PAAT

PROGRESS IN AEROSPACE AND AVIATION TECHNOLOGY
e-ISSN: 2821-2924

Vol. 6 No. 1 (2026) 39-46
https://publisher.uthm.edu.my/ojs/index.php/paat

Integrated Conceptual Design of Landing Gear, Propulsion, and Communication Subsystems for a Medium-Altitude Long-Endurance (MALE) Unmanned Aerial Vehicle

Nur Asyraf[1], Zamri Omar[1]*

[1] *Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Johor, MALAYSIA*

*Corresponding Author: zamri@uthm.com
DOI: https://doi.org/10.30880/paat.2026.06.01.005

Article Info

Received: 1 January 2026
Accepted: 1 May 2026
Available online: 30 June 2026

Keywords

MALE UAV, landing gear design, propulsion system, communication system, conceptual design, center of gravity

Abstract

Medium-Altitude Long-Endurance (MALE) unmanned aerial vehicles (UAVs) are widely used for intelligence, surveillance, reconnaissance, and other long-duration missions because of their extended endurance, operational flexibility, and ability to carry mission-specific payloads. The effectiveness of a MALE UAV depends strongly on the integrated configuration of its major subsystems, particularly the landing gear, propulsion, and communication systems. This study presents the conceptual design and integration of these three critical subsystems for a MALE UAV platform benchmarked against operational UAV configurations such as the TAI Anka-S. A retractable tricycle landing gear configuration was selected to provide stable ground handling and improved aerodynamic efficiency when retracted. The propulsion subsystem adopts a rear-mounted pusher configuration powered by a TEI-PD170 turbodiesel engine to support long-endurance operation while maintaining an unobstructed forward payload bay. The communication subsystem combines Line-of-Sight (LOS) and Beyond-Line-of-Sight (BLOS) architecture to support command, control, telemetry, and long-range mission data transmission. Aircraft mass distribution, center of gravity (CG) characteristics, landing gear geometry, and subsystem compatibility were evaluated using conceptual engineering calculations. The results indicate that the proposed configuration provides acceptable mass balance, adequate ground handling characteristics, sufficient propeller ground clearance, and effective subsystem integration. The developed conceptual design provides a technically feasible foundation for subsequent aerodynamic analysis, structural assessment, prototype development, and flight performance evaluation.

1. Introduction

Unmanned aerial vehicles (UAVs) have become important platforms for military and civilian applications, including intelligence, surveillance, reconnaissance, environmental monitoring, disaster assessment, and border security missions [1], [2]. Among the different UAV classes, Medium-Altitude Long-Endurance (MALE) UAVs provide a practical balance among endurance, payload capacity, operating altitude, and mission flexibility. MALE UAVs are generally designed for sustained operation at medium altitude and can support surveillance or monitoring missions that require long flight duration [3, 4].

The effectiveness of a MALE UAV is governed not only by its aerodynamic layout but also by the compatibility of its major subsystems. The landing gear subsystem affects takeoff, landing, ground handling, and aircraft clearance. The propulsion subsystem influences endurance, fuel consumption, payload arrangement, and aircraft balance. The communication subsystem enables command, control, telemetry, and payload data transmission during both short-range and long-range operations. Preliminary aircraft design methods therefore emphasize early subsystem integration so that mass distribution, structural interfaces, and operational requirements can be addressed before detailed design begins [5]-[7].

Although landing gear, propulsion, and communication subsystems are often treated as separate design tasks, inadequate integration can lead to center-of-gravity imbalance, structural incompatibility, limited payload installation space, and reduced mission reliability. UAV communication studies also highlight the importance of selecting appropriate Line-of-Sight (LOS) and Beyond-Line-of-Sight (BLOS) links to sustain command, control, and mission data transfer during extended operations [8], [9]. This study therefore focuses on the integrated conceptual design of the landing gear, propulsion, and communication subsystems for a MALE UAV platform. The objective is to develop a technically feasible subsystem arrangement that supports long-endurance mission requirements while maintaining acceptable aircraft balance, ground stability, propulsion compatibility, and communication capability.

