Multi-Criteria Propeller Design App (MCDM)

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Abstract*: This research presents a Python-based Multi-Criteria Decision-Making (MCDM) application for propeller design in civil and light aviation aircraft, integrating a structured logical process that evaluates multiple parameters, including aircraft category, engine type and power, environmental conditions, and priorities such as weight, noise, and cost. Based on EASA Module 17 – Propeller, the app recommends optimal propeller configurations, including blade material, pitch type, actuation method, anti-icing system, blade count, and rotation strategy, while ensuring compatibility between subsystems and preventing critical mistakes such as unsafe material-power combinations, incorrect pitch selection, or improper anti-icing systems. The system also accounts for operational factors like critical engine effects and noise mitigation strategies such as synchrophasing and synchronization, balancing efficiency, performance, and safety. By combining these factors in a multi-criteria framework, the tool provides designers, technicians, and students with reliable guidance to explore feasible propeller designs while maintaining operational safety and system efficiency.*

Keywords*: Multi-Criteria Decision-Making (MCDM), Aircraft Propulsion, Noise Mitigation, Critical Engine*

The problem and solution

The design and selection of propellers for aircraft involve multiple interacting factors, including engine power, aircraft type, environmental conditions, and operational priorities like weight, noise, and cost. Improper selection can lead to critical operational issues, reduced efficiency, increased maintenance, or even safety hazards, particularly in multi-engine aircraft where critical engine effects may occur. Traditional design approaches rely heavily on manual calculation, experience, and iterative trial-and-error, which are time-consuming and prone to errors.

The proposed Python-based application addresses this problem by implementing a multi-criteria decision-making framework that systematically evaluates input parameters and their interdependencies. The tool ensures that selected propeller configurations are compatible with engine type, power levels, and operational priorities, while preventing critical mistakes such as unsafe combinations of blade material and engine power. By providing clear recommendations for propeller pitch, blade count, material, actuation method, anti-icing system, rotation direction, and noise mitigation strategies like synchrophasing, the app enables designers and students to quickly identify safe, efficient, and practical solutions. This approach reduces the risk of human error, improves design efficiency, and offers a structured methodology for educational and practical applications in propeller system design.

Introduction

The design and selection of propellers for aircraft involve multiple interdependent factors, including aircraft type, engine power, number of engines, weight limitations, noise requirements, operational environment, and cost considerations. Traditionally, propeller selection has been based on empirical data, experience, and standard recommendations from regulatory guidance such as EASA Part 66 Module 17 [1]. However, as aviation systems grow more complex, the need for a systematic, multi-criteria decision-making approach becomes essential to ensure compatible and efficient designs while minimizing critical mistakes, such as selecting an inappropriate propeller material for high-power engines or mismanaging critical engine considerations [2].

The Multi-Criteria Decision-Making Propeller Design App (MCDM) is developed in Python programming language to integrate these various parameters into a coherent logic. The app evaluates input parameters such as aircraft category, engine type, total power, weight and noise priorities, cost priorities, climate considerations, and propeller pitch preferences. Based on these inputs, the app outputs recommendations including propeller pitch type, actuation method, blade count, material, anti-icing requirements, direction of rotation, and additional suggestions for noise cancellation features such as synchronizing and synchrophasing [3,4]. This structured approach allows the user to identify optimal propeller configurations that are compatible with the aircraft and engine characteristics while preventing incompatible or unsafe choices.

The program applies classification logic for engine power, evaluates material compatibility with power levels, considers environmental factors for anti-icing requirements, and integrates critical engine concepts for multi-engine designs to manage yawing moments and operational safety. It also offers flexibility for optional inputs, maintaining robust outputs regardless of whether the user provides all details, which enhances its usability and applicability across a wide range of aircraft types.

This MCDM approach can be further developed to incorporate detailed engine design parameters, databases of existing propeller brands, and automatic sizing recommendations, providing a more comprehensive tool for aircraft designers, engineers, and maintenance personnel. By integrating more precise aerodynamic models and manufacturer specifications, the app could evolve into a full-scale decision support system for both conventional and advanced aircraft propulsion configurations [2, 3, 6].

Parameters, Outputs, and Logical Interdependencies

To facilitate a clear understanding of the Multi-Criteria Decision-Making (MCDM) approach employed by the propeller design application, all input and output parameters considered by the app are summarized in Table 1. Each parameter represents a critical factor affecting propeller selection, including aircraft characteristics, engine specifications, environmental conditions, and operational priorities such as weight, noise, and cost. The table provides a concise reference to the parameter name (as used in the app code), a brief description, whether the parameter is an input or an output, the type of input expected (e.g., Selective, Optional, Numerical), units where applicable, the valid range or selectable options, and additional notes. By consulting this table, users can better understand the rationale behind each input and its influence on the resulting propeller configuration recommended by the app.

