation.

Given that the initial objective of the interviews was to identify the selection criteria for aeronautical products and the national suppliers that manufacture and supply them, it was determined to carry out a theoretical exploration to determine the criteria most corresponding to the explanation as can be identified in the Table 1. Review of criteria of supplier selection.

Table 1. Review of criteria of selection of supplier

#	Articles analysed	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6
1	A Predictive Performance Measurement System for Decision Making Supply Chain (Loraine Sanchez - Jimenez, Tomás E. Salais-Fierro, 2021)	Reliability	Agility	Asset management	Costs	Responsiveness	
2	Planejamento do sistema de meteorologia no apoio da logística humanitária: a visão dos previsores utilizando a Teoria de Valor Multiatributo (Amaury Caruzzo a*, Daniel Manso b, Mischel Carmen Neyra Belderrain, 2013)	Human resources	Meteorological observation network	Numerical modelling	Meteorological communication systems		
3	A Hybrid Multi-Criteria Approach for Evaluation and Selection of Sustainable Suppliers in the Avionics Industry of Pakistan (Noor Muhammad, Zhigeng Fang, Syed Ahsan Ali Shah, Muhammad Azeem Akbar, Ahmed Alsanad, Abdu Gumaei and Yasir Ahmed Solangi, 2020)	Traceability	Quality	Aftersales	Cost	Risk	Delivery
4	Sustainable supplier selection and order allocation under demand, supplier availability and supplier grading uncertainties (Zahra Sadat Hosseini, Simme Douwe Flapper & Mohammadali Pirayesh; 2022)	Economic	Environmental	Social			
5	An integrated multi-criteria decision-making approach to optimize the number of leagile-sustainable suppliers in supply chains (Darvazeh et al., 2022)	Delay	Environmental	Agile	Lean		
6	Evaluation of supplier selection in the defence industry using q-rung orthopair fuzzy set based EDAS approach (Güneri & Deveci, 2023)	Technical	Financial	Social	Performance		

Considering the previous criteria, to establish which are the most applicable, the Manual for the Identification and Coverage of Risk in Contracting Processes was consulted in (Colombia Compra Eficiente, 2017), where types of risks in contractual processes are shown and they are associated these concepts to those previously reviewed. Once these criteria have been chosen, it is necessary to disaggregate them into sub-criteria. In this sense, the sub-criteria used in Selecting the Right Suppliers in Procurement Process along Supply Chain-a Mathematical Modeling Approach (Duica et al., 2018) Dickson's supplier quality evaluation criteria) are described in Table 2.

Table 2. Dickson's supplier quality evaluation criteria

Selecting the Right Suppliers in Procurement Process along Supply Chain- a Mathematical Modeling Approach Dickson's supplier quality evaluation	1	Quality	9	Procedural Compliance	17	Impression
	2	Delivery	10	Communication System	18	Packaging Ability
	3	Performance History	11	Reputation and Position in Industry	19	Labor Relations Record
	4	Warranties and Claim Policies	12	Desire for Business Importance	20	Geographical Location
	5	Production Facilities and Capacity	13	Management And Organization	21	Amount of Past Business
	6	Price	14	Operating Controls	22	Training Aids

criteria (Attribute Rank Attribute)	7	Technical Capability	15	Repair Service	23	Reciprocal Arrangements
	8	Financial Position	16	Attitude		

In the order to associate criteria and sub criteria, it was used the co-occurrence diagrams Sankey to validate the semantic relation between criteria and sub criteria (Figure 5.), like is shown below (for instance for Environmental criteria) in Figure 5.

