Strengthening Indonesia's Unmanned Aerial Vehicle Manufacturing Industry: A Technology-Focused Strategic Analysis

Satrio Utomo, Gani Soehadi, Sarjono Sarjono, Yanuar Iman Dwiananto, Adi Akhmadi Pamungkas,
Ellia Kristiningrum, Budi Setiadi Sadikin, Hardono Hardono, Rizki Arizal Purnama, Helen Fifianny
National Research and Innovation Agency (BRIN), Indonesia

Abstract—**The development of national Unmanned Aerial Vehicle (UAV) technology represents a strategic imperative that requires immediate implementation. This study provides strategic recommendations to strengthen Indonesia's UAV industry by employing SWOT analysis, the Analytical Hierarchy Process (AHP), and the Quantitative Strategic Planning Matrix (QSPM). Sixteen key internal and external factors were identified, with SWOT mapping situating UAVs in Quadrant I (Aggressive Strategy) at coordinates +1.24 and +0.60. AHP prioritization indicates that the strengths–opportunities (S–O) strategy (0.348) is of highest importance, emphasizing infrastructure enhancement and the adoption of advanced technologies. IFAS–EFAS integration confirms Wulung UAV's aggressive growth position, while internal strengths account for 37.1% of overall strategic influence. QSPM analysis further validates the S–O strategy as optimal, with the highest internal (4.88) and external competitive (4.63) impact scores. Implementation of this strategy necessitates immediate action focused on manufacturing infrastructure enhancement, technological adoption, development of technical human capital, organizational capability strengthening, establishment of a domestic supply chain and supporting industries, and enforcement of robust industrial governance.**

Keywords—Unmanned Aerial Vehicle; technology adoption; strategic development; SWOT; AHP; QSPM

I. Introduction

Currently, Indonesia is developing an Unmanned Aerial Vehicle (UAV) [12] technology named Wulung. Equipped with an integrated autopilot system, Wulung can execute flight missions autonomously, offering greater efficiency and cost-effectiveness compared to conventional aircraft, with faster and more precise flight operations. Developing a national UAV industry is a strategic necessity that requires immediate implementation to protect Indonesia's territorial sovereignty, reduce disaster impacts, improve industrial competitiveness, and conserve foreign exchange to support the national economy [1]. The development of this UAV product will both fulfil present societal demands and drive the direction of future technological advancements.

The Wulung UAV still faces technological limitations, including a noisy engine and a restricted flight range of 73 kilometers, while most components are imported, raising production costs. Extended operational range and endurance are essential for national defense and post-disaster response. Therefore, further research and development, including extensive testing, is required to ensure compliance with operational, quality, and user standards. This evaluation must address system accuracy, reliability, and the supporting business processes for data management and maintenance.

Future UAV development requires strengthening domestic supporting industries to ensure a sustainable component supply and increase the Domestic Component Level (TKDN). Although the adoption of advanced technology is critical for enhancing industrial competitiveness, efforts to master and develop such technology remain limited. Continuous technological innovation is therefore essential to improve capabilities and generate higher value-added products. This study provides an in-depth analysis of UAV technological capabilities and strategic measures to enhance their contribution to the domestic manufacturing industry.

Indonesia remains highly dependent on foreign sources for electronics, including UAV engines and core components [2]. Using imported components also means having limited control over the quality and innovation of the raw materials used. Developing the national electronics industry is therefore essential, emphasizing import substitution, increased use of local components, and advancements in technological and manufacturing expertise. Strengthening the sector also requires robust maintenance and support services, as well as workforce development through vocational education and foreign talent programs. Accelerated technological mastery and targeted innovation programs are critical to enhance competitiveness and reduce import reliance

Limited mastery of UAV technology poses a significant barrier for the domestic industry in competing with imported products. The number of engineers capable of high-technology UAV engineering remains limited, and domestic R&D capacity is insufficient to address comprehensive technological needs, which require substantial investment. Moreover, countries with advanced UAV technologies are generally unwilling to transfer them freely due to the economic value of their Intellectual Property Rights [3]. The Wulung UAV technology still requires further research and development to enhance flight endurance, reinforce the landing gear for operations from all types of runways, reduce mechanical noise, integrate an automated control system, and incorporate components manufactured domestically.

This study evaluates and analyses the development of UAV technology in Indonesia and formulates strategic plans to assess the level of independence in the domestic manufacturing industry. It serves as a reference for industry, academia, and policymakers to support commercialization and identify strategies to enhance UAV technology quality.

To address these challenges, this study employs a combination of Strengths–Weaknesses–Opportunities–Threats (SWOT) analysis, the Analytical Hierarchy Process (AHP), and the Quantitative Strategic Planning Matrix (QSPM) to leverage the strengths of each method for more accurate and detailed results. SWOT specifically evaluates business conditions by assessing strengths, weaknesses, opportunities, and threats [4]. The Analytical Hierarchy Process (AHP) is a decision support tool used to prioritize internal and external factors [5]. The Quantitative Strategic Planning Matrix (QSPM) objectively evaluates alternative options to determine the optimal strategy [6]. Integrating these methods provides a systematic and structured analytical approach, enhancing decision-making and promoting comprehensive strategic thinking in business development [7] .

The originality of this research lies in the integration of three methods—SWOT, AHP, and QSPM—for assessing the readiness of UAV technology development. The study makes a novel contribution by mapping 16 measurable strategic factors: 7 Strengths (S), 9 Weaknesses (W), 4 Opportunities (O), and 6 Threats (T), highlighting dominant factors (S1, W2, O1, and T1) through quantitative analysis. This provides a strategic data foundation not previously documented in UAV literature. Furthermore, the selection of research objects related to UAV technology development represents a new and necessary focus in Indonesia.

