

## ELECTRONIC COMPONENTS SELECTION FOR THE PROTOTYPE OF A 3D PRINTED MEDICAL DRONE

**Abstract:** The intention of this paper is to present the process of selection for all electronic components required for the autonomous flight of a prototyped 3D medical drone. The overarching objective of this initiative is to identify components that satisfy the criteria of performance and cost-effectiveness, thereby providing a sustainable and economical solution for medical units to facilitate the transportation of consumables in remote regions.

**Key words:** 3D printing; Drone design; Additive manufacturing; Medical delivery system; Autonomous flight; Component selection.

### 1. INTRODUCTION

In the medical sector, three companies- Zipline, Swoop Aero, and Matternet- have established a foothold as leading entities in the domain of drone utilization for medical transportation. However, extant solutions have been shown to have several deficiencies, including elevated acquisition and operating costs, the utilization of parachute-based payload delivery mechanisms, which can result in the potential compromise of the package's contents upon impact with the ground, constrained carrying capacity, and the necessity of a fixed take-off and landing location.

Consequently, this study will methodically navigate the selection of primary components to ensure the autonomy of flight, thereby facilitating a precise and controlled landing. This approach is designed to mitigate the risks associated with conventional delivery methods, eliminate the necessity for fixed take-off and landing sites, and reduce the maintenance costs of electric components.

The decision to undertake the theoretical component of the computation, in addition to the selection of components for a small-scale prototype, was driven by time and cost constraints. However, these actions sufficed to demonstrate the feasibility of the proposed concept and the compatibility of all elements constituting the operational core of the entire system.

### 2. THE GENERAL MODE OF OPERATION OF A DRONE

The operation of a drone flight system is predicated on the precise control of its movements in space, facilitated by three axes of rotation: the X-axis (pitch), the Y-axis (roll), and the Z-axis (yaw). These axes permit the manipulation of the drone's direction and stability, while the motors regulate the speed and direction of travel. The X-axis, which governs the drone's vertical movement, i.e. its forward and backward tilting, is achieved by adjusting the speeds of the front and rear motors. The Y-axis governs the lateral movement, i.e. left-right tilt, by modifying the speeds of the lateral motors, while the Z-axis exerts an influence on the drone's vertical axis rotation by generating a torque through the differentiation

of speeds between the opposing motors, thereby enabling the drone to rotate around this axis. [1]

The drone's behaviour is impacted by fundamental forces, including the lift force generated by the propeller, which counteracts the weight due to gravity, enabling sustained flight; the thrust force produced by the motors, which steers the drone in the desired direction; and the drag force, represented by the resistance that opposes movement, which reduces the drone's speed and influences flight stability [1].

The visual representation of these elements is provided in Figure 1.

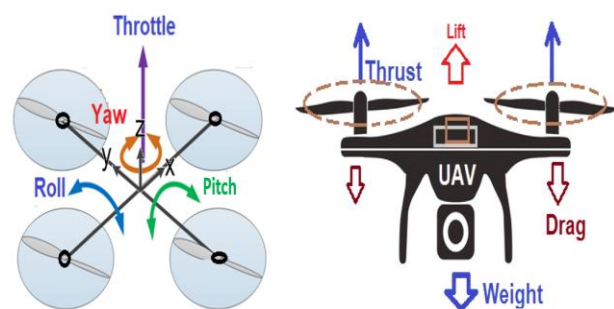


Figure 1. Forces acting on the dynamic assembly[1]

#### 2.1 Determining configuration and performance requirements

The starting point of the prototype was determined by the need to validate the feasibility of the proposed concept, as well as the compatibility between components. The starting condition was that the drone should be able to carry a maximum payload of 25 kg, fully equipped, in order to meet the current limitations on the payload carried.

Taking this constraint into account, the sizing of the model was carried out at a scale of 1:2, resulting in a total weight of 3,125 kg for the prototype. Thus to optimize stability and performance under varying conditions, a quadcopter configuration was chosen. This will allow for a balanced distribution of forces due to the four engines, ensuring precise manoeuvrability and stable control, even in windy or difficult environments.