2. Methodology

This study adopted a top-down conceptual design methodology consistent with preliminary aircraft development practice [5]-[7]. Existing MALE UAV platforms, particularly the TAI Anka-S, were used as design references to define the baseline mission requirements, subsystem arrangement, and overall airframe configuration [10]. The propulsion selection was guided by the performance suitability of the TEI-PD170 turbodiesel engine for MALE UAV applications [11]. The overall design procedure is summarized in Fig. 1.

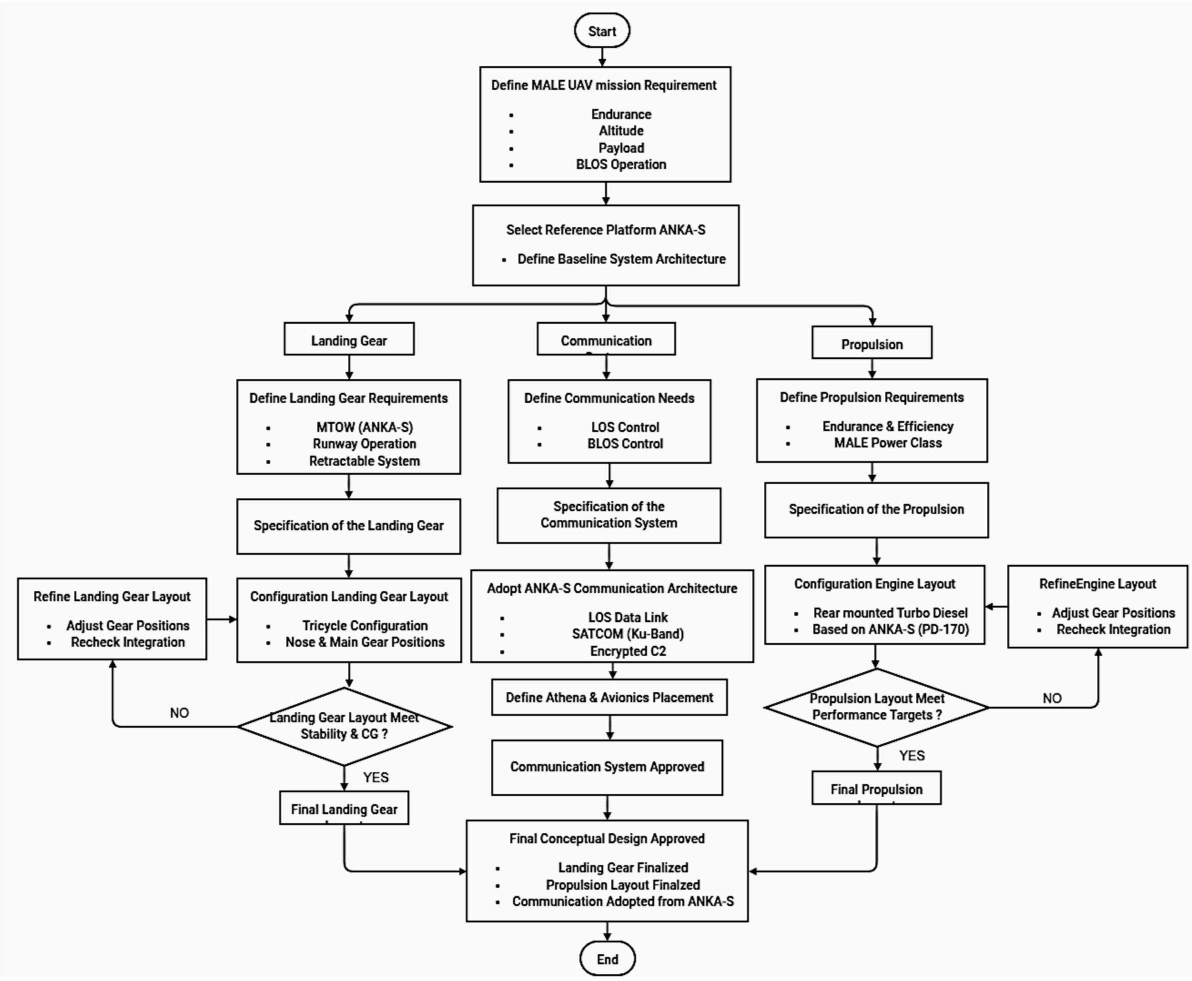

Fig. 1 *Methodology chart for MALE UAV conceptual design*

Prog. Aerosp. Aviat. Technol. Vol. 6 No. 1 (2026) p. 39-46

The methodology began with the identification of mission requirements, including endurance, operating altitude, payload provision, and BLOS operation. A literature review and benchmark assessment were then conducted to identify suitable subsystem architectures. The landing gear, propulsion, and communication subsystems were designed in parallel and subsequently evaluated as an integrated configuration. The final assessment considered CG location, landing gear geometry, propulsion layout, propeller ground clearance, and communication system compatibility.

For the landing gear subsystem, a retractable tricycle configuration was selected because this arrangement provides stable ground handling, practical taxiing characteristics, and reduced aerodynamic drag after retraction. The design assessment considered CG location, wheel load distribution, wheelbase, wheel track, tip-back angle, shock absorber sizing, and ground clearance using conceptual landing gear design principles [12]. For the propulsion subsystem, a rear-mounted pusher layout was adopted. This configuration places the engine and propeller at the aft section of the aircraft, leaving the forward fuselage available for optical payloads, avionics, and communication equipment. Engine