II. Literature Review

UAVs are aircraft that are controlled by a remote control system via radio waves [8]. Their use is increasing due to relatively low costs and diverse benefits, including the ability to collect accurate visual and geospatial data [9]. This data supports applications such as inspections, surveillance, reconnaissance, and mapping, including monitoring regional spatial planning, mapping agricultural and forest areas for conservation and resource management, producing post-disaster maps, monitoring fire-prone regions, detecting deforestation, and identifying sources of pollution or illegal resource exploitation, such as fishing, mining, and logging. UAVs are therefore a valuable technological tool for rescue and disaster mitigation, enabling rapid and accurate mapping of infrastructure affected by events like volcanic eruptions and forest fires—disasters that occur frequently in Indonesia.

The development of UAV technology in Indonesia has been driven by government policy, including Law Number 16 of 2012 and Presidential Regulation Number 8 of 2021, which prioritize defense industry independence and UAV programs [10]. The Wulung UAV project began in 2015 through a consortium of government agencies, universities, and industries, including the Directorate General of Defense Potential of the Ministry of Defense, the Indonesian Institute of Sciences, the Agency for the Assessment and Application of Technology, the Indonesian Institute of Sciences, the Bandung Institute of Technology, PT Dirgantara Indonesia (PT DI), and PT LEN Industri. In 2022, the National Research and Innovation Agency (BRIN) continued UAV development in collaboration with PT DI, which holds a Design Organization Approval Certificate [11]. As a result, the UAV has become a national strategic program and a pilot initiative for technological acquisition and advancement.

The Wulung features autopilot capabilities and a modular composite structure for quick assembly, with a weight of 125 kg, wingspan of 6.36 meters, a 35-liter fuel tank, a 22-Hp piston pusher engine, a cruising speed of 110 km/h, and a four-hour endurance. Critical UAV technologies, including composites, flight control, telemetry, system integration, and propulsion, remain controlled by other countries [14].

III. Methodology

This study employs a descriptive qualitative–quantitative approach, utilizing primary data from interviews, observations, and expert questionnaires, and secondary data from literature, reports, and journals. The data are classified into internal (strengths and weaknesses) and external (opportunities and threats) factors, weighted, and mapped onto a Cartesian diagram to support SWOT-based strategy formulation [15]. The resulting strategies were analysed using QSPM to determine strategic priorities [13], while AHP was applied to select the optimal strategy from the SWOT alternatives [14].

After data collection, the information is processed using the External Factor Analysis Summary (EFAS) and Internal Factor Analysis Summary (IFAS) matrices [15]. Once the criteria are established, SWOT analysis is applied, followed by the determination of importance weights and ratings. The results from the IFAS and EFAS matrices are then mapped onto a Cartesian diagram, which consists of an X and Y-axis coordinate system [16].

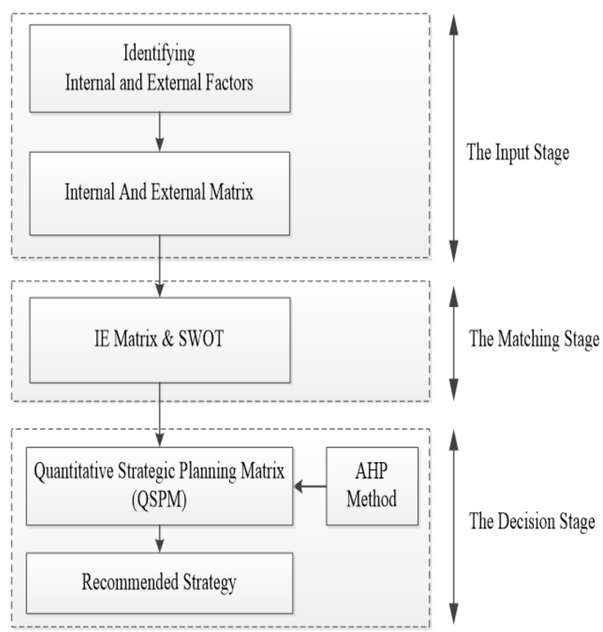

Fig. 1. Stages in UAV framework.

Based on Fig. 1, the formulation of a UAV technology development strategy is divided into three stages framework: input stage, matching stage, and decision stage. The strategy formulation methods used are:

- Input Stage

The input stage compiles the fundamental data necessary for developing a strategy. At this stage, an analysis of internal and external factors is carried out using the IFE (Internal Factor Evaluation) and EFE (External Factor Evaluation) matrices.

The IFE matrix identifies the key internal factors that determine strategy. These internal factors are analysed in terms of strengths and weaknesses, such as production, human resources, R&D, and management information systems. The EFE matrix identifies key external factors in determining strategy. The external environmental analysis identifies opportunities and threats, including economic, social, demographic, environmental, technological, and competitive factors. Then, the SWOT table is filled with indicators of strengths (S), weaknesses (W), opportunities (O), and threats (T). The next step is to compile four main strategic alternatives: S-O, S-T, W-O, and W-T strategies. These are alternative solutions for developing UAV technology. The S-O strategy uses strengths to create more opportunities. The S-T strategy uses strengths to overcome threats. The W-O strategy involves overcoming weaknesses to create more opportunities. The W-T strategy involves identifying and addressing weaknesses and threats. Next, create a pairwise comparison matrix to determine importance weights and ratings. Weights are determined in the assessment based on importance, measured on a scale of 1 to 5. The levels are as follows: 1 (not important); 2 (slightly important); 3 (important); 4 (quite important); and 5 (very important) [17]. Comparisons are made based on the decision maker's judgment by assessing the importance of one element compared to others.

- Matching Stage

The matching stage compares key internal and external factors, which are then analysed using quantitative models. The industry's current position is determined, and alternative strategies are designed using the IE matrix and the SWOT matrix. The rating is determined by assessing the level of influence within the company on a scale of 1 to 4 (1 (not strong); 2 (slightly strong); 3 (strong), and 4(very strong)). The score is then calculated by multiplying the weight by the rating [18].

- Decision Stage

The decision stage involves analysing the QSPM and AHP to determine the best alternative strategy [19]. At this stage, the weight of each internal and external factor is assessed using the AHP method, which prioritizes all factors identified in the IFE and EFE matrices. The weighting in the AHP model uses a scale of 1 to 9 [20]. Next, the priority order of various strategic alternatives is determined using the QSPM matrix. The QSPM is used to determine which strategies will be prioritized in selecting strategic alternatives recommended through the SWOT matrix [21].