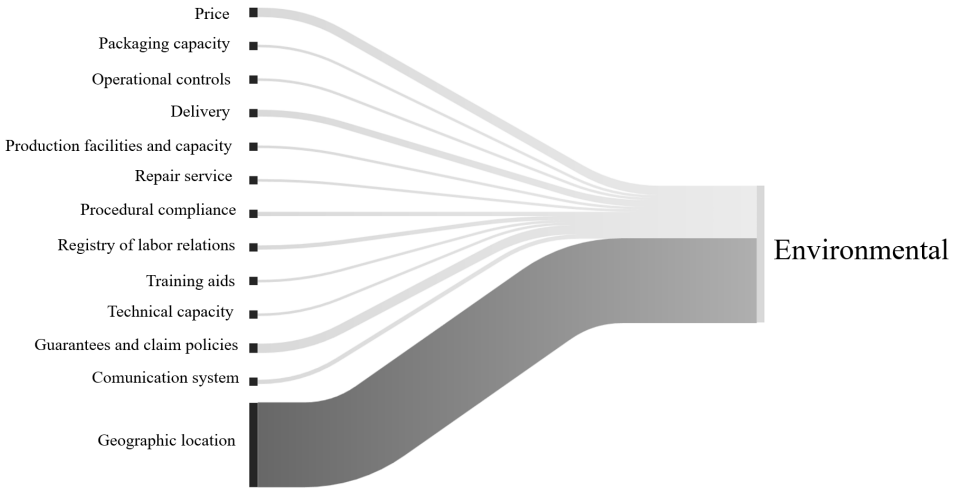

Figure 5. Environmental Code Co-occurrence Sankey Diagram

For this case, it was correlated the Dickson's supplier quality evaluation criteria with concepts taken from Conpes Document 3714 - Foreseeable Risk in the Framework of Public Procurement Policy (2011) considering its semantic affinity to be established in Table 3. like this:

Table 3. Semantic relationship table between criteria and sub criteria

Codes (22)		
Environmental: Location Geographic	Social or political: Desire for Business Importance	Technological: Guarantees and Claim Policies
Economic: Position Financial	Social or political: Registry of Labor Relations	Technological: Management and Organization
Economical: Price	Social or political: Reputation and Position in the Industry	Technological: Performance History
Economic: Previous Business Volume	Technological: Attitude	Technological: Printing
Operational: Packaging Capacity	Technological: Training Aids	Technological: Communication System
Operational: Controls Operational	Technological: Technical Capacity	Operational: Repair Service
Operational: Delivery	Regulatory: Compliance Procedural	Regulatory: Agreements Reciprocals
Operational: Production Facilities and Capacity		

On the other hand, with the purpose of incorporating these criteria into a legitimate selection by the public administration, a consultation was carried out on the legal framework applicable to state contracting processes in Colombia (Estatuto General de Contratación de La Administración Pública, 1993), where the principles of the Contracting Statute and the relevant aspects of Law 1150/2007 like Principles of the Colombian Contracting Statute. Relevant aspects of Colombian

Law 1150/2007: Define the general principles that should govern public purchases in Colombia. Establishes different types of contracting procedures, such as public bidding, abbreviated selection, and direct contracting. It promotes competition among bidders and guarantees equal conditions to participate in contracting processes. Implements an objective selection system based on technical and financial criteria. Protects the rights of contractors, including timely payment of their fees and fair resolution of disputes. Establishes control and supervision mechanisms to prevent irregularities in contracting processes.

In addition to the contracting framework, a consultation was carried out on the promotional efforts of companies in the aeronautical sector and Colombian Decree 442 of March 28, 2022 was identified "By which Decree 1082 of 2015, Single Regulation of the Administrative Planning Sector National, to regulate article 36 of Law 2069 of 2020 regarding the promotion of public purchases of technology and innovation", as a general input for the acquisition method. Likewise, by the same author (Beltrán Giraldo, 2020), a series of aeronautical specialties of the industrial sector in Colombia.

5. Results and Discussion

According to the data collected, it is possible determine an initial process with the next steps. Step 1. Selection of potential aeronautical products for acquisition from a national manufacturer: Initially and according to Beltrán (2020), the aeronautical products to be acquired by state aviation must be selected for the aircraft with the longest service time, which usually lose the technical support of the manufacturer, where we move on to the second criterion that contemplates is the verification of an active production line of this product on the market, calculation of the operational performance indicator and identification of unavailability. Therefore, it is determined that the aeronautical products applicable to this methodology must be class II and III aeronautical products, with the purpose of reducing the criticality of the components required by state aviation. Likewise, what is established in Table 3. With the Aeronautical Specialties of the Industrial Sector in Colombia should be followed (Beltrán Giraldo, 2020), so companies specialized in Mechanical, Electromechanical, Hydraulic and Tire Components, Military Vehicles, Tactical Vehicles, Logistics Support Equipment and related, Composites, Plastics and Rubber, Electrical, Electronics and Electro-optics where we find a prioritization criterion for the acquisition of aeronautical products from national manufacturers.