placement, propeller integration, and ground clearance were evaluated to ensure compatibility with the fuselage layout and landing gear arrangement [11]. For the communication subsystem, a dual-link architecture consisting of LOS and BLOS communication was selected. The subsystem includes data-link transceivers, a SATCOM terminal, antennas, and a communication management computer. This architecture was selected to support low-latency local control during take-off and landing, as well as long-range command, telemetry, and payload data transmission during extended missions [8], [9].

3. Results

3.1 Aircraft Mass Distribution and Centre of Gravity Analysis

The mass distribution of the proposed MALE UAV was determined based on the estimated mass and location of the major aircraft components, including the fuselage, wing, tail assembly, payload, propulsion system, avionics, landing gear, and fuel system. The component-level mass distribution is summarized in Table 1. This analysis is essential because preliminary aircraft design requires the CG to remain within an acceptable range for stability, controllability, and subsystem compatibility [5], [6].

Table 1 *Mass distribution of major UAV components*

Part	X – Direction			Y-Direction		
	Positions (m)	Weight (kg)	Moment (N)	Positions (m)	Weight (kg)	Moment (N)
Fuselage	4.7	250	1175	0	250	0
Wing	4.8	350	1680	0.4	350	140
Tail	7.7	100	770	1.7	100	170
Optics	-0.6	120	-72	-0.7	120	-84
Munition (MAM-C)	4.8	15	72	-0.1	15	-1.5
Propulsion + Propeller	7.6	230	1748	0	230	0
Avionics + System	-0.52	150	-78	0	150	0
Landing Gear	3.6	240	864	-1.4	240	-528
Fuel	4.6	420	1932	0	420	0
TOTAL	36.68	1875	8091	-0.9	1875	-303.5

The overall conceptual arrangement of the proposed MALE UAV is illustrated in Fig. 2. The configuration was developed to achieve a balanced mass distribution while providing sufficient space for payload integration, propulsion installation, and communication equipment placement.