Table 1: Input and Output Parameters for the MCDM Propeller Design App

Parameter	Description	Type	Input Type / Unit	Options / Range	Notes
P1	Aircraft Category	Input	Selective	12 Option	Defines the type of aircraft, affects material, pitch, blade count, etc.
P2	Number of Engines	Input	Numerical	1, 2, 4, 6, 8	Determines rotation direction logic and critical engine consideration
P3	Engine Total Power	Input	Numerical	Positive values	Used to classify power: Low / Medium / High; affects pitch type, blade count, material
P4	Environment	Input	Selective	8 Options	Influences anti-icing selection
P5	Engine Type	Input	Optional / Selective	1: Piston, 2: Turboprop, 3: Electric	Affects blade number, material constraints
P6	Weight Priority	Input	Selective	High priority (Light design), Moderate priority	Influences pitch type, material selection, blade count
P7	Noise Priority	Input	Selective	High priority (Minimum noise), Moderate priority	Affects blade count, rotation logic, synchrophasing suggestions
P8	Cost Priority (Build)	Input	Selective	High priority (Economy), Moderate priority	Impacts pitch type, actuation complexity
P9	Cost Priority (Maintenance)	Input	Selective	High priority (Economy), Moderate priority	Affects anti-icing type, maintenance-friendly material selection
P10	Propeller Pitch Type	Input	Optional Selective	1: Fixed, 2: Ground Adjustable, 3: Variable / Constant-Speed	Overrides default pitch selection if specified
P11	Material Recommendation	Input	Optional Selective	1: Wood, 2: Aluminum/Metal, 3: Composite	Overrides default material choice if specified; checked against power constraints
P12	Power Classification	Output	Derived	Low / Medium / High	Derived from P3; affects pitch type, blade count, actuation
O1	Propeller Pitch Type	Output	Selective	Fixed, Ground Adjustable, Variable / Constant-Speed	Determined from power, weight, noise, and optional input P10
O2	Actuation Method	Output	Text	No Actuation, Single-Acting, Double-Acting	Derived from pitch type, engine type, power

O3	Blade Count Recommendation	Output	Numerical	2–6 blades	Based on power classification, engine type, noise priority
O4	Material Recommendation	Output	Text	Wood, Aluminum/Metal, Composite	Based on aircraft type, power, user preference P11
O5	Anti-Icing Type	Output	Text	None, Electrical, Fluid	Determined from environment (P4) and maintenance/cost priorities
O6	Direction of Rotation	Output	Text	Right-Hand, Left-Hand, Contra-Rotation	Determined from number of engines, noise priority, critical engine consideration
O7	Noise Reduction Suggestion	Output	Text	Synchrophasing / Synchronizing recommended or not	Suggested if noise priority is high; increases weight and cost slightly

Parameter Explanations and Interdependencies

1. Aircraft Category (P1):
The aircraft category defines the operational role and physical characteristics of the aircraft, which significantly influence propeller selection. Small aircraft, regional transport, ultralight, and training aircraft each impose different constraints on engine power, number of blades, allowable materials, and propeller pitch types [1, 7]. The app uses this input to constrain other design choices such as maximum allowable power, suitable materials, and appropriate propeller configurations. As indicated in the logic, mappings such as:

$$\big(\text{Allowed Power Range} = f(P1)\big) and \ (\text{Allowed Materials} = g(P1))$$

P1: Aircraft Category

ensure that only compatible designs are recommended, preventing critical selection mistakes [2].

2. Number of Engines (P2):
The number of engines directly affects propeller rotation patterns and aircraft yaw control in the event of an engine failure. For single-engine aircraft, rotation is usually fixed and right-hand rotation. For multi-engine aircraft, rotation may be alternating (R/L) to reduce noise and improve balance if noise priority is high, or uniform (all Righ Handed) if noise concerns are moderate [1, 7]. The app also considers the critical engine concept, where the engine whose failure produces maximum yawing moment is identified. If the user selects "No Critical Engine," a left-hand rotation may be recommended, which slightly increases maintenance and production costs [8, 2].
These interdependencies are formalized in the logic:

$$(\text{Rotation Pattern} = f(P2, P7, \text{Critical Engine}))$$

P2: Number of Engines

P7: Noise Priority

8. **Engine Power /(P3):**

Engine power or thrust is classified into low, medium, and high categories. This classification is crucial because it dictates allowable propeller types, actuation methods, blade counts, and materials. Low-power engines can use fixed or ground-adjustable propellers, medium-power engines may require variable or ground-adjustable pitch depending on noise priority, and high-power engines must use variable/constant-speed propellers [1, 2, 5].

