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## TECHNICAL REVIEW ON UNMANNED AERIAL VEHICLE (UAV) TECHNOLOGIES

BY

**ANA-GEORGIANA LUPU\* and DORU POPA**

“Gheorghe Asachi” Technical University of Iași,  
Faculty of Mechanical Engineering, Iași, Romania

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**Abstract.** Unmanned Aerial Vehicles (UAVs), commonly known as drones, have transitioned from specialized military assets to commonly found tools across agriculture, logistics, surveillance, and disaster management. As UAV technology advances rapidly, establishing a clear framework for understanding their diverse capabilities becomes essential. This paper presents a comprehensive literature review aimed at synthesizing foundational UAV concepts and establishing a standardized classification. Authors examine the core technical characteristics, operational principles, and historical evolution that define modern drone systems. Furthermore, this study categorizes UAVs based on operational parameters, including aerodynamic design (fixed-wing, rotary-wing, and hybrid systems), weight, range, altitude, and autonomy levels. By consolidating fragmented data from contemporary research, this paper provides a streamlined reference model for classification. Ultimately, this review bridges the gap between basic UAV mechanics and complex operational frameworks, offering researchers and industry professionals a foundational guide to navigate the current drone landscape and identify future technological advancements.

**Keywords:** civilian drones, basic characteristics, classification.

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\*Corresponding author; *e-mail*: ana-georgiana.lupu@academic.tuiasi.ro

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## 1. Introduction

The 21st century witnessed a revolution in unmanned and autonomous flight comparable to the dawn of crewed aviation in the previous century. Driven by rapid advancements in microcontrollers, sensor technologies, and control systems, Unmanned Aerial Vehicles (UAVs) have transitioned from specialized military assets to ubiquitous tools for industry, academia, and commerce, that represents a fundamental change in data acquisition and logistics.

From a systems architecture perspective, the strategic implementation of UAV technology requires a critical evaluation of the trade-offs between vehicle scale, operational range, and propulsion physics. These parameters are linked, since the energy density of a power source dictates endurance, while the airframe configuration determines the aerodynamic lift efficiency (lift-to-drag ratio) and regulatory tier. For engineers, understanding these interdependencies is essential for mission success. Over-specifying a platform leads to unnecessary capital expenditure and regulatory friction, while under-specifying leads to mechanical failure or insufficient data fidelity. The following sections provide the formal classification frameworks and technical data required to navigate this evolving landscape (Hassanalain and Abdelkefi, 2017; Ahmed *et al.*, 2022; Mehmet Tuğrul, 2023).

## 2. The State of Autonomous Flight. Classification Frameworks

Although mentioned here briefly, the military applications for UAV do not represent the goal of the present paper, although at times the end use of these devices may cross the boundaries of civilian intended purpose.

UAVs have transitioned from specialized military assets to omnipresent tools driving innovation across agriculture, logistics, and disaster management. Keeping pace with their evolving characteristics is vital for guiding the next generation of aerospace engineering and autonomous system design.

Standardized nomenclature is vital for managing global airspace safety and ensuring precise communication between systems designers, regulators, and operators. While "drone" represents the common public descriptor, professionals distinguish between the Unmanned Aerial Vehicle (UAV), the physical flight platform, and the Unmanned Aircraft System (UAS), which encompasses the vehicle, the ground-based controller, and the communication architecture.

The technical definition of a UAV is increasingly rigorous. While the Federal Aviation Administration (FAA) provides a broad legal definition (any aircraft intended for flight without an on-board pilot), technical standards differentiate between aerodynes and aerostats. A true UAV is defined as a powered vehicle capable of autonomous or remote flight that generates aerodynamic lift. This excludes ballistic or cruise missiles (which lack sustained

aerodynamic control) and aerostatic systems like radiosondes, which rely on buoyancy rather than lift (FAA, 2026).

### 2.1. USA Department of Defense (DoD) Classification

The US DoD uses five categories based on mass, speed, and altitude to manage operational tiers within the National Airspace System (NAS), Table 1.

