UAV Launch Methods

Oleksandr Dobrodomov
ORCID: https://orcid.org/0009-0005-9926-6638
Oles Honchar Dnipro National University, Dnipro, Ukraine

Vladyslav Proroka
ORCID: https://orcid.org/0000-0001-6884-3934
Oles Honchar Dnipro National University, Dnipro, Ukraine

Oleksii Kulyk
ORCID: https://orcid.org/0000-0001-6884-3934
Oles Honchar Dnipro National University, Dnipro, Ukraine

Introduction

This paper will discuss the different methods for launching fixed-wing unmanned aerial vehicle (UAVs) in various conditions such as availability of a runway, accessibility of the launch site, weather conditions (wind, temperature, precipitation). The use of UAVs has become widespread in recent years due to a number of factors, including:

Civilian applications:

– Safety and security: traffic accident analysis, monitoring of large events, criminal tracking, search and rescue operations, emergency response.

– Scientific research: mapping; terrain research for scientific programs in archaeology, geology, biology, and other sciences; Space research; environmental monitoring; anti-poaching and illegal logging; monitoring forest health, fire detection; glacier melt monitoring.

– Logistics and manufacturing: nventory of warehouses, cargo delivery (unmanned airmail).

– Construction: planning and monitoring of construction work, site demarcation, security control, building inspection.

– Agriculture: spraying of fertilizers and plant and soil protection products; obtaining up-to-date and accurate information on the area, relief, soil characteristics of fields, plant and soil condition; inventory of agricultural land; assessment of seedling emergence; yield forecasting; use instead of dogs for grazing.

– Power industry: inspection of power plants, power lines and heating networks.

– Oil and gas sector: obtaining information from hard-to-reach places, surveys of oil infrastructure, leaks and violations, identification of accident

areas and their reduction, detection of unauthorized work

– Military applications: aerial reconnaissance, fire control and targeting, strikes against ground and sea targets, interception of air targets, radio interference, relay of messages and data, delivery of cargo to units.

As can be seen from the above, UAVs play an important role in the modern world and are often irreplaceable. Currently, there is no generally accepted classification of UAVs. They are classified according to various characteristics, such as: use (civilian/military), control system type, flight speed, wing type, takeoff weight, range, altitude, type of powerplant and so on. [1-8]. When choosing a UAV launch method, the mass of the aircraft and the stall speed are of primary importance, that is, the minimum speed at which the aircraft can move stably and the controls will be effective. So you need to use impulse to compare launch methods. In terms of mass, the most structured classification is the NATO classification for combat UAVs, but it is also suitable for civilian aircraft:

Class:

– I - full takeoff weight up to 150 kg;
– II - full takeoff weight up to 600 kg (Hermes 450, Fig. 1);
– III - full takeoff weight over 600 kg(Bayraktar TB2, Fig. 2).

Class I is divided into categories:

– Micro - up to 2 kg (SWITCHBLADE 300 BLOCK 20, Fig. 3);
– Mini - up to 15 kg (RQ-20 Puma Fig. 4.);
– Small - from 15 kg [9] (PD-2, Fig. 5.).

Figure 1 – Hermes 450 [10]

Figure 2 – Bayraktar TB2 [11]

Figure 3 – SWITCHBLADE 300 BLOCK 20 [12]

Figure 4 – RQ-20 Puma [13]

Figure 5 – PD-2 [14]

UAV Launch Methods

The main task of the launch device is to transfer the necessary energy to the aircraft for stable flight, the problem in this case is the storage of this energy in some energy carrier and its rapid release. The classification will be based on the type of energy carrier:

Figure 6 – RQ-20 puma launch [15]

Figure 7 – Bayraktar TB2 taking off a runway [16]

Figure 8 – Bell Eagle Eye [17]

Without a launch device

The simplest launch method is the absence of any additional devices, it is divided into two subtypes:

– Manual launch (fig. 6):

Description: The simplest method, in which a person throws the UAV into the air.

Advantages: simplicity of implementation, low cost, mobility.

Disadvantages: limited takeoff height and speed, dependence on physical fitness and weather conditions, not suitable for UAVs with a large mass.

Application: Used to launch small UAVs in conditions where the use of other methods is impossible or impractical.

– Using a runway (fig. 7):

Description: The UAV accelerates along the runway using its own engine and then takes off.

Advantages: possibility to launch UAVs with a large mass, independence from weather conditions, simplicity of implementation, low cost.

Disadvantages: requires a runway, limited mobility.