The logic is represented as:

$$\begin{cases} \text{Low Power,} & P3 \leq 112 \text{ kW} \\ \text{Medium Power,} & 113 \leq P3 \leq 746 \text{ kW} \\ \text{High Power,} & P3 > 746 \text{ kW} \end{cases}$$

P3: Power Input (hp or KW)

This classification informs subsequent design decisions, such as allowable blade number, pitch type, and material selection.

8. **Environment / Climate (P4):**
   The operational environment affects anti-icing requirements and indirectly impacts propeller materials. Aircraft operating in temperate or cold climates may require electrical or fluid anti-icing systems [1, 3, 5]. In contrast, warm climates require no anti-icing. The app translates this input into anti-icing recommendations using the formula, numbers indicated below are classification of environmental condition:

$$[O5 = \{\text{No Anti-Icing,} \quad P4 \in 1{,}2{,}3 \text{ Electrical,} \quad P4 \in 4{,}5 \text{ Fluid,} \quad P4 \in 6{,}7{,}8]$$

P4: Environmental Condition
$O5$: *Icing System*

This logic ensures that environmental conditions are considered in the propeller subsystem design, maintaining safety and performance.

8. **Engine Type (P5):**
   Engine type (piston, turboprop, or electric) affects permissible materials, propeller blade counts, and actuation methods. Piston engines can use wood or aluminum, turboprops typically use aluminum or composite, and high-power electric engines favor composite materials. The formula-based logic:

$$[\text{Allowed Materials} = f(P5)]$$

$P5: Engine\ Type$
guarantees that material recommendations are compatible with both engine type and power class. This interdependency prevents conflicts, such as using wood with high-power turboprops [1, 5, 3, 2].

6. Weight Priority (P6), Noise Priority (P7), Cost Priorities (P8, P9):
These parameters represent multi-factor decision criteria that influence final propeller selection. High weight priority promotes lighter materials and simpler actuation methods. High noise priority may suggest synchrophasing or alternating rotation, slightly increasing weight and cost. Cost priorities influence material and maintenance recommendations. These priorities are evaluated as weighted constraints in the logic [9]:

$$[\text{Noise Reduction Feature} = \{\text{Enabled}, \quad P7 = \text{High Disabled}, \quad P7 = \text{Moderate}]$$

This approach integrates multiple criteria in a scientifically consistent manner.

7. Propeller Pitch Type (O1) and Material (O4):
Propeller pitch type and material are outputs determined from all previous inputs and must satisfy compatibility rules. For example, high-power engines cannot use wood, and low-power engines can avoid complex variable-pitch mechanisms to reduce cost. The actuation method is determined based on pitch type and power class O2O_2O2 [9]:

- Fixed pitch and ground-adjustable propellers do not require actuation mechanisms.
- Variable or constant-speed propellers require actuation:
  - Single-acting: simpler, lighter, typically using spring or gas pressure for blade angle changes.
  - Double-acting: more precise, faster response, but heavier and increases maintenance cost.

$$\begin{cases} \text{None,} & O_1 = \text{Fixed or Ground-Adjustable} \\ \text{Single-Acting,} & O_1 = \text{Variable / Low-to-Medium Power, weight} \\ \text{Double-Acting,} & O_1 = \text{Variable / High Power, weight} \end{cases}$$

These rules ensure safe and efficient propeller selection while preventing incompatible or unsafe designs.

8. Outputs Integration:
All output parameters; propeller pitch, actuation, blade count, material, anti-icing, direction of rotation, and optional noise reduction; are derived from a combination of user inputs, classifications, and compatibility rules. Mathematical logic, comparisons, and conditional mappings enforce multi-factor decision making, allowing the app to provide recommendations that are compatible, efficient, and safe [2, 9].

Worked Example of Propeller Design Recommendation

The application was tested using the following input parameters Table 2. to demonstrate its decision-making and propeller recommendation capabilities.