**Table 1**  
*US DoD Classification for UAV*

| Category | Size       | Maximum Take-off Mass (kg) | Operating Altitude (m) | Airspeed (m/s) |
|----------|------------|----------------------------|------------------------|----------------|
| Class 1  | Small      | 0–9                        | < 366 (AGL)            | < 51.4         |
| Class 2  | Medium     | 9–25                       | < 1,067 (AGL)          | < 128.6        |
| Class 3  | Large      | < 600                      | < 5,486 (MSL)          | < 128.6        |
| Class 4  | Very Large | > 600                      | < 5,486 (MSL)          | Any            |
| Class 5  | Very Large | > 1,320                    | > 5,486 (MSL)          | Any            |

Note: AGL = Above Ground Level; MSL = Mean Sea Level.

### 2.2. Weight and Flight Range Classification

Beyond military standards, industrial classifications focus on logistical reach and mass of the vehicle, which correlate directly to their energy density requirements, Table 2.

Design engineers must account for data variance between classification schemes. For example, a "Small" designation in the DoD framework overlaps with "Micro" and "Mini" academic designations. Furthermore, the technology spectrum includes extreme scales such as Pico Air Vehicles (PAV) (0.5–3g) and Smart Dust (SD) (down to 0.005g). These discrepancies exist because military tiers prioritize airspace integration (altitude and speed), while commercial tiers prioritize logistical footprints (weight and range). A multi-tiered approach is necessary to satisfy different regulatory jurisdictions and mission-specific lift requirements (Kahn *et al.*, 1999; Zakora and Molodchick, 2010; Stewart and Martin, 2021; Seidaliyeva *et al.*, 2024).

**Table 2**  
*UAV Classification on Weight and Flight Range*

| Designation                | Weight Range (kg)  | Flight Range (km) |
|----------------------------|--------------------|-------------------|
| Micro and Mini UAVs        | $W \leq 5$         | 25 – 40           |
| Lightweight (Small Range)  | $5 < W \leq 50$    | 10 – 70           |
| Lightweight (Medium Range) | $50 < W \leq 100$  | 70 – 250          |
| Average UAVs               | $100 < W \leq 300$ | 150 – 1,000       |

|                          |                    |              |
|--------------------------|--------------------|--------------|
| Medium Heavy UAVs        | $300 < W \leq 500$ | 70 – 300     |
| Heavy (Medium Range)     | $500 \leq W$       | 70 – 300     |
| Heavy (Large Endurance)  | $1,500 \leq W$     | $\leq 1,500$ |
| Unmanned Combat Aircraft | $500 < W$          | $\leq 1,500$ |

### 2.3. Propulsion and Energy Systems Classification

The conversion of stored energy into thrust is the primary problem for UAV endurance. Unlike manned aircraft, which support massive fuel loads, UAVs are constrained by the "energy density" of their power sources.

The *electrical batteries*, such as Li-Po/Li-ion, dominate the consumer market due to high discharge rates and mechanical simplicity. However, they possess a low mass-specific energy (approx. 200–300 Wh/kg). This creates a physical upper limit for endurance; adding batteries eventually adds more mass than the marginal lift can support, rendering them ineffective for missions exceeding 45–60 minutes (Panagiotopoulos *et al.*, 2024).

The classic propulsion with Internal Combustion Engines or Turbines (*Gasoline*) offers significantly higher energy density (reaching over 10,000 Wh/kg) and rapid refuelling. This is the optimal choice for heavy-lift or long-endurance missions. Trade-offs include mechanical complexity, high noise signatures, and vibration that can jeopardize sensitive sensor data.

Newer solutions include *Hydrogen Fuel Cells*, a technology that provides high energy density and zero emissions with a low acoustic signature. It is ideal for persistent surveillance, though currently limited by a lack of refuelling infrastructure and high hardware costs (Wu *et al.*, 2025).

The hybrid technology includes *Solar power*, that offers theoretical "indefinite" flight. However, it is highly vulnerable to atmospheric conditions, and the weight of photovoltaic panels and storage hardware often limits the payload capacity to negligible levels.

These energy constraints dictate the physical airframe configuration. The industry's shift toward Hybrid VTOL configurations was forced by these physical limits: batteries lack the density to support long-range hovering, necessitating wings to provide lift via forward motion during the cruise phase, Table 3.

