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SIMULATION OF AN INFRA-RED MINI UAV SURVEILLANCE DRONE TECHNOLOGY – AN EFFECTIVE REMEDY FOR NIGERIA'S SECURITY CHALLENGES

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For Nigeria to align with the emerging world, it has to frantically address the issue of insecurity, which has become a hydra-headed monster unsurmountable by Nigerian security agencies. The dimensions of insecurity in Nigeria are multifaceted and continue to increase unabated. The manifestations of insecurity in Nigeria range from armed bandits' attacks, tribal and religious militia terrorist attacks, bombings, kidnapping/hostage takings, destruction of property, armed robbery, and cattle rustling, to mention but a few. The attendant effects of these security menaces include the ignition of fear and panic, which is detrimental to the general well-being of the people, illnesses, low life expectancy, low quality of life, and even death. Economically, insecurity has led to the destruction of businesses, properties, and equipment, as well as relocation and closing down of businesses. This paper presents the simulation of Noiseless infra-red mini-UAV surveillance drone technology as a real-time solution for tracking and relaying live signals from remote locations. The system design simulation in MATLAB/SIMULINK incorporates multidimensional capabilities that encapsulate flight to desired places, day and night scene monitoring, and real-time GSM-based signal transmission from remote locations. Thus, using this integrated approach, the resultant system yields a novel technology that potentially reduces the myriad security challenges bedeviling Nigeria. Hence, the technology is an attractive and valuable innovation in the increasing search for solutions to the myriad of security challenges in the nation.

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Keywords- Insecurity, Drone Technology, Infrared Unmanned Arial Vehicle (UAV), Surveillance

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INTRODUCTION

Technology connected to UAVs has been consistently and swiftly advancing in recent years. Unmanned aerial vehicles, often known as drones, are the most prevalent type of US. Drone stands for "dynamic remotely operated navigation equipment." In the academic literature, they are referred to under several acronyms, such as UAVs [1], UASs (Unmanned Aerial Systems) [2], RPAs (Remotely Piloted Aircraft) [3], or ROAs (Remotely Operated Aircraft) [4]. A UV can fly in the air, surveying large areas and reaching human-hostile environments. Unmanned aerial vehicles with increasing autonomy can perform many functions, such as automated take-off, landing, obstacle avoidance, and course planning [5]. Drones are transforming the world into a cyber-mechatronics environment. A drone is a unique aircraft with advanced robotics, aeronautics, and electrical components. Drones have legitimate alternatives for obtaining information that satellites would otherwise transmit faster and more cost-effectively [6]. The ability for drones to be beneficial and cost-effective in many applications is widely understood and applied nationally and internationally. Beneficially envisioned and applied applications of drones include Agriculture and remote sensing [7], Disaster management [8], Waste management [9], Smart city applications [10], Wildlife survey [11], Geographic mapping [12], logistics [13] Healthcare [14], wireless hotpot service [15], mine surveys [16]. Drone technology can be a powerful and cost-effective tool for the government, private sector, and society. The result has been increased interest in using them over all of the objections above. According to the latest Goldman Sachs report, by 2020, there would be 7.8 million consumer UAV shipments and USD 3.3 billion in revenue, versus only 450,000 shipments and USD 700 million in revenue in 2014 in the commercial UAV segment [17]. The market is anticipated to register a Compound Annual Growth Rate (CAGR) of 56.5% from now till 2025 [18]. UAVs are expected to play a massive role in upcoming 5G networks by supporting flexible deployment and backhaul connectivity operations [19, 20]. Blockchain and other distributed ledger technologies are expected to enable trusted and transparent sharing of UAVs across different commercial enterprises [21, 22, 23, 24, 25]. UAVs are also used for various military applications such as surveillance, target tracking, and air-to-ground combat. The US military spending on UAVs is estimated to be around USD 17 billion from 2017 to 2021 [17]. For such critical applications, the security of wireless UAV-UAV and ground-UAV communications is a must. Security schemes and techniques to ensure essential security features such as mutual authentication and privacy protection and methods to analyze security vulnerabilities in UAV networks are also being developed [26, 27, 28, 29, 30, 31].