The QSPM is the result of strategic decisions after assessing the Attractiveness Score (AS) of each strategic factor, both internal and external. The resulting weighted score is multiplied by the attractiveness level to obtain a Total Attractiveness Score (TAS). This can be done by ranking the AS on a scale of 1 to 4 (1 = Not Attractive, 2 = Somewhat Attractive, 3 = Quite Attractive, and 4 = Very Attractive). By multiplying the weights and the AS score, the TAS score can be obtained [22]. The QSPM matrix is calculated by combining internal and external components with developed alternative techniques. Weighting is carried out using AS and TAS.

IV. Results

The data processing cycle consists of three stages: input, matching, and decision. The first stage involves collecting and summarizing the information necessary for formulating a strategy. Weights, ratings, and weighted values are calculated based on IFE and EFE matrices. The second stage involves creating alternative strategies using the IFE and SWOT matrices. The final stage is the decision stage, which uses the AHP and QSPM methods to evaluate feasible strategies and provide specific alternatives [23].

A. *The Input Stage*

At this stage, an internal and external environmental analysis is conducted. The internal analysis identifies the organization's strengths and weaknesses, while the external analysis identifies opportunities and threats. Internal and external factors are obtained through interviews and field observations. As a result, 16 internal and external factor variables were identified: 7 Strengths (S), 9 Weaknesses (W), 4 Opportunities (O), and 6 Threats (T). The SWOT analysis uses the AHP technique to compare the criteria for each factor contained in the analysis [24]. A consistency ratio calculation is carried out to measure the consistency of each factor.

The following analyzes the industry's internal (strengths, weaknesses) and external (opportunities, threats) factors:

TABLE I. INTERNAL FACTORS: STRENGTHS (S)

Code	Strengths (S)
S1	The product under development is highly specialized, designed for multifunctional and flexible data collection,
S2	A skilled, professional technical team with Bachelors, masters and Doctoral degrees
S3	Has good quality control and is produced using manufacturing processes and components that comply with industry standard.
S4	Development or research of appropriate, visible and certified products
S5	Always innovate and follow future UAV trends
S6	The budget is fully funded by the State (APBN)
S7	Have adequate infrastructure facilities and infrastructure

As shown in Table I, the Strength (S) category includes seven strengths (S1–S7), such as highly specialized and multifunctional products supported by a competent technical workforce. These strengths are further reinforced by standardized manufacturing processes, ongoing R&D and innovation, government funding, and adequate production infrastructure.

TABLE II. INTERNAL FACTORS: WEAKNESSES (W)

Code	Weaknesses (W)
W1	Some industrial processes remain manual, with machinery largely mechanical rather than fully automated
W2	Dependence on imported raw materials, whose prices are unstable and tied to global markets, can disrupt the supply chain
W3	The lack of technology transfer reinforces reliance on foreign electronic components
W4	Not all facilities have obtained certification, which may affect the productivity and performance of technical teams.
W5	Employee competency development remains incomplete,
W6	SOP-compliant documentation has not been fully implemented, leading to potential inconsistencies, errors, and reduced efficiency
W7	Technical human resources for technology design are limited,
W8	Production facility maintenance costs are high
W9	The product's high specialization drives up production costs due to customization and extended manufacturing time.

As shown in Table II, the Weaknesses (W) category includes nine Weaknesses (W1–W9), such as high dependence on imported components, limited technology mastery and transfer, insufficient high-skilled technical personnel, non-automated production processes, and high production and maintenance costs. These weaknesses reduce efficiency, increase vulnerability to external disruptions, and weaken industry competitiveness.

TABLE III. EXTERNAL FACTORS: OPPORTUNITIES (O)

Code	Opportunities (O)
O1	UAVs are widely used in many fields such as spatial planning, monitoring, agriculture, disaster response, and regional security
O2	Government support, particularly through policies aimed at increasing local content, promotes component availability by fostering partnerships with domestic component industries.
O3	The development of Industry 4.0-based Lean Manufacturing provides opportunities to be more efficient and productive.
O4	UAV technology creates opportunities for other products and services such as maintenance, training, and more.

As shown in Table III, the Opportunity (O) category includes four Opportunities (OI-O4), such as the UAV industry, which presents significant opportunities through increasing multi-sector demand, government support for local content policies (TKDN), the adoption of Industry 4.0-based manufacturing, and the expansion of supporting services such as maintenance and training, which collectively enhance productivity and market potential.

TABLE IV. EXTERNAL FACTORS: THREATS (T)

Code	Threats (T)
T1	There is still a lack of supporting companies for the provision of raw materials.
T2	Import procedures/import regulations are still complicated/take a long time.
T3	There is a threat of embargo from supplier countries
T4	There is an increase in industrial labor costs/wages.
T5	It is high technology and high finance/capital.
T6	Price fluctuations due to dependence on imported raw materials, thus threatening component supplies.

As shown in Table IV, the Threats (T) category includes six threats (T1–T6), such as limited domestic suppliers, complex import regulations, embargo risks, rising labour costs, high capital requirements, and price volatility from import dependence, which collectively increase operational risk and weaken industry competitiveness.

The following information in Table V shows the alternative strategies developed: Strengths-Opportunities (S-O) strategy; Strengths-Threats (S-T) strategy; Weaknesses-Opportunities (W-O) strategy; Weaknesses-Threats (W-T) strategy.

TABLE V. LIST OF ALTERNATIVE INDUSTRIAL STRATEGIES

Code	Alternative Industrial Strategies (S-O, S-T, W-O, W-T)
S-O	Developing infrastructure and the adoption of new technologies.
S-T	Strengthening human resources to master technology.
W-O	Production efficiency and reducing dependence on imports.
W-T	Improving company management, especially financial aspects.

The IFE matrix analysis is the result of identifying internal factors, including strengths and weaknesses, that influence UAV products. Values and weights are determined using the paired comparison method. The weighting of internal and external factors is done by asking questions to respondents. The results of the IFE matrix analysis can be seen in Tables VI and VII.