**Table 3**  
*Propulsion System Comparison Matrix*

| Energy Source  | Primary Advantage                  | Major Constraint                     | Ideal Environment           |
|----------------|------------------------------------|--------------------------------------|-----------------------------|
| Li-Po Battery  | Agile,<br>low maintenance          | Low energy density<br>(Short flight) | Short-range<br>inspection   |
| Gasoline (ICE) | High endurance,<br>fast refuelling | Mechanical<br>complexity, noise      | Large-area rural<br>mapping |

|               |                                |                                   |                            |
|---------------|--------------------------------|-----------------------------------|----------------------------|
| Hydrogen Cell | Sustainable, high density      | Limited infrastructure, high cost | Covert/Long-endurance      |
| Solar         | Potential for perpetual flight | Weather-dependent, low payload    | High-altitude surveillance |

#### 2.4. Operational Profiles and Airframe Configurations

Airframe geometry is a direct response to the laws of physics. For small UAVs ( $< 25\text{kg}$ ), the Reynolds numbers of the flow are relatively low. This ensures that the flow cannot be considered "inviscid"; viscous effects are significant, and modelling the aerodynamics is correspondingly more complicated than for full-scale aircraft.

- Multi-rotor (VTOL): utilize vertical thrust from fixed-pitch propellers. Their distinct characteristic is manoeuvrability and the ability to hover. However, they suffer from high parasitic power draw during static thrust, as they must constantly expend energy just to maintain altitude.
- Fixed-wing (HTOL): generate lift via air foils. They are significantly more efficient for large-area mapping because they utilize high lift-to-drag ratios to stay aloft. Their limitation is the requirement for a runway and the lack of hovering capability.
- Hybrid VTOL: is the current "gold standard" for industrial applications, combining the vertical launch flexibility of a multi-rotor with the high-speed cruise efficiency of a fixed-wing.

A new trend in drone design focuses on *ornithopter*, trying to mimic the wing flapping from nature. Although progresses are made, this type of airframe configuration and its propulsion is still under development.

Based on classifications above and compiling data from several papers published to date, authors propose the comprehensive classification in Fig. 1.

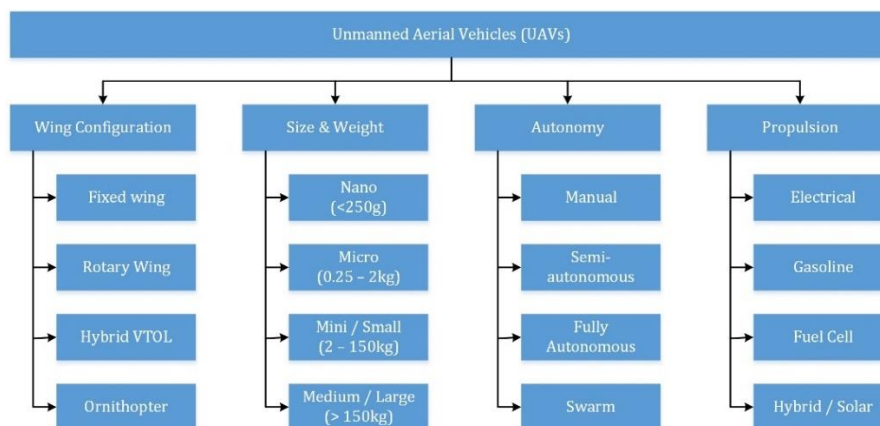


Fig. 1 – UAVs Comprehensive Classification.

## 2.5. Civilian drone application domains

As drone technology advances, these aircraft will become more powerful and sophisticated, allowing for longer flight times and heavier payloads. The industry offers massive opportunities for businesses and is rapidly becoming mainstream. Therefore, it is crucial for organizations to evaluate how drone technology fits into their operations, build the necessary infrastructure, and begin testing their services (Priya and Kamlu, 2022; Moshan *et al.*, 2023; Kale, 2026).

The following categories include main applications currently known, but obviously not limited to these. And as mentioned before, even though the military uses are not analysed here, these may interfere or overlap with some of civilian applications mentioned further.