The use of drones for monitoring destructive activities, such as poaching and illegal logging, has been notably applied in Africa, Asia, and South America. The World Wildlife Fund (WWF) has been using drones to monitor illicit trade in Africa by tracking poachers and the wildlife they pursue in real time [32]. In South America, Brazil has purchased fourteen drones for $350 million for the São Paulo Environmental Police to monitor deforestation in the Amazon, track poachers, and seek out illegal mining operations [33]. International efforts in drone technology could be used to expand efforts to monitor, assess, and calculate deforestation and carbon sequestration benefits and needs globally. A low-cost drone would benefit governments and NGOs operating with small budgets and seeking better monitoring of natural assets with improved data collection efforts globally.

Beyond the use of monitoring for illegal activity, drones can monitor highways vulnerable to landslides using high-resolution cameras to detect cracks that may indicate the onset of a landslide and sensors to detect changes in stress. Once detected, data collected from the drone can be used by authorities to initiate an early warning, allowing people currently in the area to escape and those traveling to the area to avoid the disaster event before it occurs.

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Several federal agencies, including the US Forest Service, have tested using drones for early warning of forest fires. By collecting data on forest fires, firefighters can better plan and manage fires. While manned helicopters and planes could collect similar information when considering flight costs, contract requirements, regulations, and risks, there is no doubt an excellent use for drones in the future.

Spatially Integrated Small-Format Aerial Photography (SFAP), a newly developed low-cost technology, is proposed to supplement current bridge inspection techniques. [34] Using top-down views, drones flying at about one thousand feet can allow visualization of sub-inch (large) cracks and joint openings on bridge decks or highway pavements. With nightly news stories informing us about the poor state of our bridge infrastructure in the United States, this new technology can help us keep a better assessment of our bridge and highway system at a much lower cost.

This paper presents the simulation of an infra-red noiseless UAV surveillance drone that was simulated in MATLAB SIMULINK. The design is for security monitoring and surveillance in an increasingly complex emerging Nigeria. Thus, the paper's layout features a review of the abysmal security state of Nigeria and the design methodology and results as simulated and analyzed using MATLAB SIMULINK. This is the approach adopted to draw conclusions and make recommendations.

REVIEW OF SECURITY CONCERNS IN NIGERIA

Different thoughts have been advanced on the concept of human security. The United Nations Development Programme (1994) stated that human security could be defined as protection from hidden and hurtful disruptions in daily activities at homes, offices, or communities. This implies that security encompasses being safe and secure from danger and protection from chronic threats such as hunger, disease, and repression.

To the Commission on Human Security (2003), human security is the protection of essential aspects of human lives in a way that would enhance human freedoms and fulfillment. Human security encompasses freedom from want, harm, fear and the freedom to take appropriate actions without hindrance. It is also the assurance of future well-being and freedom from threat.

[35] who sees security from the socio-political perspective averred that security involves the capacity to pursue cherished political and social ambitions. That is, security is socio-political, as without security, there can be no political stability, and consequently, social activities will be in chaos. [36] argues that there is a connection between security and survival. For him, security is an essential condition for the survival of human beings. Thus, security is synonymous with freedom from danger, fear, and doubt.

[37] posits that security is an essential concept commonly associated with alleviating threats to the survival of individuals or groups. Thus, for him, security can be equated with freedom from present and future danger, harm, or

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anxiety; however, security may not be the absence of threats but the ability to respond to these threats with appropriate skill and expertise.

In the views of [38], security relates to peace, safety, happiness, and the protection of human and physical resources or the absence of crisis, for [39] security is any laid down procedure for protecting persons and property against hostile persons. It is a situation whereby a conducive atmosphere is created within which people in the state can go about their normal daily activities without threat to either their lives or properties. Thus, security encompasses all approaches toward safeguarding human and material resources in the state against aggression or violent conduct.