Table 1

Proposed performance requirements for the prototype	
Performance requirements	
Maximum takeoff weight	3,125 kg
Payload	≅ 0,5 kg
Flight autonomy	5-10 minutes
Maximum speed	5,5 m/s
Operational radius	1000 m
Durability	It is imperative that operation is maintained throughout the testing process
Operating temperatures	- 10 °C to +40 °C
Safety fetures	Automatic return function in case of signal loss

Thus, the evaluation of the prototype to validate its theoretical feasibility will be based on the performance requirements presented in Table 1.

### 3. SELECTION OF THE PROPULSION SYSTEM

To comprehend the significance of this selection process, it is important to grasp the function of a drone's propulsion system. This system can be characterised as a series of components that facilitate the conversion of electrical energy from a power source into mechanical energy, thereby enabling the vehicle to move through the airspace.

Components that constitute the propulsion system include motors, speed controllers, a power distribution board, a battery, and propellers.[2]

#### 3.1 Drone motors

In the process of motors selection, emphasis will be placed on a number of characteristics such as motor type, Kv ratio, motor size and motor motion.

From a typological point of view, the motors used for the construction of drones are divided into two categories: brush motors and brushless motors.

Brush motors operate by applying electrical energy to the rotor brushes, which will generate a magnetic field that

interacts with the magnetic field of the stator, resulting in a rotary motion. The direction of current through the commutator is switched by the brushes, ensuring continuous rotation. [3]

At the opposite end of the spectrum, brushless motors employ an electrical control mechanism, superseding the conventional mechanical system, to regulate the motor's rotation.

The electronic controller supplies power to the stator coils in a predetermined sequence, thereby generating a rotating magnetic field that interacts with the permanent magnets of the rotor, inducing rotational movement. Furthermore, the electronic controller functions as a permanent regulator of the energy supplied to the coils, thereby ensuring a consistent and uninterrupted rotation of the rotor without any fluctuations in speed.[3]

The two motor types and their respective components are illustrated in Figure 2, while Table 2 will present additional characteristics of the two motor types.

Table 2

Characteristics of brush and brushless motors

Features	Brush motor	Brushless motor
Switching mode	Mechanic	Electric
Lifespan	≈ 3000 hours	>10000 hours
Failure mode	Wear of the brush	Wear of the bearing
Electrical noise	The primary factor is identified as the occurrence of contact between the motor brushes and the armature bars.	-
Maximum number of rotations per minute	≈ 5000 rpm	>10000 rpm
Eficiență	≈ 50-60%	≈ 80-90%
Cost	Low	High

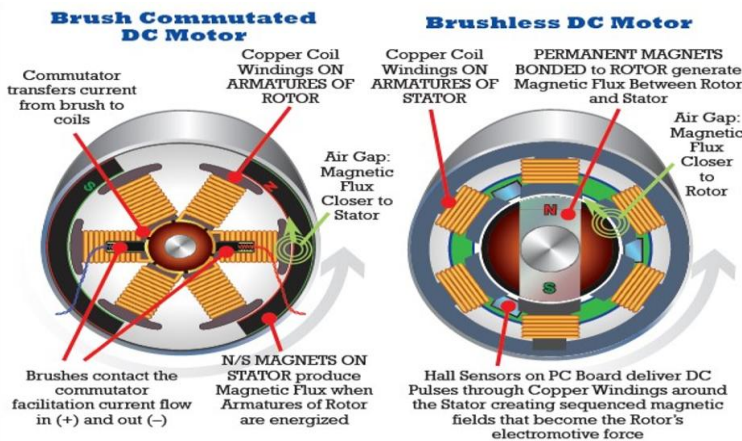


Figure 2. Types of drone engines [3]

From a technical standpoint, the propeller-motor assembly is responsible for generating the thrust force, thereby enabling the drone to both lift and maintain its position in the air, in addition to moving in various directions. This force must be sufficiently large to counterbalance the total weight of the drone, whilst also ensuring adequate manoeuvrability. To meet these requirements, it is generally recommended to select a minimum 2:1 thrust-to-weight ratio.[4]

The thrust force equation can be expressed as follows:

$$T = C_T \cdot \rho \cdot A \cdot v^2 \quad (1)$$

where:  $T$ = Traction force,  $\rho$ = Air density,  $v^2$ =Propeller speed,  $C_T$ =Traction coefficient,  $A$ =Propeller disc area.