Application: Used to launch UAVs with large mass and dimensions

– Vertical takeoff using its own engines (fig. 8):

Advantages: high mobility;

Disadvantages: excess engine power for horizontal flight, which reduces the range;

Application: Used for terrain monitoring in both civilian and military applications.

By catapult

Figure 9 – Elastic launcher with a drone on it [18]

Figure 10 – MAAS 90 started with pneumatic launcher [19]

Figure 11 – F-18 Hornet ready for launch with electromagnetic catapult [20]

The most common method of launching UAVs, it has a number of subclasses depending on the type of energy storage:

– Using the elastic force of tension/compression of structural elements (springs, rubber, or other elastomer). Both muscular force and special tensioners can arm the catapult (fig. 9):

Description: The UAV is accelerated along rails using elastic force and then takes off.

Advantages: simplicity in design and operation.

Disadvantages: limited mobility, under certain weather conditions (high ultraviolet index, low temperatures, etc.), elastic elements can deteriorate.

Application: Used to launch UAVs from ship decks, in confined spaces, and for research purposes.

– Pneumatic launcher (fig. 10):

Description: The UAV is accelerated along rails using compressed gas.

Advantages: relatively simple and inexpensive design, possibility to launch UAVs of various weights, independence from weather conditions.

Disadvantages: limited mobility, noisier than the previous type.

Application: Used for launching UAVs in field conditions, for military purposes.

– Electric and electromagnetic launch (fig. 11):

Description: The UAV is accelerated to the required speed using electrical or electromagnetic means.

Advantages: possibility to launch heavy aircraft, independence from weather conditions

Disadvantages: due to the low density of electrical energy, high-power installations necessary for launch are stationary

Application: Often used on aircraft carrier decks to launch heavy UAVs and aircraft.

USING A CARRIER

This method utilizes an additional manned or unmanned aircraft.

Figure 12 – Blackhawk launches ALTIUS 600 drone [21]

Figure 13 – The XQ-58A Valkyrie demonstrates the separation of the ALTIUS-600 [22]

Figure 14 – Navy balloon drone launch concept [23]

– Using a helicopter or helicopter-type UAV (fig. 12):

Description: The UAV is delivered to the launch site by a helicopter or helicopter-type UAV, and then dropped or detached from it.

Advantages: possibility to launch UAVs in hard-to-reach places, expansion of the UAV's operational radius, possibility to launch UAVs in conditions with a limited runway.

Disadvantages: complexity and high cost of the operation, dependence on the availability of additional resources.

Application: Used for military, rescue, and research purposes, as well as for launching UAVs in remote mountainous, forested, and water areas.

– Using an airplane (fig. 13):

Description: The UAV is transported under the wing or inside an airplane, and then dropped or detached from it.

Advantages: provides maximum operational radius for the UAV,

possibility to launch UAVs in hard-to-reach places, fast delivery of the UAV to the destination.

Disadvantages: complexity and high cost of the operation, dependence on the availability of an airplane, limitations on the mass and dimensions of the UAV.

Application: Used for military, reconnaissance, and research purposes, as well as for launching UAVs in remote regions.

– Using a balloon (fig. 14):

Description: The UAV is lifted into the air by a balloon and then separates from it.

Advantages: provides long flight time for the UAV in the air, possibility to launch UAVs in conditions with a limited runway, low noise level.

Disadvantages: limited altitude and speed of flight, dependence on weather conditions, necessity of having a balloon.

Application: Used for scientific research, environmental monitoring, and signal relaying.

USING CHEMICAL REACTIONS

Figure 15 – Shahed-136 rocket launch [24]

Figure 16 – V1 launch site with hydrogen peroxide gas generator [25]

Figure 17 – Switchblade 300 drone launches with a mortar [26]

– Using a launch booster (fig. 15):

Description: The UAV is launched with a rocket booster.

Advantages: provides maximum launch altitude and speed, high mobility, possibility of simultaneous launch of a large number of UAVs

Disadvantages: complexity and high cost of the operation, noise

Application: Used for scientific research and military purposes.

– Launch with a chemical gas generator (fig. 16, 17):

Description: Launch of the UAV based on the principle of an overcaliber projectile or a mortar.

Advantages: high mobility

Disadvantages: complexity of the launcher

Application: Used for launching small UAVs. Also used during World War II for launching V-1 cruise missiles from a stationary launcher.

USING COMBINED METHODS

Advantages: expands the possibilities of UAV application.

Disadvantages: complexity of implementation, increased cost.

Application: Used to solve complex tasks that require maximum flexibility and versatility from the UAV.

RESULTS

Based on the results of the conducted research, a flowchart for selecting the method of UAV launch was proposed, depending on the requirements and operating conditions.