TABLE VI. IFE MATRIX: STRENGTHS (S)

Code	S1	S2	S3	S4	S5	S6	S7	Weight (%)
S1	1.00	3.00	3.00	5.00	0.33	3.00	3.00	25.92
S2	0.33	1.00	0.33	3.00	0.33	3.00	3.00	15.55
S3	0.33	3.00	1.00	0.33	3.00	5.00	0.20	10.84
S4	0.20	0.33	3.00	1.00	0.33	0.33	0.33	6.88
S5	3.00	3.00	0.33	3.00	1.00	0.33	0.33	14.61
S6	0.33	0.33	0.20	3.00	3.00	1.00	0.33	9.71
S7	0.33	0.33	5.00	3.00	3.00	3.00	1.00	16.49
								100.00

Based on the IFE matrix: Strength (S) weighting in Table VI, the UAV industry's main strength is its highly specific and multifunctional product design (S1, 25.92%), which is difficult to imitate. This Strength is reinforced by competent human resources, adequate infrastructure, continuous innovation, standardized manufacturing and quality control, government funding, and certified product development, forming a strong foundation for future growth and competitiveness.

TABLE VII. IFE MATRIX: WEAKNESSES (W)

Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	Weight (%)
W1	1.00	0.20	3.00	0.33	3.00	0.33	3.00	0.33	5.00	8.72
W2	5.00	1.00	3.00	0.33	0.33	0.20	3.00	3.00	0.33	17.95
W3	0.33	0.33	1.00	5.00	3.00	3.00	3.00	5.00	3.00	12.82
W4	3.00	3.00	0.20	1.00	3.00	5.00	0.20	0.33	3.00	13.85
W5	3.00	0.33	0.33	0.33	1.00	5.00	3.00	0.33	0.33	7.69
W6	3.00	0.33	0.33	0.20	0.20	1.00	3.00	5.00	3.00	7.44
W7	0.33	0.33	0.33	5.00	0.33	0.33	1.00	5.00	3.00	11.54
W8	3.00	0.33	0.20	3.00	3.00	0.20	0.20	1.00	5.00	12.56
W9	0.20	3.00	0.33	0.33	3.00	0.33	0.33	0.20	1.00	7.44
										100.00

Based on the IFE matrix: Weakness (W) in Table VII, the main weakness is dependence on imported raw materials with unstable global prices (W2, 17.95%), which increases supply-chain risk and cost uncertainty. Other notable weaknesses include a lack of facility certification (W4, 13.85%), limited technology transfer (W3, 12.82%), and high production and maintenance costs (W8, 12.56%). and insufficient technical human resources (W7, 12.54%). Overall, technological constraints and strong import dependence remain the key internal challenges for the national UAV industry.

TABLE VIII. EFE MATRIX: OPPORTUNITIES (O)

Code	O1	O2	O3	O4	Weight (%)
O1	1.00	0.33	3.00	5.00	29.66
O2	3.00	1.00	5.00	0.20	29.24
O3	0.33	0.20	1.00	5.00	20.76
O4	0.20	5.00	0.20	1.00	20.34
					100.00

Based on the EFE matrix opportunity (O) weighting in Table VIII, the dominant external opportunity is the expanding multi-sector utilization of UAVs (O1, 29.66%), followed by policy-driven support for local content (TKDN) and domestic component integration (O2, 29.24%). Furthermore, the adoption of Industry 4.0–based manufacturing systems (O3, 20.76%) and the development of downstream services, including maintenance and technical training (O4, 20.34%), enhance manufacturing scalability, operational efficiency, and the long-term competitiveness of the national UAV manufacturing industry.

TABLE IX. EFE MATRIX: THREATS (T)

Code	T1	T2	T3	T4	T5	T6	Weight (%)
T1	1.00	0.33	3.00	3.00	3.00	3.00	22.32
T2	3.00	1.00	3.00	3.00	0.33	0.33	17.86
T3	0.33	0.33	1.00	3.00	3.00	0.33	13.39
T4	0.33	0.33	0.33	1.00	5.00	3.00	16.74
T5	0.33	3.00	0.33	0.20	1.00	0.20	8.48
T6	0.33	3.00	3.00	0.33	5.00	1.00	21.21
							100.00

Based on the EFE matrix threat (T) weighting in Table IX, the limited availability of domestic raw-material suppliers (T1, 22.32%) and price volatility resulting from import dependence (T6, 21.21%) are identified as the dominant external threats. These threats are further exacerbated by restrictive import regulations, rising labour costs, and potential embargo risks, collectively increasing supply-chain fragility and cost instability in the UAV manufacturing industry.

B. Matching Stage

The IFAS and EFAS tables identify internal (strengths, weaknesses) and external (opportunities, threats) factors, respectively. Each factor is weighted, ranked by expert judgment, and multiplied to obtain scores, which are then summed to highlight company priorities.

TABLE X. IFAS CALCULATION TABLE

Code	Weight (%)	Rating	Score	Priority
S1	25.92	3	0.78	1
S2	15.55	3	0.47	3
S3	10.84	4	0.43	5
S4	6.88	1	0.07	7
S5	14.61	3	0.44	4
S6	9.71	3	0.29	6
S7	16.49	3	0.49	2
Sub total Strength =			**2.97**	
W1	8.72	3	0.26	2
W2	17.95	1	0.18	5
W3	12.82	3	0.38	1
W4	13.85	1	0.14	6
W5	7.69	3	0.23	3
W6	7.44	1	0.07	9
W7	11.54	1	0.12	8
W8	12.56	1	0.13	7
W9	7.44	3	0.22	4
Sub total Weakness =			**1.73**	
Strength – Weakness =			**(2.97 – 1.73) = 1.24**	

Based on the IFAS calculation in Table X, the total strength score (2.97) exceeds the total weakness score (1.73), resulting in a positive internal factor value of +1.24. The most dominant strength is S1 (25.92%; score 0.78), indicating that the highly specific and multifunctional UAV product design provides a strong competitive advantage, supported by competent human resources and adequate infrastructure. In contrast, the main internal weakness is W3 (12.82%; score 0.38), reflecting a high dependence on imported electronic components, which increases vulnerability to supply-chain disruptions and highlights the need for import substitution and enhanced technological capability.