Recent international indices indicate that Nigeria is the most insecure country in Africa and the third most insecure country in the world. The prevalence of insecurity is seen in the rising ramifications of tribal and religious militia Killings, armed banditry killings, kidnappings, armed robbery, cattle rustling, and other forms of insecurity, including terrorist bombings and politically and economically related assassinations—data reports by the International Organization on Peace Building and Social Justice [40]. Data Team reveals that within the first half of 2020, at least 2538 persons have been killed, 802 kidnapped, and 487 persons injured across. Nigeria. Figure 1 shows the number of deaths, kidnappings, and injuries caused by these atrocities from January to June 2020 in Nigeria [40]

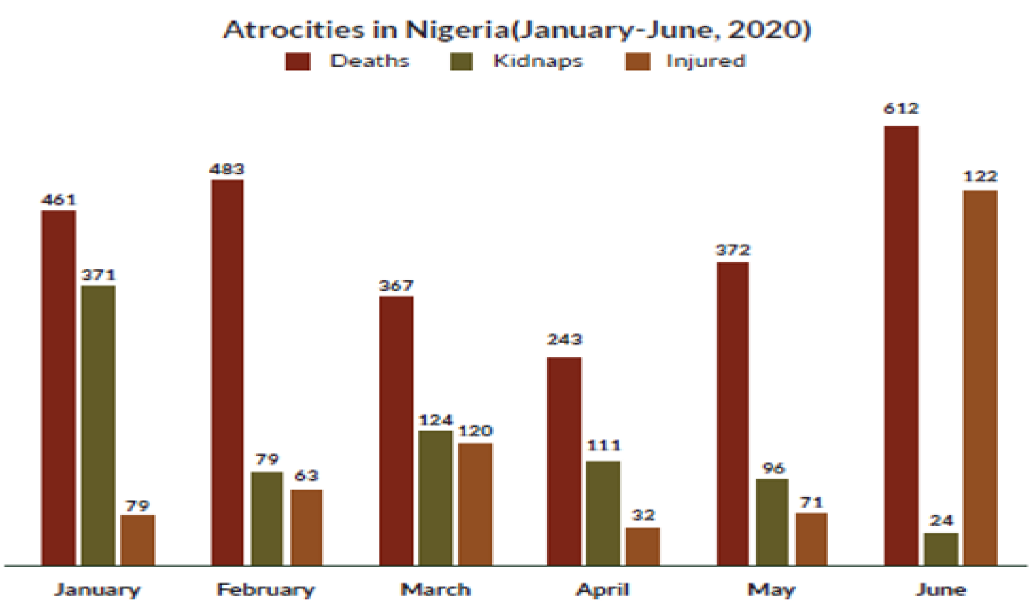

Fig. 1. Atrocities in Nigeria from January to June 2020

This empirical data is very conservative, considering how challenging it is to gather data that depicts the actual scenario as it is. This is due to fear, traumatization, and lack of trust by the victims or close relatives who could have given appropriate and copious information on the rate and frequency of the mishaps. The insecurity paranoia continues

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to haunt most inhabitants of Nigeria. Sadly, it is already fast dawning on them that the government cannot effectively guarantee the security of lives and properties. Most Nigerians perceive the government as not only being impotent to curtail the growing menace of insecurity but, worst still, complicit in perpetuating the insecurity. The state security agents who are saddled with the responsibility for the security of lives and property, which include- the police, state security agencies, the military, immigration, and prison service, have all, by their inaction, performed abysmally in the discharge of their duties, to the extent that every effort mobilized by the government is primarily adjudged as a deceitful cosmetic arrangement to conceal complicity. Thus, the government security apparatus could be more reliable and trustworthy.

Thus, the prompting for the infra-red Mini-unmanned aerial vehicle (UAV) surveillance drone technology is presented here.

DESIGN MATERIALS, SIMULATION METHODOLOGY, AND ANALYSIS IN MATLAB SIMULINK

The infra-red unmanned aerial Vehicle (UAV) surveillance drone technology simulated is to serve as a panacea against the myriad of Nigeria's security challenges. This is a miniature version of the conventional UAV with enhanced capabilities suited to address the peculiarities of Nigeria's security challenges. Thus, the system operates on basic principles similar to a UAV.

Design Features

Given the peculiarity of the nocturnal operations of perpetrators of security mayhem in Nigeria, the surveillance drone design here presented encapsulates the following capabilities:

i. Flight capabilities
ii. Night Visibility
iii. Recording Capacities
iv. Remote GSM-based instant Signal Transmission Capabilities
v. Noiseless Capabilities

The assumptions made for proper design analysis of the drone system design are:

1. Flow over the wing is incompressible, i.e., constant density.
2. No slip condition is present, i.e., the velocity of the fluid on the surface is the same as that of the surface.
3. The center of gravity of the USAV is located at a 30 % wing chord.
4. Propeller efficiency (ηprop) is at 70 %.