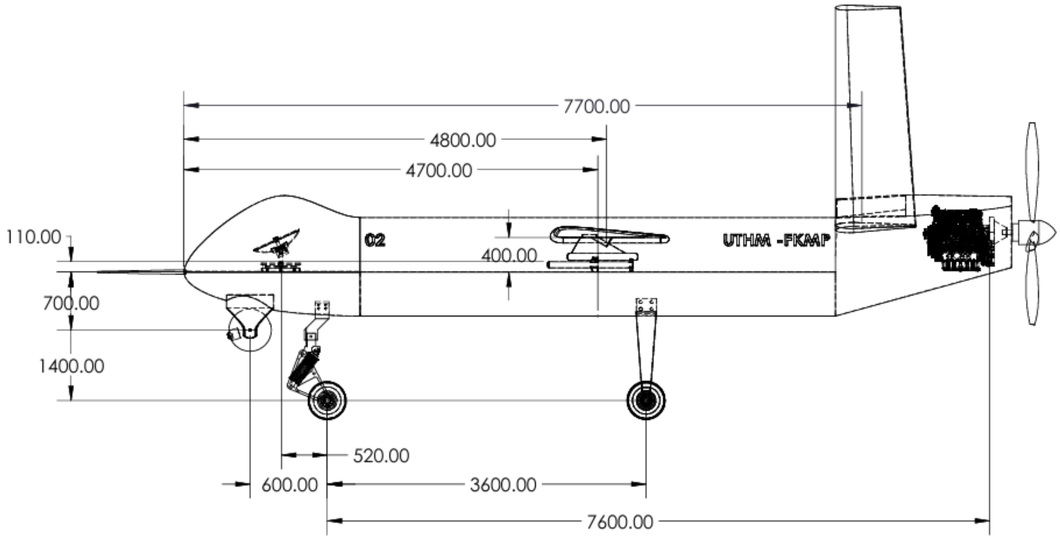

Fig. 2 *Overall conceptual design and subsystem arrangement of the proposed MALE UAV*

The longitudinal center of gravity (CG) was calculated using Equation (1):

$$XCG = \frac{\sum W_i X_i}{\sum W_i} \tag{1}$$

where W_i is the weight of each component and X_i is the longitudinal position measured from the reference datum [5], [6]. Substituting the calculated values in Table 1 gives $XCG = 4.315$ m. The lateral center of gravity was evaluated using Equation (2):

$$YCG = \frac{\sum W_i Y_i}{\sum W_i} \tag{2}$$

where Y_i represents the lateral position of each component relative to the aircraft centerline. Substituting the calculated values gives $YCG = -0.162$ m.

The calculated longitudinal center of gravity was located at 4.315 m from the reference datum, while the lateral center of gravity was located at -0.162 m relative to the aircraft centerline. The negative lateral CG value indicates a slight offset toward the left side of the aircraft. However, the deviation is relatively small compared with the overall aircraft dimensions and is not expected to significantly affect flight stability or controllability. These results indicate that the proposed subsystem arrangement provides acceptable mass balance and stability characteristics suitable for MALE UAV operations.

To further evaluate aircraft stability, the center of gravity location was assessed relative to the Mean Aerodynamic Chord (MAC) using Equation (3), where XLEMAC is the longitudinal location of the leading edge of the MAC and LMAC is the MAC length [6]:

$$\%MAC = \left[\frac{XCG - XLEMAC}{LMAC}\right] \times 100\% \tag{3}$$

Based on the adopted conceptual geometry, the calculated CG location remained within the preliminary stability envelope for a conventional fixed-wing UAV. This result indicates that the proposed subsystem arrangement provides acceptable mass balance for further aerodynamic and structural development.

3.2 Landing Gear Geometry Analysis

The landing gear subsystem adopted a retractable tricycle configuration consisting of two main landing gears and one nose landing gear. This arrangement was selected because tricycle landing gear provides stable taxiing, improved directional control during ground operation, and reduced drag when retracted during cruise [12]. The conceptual landing gear arrangement relative to the aircraft CG is shown in Fig. 3.