In the subsequent analysis, the ratio  $K_v$  will be considered as a significant parameter. This ratio is an indicator of the speed that a motor can attain per applied voltage. To elaborate, it quantifies the number of revolutions per minute that a rotor can produce for each volt applied to its terminals [5]. The expression for this ratio is as follows:

$$K_v = \frac{RPM}{Voltage (V)} \left[ \frac{RPM}{V} \right] \quad (2)$$

It can be stated that the  $K_v$  value will determine a balance between rpm and torque, thus influencing the performance of the drone. Engines with a  $K_v$  ratio  $>1500$  will provide higher RPMs, but do not excel when combined with larger propellers or for heavy lifting. In contrast, motors with a  $K_v$  value between 50-1500 will generate much higher torque and are suitable for use with larger propellers and for carrying heavy loads.[5]

The size of the motor will be marked on the motor as a four-digit code (XXYY), where XX is the stator diameter and YY is the stator height. It is evident that larger motors are optimised for handling heavy loads and long flights, providing superior thrust and increased efficiency. Conversely, smaller motors will provide a higher rpm efficiency and are suitable for speed applications. [5]

Thus, based on the analysis of the different configurations, Table 3 has been developed as a guideline for motor selection.

Table 3

Information table for engine selection

Diagonal wheelbase	Propeller Size	Engine size	$K_v$ ratio
150 mm >	3 inch >	1105-1306 >	3000 $K_v$ <
180 mm	4 inch	1806-2204	2600-3000 $K_v$
210 mm	5 inch	2204-2208, 2305/2306	2300-2600 $K_v$
250 mm	6 inch	2206-2208, 2306	2000-2300 $K_v$
350 mm	7 inch	2506-2508	1600 $K_v$
450 mm <	8-10 inch	26YY >	1000 $K_v$ >

In conclusion, the selection of the motor to be used for the validation prototype is the Readytosky 2812 900  $K_v$  motor. This motor is the best solution for the validation prototype due to its efficiency, which ensures a balance between power output and energy conservation, which is essential for long duration missions. Its compatibility with propellers ranging from 7 to 9 inches allows for optimal thrust generation, and its robust construction will guarantee durability and reliability.

### 3.2 Electronic speed controllers

The electronic speed controller plays a pivotal role in regulating and adjusting the motor's speed in response to a signal from the flight controller. This enables the motor voltage to be modulated, either increased or decreased,

thereby facilitating precise control over the motor's performance. In selecting this component, the nominal current and the nominal voltage are critical factors that must be considered.

In the 4-in-1 group configuration (Figure 3), regulators are integrated within a singular module, offering several advantages, including simplified wiring, reduced weight and space saving, making it ideal for applications requiring high performance and efficiency. However, a significant disadvantage is that a failure in a single regulator can affect the entire system. Additionally, due to the compact design, customisation options are considerably limited, constraining the specific adjustments required depending on the nature of the application.[6]

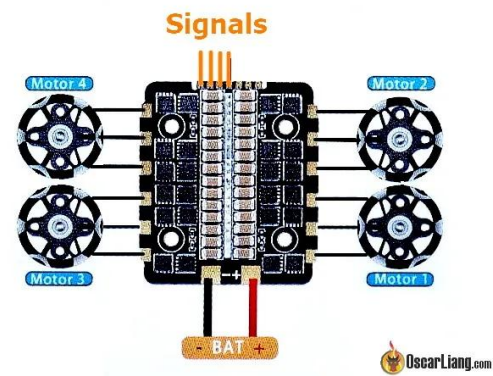


Figure 3. 4in1 Speed Controller [6]

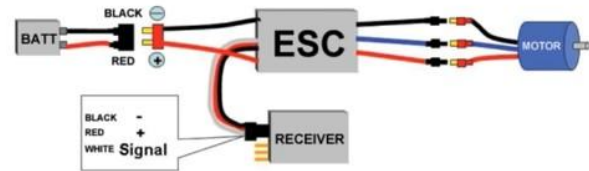


Figure 4. Individual Speed Controller [8]

In contrast, individual electronic speed controllers (Figure 4) offer greater flexibility in terms of application configuration. They also have very good management of heat dissipation during operation, which makes them useful for applications with an emphasis on redundancy and carrying capacity. However, their design can introduce a level of complexity in the wiring and can contribute to the overall weight of the drone.[6][7]