The primary views scaled in MATLAB Simulink are the plan, front, side, and isometric views, as shown in Fig. 1 - 4.

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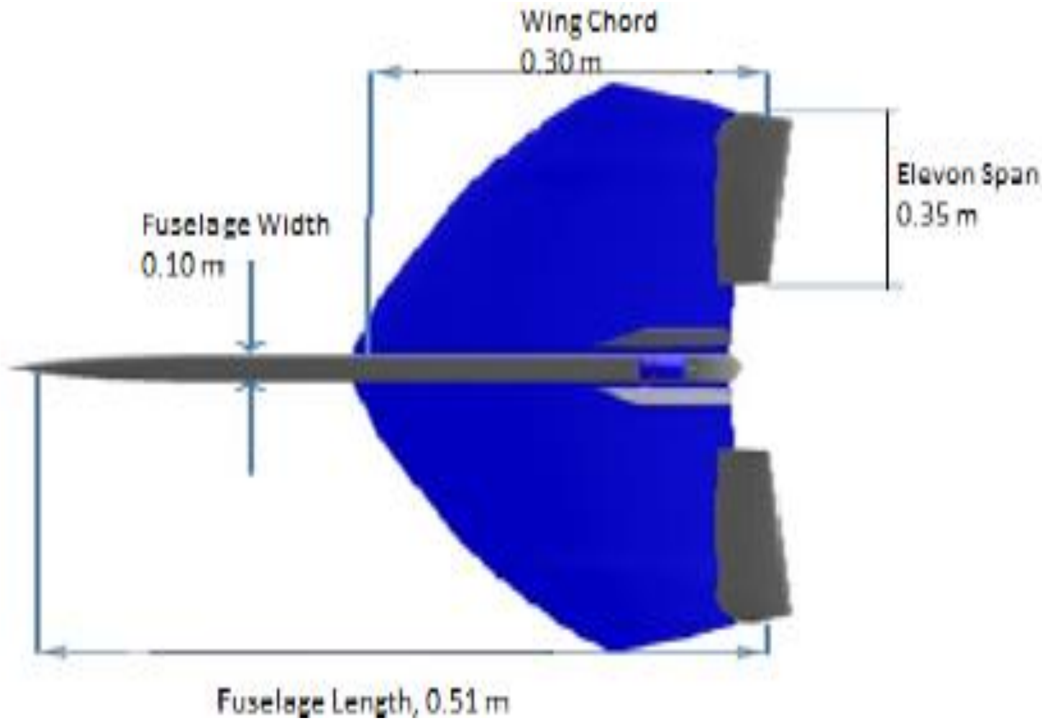