Tabel 2. Input Parameters for Propeller Design Recommendation

Parameter	**Code**	**Input**	**Description**
Aircraft Category	P1	3	Ultralight/Sport
Number of Engines	P2	2	Twin-engine configuration
Engine Total Power	P3	120 kW	Total power across engines
Environment / Climate	P4	4	Seasonal Cold Climate (Possible Icing)
Engine Type	P5	1	Piston engine
Weight Priority	P6	1	Highest priority (Light Design)
Noise Priority	P7	2	Moderate noise concern
Cost Priority (Build)	P8	2	Moderate
Cost Priority (Maintenance)	P9	1	High (economy)
Propeller Pitch Type	P10	None	Optional input left blank
Material Recommendation	P11	None	Optional input left blank
Critical Engine Design	CE	No Critical Engine	Optional input; the program considers implications on engine selection and maintenance

Step-by-Step Logic:

1. **Power Classification (P12):**
   - $$\begin{cases} \text{Low}, & P3 \leq 112 \text{ kW} \\ \text{Medium} & 112 < P3 \leq 746 \text{ kW} \\ \text{High} & P3 > 746 \text{ kW} \end{cases}$$

   Here, P3 = 120 kW → P12 = Medium Power

2. **Propeller Pitch Type (O1):**
   - Since P10 is blank, logic checks P12, P6, and P7.
   - Medium power + moderate noise → Ground Adjustable

3. **Actuation Method (O2):**
   - Ground Adjustable → Simple Actuation (on ground)
4. **Blade Count Recommendation (O3):**
   - Medium power + Piston engine → 3 blades

5. **Material Recommendation (O4):**
   - P1 = Ultralight, P5 = Piston → Composite, Wood suitable (light and simple)

6. **Anti-Icing Type (O5):**

   - $\begin{cases} \text{No Anti-Icing,} & P4 \in \{1,2,3\} \\ \text{Electrical,} & P4 \in \{4,5\} \\ \text{Fluid,} & P4 \in \{6,7,8\} \end{cases}$
   - P4 = 4 → Electrical Anti-Icing Recommended

7. **Direction of Rotation (O6):**
   - P2 = 2, P7 = Moderate noise → All engines Right-Hand Rotation
   - Noise reduction features like synchrophasing are optional and not applied here due to moderate noise concern

8. **Critical Engine Consideration:**

   In this design, the "No Critical Engine" option was selected. By definition, a critical engine is one whose failure produces the maximum adverse yawing moment, making climb or recovery particularly challenging for the pilot. When no engine is considered critical, the program may recommend that the left-hand engine operate in a counter-rotating direction relative to the right-hand engine to balance torque and improve performance. This configuration helps maintain symmetrical thrust in case of failure, but it may introduce additional complexity in production and maintenance. Specifically, left-hand propellers and associated engine components are less common, which can increase both manufacturing and maintenance costs due to the need for specialized parts.

   The app integrates this logic to prevent critical mistakes in engine and propeller selection, ensuring the design remains safe, efficient, and compatible with multi-engine configurations. The resulting recommendation, including direction of rotation, actuation method, and noise mitigation measures, is summarized in the Output Table shown below.

Table 3: Output Parameters from Propeller Design Recommendation

Output Parameter	**Value**	**Notes / Logic Reference**
Propeller Pitch Type (O1)	Ground Adjustable	Medium power, moderate noise
Actuation Method (O2)	Simple Actuation (on ground)	Ground adjustable pitch
Blade Count (O3)	3	Medium power, piston engine
Material (O4)	Wood, Composite	Lightweight, compatible with ultralight aircraft
Anti-Icing Type (O5)	Electrical Anti-Icing Recommended	Cold seasonal environment
Direction of Rotation (O6)	All engines Right-Hand Rotation	Twin-engine, moderate noise
Noise Reduction Feature	Not applied	Optional, only for high noise priority
Engine Recommendation	Piston	Based on input P5 and power class

Critical Engine Consideration	No Critical Engine	Left-hand engine may be used; adds slight cost and maintenance complexity due to uncommon parts

Conclusion and Future Work:

The Multi-Criteria Decision-Making (MCDM) Propeller Design App developed in this work demonstrates a structured, accurate, and safety-oriented approach for selecting propeller subsystems for small and medium aircraft applications. By integrating technical parameters such as aircraft category, engine power, environmental conditions, noise requirements, material constraints, and multi-engine rotation logic, the system ensures that every recommendation falls within the safe and compatible operational limits of real propeller-engine configurations.