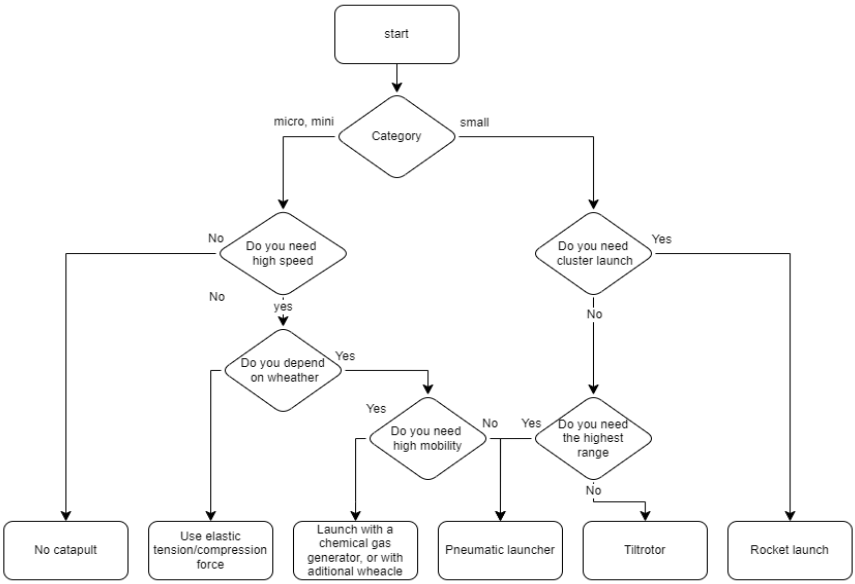

Figure 17 – Methodology for choosing UAV I class launch type

The flowcharts (fig. 17, 18) provides a step-by-step decision-making process for selecting the most suitable launch method for a given UAV, considering factors such as UAV size, speed requirements, weather

dependence, mobility needs, and range requirements. This flowcharts focuses on UAV size (micro, mini, small, large) and speed requirements (high speed or not) to determine the launch method.

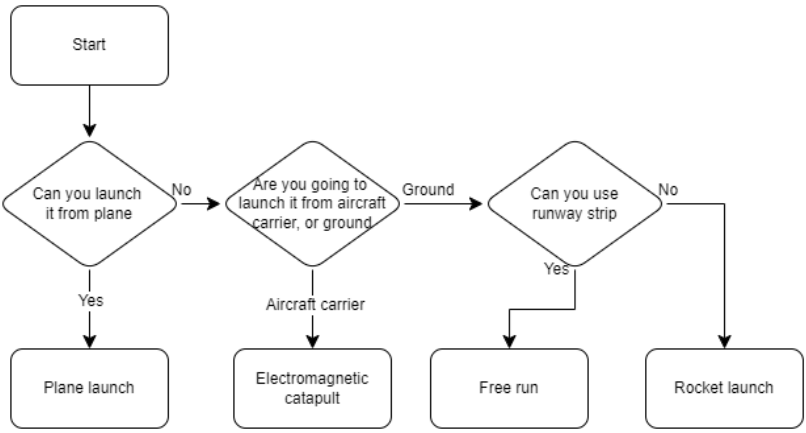

Figure 18 – Methodology for choosing UAV II, III class launch type

*The provided classification is not rigid due to the variability of UAV classification and can be slightly adjusted based on requirements.

Overall, these flowcharts provide a simplified decision-making process for selecting UAV and airplane launch methods based on key factors like size, speed, weather dependence, mobility, range, runway compatibility, and carrier availability.

Conclusion

Several factors determine the optimal UAV launch method, such as:

– Type of UAV: mass, dimensions, engine type

– Flight requirements: altitude, speed, duration

– Terrain conditions: availability of a runway, accessibility of the launch site

– Weather conditions: wind, temperature, precipitation

– Budget: cost of equipment and operation

The choice of UAV launch method is an important task that affects the safety, efficiency, and functionality of the tasks to be performed. As UAVs are a new field of technology, new ways of launching them will emerge and existing ones will be significantly modified.

References

1. Курепін, В. М. (2020). Безпілотні літальні апарати як інструмент сучасного землеробства.

2. Книш, Б. П., & Алєксєєв, М. А. (2020). Безпілотні літальні апарати та відеоаналітика (Doctoral dissertation, ВНТУ).

3. Комаров, Д. Безпілотні літальні апарати та їх використання. Організаційний комітет, 47.