TABLE XI. EFAS CALCULATION TABLE

Code	Weight (%)	Rating	Score	Priority
O1	29.66	3	0.89	1
O2	29.24	1	0.29	4
O3	20.76	4	0.83	2
O4	20.34	3	0.61	3
Sub total Opportunity =			2.62	
T1	22.32	1	0.22	4
T2	17.86	1	0.18	5
T3	13.39	3	0.40	3
T4	16.74	3	0.50	2
T5	8.48	1	0.08	6
T6	21.21	3	0.64	1
Sub Total Threat =			2.02	
Opportunity – Threat =			(2,62 – 2.02) = 0.60	

Based on the EFAS calculation in Table XI, the total opportunity score (2.62) exceeds the total threat score (2.02), resulting in a positive external factor value of +0.60. The most dominant opportunity is O1 (29.66%; score 0.89), indicating strong multi-sector demand for UAV applications, supported by government policies and the adoption of Industry 4.0. Conversely, the main external threat is T6 (21.21%; score 0.64), reflecting vulnerability to price fluctuations due to dependence on imported raw materials, which directly affects cost stability and supply-chain sustainability.

Strategy formulation requires confirming the organization's position along the strength–weakness and opportunity–threat axes. The following is how to calculate the coordinates:

a) IFAS Coordinates (Total Strength Score – Total Weakness Score) = (2.97 – 1.73) = +1.24

b) EFAS Coordinates (Total Opportunity Score– Total Threat Score) = (2.62 – 2.03) = +0.60

Based on the calculations, the coordinate point is located in Quadrant I (+1.24; +0.60). These coordinates are presented in a SWOT matrix diagram in Fig. 2 to determine the development position.

The measurement results shown in the Cartesian SWOT analysis shows that the net internal factor score (Strength–Weakness) is +1.24 and the net external factor score (Opportunity–Threat) is +0.60, positioning the organization in Quadrant I (+1.24; +0.60). This configuration indicates dominant internal strengths and favourable external opportunities, thereby supporting the implementation of an aggressive 'Grow and Build' strategy focused on strategic expansion and capability enhancement.

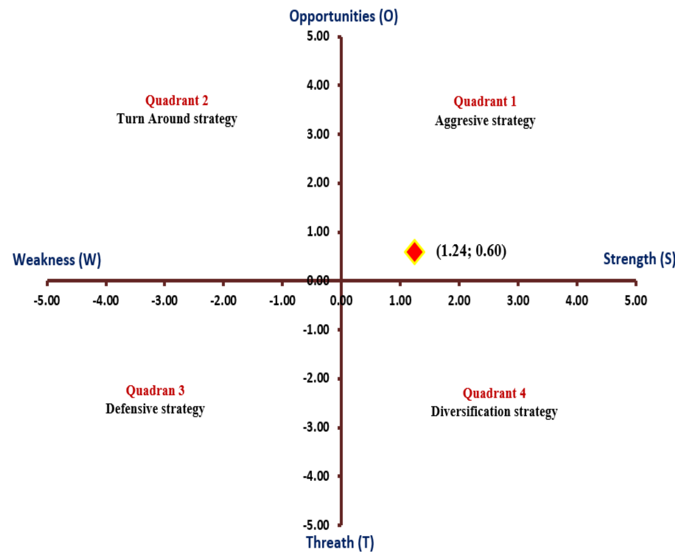

Fig. 2. Cartesian diagram.

The adopted strategy supports an aggressive development and growth orientation through the implementation of one or a combination of the following strategic initiatives:

a) Continuously enhancing the reliability of infrastructure and technological systems to accommodate increasing operational and equipment demands.

b) Strengthening technical education and professional training programs to improve the competencies of technical human resources.

c) Conducting periodic inspections and maintenance of manufacturing equipment and machinery to ensure operational reliability and production continuity.

d) Prioritizing the use of information systems and digital technologies to accelerate system integration and monitoring, thereby enhancing the effectiveness and efficiency of production operations.

e) Implementing specialized training programs for engineers to enhance technical proficiency, teamwork quality, and organizational performance.

*f)*Expanding collaborative networks through research partnerships with universities and strategic alliances with related industries.

g) Recognizing and valuing educational attainment and professional certification as mechanisms to motivate employees, improve performance, and strengthen organizational assets.

h) Pursuing strategies in market development, product innovation, and cost efficiency to enhance competitiveness, maintain relationships with customers and suppliers, and support long-term organizational growth.

C. Decision Stage

At this stage, an AHP analysis was conducted based on the SWOT results to determine the most appropriate and effective strategic formulations (S–O, S–T, W–O, W–T). Expert Choice software was used to efficiently identify the priority strategies. A hierarchical structure was constructed to illustrate the relationship between SWOT sub-criteria and strategic decision priorities, as shown in Fig. 3:

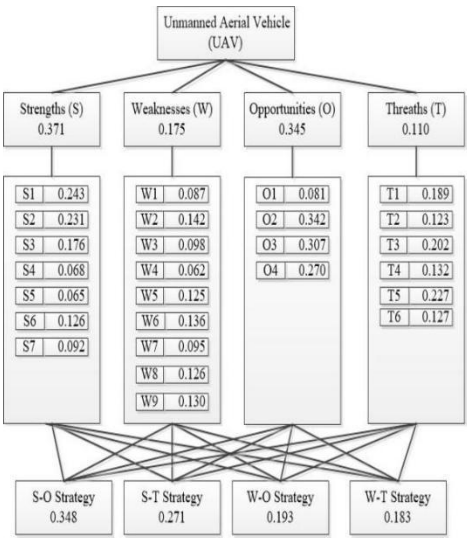

Fig. 3. SWOT-AHP hierarchical structure for selecting the best strategy.