In the subsequent section, the most salient characteristics to be considered are the rated current and voltage. The rated current (Figure 5) is measured in amperes (A) and denotes the maximum value that a speed controller can withstand without overheating or damage. It is therefore imperative that the selection is made after the motor has been chosen, given that the motor consumes a constant current during rotary motion. If the regulator is required to withstand a current higher than the permissible limit, there is a risk of overheating or failure. It is therefore vital that the rated current is 10-20 percent higher than the maximum current drawn by the motor at maximum throttle, in order to ensure system reliability.[7]



**Figure 5.** Identifying the rated current on the speed controller [7]

In addition to the amperage, speed controllers are characterised by a maximum voltage level that they are able to withstand. This is generally specified by the number of battery cells (1S-6S), corresponding to the maximum voltage delivered from the power supply. It is essential that the rated voltage of the speed controller is compatible with or exceeds the voltage of the battery used (Figure 6). [7]



**Figure 6.** Identifying the rated voltage on the speed controller [7]

Based on the information provided, both in terms of component selection and after analysing the data sheet of the Readytosky 2812 900 Kv motor, which indicates that it will require a current of approximately 50 A at maximum throttle, it was decided to use a HobbyWing Skywalker 60A individual speed controller. This is a strategic choice given its ability to improve the performance and reliability of the drone under study. In addition, the flexibility offered by the support for various battery configurations will allow the system to be adapted to varying operational requirements. In addition, its design will allow efficient heat distribution, ensuring that the engine operates within safe temperature limits. In terms of performance-cost ratio, compared to other variants on the market, the controllers in this range offer the right balance between the two.

### 3.3. Power distribution board

The power distribution board plays a pivotal role in connecting all speed controllers to the power supply. Its selection is determined by the rated current, which is sized to withstand a total current per terminal 10-20% higher than the total current consumption of the regulator. This ensures safety and optimises performance. Additionally, the voltage rating of the plate must be compatible with the battery voltage used. In the event of the board being supplied with pre-assembled connectors, these must be compatible with those of the battery and speed controllers in order to prevent wiring errors. Furthermore, the size and weight of the board must be reduced so as not to affect the drone's performance, thus ensuring a balance between

functionality and compactness. The selection of the power distribution board will consider both the technical selection criteria outlined above and the characteristics of the motors and speed controllers chosen. [9]

In this context, the MATEKconsiderHUB-12S (Figure 7) is identified as the optimal solution due to its excellent performance and compatibility with the selected systems. The board can support input voltages up to 70 A per terminal, making it suitable for high current requirements. It can provide support for a DC current of 280 A and 440 A in bursts, ensuring reliable operation even under high load conditions.

The efficient power distribution will also enable optimal power supply to critical components such as the flight controller, providing a robust, reliable and efficient solution suitable for systems requiring stable and long-term operation.



**Figure 7.** MATEKSYS XCLASS PDB FCHUB-12S [10]

### 3.4. Battery selection

The selection of an appropriate battery is of paramount importance when optimising performance and flight endurance parameters. A comprehensive evaluation of factors such as gauge dimensions, weight, voltage and capacity rating, discharge rate, and connector type is necessary to ensure both safety and optimal performance of the drone. The physical dimensions of the battery must be compatible with the designated battery compartment to avoid physical incompatibility or inadequate power. Furthermore, an increase in battery size will result in an increase in the overall weight of the drone, which will have a detrimental effect on performance and reduce flight stability by exceeding the maximum allowable take-off weight.