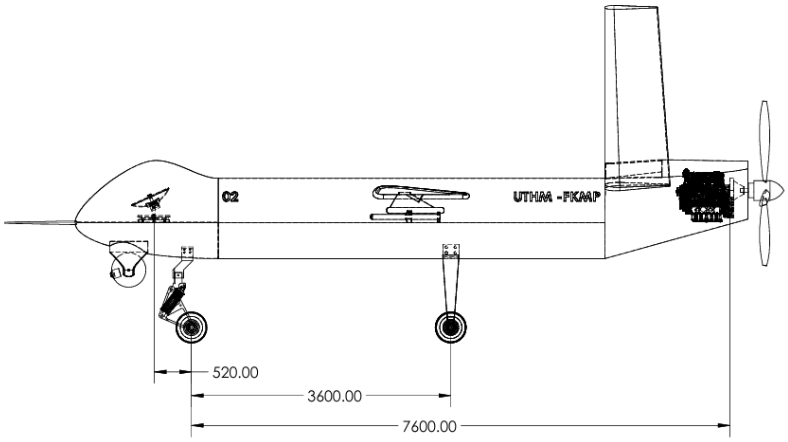

Fig. 3 *Main landing gear position is relative to the aircraft's center of gravity*

The main landing gear was positioned slightly aft of the aircraft's center of gravity to provide adequate longitudinal stability during takeoff and landing operations. The nose wheel load was estimated using Equation (4).

$$W_n = \frac{W \times d_m}{L} \tag{4}$$

where W_n is the nose wheel load, W is the total aircraft weight, d_m is the distance between the center of gravity and the main landing gear, and L is the wheelbase [12]. The calculated load distribution indicated that approximately 10% of the aircraft weight is supported by the nose landing gear, while the remaining 90% is carried by the main landing gear assembly. This distribution falls within the recommended range for aircraft with tricycle landing gear.

The impact energy during landing was estimated using Equation (5):

$$E = \frac{1}{2}mv^2 + mgh \tag{5}$$

where E is the landing impact energy, m is the aircraft mass, v is the sink velocity, g is the gravitational acceleration, and h is the vertical displacement. The calculated impact energy was used to determine the required stroke length for the selected oleo-pneumatic shock absorber. This type of shock absorber was selected due to its superior energy absorption capability and proven application in medium-sized UAV platforms [12]. The design parameters for the landing gear are summarized in Table 2.

Table 2 *Landing gear design parameters and calculated results*

Parameter	Value
Aircraft Mass	1875 kg
Longitudinal CG Position	4.315 m
Lateral CG Position	-0.162 m
Nose Wheel Load	184 kg
Main Landing Gear Load	1691 kg
Wheelbase	3.60 m
Wheel Track Width	2.20 m
Tip-Back Angle	32.47°
Shock Absorber Stroke Length	0.30 m
Propeller Ground Clearance	0.60 m
Landing Gear Configuration	Retractable Tricycle
Shock Absorber Type	Oleo-Pneumatic

The calculated wheel track and tip-back angle demonstrated adequate ground stability during taxiing, take-off, and landing operations. In addition, the propeller ground clearance of approximately 0.60 m provides sufficient protection against propeller strikes during runway operations.

3.3 Propulsion Subsystem Integration

The propulsion subsystem adopts a rear-mounted pusher configuration powered by the TEI-PD170 turbodiesel engine. This arrangement provides an unobstructed forward fuselage section for ISR payload integration and reduces the likelihood of aerodynamic interference with nose-mounted surveillance sensors. The TEI-PD170 engine was selected because it is suitable for MALE UAV applications and provides approximately 170 hp with low fuel consumption and high-altitude operating capability [11]. The rear-mounted pusher configuration also supports the desired mass distribution by locating the propulsion group aft of the wing-fuselage region while preserving space for avionics, payloads, and communication equipment.

Propeller ground clearance analysis indicated a clearance of approximately 0.60 m between the propeller tip and the ground surface. This clearance is considered sufficient to reduce the risk of propeller strikes during takeoff, landing, and taxiing. Overall, the propulsion arrangement demonstrated acceptable compatibility with the CG location, landing gear geometry, and long-endurance mission requirements. The propulsion layout is shown in Fig. 4.