5.1 Numerical Results

Step 2. Evaluation of national manufacturer suppliers for defence. As a first step to determine the weights of the selection criteria for suppliers of national aeronautical products, it is determined in Table No. 3 Table of semantic relationship between criteria and sub-criteria, the statements of the experts were coded where they mentioned aspects related to the sub-criterion and were determined the frequency of each one, with which the following results were obtained, like is shown in Figure 6.:

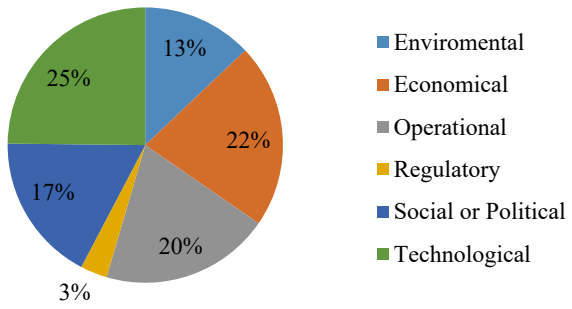

Figure 6. Frequencies determined for criteria by coding interviews in Atlas.ti

According to the previous results, it is possible to determine which are the criteria for the relevant actors in the industry common to all, thus considering the supplier selection criteria (national manufacturers), decreasing from 23 to 15 criteria highlighted by the interviewees (the criteria not mentioned were: Operational: Packaging Capacity, Technological: Attitude, Technological: Management and Organization, Technological: Performance History and Technological:

Printing), results obtained based on the aforementioned cumulative frequency of the sub criteria by the experts, obtaining the criteria and possible weights (that must be validated based on method acknowledged) as shown in Table 4.

Table 4. Criteria and preliminary weights to evaluate suppliers

Sub criteria	Weight	Sub criteria	Weight
Environmental: Location Geographic	12.02%	Operational: Production Facilities and Capacity	1.71%
Economic: Position Financial	1.47%	Operational: Repair Service	1.15%
Economical: Price	11.96%	Regulatory: Agreements Reciprocals	3.20%
Economic: Previous Business Volume	8.63%	Social or political: Record of Labor Relations	10.83%
Operational: Controls Operations	3.18%	Social or political: Reputation and Position in the Industry	7.01%
Operational: Delivery	12.10%	Technological: Training Aids	4.90%
Technological: Guarantees and Claim Policies	12.95%	Technological: Technical Capacity	4.78%
Technological: Communication System	1.16%		

Step 3. Compliance with the steps of the legal framework: Given that any decision in public procurement must obey a process that follows the principles listed in the Colombian public procurement statute, a proposal is presented to mitigate the risks of non-compliance with these principles as follows in the Figure 7.

5.2 Graphical Results

Figure 7. Diagram of Contractual strategy

In this sense, in accordance with what was expressed by the experts in the semi-structured interviews, the framework strategies were developed for the application of the supplier selection methodology following each of the contracting principles of the Colombian public administration (transparency, competition, responsibility, equity, impartiality and publicity), thus:

- Transparency, Clear policies and public criteria: Permanent and public policies and criteria must be established to evaluate the proposals of Colombian manufacturers of aeronautical products (initially for classes II and III). These criteria will be publicly accessible and will cover technical aspects, quality, compliance and experience to ensure an objective and feedback evaluation.