The energy storage capacity of the battery, expressed in milliampere-hours (mAh), will directly influence the flight duration. Thus, a higher capacity will allow an extended flight time, which is essential for long missions.[4]

Flight time, T, is calculated by dividing the battery capacity by the current consumption, according to the equation:

$$T = \frac{\text{Battery capacity}}{\text{Current consumption}} \cdot 60 \text{ [min]} \quad (3)$$

The nominal battery voltage exerts an influence on the power delivered to the motor. Consequently, an increase in voltage results in an increase in both power and weight. It is essential to check its compatibility with the motor specifications and ensure its compatibility with the cell count and voltage range.[4]

The battery discharge rate (C) indicates the maximum rate at which energy can be discharged without causing damage to the battery. A higher discharge rate will improve the performance of the motor, allowing it to reach maximum power ( $C_{max}$ ) in a short time.[4]

$$C_{max} = \frac{\text{Battery capacity} \cdot C}{100} [A] \quad (4)$$

A final critical factor in the selection of a battery is the type of connector, which must be compatible with the system's requirements and ensure an efficient power supply. For this purpose, the most popular connector typologies used in the design of a drone have been indexed in Table 4.[11]

Table 4

Types of battery connectors

Connector type	Maximum withstand current	Applicability
XT30	30 A	Drones of a compact nature that exhibit minimal energy requirements
XT60	60 A	Drones of a medium size, characterised by a power-to-weight ratio that must be taken into account.
XT90	90 A	Drones of a considerable size, which require substantial power.
EC3	60 A	Small and medium radio-controlled models.
EC5	120 A continuous, 150 A burst	High performance systems
EC8	>150 A	Large aircraft or electric vehicles

Following the selection of the essential components within the propulsion system, the power supply will be facilitated by an HRB 6S 5000 mAh LiPo HRB 6S 5000 mAh LiPo battery with XT90 connector. This will provide an optimally balanced capacity and voltage of 22.2 V, which is compatible with the chosen configuration. Its capacity of 5000 mAh will provide a flight time of approximately 13 minutes, which is sufficient for testing and to allow a balance between flight time and weight. The use of an XT90 connector will ensure safe operation and easy integration. The dimensions and weight of the battery are also noteworthy: measuring 155 x 48 x 46 mm and weighing approximately 725 g, it helps to maintain flight stability and manoeuvrability. From a cost perspective, this type of battery offers a high-performance solution at a competitive price.

### 3.4 Propeller selection

The selection of propeller sizes for unmanned aerial vehicles (UAVs) is determined by the dimensions of the drone's frame, as larger diameters yield higher thrust, though this is accompanied by an increase in power consumption. The propeller pitch, which is the distance from the propeller's centre to its blade tips, influences both speed and control. A larger pitch is optimal for speed applications, while a smaller pitch provides enhanced stability during manoeuvres. In terms of propeller type, classic 2-bladed propellers offer general efficiency and are suitable for all types of applications, while 3-bladed propellers will provide additional stability, especially in adverse weather conditions.

From a technical perspective, the selection of suitable propellers for the proposed configuration will utilise a 9045 type dual propeller with a 9 inch diameter and 4.5 pitch, as recommended by the supplier. The rationale behind this selection is that it strikes an optimal balance between energy efficiency and thrust, while concurrently maintaining moderate fuel consumption, a prerequisite for maximising flight times.

## 4. SELECTION OF ELECTRONIC COMPONENTS

In this section, a comprehensive examination will be conducted to establish a robust foundation for the drone's entire operational system, encompassing the flight controller, power module, GPS module, telemetry system, and the receiver and transmitter.

### 4.1 Flight controller

The selection of a flight controller is of paramount importance for responsiveness, flight stability and compatibility with other components. Key selection parameters include processor performance, which impacts reaction time, with H7 being the fastest and L0 the slowest. Additionally, high-quality sensors (gyroscopes, accelerometers) are essential for accurate data acquisition, ensuring stable flight and efficient manoeuvrability. The quality of these sensors directly affects the drone's ability to maintain altitude and position.

The integration of GPS functionality is a further consideration, with the physical dimensions of the flight controller matching those of the frame. Small controllers are ideal for compact constructions, while larger controllers are required for more complex configurations.[12]

Table 5

Classification of flight controllers

NAZE32	Type: Classic
	Processor: F1
	Features: The device is characterised by its rudimentary stabilisation capabilities and restricted functionality.
	RAM memory: 64 KB
	Maximum frequency: 72 MHz
	Dimensions: 36x36 mm
	Weight: 10 g
	Cost: Low