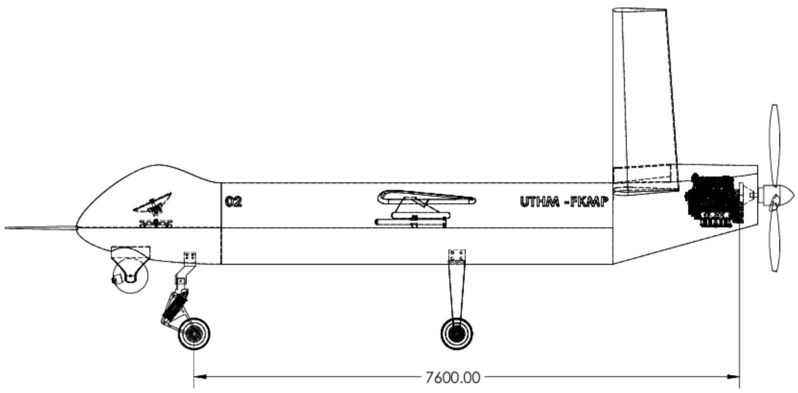

Fig. 4 *Rear-mounted TEI-PD170 engine and pusher propeller configuration*

3.4 Communication Subsystem Integration

The communication subsystem was designed to support both LOS and BLOS mission requirements. This dual-link architecture enables reliable command, control, telemetry, and payload data transmission during different phases of operation. The LOS link supports low-latency communication during takeoff, landing, and short-range missions, whereas the BLOS link uses satellite communication to support long-range surveillance and reconnaissance missions [8], [9]. The proposed communication architecture is illustrated in Fig. 5.

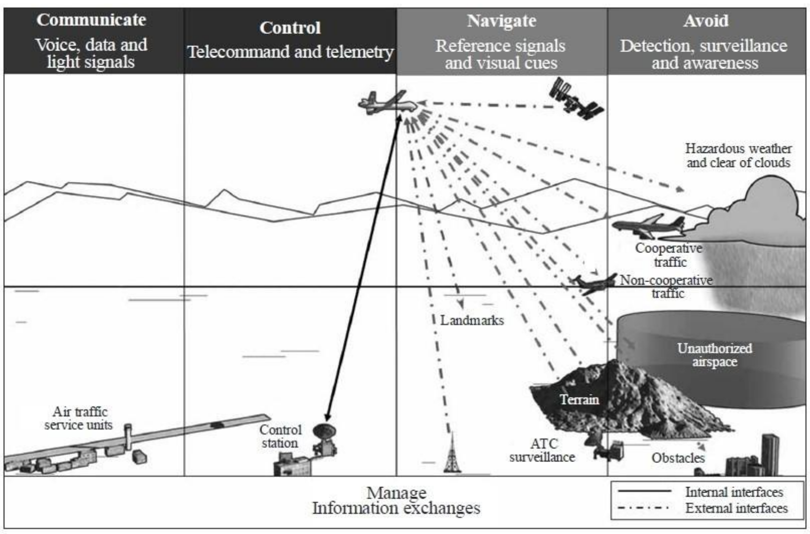

Fig. 5 *Integrated LOS and BLOS communication architecture of the proposed MALE UAV*

The LOS subsystem supports low-latency communication during take-off, landing, and short-range missions, while the BLOS subsystem utilizes satellite communication (SATCOM) technology for long-range surveillance and reconnaissance operations. A communication management computer was incorporated to coordinate data routing and communication link management between subsystems. The communication subsystem characteristics are summarized in Table 3. The proposed communication subsystem provides operational flexibility and compatibility with contemporary MALE UAV mission requirements. Its LOS/BLOS structure supports local control, long-range command and telemetry, and payload data transmission, while the dedicated management computer improves coordination between communication links [8], [9].

Table 3 *Communication subsystem characteristics*

Component	Function	Weight (kg)	Power Consumption (W)
LOS Data Link	Short-range command, control, and telemetry transmission	5	150
SATCOM Terminal	Beyond-Line-of-Sight communication	8	250
Communication Management Computer (CMC)	Communication link management and data routing	2	50
Antenna System	Signal transmission and reception	2	50
Total	-	17	500

3.5 Overall System Integration

The integrated subsystem arrangement combines the landing gear, propulsion, and communication systems into a coherent MALE UAV platform. The results show that the mass distribution in Table 1 produced an acceptable longitudinal CG position of 4.315 m and a small lateral CG offset of -0.162 m. The landing gear parameters in Table 2 provide adequate wheelbase, wheel track, tip-back angle, shock absorber stroke, and propeller ground clearance. The propulsion layout in Fig. 4 remains compatible with the aft-mounted engine concept, while the communication architecture in Fig. 5 provides both short-range and long-range mission connectivity.