- Competition and economics, equal opportunities for competent bidders: Guarantee the plurality of bidders with competence in the development and/or manufacturing of the aeronautical product, this encourages competitive quality and the acquisition of greater quality-price ratio, avoid the massive purchase of class II and III aeronautical products, given that when generating lots of products in contracting reduces the possibility of national companies developing their design and manufacturing capacity, given that it requires dedication to generally reverse engineering processes.
- Responsibility, dedicated teams and clear timelines: Create dedicated teams responsible for each phase of the selection process. These teams will ensure transparent and robust publication, rigorous evaluation, timely execution, and clear deadlines for effective contract management.
- Equity validated technical criteria and proximity to the buyer-seller: Use validated technical criteria that align with the perspectives of the buyer and seller with specific weights proposed in Table 4., fostering trust and alignment between the parties.
- Impartiality, Objective Evaluation by Committees of Experts: Have clear weightings through robust rubrics to conduct objective evaluations by expert committees to minimize bias and ensure merit-based selection of manufacturers according to standardized criteria.
- Advertising, wide dissemination of contracting processes: Promote wide dissemination of contracting processes with sufficient advance notice, to attract a diverse group of competent bidders, encouraging greater participation.

5.3 Proposed Improvements

The enhancement of supplier communication and transparency is paramount in optimizing the acquisition process. Establishing clear channels for feedback and information exchange fosters understanding, trust, and collaboration between buyers and suppliers. Furthermore, strengthening confidentiality measures ensures the protection of sensitive information, promoting a secure environment for the exchange of proprietary data. By fostering a culture of trust and collaboration, organizations can encourage joint problem-solving and innovation initiatives, driving mutual success. Aligning procurement strategies with long-term organizational goals and objectives facilitates strategic planning and sustainable supplier relationships. Integrating insights from interviews underscores the importance of transparency, confidentiality, and trust-building, alongside long-term planning, and supplier training initiatives. Moreover, fostering the development of local suppliers contributes to strategic independence and resilience in the supply chain, ultimately creating a robust procurement framework focused on transparency, trust, and long-term sustainability in supplier relationships.

5.4 Validation

With the purpose of verifying the validity of the deductive coding method based on previous theory with which the weights of the criteria in Table 5 were determined. The following statistical verifications were carried out: As a first measure, the verification of the linear relationship between different pairs of experts was determined, as evidenced in Table 5.

Table 5. Pearson Expert Correlation Matrix.

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Expert 1	1.000000	0.320834	0.659147	0.195834	0.441384	0.464249
Expert 2	0.320834	1.000000	0.462546	0.680035	0.139405	0.745507
Expert 3	0.659147	0.462546	1.000000	0.434641	0.563337	0.718488
Expert 4	0.195834	0.680035	0.434641	1.000000	0.338830	0.453531
Expert 5	0.441384	0.139405	0.563337	0.338830	1.000000	0.215288
Expert 6	0.464249	0.745507	0.718488	0.453531	0.215288	1.000000
Pearson General Correlation Coefficient: -0.24826100220438158						

According to the above it can be understood that:

- Strong relationships: High values in the matrix indicate relatively strong correlations. For example, there appears to be a relatively strong correlation between Expert 2 and Expert 6, with a correlation coefficient of 0.745507. This suggests that the assessments of these two experts tend to go together in the same direction.

- Weak relationships: Conversely, lower values in the matrix indicate weaker correlations. For example, the correlation coefficient between Expert 1 and Expert 4 is 0.195834, suggesting a weak correlation between their evaluations.
- Correlation patterns: It is essential to observe if there is any pattern in the matrix. This could indicate similarities in how they evaluate the product.