KISS FC	Type: Clasic
	Processor: F4
	Features: The configuration process is straightforward and the OSD is integrated.
	RAM memory: 32 KB
	Maximum frequency: 30 MHz
	Dimensions: 30.5 x 30.5 mm
	Weight: 20 g
	Cost: Medium
PIXHAWK 2.4.8	Type: Autonom
	Processor: STM32427 Cortex-M4
	Features: The functionality of advanced GPS telemetry and navigation mode
	RAM memory: 256 KB
	Maximum frequency: 168 MHz
	Dimensions: 80 x 48 x 15 mm
	Weight: 40 g
	Cost: High
Kakute F7	Type: Autonom
	Processor: F7
	Features: Compatibility of Betaflight with integrated OSD
	RAM memory: 128 KB
	Maximum frequency: 216 MHz
	Dimensions: 35 x 41 x 7 mm
	Weight: ~35 g
	Cost: Medium

Table 5 provides a comparison of the most popular existing controllers. It includes both classical controllers that require the manual input of the operating code and more advanced ones that allow autonomous flight.

As demonstrated in Table 5, the Pixhawk 2.4.8 flight controller emerges as the optimal selection. This controller is equipped with a 32-bit STM32427 Cortex-M4 Cortex-M4 core, which ensures superior processing capability, thereby facilitating efficient and precise flight operations. Additionally, its extensive compatibility with diverse connector interfaces enhances its integration potential with a wide range of peripherals and sensors. Furthermore, the incorporation of a built-in fail-safe co-processor, alongside inputs for dual power supply, ensures operational continuity in the event of a failure.

A notable feature is the capacity for autonomous operation and compatibility with the MissionPlanner platform, which facilitates the direct transmission of mission coordinates to the controller, thereby eliminating the requirement for manual coding.

#### 4.2 Power module

In selecting a power supply module, it is essential to consider several technical characteristics that ensure

optimal performance and reliability. The input voltage is the primary consideration, as it determines the compatibility of the module with the battery. The maximum current capability is also important to ensure the module can manage power with the rest of the components. Furthermore, the ability to provide a stable output voltage required to power the flight controller or other peripherals is crucial.

In addition to the previously mentioned aspects, the compatibility of the battery type and the battery pack type is imperative in order to facilitate the installation process, enhance safety measures, and ensure a reliable connection. Furthermore, meticulous attention will be allocated to the type of connector, weight, and integration options within the system to avoid any compromise to system performance.

The Power Module PRO 2S-12S with XT90 connector will be utilised for the purpose of ensuring compatibility between the battery and the power distribution board, with the additional DC BEC connector providing additional flexibility by powering critical electronic components such as the flight controller, thereby minimising the risk of component failure.

#### 4.3 GPS module

The selection of a GPS module in a stand-alone system necessitates meticulous evaluation due to its impact on the accuracy of the system. The accuracy of a GPS module is a pivotal selection criteria, as it determines the module's capacity to provide precise location data. Standard modules offer an accuracy range of 1 to 5 metres, while real-time kinematic systems can achieve centimetric accuracies.[13]

To support this data accuracy, a large number of channels (10<) is favourable, as it will allow connection to the satellite system, increasing data reliability and accuracy. In addition, an increased update rate (5 Hz<) will contribute to smooth navigation, which is important in dynamic flight situations where rapid heading changes will require constant and accurate data.[13]

Furthermore, the GPS modules' sensitivity, measured by their capacity to receive signals below -160 dBm, ensures performance in environments with weak signals, such as urban areas. To optimise performance, the placement of the antenna, which significantly impacts data reception, should be carefully considered, ensuring it is positioned away from any electronic interfaces that could compromise signal reception.[13]

To obtain a comprehensive overview of the performance of the GPS modules, the most popular modules have been proposed in Table 6 for analysis together with a set of technical characteristics. This will allow a selection to be made of a suitable module for the drone under study.