This tool significantly reduces the risk of selecting incompatible combinations (e.g., high power with wood blades, single-acting actuation for high-power variable pitch systems, or improper rotation directions for multi-engine aircraft). The systematic logic improves decision accuracy, supports design transparency, and enables consistent evaluation of alternative configurations based on performance, cost, safety, and maintenance considerations. It is therefore an effective educational instrument for aviation engineering students and an early design-support tool for conceptual-level propulsion selection.

Beyond its immediate purpose, this project has strong potential for further development. Students can expand the app to incorporate:

- **More detailed propeller system modeling**, such as aerodynamic efficiency curves, propeller performance maps, ERAO / BEMT performance predictions, torsional vibration consideration, or fatigue life estimation.
- **Integration of real propeller manufacturer data**, including MT-Propeller, Hartzell, McCauley, and Hamilton Standard catalogs.
- **Advanced material modeling**, considering composite layup, metal fatigue factors, erosion resistance, and mass–moment-of-inertia effects.
- **Expanded actuation systems**, including oil-pressure governors, hydro-mechanical units, feathering mechanisms, reverse-thrust systems, and FADEC-controlled electric propeller drives.
- **Deeper coupling with engine design**, allowing:
    - Propeller–engine matching for specific power curves
    - Gearbox ratio selection
    - Electric motor torque/RPM optimization
    - Turboprop spool model integration
    - Hybrid-electric propulsion distribution logic

As students continue refining the app, it can evolve into a larger simulation and design-assessment platform capable of supporting full propulsion integration, aircraft performance analysis, and even preliminary sizing for hybrid-electric Distributed Propulsion Systems (DEP). Such an expanded system would serve as both a teaching tool and a computational foundation for future research at Georgian Aviation University.

Appendix - Mathematical Expressions and Logical Rules Used in the Program

This appendix contains the complete set of mathematical formulas, comparison expressions, and rule-based decision structures used throughout the program.

1. Power-to-Material Compatibility Rule

The Power-to-Material Compatibility Rule ensures that the selected propeller material is appropriate for the engine power. Specifically, if the engine power exceeds 150 hp, wood is not recommended as a material because it cannot withstand the higher mechanical stresses and rotational forces safely. Using a material incompatible with the power rating could lead to structural failure, excessive vibration, or reduced lifespan of the propeller. This rule helps prevent critical design mistakes by linking the engine's power input directly to the allowable material options [1, 3, 8, 9].

If Power (hp)>150⇒Material ≠Wood

2. Diameter Scaling Logic

The Diameter Scaling Logic determines the approximate propeller diameter based on the engine power. This approach allows designers to estimate a propeller size that can efficiently absorb the available power while maintaining aerodynamic and structural efficiency. By correlating diameter with power, the rule ensures that the propeller generates sufficient thrust without exceeding mechanical or aerodynamic limits [6, 10, 11].

$$D = k \cdot P3D = k \cdot \sqrt[3]{P}D = k \cdot 3P$$

$D: Propeller\ Diameter\ (mm, or\ in)$
$P: power\ input\ (hp)$
$K = Coefficient(mm/hp^{1/3})$

3. Blade Count Decision Rule

The Blade Count Decision Rule determines the appropriate number of propeller blades based on engine power. For low-power engines, two blades are typically sufficient. Medium-power engines may require three blades to efficiently absorb power and maintain smooth operation. High-power engines generally need four or more blades to distribute the load, reduce vibration, and ensure aerodynamic efficiency. This rule helps match the number of blades to engine output for optimal performance [5, 3, 4].

$$\begin{cases} 2, & P \leq 80 \\ 3, & 80 < P \leq 180 \\ 4, & P > 180 \end{cases}$$

$P: Power\ (hp)$

4. Synchronization / Synchrophasing Decision Rule

This rule determines whether propeller synchronization or synchrophasing should be enabled to reduce noise and vibration in multi-engine aircraft. When noise priority is high, synchronization is recommended to ensure propellers rotate in a coordinated manner, minimizing harmonic interference and tonal noise. If noise is not a primary concern, synchronization can be disabled to simplify design and reduce weight and cost [1, 3, 12].

$$\begin{cases} \text{Enabled} & N_{\text{priority}} = \text{High} \\ \text{Disabled,} & \text{otherwise} \end{cases}$$

$N: Noise\ priority$

5. Engine Recommendation Logic

This rule suggests the most suitable engine type based on the aircraft's power requirements and operational priorities. For low-power applications, a piston engine is typically recommended. For medium-power ranges, a turboprop is preferred. In cases where noise priority is low or for advanced concepts like Electric VTOL (EVTOL) or Advanced Air Mobility (AAM), electric motors are considered suitable. This ensures the engine choice aligns with power demands, noise considerations, and modern propulsion trends [1, 3, 2].