Fig. 3 shows that Strengths (37.1%) are the dominant criterion for supporting UAV development, followed by Opportunities (34.5%), Weaknesses (17.5%), and Threats (11.0%). The largest sub-factors are S1 (highly specific, hard-to-replicate products, 24.3%), W2 (dependence on imported raw materials, 14.2%), O2 (government support for local content, 34.2%), and T5 (high technology and capital requirements, 22.7%). These results highlight the strategic importance of product specificity, domestic partnerships, and technology readiness in UAV development.

Fig. 4 below shows the results of processing using Expert Choice Software tools version 11.

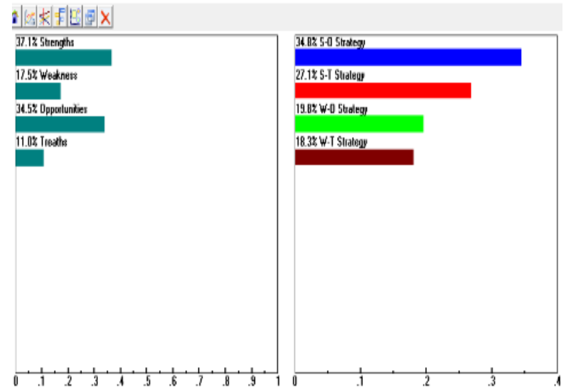

Fig. 4. Data visualization with expert choice software.

Fig. 4 shows that the highest-priority strategy is the S–O strategy, with a score of 0.348 (34.8%), followed by S–T (27.1%), W–O (19.3%), and W–T (18.3%). The S–O strategy focuses on infrastructure development and the adoption of new technology. Overall, the strategic alternatives rank from highest to lowest as S–O, S–T, W–O, and W–T.

QSPM analysis was used to determine priority strategies for UAV product and technology development. Weighted internal and external factors, combined with attractiveness scores, form the basis for identifying optimal strategies that require immediate implementation. In QSPM, the total attractiveness score (TAS) is calculated by multiplying the weighted values by the attractiveness scores (AS), as shown in the QSPM matrix in Table XII.

TABLE XII. QSPM MATRIX CALCULATION

Strategic Key Factors	**Weight (%)**	**S-O Strategy**		**S-T Strategy**		**W-O Strategy**		**W-T Strategy**	
		AS	**TAS**	**AS**	**TAS**	**AS**	**TAS**	**AS**	**TAS**
Strengths (S)									
S1	25.92	2	0.52	2	0.52	2	0.52	2	0.52
S2	15.55	3	0.47	2	0.31	3	0.47	2	0.31
S3	10.84	2	0.22	2	0.22	2	0.22	2	0.22
S4	6.88	2	0.14	3	0.21	3	0.21	2	0.14
S5	14.61	3	0.44	3	0.44	2	0.29	3	0.44
S6	9.71	3	0.29	3	0.29	2	0.19	2	0.19
S7	16.49	2	0.33	2	0.33	3	0.49	3	0.49
			Σ = 2.40		**Σ = 2.31**		**Σ = 2.39**		**Σ = 2.31**
Weaknesses (W)									
W1	8.72	3	0.26	2	0.17	3	0.26	2	0.17
W2	17.95	2	0.36	2	0.36	2	0.36	2	0.36
W3	12.82	3	0.38	3	0.38	2	0.26	3	0.38
W4	13.85	2	0.28	3	0.42	2	0.28	2	0.28
W5	7.69	3	0.23	3	0.23	2	0.15	2	0.15
W6	7.44	2	0.15	2	0.15	3	0.22	3	0.22
W7	11.54	3	0.35	3	0.35	2	0.23	2	0.23

W8	12.56	2	0.25	2	0.25	3	0.38	3	0.38
W9	7.44	3	0.22	3	0.22	3	0.22	3	0.22
			Σ = 2.48		**Σ = 2.53**		**Σ = 2.36**		**Σ = 2.40**
Opportunities (O)									
O1	29.66	3	0.89	2	0.59	2	0.59	2	0.59
O2	29.24	2	0.58	2	0.58	2	0.58	2	0.58
O3	20.76	2	0.42	3	0.62	3	0.62	2	0.42
O4	20.34	3	0.61	3	0.61	3	0.61	2	0.41
			Σ = 2.50		**Σ = 2.41**		**Σ = 2.41**		**Σ = 2.00**
Threats (T)									
T1	22.32	2	0.45	3	0.67	3.00	0.67	3	0.67
T2	17.86	2	0.36	2	0.36	2.00	0.36	2	0.36
T3	13.39	3	0.40	2	0.27	2.00	0.27	3	0.40
T4	16.74	2	0.33	2	0.33	3.00	0.50	3	0.50
T5	8.48	2	0.17	3	0.25	2.00	0.17	3	0.25
T6	21.21	2	0.42	3	0.64	2.00	0.42	2	0.42
			Σ = 2.13		**Σ = 1.88**		**Σ = 2.39**		**Σ = 2.61**

TABLE XIII. INTERNAL AND EXTERNAL ACHIEVEMENT SCORE

Strategic Key Factors	**Internal Achievement Score (Σ Strengths + Σ Weaknesses)**	**External Achievement Score (Σ Opportunities + Σ Threats)**
S-O	2.40 + 2.48 = 4.88	2.50 + 2.13= 4.63
S-T	2.31 + 2.53 = 4.85	2.41 + 1.81 = 4.29
W-O	2.39 + 2.36 = 4.75	2.41 + 2.39 = 4.80
W-T	2.31 + 2.40 = 4.71	2.00 + 2.61 = 4.61

Based on Table XIII, the internal and external achievement scores indicate that the S–O strategy has the highest internal score (4.88), reflecting effective utilization of internal capabilities, while the W–O strategy achieves the highest external score (4.80), indicating greater responsiveness to external opportunities. Overall, the S–O strategy demonstrates the most balanced performance across both dimensions, supporting its selection as the primary strategic priority. Accordingly, the preferred strategic focus is the S–O strategy, which emphasizes infrastructure development and the adoption of new technologies to enhance productivity, energy efficiency, and innovation. Effective technology adoption requires not only hardware and software implementation but also the development of digital skills and well-integrated standard operating procedures to ensure consistent and reliable process execution.