Table 6

GPS Modules	
GPS M8N Module	Dimensions: 25 x 25 mm
	Refresh rate : 1-10 Hz
	Bandwidth: 9600-115200 bps
	Navigational sensitivity: -165 dBm
	Power needed: 3,3 – 5 V
Number of channels: 66 + 22 for tracking	

NEO 6M	Low-temperature start-up time : <30 s
	High-temperature start-up time: < 1 s
	Dimensions: 23 x 30 mm
	Refresh rate: 1-5 Hz
	Bandwidth: 9600- 230400 bps
	Navigational sensitivity: -161 dBm
	Alimentare necesară 3– 5 V
	Number of channels: 50 + 22 for tracking
	Low-temperature start-up time : ~27 s
	High-temperature start-up time: ~ 1 s
GPS Grove Module	Dimensions: 40 x 20 x 10 mm
	Refresh rate: 1-10 Hz
	Bandwidth: 9600- 115200 bps
	Sensibilitatea navigației: -160 dBm
	Alimentare necesară 3,3 – 5 V
	Number of channels: 66 + 22 for tracking
	Low-temperature start-up time : ~13 s
High-temperature start-up time: <1 s	

As demonstrated in Table 6, the utilisation of the M8N GPS module is proposed as the optimal choice, primarily due to its capacity to ensure operational accuracy and reliability. Notable features include a 2.5 m position error, a compact design that facilitates seamless integration and offers low power consumption, thereby extending flight time. Additionally, its compatibility with Pixhawk and Ardupilot ensures uncomplicated integration and efficient communication, facilitating seamless data exchange. The GPS module's cost-effectiveness is further enhanced by its built-in compass, which improves navigation capability.

**4.4 Telemetry module**

The telemetry system is indispensable for ensuring reliable real-time communication between the drone and the ground control station. In selecting a telemetry system, several factors must be given full consideration to ensure optimal performance. The selection of frequency and bandwidth is fundamental, with the former determining the communication channel used and the latter representing the capacity to transmit the information volume.

Ensuring compatibility with both the flight controller and the ground control station is paramount to facilitate effective real-time data transfer, which is essential for real-time monitoring and control.

Following a thorough market analysis, the FPV radio telemetry kit emerges as a cost-effective solution, ideal for users with limited financial resources and for experimental projects. A key benefit of this kit is its dual functionality, which serves as both a telemetry and a control link. This feature simplifies the installation process and reduces the necessity for additional equipment. Furthermore, the utilisation of standardised UART and TTL connection interfaces ensures seamless integration with most flight computers and control stations, enhancing its versatility and ease of use.

**4.5 Receiver and transmitter**

In the final stage of the component selection process, the selection of the receiver and transmitter is significant, with reliability being a fundamental consideration. About

the selection of the receiving device, its compatibility is a primary criterion, given the necessity to align the receiver with the transmitter protocol. Additionally, the number of channels has a direct impact on the receiver's capacity to manage multiple commands. Consequently, many channels enable the integration of supplementary functions, such as GPS navigation.

The range of the drone is another crucial factor, as it directly impacts the operational distance. The presence of an auto-righting function is also a crucial consideration, as it ensures the safe return of the drone in the event of signal loss. With regard to the transmitter, its compatibility with the receiver in terms of frequency, protocol and number of channels is essential.

Finally, when selecting the receiver and transmitter, it is essential to consider factors such as compatibility, range, number of channels, safety and ergonomic features. It is therefore concluded that the FlySky FD-i6X transmitter (Table 7) in combination with the IA10B receiver (Table 8) will represent a reliable and cost-effective choice for the purpose of the studied application, offering a balance between functionality and performance. Due to the appropriate features and affordability, this system will provide an excellent connection for the prototype test conditions.

Table 7

Features of the transmitter	
FlySky FD-i6X transmitter	Frequency: 2.4 GHz
	Protocol: AFHDS 2A
	Number of channels: 6-10
	Fail-safe: YES
	Weight: 19.3 g
	Built-in telemetry: NO

Table 8

Features of the receiver	
IA10B Receiver	Protocol: AFHDS 2A
	Operating distance: 1km
	Number of channels: 10
	Output power: < 20 dBm
	Ergonomics: Good

**7. CONCLUSIONS**

In conclusion, it can be stated that the proposed objectives have been adequately achieved, given the rigorous selection of all components, each of which contributes significantly to the realization of optimal system operation. The compatibility and theoretical feasibility of the proposed concept are ensured by the interaction of the Readytosky 1812 900 Kv motor with the Skywalker 60 A speed controller and the other components, which together will guarantee a constant and efficient performance.

However, experimental tests are required to validate the system's real-world feasibility. These tests should be conducted under conditions that emulate real-use

scenarios, allowing for the evaluation of the system's performance, stability, and reliability in various situations. The validation of the proposed concept's practical implementation is contingent upon the successful completion of these experimental tests, which should substantiate the accuracy and efficiency of the theoretical estimations.