$$\begin{cases} \text{Piston Engine,} & P < 200 \\ \text{Turboprop,} & 200 \leq P < 1500 \\ \text{Electric Motor,} & \text{Low noise priority OR EVTOL} \end{cases}$$

$P: Power\ (hp)$

6. Hub Type Selection Rule (Expanded to Multiple Lines)

This rule determines the appropriate propeller hub type based on the selected pitch mechanism and engine power. Fixed propellers require no hub actuation, ground-adjustable or low-power configurations typically use a simple single-acting hub, while variable or high-power propellers demand a more sophisticated double-acting hub to ensure rapid response and reliable performance. The selection ensures compatibility between the hub mechanism and the propeller’s operational demands [1, 5, 3, 9].

$$\begin{cases} \text{None,} & O1 = \text{Fixed} \\ \text{Single-Acting,} & O1 = \text{Ground Adjustable / Low-Power} \\ \text{Double-Acting,} & O1 = \text{Variable / High-Power} \end{cases}$$

$O1$ = Propeller Pitch Type outputed

7. Critical Engine Logic

This rule addresses multi-engine configurations by evaluating whether a critical engine exists. A critical engine is defined as the one whose failure produces the maximum adverse yaw, making recovery difficult. If no engine is designated as critical, the program may recommend a left-hand counter-rotating propeller to balance torque and maintain symmetrical thrust. This approach improves overall handling and safety but can slightly increase production and maintenance complexity due to the rarity of left-hand propeller components [2, 5, 10].

If No Critical Engine⇒Recommend LH counter-rotating propeller

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პროპელერის მრავალკრიტერიუმიანი პროექტირების აპლიკაცია (MCDM)

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რეზიუმე: *მოცემულ კვლევაში წარმოდგენილია Python-ზე დაფუძნებული მრავალკრიტერიული გადაწყვეტილების მიღების (MCDM) აპლიკაცია სამოქალაქო და მსუბუქ ავიაციაში გამოყენებული პროპელერების კონსტრუქციისთვის, რომელიც აერთიანებს სტრუქტურირებულ ლოგიკურ პროცესს და აფასებს მრავალ პარამეტრს, მათ შორის: საავიაციო ხომალდის კატეგორიას, ძრავის ტიპს და სიმძლავრეს, გარემო პირობებს, ასევე პრიორიტეტებს, როგორიცაა წონა, ხმაური და ღირებულება. EASA-ის მოდული 17, „პროპელერი"-ს მიხედვით, აპლიკაცია რეკომენდაციას აძლევს პროპელერის ოპტიმალურ კონფიგურაციებს, მათ შორის: Pitch-ის ტიპის ფრთის მასალას, ამოქმედების მექანიზმს, შემოყინვის საწინააღმდეგო სისტემას, ფრთების რაოდენობას და ბრუნვის სტრატეგიას. ამავე დროს უზრუნველყოფს ქვესისტემებს შორის თავსებადობას და თავიდან იცილებს კრიტიკულ შეცდომებს, როგორიცაა არასამთავდებლო მასალა-სიმძლავრის კომბინაციები, არასწორი ტიპის მასალის არჩევა ან შეუსაბამო შემოყინვის საწინააღმდეგო სისტემა. ის ასევე ითვალისწინებს ოპერაციულ ფაქტორებს, როგორიცაა კრიტიკული ძრავის ეფექტები და ხმაურის შემამცირებელი ტექნოლოგიები, მათ შორის სინქროფეიზირება და სინქრონიზაცია, რაც უზრუნველყოფს ეფექტიანობის, წარმადობის და უსაფრთხოების ბალანსს. ამ ფაქტორების მრავალკრიტერიულ ჩარჩოში გაერთიანებით, წარმოდგენილი მეთოდიკა ინჟინრებს, ტექნიკოსებს და სტუდენტებს სთავაზობს საიმედო გზამკვლევს, რათა გამოიკვლიონ პროპელერის განხორციელებადი კონსტრუქციები ოპერაციული უსაფრთხოების და სისტემური ეფექტიანობის შენარჩუნების პირობებში.*

საკვანძო სიტყვები: *მრავალკრიტერიული გადაწყვეტილების მიღება (MCDM), საავიაციო ძალური დანადგარი, ხმაურის შემცირება, კრიტიკული ძრავი.*