V. DISCUSSION

The results indicate that Indonesia's UAV manufacturing industry is positioned in Quadrant I, reflecting strong internal capabilities supported by technological expertise, product specialization, infrastructure availability, and government funding. Despite this favourable position, high dependence on imported materials and components, limited technology transfer, incomplete certification, and weak process standardization increase manufacturing risk exposure and constrain production scalability. Externally, expanding multi-sector UAV demand and strong local content (TKDN) policies create significant growth opportunities; however, these are offset by limited domestic supplier ecosystems, regulatory barriers, rising labour costs, and potential embargo risks.

The integrated SWOT–AHP–QSPM analysis consistently prioritizes the S–O strategy, highlighting infrastructure modernization and Industry 4.0–based technology adoption as key drivers of productivity, energy efficiency, and innovation. From a policy perspective, these findings underscore the need for targeted government interventions, including incentives for domestic supplier development, accelerated facility certification, structured technology transfer, and workforce upskilling aligned with digital manufacturing. Such measures are essential to reduce import dependency, mitigate supply-chain risks, and strengthen the long-term resilience and competitiveness of the national UAV manufacturing industry.

At the UAV product and technology development stage, both design maturity and manufacturing process control are essential. Enhancing manufacturing maturity requires improving productivity, standardizing UAV technologies, strengthening engineering human resource capabilities, providing management training, conducting technical skills workshops, establishing technical assistance guidelines, and promoting technology and product innovation through benchmarking activities.

The competitive strategic advantages in the UAV manufacturing industry can be summarized as follows:

a) Strengthening partnerships between suppliers, customers, and competitors by ensuring human resource availability through government support.

b) Reducing production costs through human resource efficiency and developing new technologies.

c) Improving production quality through cost leadership and differentiation strategies to increase market potential.

d) Increasing the use of manufacturing and information technology to enhance flexibility and bargaining power.

e) Increasing government support to minimize piracy and manage intellectual property rights.

f) Improving technological capabilities to develop new products.

In production, strong supplier relationships are essential to mitigate cost volatility and supply risks under fluctuating economic conditions. Investment in advanced machinery, automation, and digital technologies, combined with industry-wide collaboration across the value chain, is critical to improving efficiency, fostering innovation, and sustaining global competitiveness.

This study supports managerial decision-making by recommending strategic alternatives that include continuous adoption of advanced UAV technologies, strengthened collaboration with academia and industry, and optimization of Quality Control (QC) functions to reduce product defects and losses of imported components that may disrupt productivity. Efficient management of imported raw materials through accurate component planning is also necessary to minimize import costs and lead times. Furthermore, improved accounting practices, supported by transparent financial reporting and KPI-based performance measurement aligned with Good Corporate Governance (GCG) principles, are essential to enhance operational effectiveness and investor confidence.

VI. Conclusion

In conclusion, UAV industrial independence is a strategic necessity for strengthening national defense, reducing import dependence, and enhancing Indonesia's manufacturing competitiveness. The SWOT–AHP–QSPM results confirm that an S–O strategy focused on infrastructure and technology adoption is the most effective pathway to achieve sustainable and innovation-driven industrial growth. By reducing import dependence, enhancing human resource competence, and reinforcing domestic supply chains, Indonesia can transform UAV technology into a catalyst for innovation-driven manufacturing and long-term national economic sovereignty.

Therefore, the attainment of UAV industrial independence is strategically vital, as it transforms technological capability into national economic leverage, policy resilience, and long-term industrial sustainability.

However, this study is limited to a single case study of the Wulung UAV, which restricts the generalizability of the findings, and the integrated SWOT–AHP–QSPM approach relies on expert judgment that may introduce subjectivity despite consistency verification. In addition, the analysis focuses on strategic and managerial aspects without incorporating detailed quantitative technical performance testing or comprehensive financial feasibility evaluation, while external factors such as regulatory and global supply-chain changes may affect strategy implementation. Therefore, future research should extend the framework through multi-case analysis and the integration of quantitative technical and financial indicators to strengthen technology readiness, manufacturing readiness, and decision-making robustness.

Acknowledgment

The authors thank the management of the National Research and Innovation Agency (BRIN) for the support to complete this research. We also thank the anonymous reviewers for their valuable comments on revising the study.

References

[1] N. Nurhuda, S. Anwar, and R. E. Hs, "Optimization of Unmanned Aerial Vehicle (UAV) Development in the Defense Industry Related to Future Defense and Security Needs," *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, vol. 5, p. : 2466-2477, 2022, doi: 10.33258/birci.v5i1.3853.

[2] A. Krisnowo *et al.*, "Readiness of the Technological Innovation Ecosystem of Medium Altitude Long Endurance Unmanned Aerial Vehicle in Indonesia," in *Advances in Unmanned Aerial Vehicles - New Trends and Applications [Working Title]*, IntechOpen, 2025. doi: 10.5772/intechopen.1010027.

[3] G. M. Man, D. Zamfir, D. Diaconescu, A. V. Radu, F. Aldea, and G. Ionescu, "The Role of Digital Technologies and Intellectual Property Management in Driving Sustainable Innovation," *Sustainability (Switzerland)*, vol. 17, no. 7, Apr. 2025, doi: 10.3390/su17073135.

[4] M. Rausyan Fikri, T. Candra, K. Saptaji, A. Nindi Noviarini, and D. Ayu Wardani, "A review of Implementation and Challenges of Unmanned Aerial Vehicles for Spraying Applications and Crop Monitoring in Indonesia," Jan. 2023. doi: 10.48550/arXiv.2301.00379.

[5] M. Merati, "Appraisal of Industrial Plans with Expected Monetary Value Approach Using FAHP in the Ceramic and Tile Industry," *Journal of Optimization in Industrial Engineering*, vol. 17, no. 1, pp. 129–142, Jun. 2024, doi: 10.22094/QJIE.2024.1107393.