Finally, the report has been written to emphasise the importance of compatibility between the various systems that make up a drone, highlighting the complexity of the interdependence of all the components that contribute to its optimal functioning. Through this work, the aim was to delve deeper into what a drone system really entails, beyond the superficial aspects, and to explore in detail the essential technical interactions underlying this type of aerial vehicle.

## REFERENCES

- [1] CFD FLOW ENGINEERING, *Working Principle and Components of Drone*, available at: <https://cfdflowengineering.com/working-principle-and-components-of-drone/> Accessed: 2024-12-10
- [2] PLETTENBERG MOTORS.(2023).*How to select the ideal propulsion system for an Unmanned Aerial Vehicle*), available at: <https://plettenbergmotors.com/how-to-select-the-ideal-propulsion-system-for-an-unmanned-aerial-vehicle/> Accessed: 2024-12-10
- [3] AMETEK.(2023). *What is the Difference Between a Brush and a Brushless Motor?*, available at: <https://www.haydonkerkittman.com/learningzone/blog/2023/august/what-is-the-difference-between-a-brush-and-a-brushless-motor#:~:text=With%20brush%20motors%2C%20the%20stationary,field%20is%20the%20permanent%20magnet.> Accessed: 2025-01-06
- [4] Utsav Singh, *Understanding Torque and Thrust in Drone Motor*, available at: <https://mechtex.com/blog/understanding-torque-and-thrust-in-drone-motor> Accessed: 2025-01-03
- [5] Oscar Liang.(2024). *How to Choose FPV Drone Motors – Considerations and Best Motor Recommendations*, available at: <https://oscarliang.com/motors/> Accessed: 2024-12-26
- [6] Oscar Liang.(2024). *Understanding ESCs for FPV Drones: How to Choose the Best Electronic Speed Controller*, available at: <https://oscarliang.com/esc/#ESC-Types> Accessed: 2024-12-26
- [7] JOUAV.(2024). *Electronic Speed Controller (ESC): Everything You Need to Know*, available at: <https://www.jouav.com/blog/electronic-speed-controller-esc.html> Accessed: 2024-12-26
- [8] RoboCraze. *How to Choose ESC for Quadcopter*, available at: [https://robocraze.com/blogs/post/how-to-choose-esc-for-quadcopter?\\_pos=1&\\_psq=how+to+choose+e&\\_ss=e&\\_v=1.0](https://robocraze.com/blogs/post/how-to-choose-esc-for-quadcopter?_pos=1&_psq=how+to+choose+e&_ss=e&_v=1.0) Accessed: 2024-12-28
- [9] GETFPV.(2024). *All About Multirotor Drone FPV Power Distribution Boards*, available at: <https://www.getfpv.com/learn/new-to-fpv/all-about-multirotor-fpv-drone-power-distribution-board/> Accessed: 2024-12-27
- [10] MATEKSYS, available at: <https://www.mateksys.com/?portfolio=fchub-12s> Accessed: 2025-01-5
- [11] Oscar Liang.(2023). *Everything You Need to Know About Electrical Wires and Connectors in FPV Drones*, available at: <https://oscarliang.com/wires-connectors/> Accessed: 2025-01-03
- [12] Oscar Liang.(2022). *Flight Controller Processors Explained: AT32, STM32 F4/G4/F7/H7*, available at: <https://oscarliang.com/f1-f3-f4-flight-controller/#Understanding-the-Different-STM32-Processors-in-Flight-Controllers> Accessed: 2025-01-03
- [13] EVELTA.(2024). *How to Choose the Best GPS Module for Your Project*, available at: <https://evelta.com/blog/how-to-choose-the-best-gps-module-for-your-project/> Accessed: 2025-01-05

## Author(s):

**Eng. Alexandra ALEXE-IONESCU**, master student, National University of Science and Technology POLITEHNICA Bucharest, Engineering Graphics and Industrial Design Department, E-mail: alexandra.i03@yahoo.com

**Prof. Ionel SIMION**, National University of Science and Technology POLITEHNICA Bucharest, Engineering Graphics and Industrial Design Department, E-mail: ionel\_simion@yahoo.com