From the engineering point of view, the most significant category of applications is related to *infrastructure inspection / monitoring*. This includes technical verifications and surveillance of engineering structures such as (but not limited to) power lines, pipelines, buildings, bridges etc. Other professionals may benefit from aerial inspections for real estate or insurance claims, as well as logistics and shipping and delivery services.

*Environment* applications include precision agriculture, to monitor, analyse, and optimize crop and livestock production, soil moisture measurements, as well as wildlife monitoring (Talaieizadeh *et al.*, 2025).

The third category, closely related to previous one, includes *earth science* applications, such as archaeology, geographic mapping for GIS professionals, weather forecast professionals, as well as surveillance of geological phenomena by gas level measurements in known volcanic or tectonic areas (Adade *et al.*, 2023).

Another category relates to *emergency* applications, with some activities overlapping with other categories, such as search and rescue, disaster response / management, humanitarian aid and/or ambulance services.

A special category, that may border military applications and/or overlap with some activities described in previous categories, is law enforcement, or *defence and security*. This includes specific activities related to drug monitoring, port or facility security, traffic surveillance, or infrastructure protection (patrol, monitoring).

A final category includes activities widely spread in civilian communities and which, most probable, influenced the most the development and spread of small-sized UAVs: *entertainment*. Activities for business or leisure included aerial photography / videography, air shows and fireworks replacements, or news media coverage.

### 3. Conclusions

This paper has provided a comprehensive literature review tracking the fundamental characteristics, operational parameters, and diverse classification frameworks of Unmanned Aerial Vehicles (UAVs). By synthesizing data from a wide range of academic, industrial, and regulatory sources, several key insights can be drawn regarding the current state and future of drone technologies.

The literature review demonstrates that no single classification system is sufficient to categorize UAVs. Instead, drones are most effectively organized through a multi-tiered approach based on weight, range, flight altitude, and configuration (fixed-wing, rotary-wing, and hybrid systems). Therefore, basic characteristics of UAVs analysed here, including propulsion, endurance, payload capacity, and autonomy, are no longer treated individually. Advances in battery chemistry (such as solid-state lithium-sulphur variants) and edge-computing AI are simultaneously driving down operational costs while increasing mission capabilities. Also, while fixed-wing UAVs dominate long-range surveillance and rotary-wing craft excel in localized, high-maneuvrability tasks, hybrid Vertical Take-off and Landing (VTOL) systems are rapidly emerging as the optimal solution for bridging the gap between endurance and deployment flexibility.

The standardization of UAV classifications presented in this paper serves as a foundational framework for both regulators and engineers, in understanding the clear thresholds in weight and autonomy for developing harmonized air traffic management systems, as well as mapping of performance characteristics critical bottlenecks in thermal management and communication latency that must be addressed to unlock true beyond visual line-of-sight (BVLOS) operations.

While the aim of this review was to present a baseline of established UAV characteristics, the rapid pace of technological evolution presents inherent limitations. Future research should expand upon this classification framework to more deeply integrate emerging technologies, such as autonomous drone swarms, bio-inspired nano-UAVs, and alternative green propulsion methods.

### REFERENCES

- Adade R., Aibinu A.M., Ekumah B., Asaana J., *Unmanned aerial Vehicle (UAV) applications in coastal zone management - a review*, Environ. Monit. Assess. 193 (2021), <https://doi.org/10.1007/s10661-021-08949-8>.
- Ahmed F., Mohanta J.C., Keshari A., Yadav P.S., *Recent Advances in Unmanned Aerial Vehicles: A Review*, Arab J Sci Eng. 47(7), 7963-7984 (2022), doi: 10.1007/s13369-022-06738-0.
- FAA, *Unmanned Aircraft Operations*, <https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107> (accessed 25 May 2026).