Furthermore, notable differences in correlations between different pairs of experts should be looked for. We must consider both the Pearson correlation coefficient and the Kendall coefficient matrix of the Table 6:

Table 6. Kendall Coefficients Matrix

0.000	0.445	0.549	0.440	0.311	0.380
0.445	0.000	0.424	0.530	0.202	0.663
0.549	0.424	0.000	0.509	0.464	0.675
0.440	0.530	0.509	0.000	0.436	0.528
0.311	0.202	0.464	0.436	0.000	0.430
0.380	0.663	0.675	0.528	0.430	0.000
Kendall general Coefficient: -0.229					

Consequently, the statistical evidence allows us to interpretate that: The analysis of expert rankings reveals noteworthy relationships among the experts. By averaging experts' assessments, individual biases are minimized, leading to a more reliable and robust estimation of the phenomenon being evaluated. This approach can help mitigate the influence of discrepancies among experts and obtain a measure that better reflects the consensus. In consequence, it was checked Expert heterogeneity, which was examined confirming the background of each one; It was considered the average weighting of opinions, to contemplate the purchaser and seller perspective of this case, and finally it was estimated a sensitivity analysis (shown in Figure 8.) to understand the result's robustness and identify potential biases or excessive influences from specific experts.

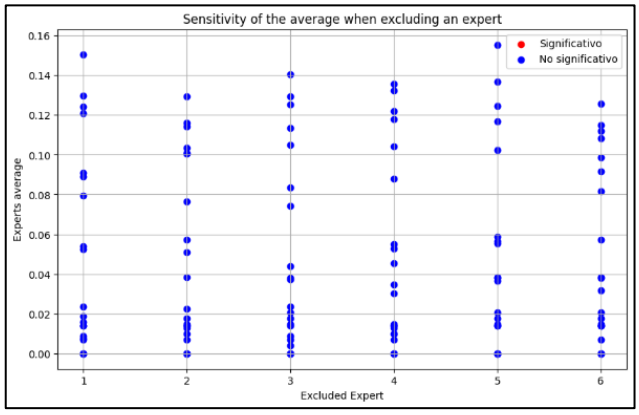

Figure 8. Sensitivity of the average when excluding an expert

6. Conclusion

The systematic analysis of data allows to conclude that, from the buyer's perspective, it is essential to prioritize aeronautical products that ensure long-term operational efficiency, especially for aircraft with extended service times. This approach aligns with the manufacturer's interests, promoting the sustained performance of aeronautical assets and ensuring continued support despite potential challenges from discontinued manufacturer support. Further, proximity to the aeronautical industry is crucial for fostering collaboration, knowledge exchange, and timely responses to operational requirements. By prioritizing local suppliers and promoting a strong domestic industry, the defense sector can enhance its resilience and reduce dependency on foreign sources. Clear rules, transparency, and legitimacy in the decision-making

method are paramount to maintain trust and credibility within the defense procurement process. This ensures that supplier selection is based on objective criteria and ethical considerations, fostering fairness and accountability. Long-term planning is essential for ensuring the sustainability and resilience of the aeronautical supply chain. By adopting a strategic outlook and considering future operational needs, the defense department can mitigate risks, anticipate challenges, and optimize resource allocation effectively. Investing in supplier training programs is critical for fostering strategic independence and reducing reliance on external sources. By equipping local suppliers with the necessary skills and capabilities, the defense sector can enhance its self-sufficiency, promote innovation, and support the growth of the domestic industry. In summary, integrating these themes into the conclusion underscores the importance of strategic decision-making, collaboration, and capacity-building initiatives in strengthening the defense department's procurement capabilities and advancing the development of the Colombian aeronautical industry.

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Biographies

Bayron Steve Ruiz Niño is an Official of Colombian Air Force - COLAF and Student of Magister in Management and Design of Process of the Engineering Department at the Universidad de la Sabana, also is Maintenance Management Specialist in charge of management of Aeronautical Ground Support Equipment at Colombian Air Force, with background in assets management, design and development in aeronautical tests, aeronautical maintenance, and metrology.

William Javier Guerrero Rueda is Associate Professor, Head of the Research Group on Logistic Systems, and Head of the IT and Process Optimization Department at Universidad de la Sabana. Likewise, is an Industrial Engineer with a Ph.D. in Optimization and Systems Reliability, bringing over 10 years of experience in research and consulting. Their expertise lies in digital transformation and Operations Management, specifically in developing innovative solutions for healthcare/humanitarian logistics. They also lead the Logistic Systems Research Team, offering research services in supply chain management and transportation science, along with expertise in data analytics and international research & innovation projects in developing economies contexts.