The overall configuration reflects common design practices used in operational MALE UAV platforms, including benchmark systems such as the Anka-S [10] and other conceptual MALE UAV design studies [3], [4]. The proposed integrated arrangement is therefore technically feasible at the conceptual design stage and provides a suitable basis for detailed aerodynamic analysis, structural design, performance assessment, and prototype development.

4. Conclusion

This study presented the integrated conceptual design of landing gear, propulsion, and communication subsystems for a medium-altitude long-endurance UAV platform. The proposed configuration successfully achieved acceptable center of gravity characteristics, stable landing gear geometry, efficient propulsion integration, and reliable communication architecture. The selected retractable tricycle landing gear, TEI-PD170 propulsion system, and dual-link communication architecture demonstrated compatibility with MALE UAV operational requirements. The conceptual design provides a strong foundation for future development, including aerodynamic analysis, structural assessment, prototype fabrication, and flight performance evaluation.

Acknowledgement

The author would like to express sincere appreciation to Universiti Tun Hussein Onn Malaysia (UTHM), the Faculty of Mechanical and Manufacturing Engineering, and Prof. Madya Dr. Zamri Bin Omar for their guidance and support throughout this study.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this work.

Author Contribution

The author was responsible for conceptual design development, data analysis, subsystem integration, and manuscript preparation. The supervisor provided technical guidance, review, and project supervision throughout the study.

References

[1] R. Austin, Unmanned Aircraft Systems: UAV Design, Development and Deployment. Chichester, U.K.: John Wiley & Sons, 2010.

[2] K. P. Valavanis and G. J. Vachtsevanos, Eds., Handbook of Unmanned Aerial Vehicles. Dordrecht, The Netherlands: Springer, 2015, doi: 10.1007/978-90-481-9707-1.

[3] A. Yilmaz, M. Temiz, and M. Demirci, "Design considerations for medium-altitude long-endurance unmanned aerial vehicles," Aerospace Science and Technology, vol. 122, p. 107404, 2022.

[4] K. Rajesh, P. S. Reddy, and V. Kumar, "Conceptual design and performance evaluation of a medium-altitude long-endurance unmanned aerial vehicle," International Journal of Aerospace Engineering, vol. 2021, pp. 1-12, 2021.

[5] M. H. Sadraey, Aircraft Design: A Systems Engineering Approach, 2nd ed. Hoboken, NJ, USA: John Wiley & Sons, 2020.

[6] D. P. Raymer, Aircraft Design: A Conceptual Approach, 6th ed. Reston, VA, USA: American Institute of Aeronautics and Astronautics, 2018.

[7] J. Roskam, Airplane Design Part I: Preliminary Sizing of Airplanes. Lawrence, KS, USA: DARcorporation, 2007.

[8] A. A. Khuwaja, Y. Chen, N. Zhao, M.-S. Alouini, and P. Dobbins, "A survey of channel modeling for UAV communications," IEEE Communications Surveys & Tutorials, vol. 20, no. 4, pp. 2804-2821, 2018, doi: 10.1109/COMST.2018.2856587.

[9] Z. Yan, H. Zhang, P. Zhang, and W. Luo, "Communication and networking technologies for UAVs: A survey," IEEE Access, vol. 7, pp. 161273-161289, 2019, doi: 10.1109/ACCESS.2019.2954070.

[10] TAI, "ANKA Unmanned Aerial Vehicle System," Turkish Aerospace Industries, 2023. [Online]. Available: https://www.tusas.com.

[11] TEI, "PD170 Turbodiesel Aircraft Engine Technical Specifications," TUSAS Engine Industries, 2023. [Online]. Available: https://www.tei.com.tr.

[12] N. S. Currey, Aircraft Landing Gear Design: Principles and Practices. Washington, DC, USA: American Institute of Aeronautics and Astronautics, 1988.