- Hassanalian M., Abdelkefi A., *Classifications, applications, and design challenges of drones: A review*, Progress in Aerospace Sciences, 91, 99-131 (2017), <https://doi.org/10.1016/j.paerosci.2017.04.003>.
- Kahn J.M., Katz R.H., Pister K.S., *Next century challenges: mobile networking for Smart Dust*, in: Proceedings of the 5th annual ACM/IEEE International Conference on Mobile computing and networking, ACM, 1999, 271-278.
- Kale A.A., *Drone Technology and Its Applications*, <http://dx.doi.org/10.2139/ssrn.3922787> (accessed 25 May 2026).
- Mohsan S.A.H., Othman N.Q.H., Li Y., Alsharif M.H., Khan M.A., *Unmanned aerial vehicles (UAVs): Practical aspects, applications, open challenges, security issues, and future trends*, Intell. Serv. Robot., 16, 109-137 (2023).
- Mehmet Tuğrul K., *Drone Technologies and Applications*. In *Drones - Various Applications*, IntechOpen, 2023, <https://doi.org/10.5772/intechopen.1001987>.
- Panagiotopoulos I., Sakellariou L., Hatziefremidis A., *Design, Construction, and Flight Performance of an Electrically Operated Fixed-Wing UAV*, Drones, 8(6), 217 (2024), <https://doi.org/10.3390/drones8060217>.
- Priya P., Kamlu S., *Robust Control Algorithm for Drones*. In *Aeronautics - New Advances*, IntechOpen, 2022, <https://doi.org/10.5772/intechopen.105966>.
- Seidaliyeva U., Ilipbayeva L., Taissariyeva K., Smailov N., Matson E.T., *Advances and Challenges in Drone Detection and Classification Techniques: A State-of-the-Art Review*, Sensors, 24(1), 125 (2024), <https://doi.org/10.3390/s24010125>.
- Stewart M., Martin S., *Unmanned Aerial Vehicles: Fundamentals, Components, Mechanics, And Regulations*. in: *Unmanned Aerial Vehicles*, Ed. Barrera N. Nova Science Publishers, Inc., NY, USA, 2021, ISBN: 978-1-53618-900-1.
- Talaeizadeh A., Sharifi I., Alasty A., Ghatrehsamani S., *Agricultural spraying drones: A comprehensive review*, Smart Agricultural Technology 12, 101519 (2025).
- Wu S., Lv M., Ning Z., Guo S., Chen Y., *Advancements in Energy Management Strategies for Hydrogen Fuel Cell Hybrid UAVs: Towards Intelligent, Sustainable, and Autonomous Flight Systems*, Aerospace, 12(12), 1097 (2025), <https://doi.org/10.3390/aerospace12121097>.
- Zakora O., Molodchick A., *Classification of UAV (Unmanned Aerial Vehicle)*, 2010, [https://read.meil.pw.edu.pl/wp-content/uploads/Program/2010/Abstracts/Student/Abstract\\_Zakora\\_Molodchik.pdf](https://read.meil.pw.edu.pl/wp-content/uploads/Program/2010/Abstracts/Student/Abstract_Zakora_Molodchik.pdf)

## STADIUL ACTUAL PRIVIND TEHNOLOGIILE VEHICULELOR AERIENE FĂRĂ PILOT (UAV)

(Rezumat)

Aeronavele Fără Pilot (UAV – Unmanned Aerial Vehicles), cunoscute în mod obișnuit sub denumirea de drone, au evoluat de la dispozitive militare specializate la instrumente omniprezente în agricultură, logistică, supraveghere și gestionarea dezastrelor. Pe măsură ce tehnologia UAV avansează rapid, stabilirea unui cadru clar pentru înțelegerea capacităților lor diverse devine esențială. Această lucrare prezintă o analiză cuprinzătoare a literaturii de specialitate, menită să sintetizeze conceptele

fundamentale ale UAV-urilor și să stabilească o clasificare standardizată. Autorii examinează caracteristicile tehnice de bază, principiile operaționale și evoluția istorică ce definesc sistemele moderne de drone. În plus, acest studiu categorizează UAV-urile pe baza parametrilor operaționali, inclusiv designul aerodinamic (sisteme cu aripă fixă, cu aripă rotativă și hibride), greutatea, raza de acțiune, altitudinea și nivelurile de autonomie. Prin analiza datelor din cercetarea contemporană, această lucrare oferă un model de referință simplificat pentru clasificare. În cele din urmă, această analiză elimină decalajul dintre mecanica de bază a UAV-urilor și cadrele operaționale complexe, oferind cercetătorilor și profesioniștilor din industrie un ghid fundamental pentru a explora în detaliu dronele și pentru a identifica viitoarele evoluții tehnologice.