[6] H. Christiadi and M. Alamsyah, "Evaluating Strategic Options Using QSPM: Enhancing Plaza Indonesia Realty's Competitive Edge," *International Journal of Indonesian Business Review*, vol. 3, no. 2, pp. 125–134, Sep. 2024, doi: 10.54099/ijibr.v3i2.1109.

[7] L. Dewi Indrasari and S. Rushanti Widodo, "Development Of Business Strategies Using QSPM and SWOT On Snail Chips," *Journal of Engineering and Management in Industrial System*, vol. 8, no. 2, pp. 79–87, Jul. 2020, doi: 10.21776/ub.jemis.2020.008.02.7.

[8] Hildawati *et al.*, "View of The Role of Unmanned Aerial Vehicles (UAVs) in Indonesian Air Defense Management," *International Journal of Humanities Education and Social Sciences*, vol. 3, no. 4, pp. 1808–1819, Feb. 2024, doi: :https://doi.org/10.55227/ijhess.v3i4.768.

[9] E. Bertran, P. Tercero, and A. Sànchez-Cerdà, "UAV generalized longitudinal model for autopilot controller designs," *Aircraft Engineering and Aerospace Technology*, vol. 94, no. 3, pp. 380–391, Feb. 2022, doi: 10.1108/AEAT-08-2020-0156.

[10] S. Mukti, E. A. Gani, M. Manawan, A. Ansori, and O. Mustopa, "The Concept of an Unmanned Aircraft with Stealth Technology to Support the Air Defense System for the Indonesian Archipelago's Capital," *The Innovation of Social Studies Journal*, vol. 5, no. 1, p. 71, Sep. 2023, doi: 10.20527/issj.v5i1.8048.

[11] M. Sholeh *et al.*, "PT Dirgantara Indonesia's Strategy in Empowering Drones for a Robust Air Defense System," Aug. 2025. doi: 10.55227/ijhess.v5i1.1856.

[12] M. Sönmez *et al.*, "Unmanned Aerial Vehicles – Classification, Types Of Composite Materials Used In Their Structure And Applications," in *ICAMS Proceedings of the International Conference on Advanced Materials and Systems*, Inst. Nat. Cercetare-Dezvoltare Text. Pielarie, 2022, pp. 77–82. doi: 10.24264/icams-2022.I.11.

[13] A. Shubbani, A. W. Rizqi, and H. Hidayat, "Marketing Strategy Analysis Using SWOT And QSPM Methods In SMEs," *Jurnal Sains dan Teknologi Industri*, vol. 20, no. 2, p. 506, Feb. 2023, doi: 10.24014/sitekin.v20i2.21587.

[14] S. Utomo *et al.*, "Technology performance of Indonesia tsunami early warning system: technometric approach," *International Journal of Electrical and Computer Engineering*, vol. 15, no. 1, pp. 129–145, Feb. 2025, doi: 10.11591/ijece.v15i1.pp129-145.

[15] Andreas Sibarani and Rina Djunita Pasaribu, "Development Strategy Analysis With IFE-EFE-IE Matrix, SWOT Matrix and AHP at PT Putra Morowali Sejahtera," *International Journal of Science, Technology & Management*, vol. 5, no. 6, pp. 1398–1405, Nov. 2024, doi: 10.46729/ijstm.v5i6.1192.

[16] M. Rakhmansyah *et al.*, "Small and Medium Enterprises (SMEs) with SWOT Analysis Method," *International Journal for Applied Information Management*, vol. 2, no. 3, pp. 50–57, 2022, doi: 10.47738/ijaim.v2i3.37.

[17] B. Phadermrod, R. M. Crowder, and G. B. Wills, "Importance-Performance Analysis based SWOT analysis," *Int. J. Inf. Manage.*, vol. 44, pp. 194–203, Feb. 2020, doi: 10.1016/j.ijinfomgt.2016.03.009.

[18] S. Syamruddin and I. Yunita, "An Investigation of the Business Development of Pure Sari Tofu Factory, South Jakarta, Indonesia: Evidence from SWOT Anal-ysis," *Frontiers in Business and Economics*, vol. 3, no. 1, pp. 1–13, Apr. 2024, doi: 10.56225/finbe.v3i1.298.

[19] A. Utomo and E. Ahyudanari, "Strategy Development of Small Qualification Company in Construction Service Business Competition," Nov. 2021, doi: 10.33258/birci.v4i4.3331.

[20] E. Repetski, S. Sarkani, and T. Mazzuchi, "Applying The Analytic Hierarchy Process (AHP) To Expert Documents," *International Journal of the Analytic Hierarchy Process*, vol. 14, no. 1, pp. 1–14, 2022, doi: 10.13033/ijahp.v14i1.919.

[21] A. Shubbani, A. W. Rizqi, and H. Hidayat, "Marketing Strategy Analysis Using SWOT And QSPM Methods In SMEs," *Jurnal Sains dan Teknologi Industri*, vol. 20, no. 2, p. 506, Feb. 2023, doi: 10.24014/sitekin.v20i2.21587.

[22] M. Zulfikar and P. Sukapto, "Proposed Marketing Strategy to Increase Sales Turnover at Retail Store X Using SWOT and QSPM Analysis," *Jurnal Imposci*, vol. 1, no. 5, Apr. 2024, doi: 10.62885/improsci.v1i5.237.

[23] M. Miftakul Amin and Y. Dwitayanti, "The model of decision support system using hybrid method and actual weighting for the study program ranking," *Bulletin of Electrical Engineering and Informatics*, vol. 13, no. 3, pp. 2048–2057, Jun. 2024, doi: 10.11591/eei.v13i3.7038.

[24] H. Li, X. Chen, and Y. Fang, "The development strategy of home-based exercise in china based on the swot-ahp model," *Int. J. Environ. Res. Public Health*, vol. 18, no. 3, pp. 1–12, Feb. 2021, doi: 10.3390/ijerph18031224.