4. Логачов, М. Г. (2023). Кібератаки на безпілотні літальні апарати: класифікація та уразливості.

5. Медведєв, В. К., Коренівська, І. С., Хажанець, Ю. А., & Салов, А. О. (2023). Безпілотні літальні апарати та їхній вплив на перебіг російсько-української війни. Наука і оборона, (2), 52-59.

6. Запорожець, А. О. (2020). Безпілотні літальні апарати для систем моніторингу в енергетиці та екології (Doctoral dissertation, Інститут проблем моделювання в енергетиці ім. ГЄ Пухова НАН України).

7. PS, R., & Jeyan, M. L. (2020). Mini Unmanned Aerial Systems (UAV)-A Review of the Parameters for Classification of a Mini UAV. International Journal of Aviation, Aeronautics, and Aerospace, 7(3), 5.

8. Szóstak, M., & Nowobilski, T. (2022). Application of unmanned aerial vehicles in construction industry. Transportation overview – przeglad komunikacyjny, 38-45. https://doi.org/10.35117/a_eng_22_02_03_05

9. Allied joint doctrine for air and space operations, NATO STANDARD (2016).

10. Hermes™ 450. https://elbitsystems.com/. https://elbitsystems.com/product/hermes-450/

11. Брюховецкая, Е. (2024, 24 березня). В Турции совершил первый полет новый прототип Bayraktar. novyny.live. https://segodnya.novyny.live/ru/u-turechchini-zdiisniv-pershii-polit-novii-prototip-bayraktar-161343.html

12. Switchblade® 300 loitering munition systems | tactical missile systems | suicide drone | kamikaze drone | aerovironment, inc. AeroVironment, Inc. https://www.avinc.com/lms/switchblade

13. Puma™ LE UAS (UAV) - group 2 UAS capabilities in a group 1 footprint | unmanned air vehicles | aerovironment, inc. AeroVironment, Inc. https://www.avinc.com/uas/puma-le

14. Unmanned system PD-2. Home - SPETSTECHNOEXPORT. https://spetstechnoexport.com/product/pd-2

15. ФОКУС, Р. (2022, 24 жовтня). ВСУ получат 11 комплексов PUMA-LE стоимостью 540 млн грн: Что известно о БПЛА. ФОКУС. https://focus.ua/digital/534239-vsu-poluchat-11-kompleksov-puma-le-

stoimostyu-540-mln-grn-chto-izvestno-o-bpla

16. Брюховецкая, Е. (2024, 24 березня). В Турции совершил первый полет новый прототип Bayraktar. novyny.live. https://segodnya.novyny.live/ru/u-turechchini-zdiisniv-pershii-polit-novii-prototip-bayraktar-161343.html

17. Kazior, W. A. (2013, 25 липня). | Bell Eagle Eye HV-911 | United States - US Coast Guard (USCG) | W.A. Kazior | JetPhotos. JetPhotos. https://www.jetphotos.com/photo/7639370

18. ElevonX Scorpion - ElevonX | Professional UAV solutions. ElevonX | Professional UAV solutions. https://www.elevonx.com/solutions/elevonx-scorpion/

19. SUAS pneumatic launcher - UAV solutions store. UAV Solutions Store. https://uav-solutions.com/accessories/rdpl/

20. Electromagnetic aircraft launch system (EMALS). NAVAIR. https://www.navair.navy.mil/product/Electromagnetic-Aircraft-Launch-System-EMALS

21. Mizokami, K. (2020, 21 травня). Black hawk helicopters can now launch drones from midair. Popular Mechanics. https://www.popularmechanics.com/military/weapons/a32617628/black-hawk-drones/

22. Valkyrie drone launches even smaller drone from inside payload bay. Defense News. https://www.defensenews.com/air/2021/04/05/the-valkyrie-drone-launches-an-even-smaller-drone-from-inside-its-payload-bay/

23. Drummond, K. (2012, 6 січня). Navy balloon launches drone, which drops two more spy bots. WIRED. https://www.wired.com/2012/01/balloon-drones/

24. Китай працює над своєю копією Shahed-136, тільки з реактивним двигуном. (2023, 26 липня). DEFENSE EXPRESS. https://defence-ua.com/news/kitaj_pratsjuje_nad_svojeju_kopijeju_shahed_136_tilki_z_reaktivnim_dvigunom-12331.html

25. V1 launch site. Nevington War Museum. https://www.nevingtonwarmuseum.com/v1-launch-site.html

26. Atherton, K. D. Everything to know about Switchblades, the attack drones the US gave Ukraine. Popular Science. https://www.popsci.com/technology/switchblade-drones-explained/