Fig.1. Plan View

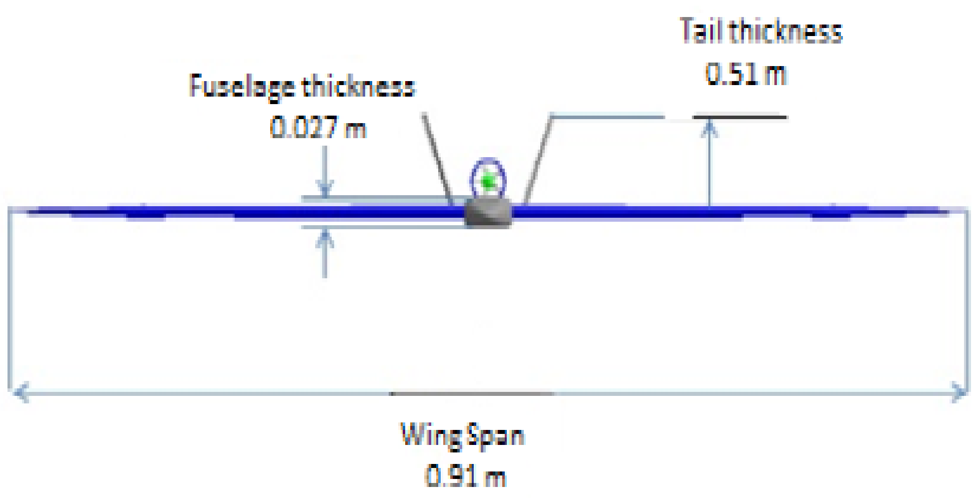

Fig. 2. Front View

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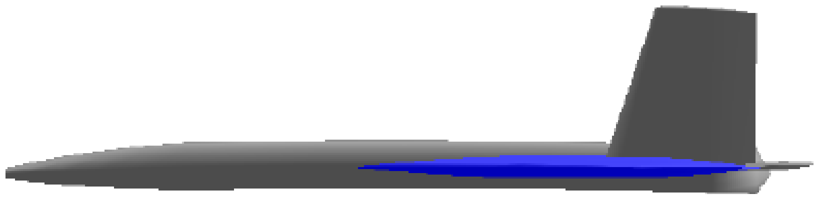

Fig. 3. Side View

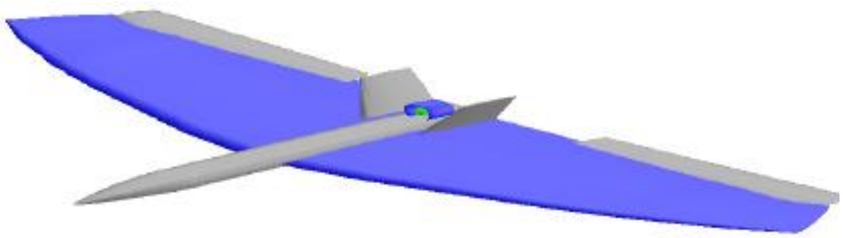

Fig. 4. Isometric View

Design Materials

The design specification for the material required for the implementation of the system stipulates a 2.4 GHz 6 channel Transmitter and Receiver, Four Micro Analog Servo, 30 Amp Electronic Speed Controller, 1200 kV motor, 6 X 4-inch propeller, 2200 mAH Lithium Polymer (Li PO) battery, eight Hinges, four push rods, six 12 X 36 inches 9mm thickness Expanded Polypropylene (EPP) sheets, Hot glue gun, cutting knife, Soldering iron and lead and Plywood.

The considerations for material selection include stress factors, availability, recyclability, low manufacturing cost, manufacturability, weight-to-stress ratio, corrosion resistance or stress concentration, etc. Given these considerations, nowadays, the primary materials used for all kinds of aircraft are polymers and aluminum alloys, which are pure aluminum mixed with other metals to improve their strength. Since the USAV does not need too much strength, only the skin with a basic holding structure would suffice.

Operational Principle of the UAV

Remote control planes are controlled by radio transmitters with two joysticks, one for each thumb. Mode 1 controllers use the left joystick to control the elevator and the rudder, while the right joystick controls the throttle and ailerons. The right stick has springs to return to the center, while the left will only be centered horizontally. This makes it easy to find the throttle control, as this stick does not center itself vertically. Moving the left stick forward will cause the plane to dive, moving the left stick will turn the aircraft left, moving the right stick forward will cause the plane to increase speed, and moving the right stick left will cause the aircraft to roll left.

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The airplane's center of gravity represents this coordinate system's origin. The axes are lateral, longitudinal, and vertical, corresponding to pitch, roll, and yaw. Table 1 explains how to control the USAV via a 2.4 GHz 6-channel transmitter.

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Table- 1 USAV Transmitter Control

Control in Transmitter	Control Panel	Motion
Aileron Stick (Left and Right)	Aileron	Roll
Elevator Stick (Up and Down)	Elevator	Pitch
Rudder Stick (Left and Right)	Rudder	Yaw

Though on varying scales, the forces experienced on their surfaces are the same. At equilibrium or cruising, four forces act on a flying body: weight, lift, drag, and thrust. The components of the drone technology include fuselage, airfoil, aileron, elevator, rudder, power plant, radio controller, and servomechanisms.

DESIGN SIMULATION AND CONSIDERATIONS IN MATLAB, RESULT, ANALYSIS, AND DISCUSSIONS

The analyses of airfoils were conducted with a computational fluid dynamic software known as Java Foil. This software can generate characteristic curves of airfoils based on the design parameters inputted to them. The design parameters inputted are listed below

1. Design coefficient of lift (Climax) = 0.22
2. Thickness to chord ratio (t/c) = 0.03
3. Aspect ratio (A.R) = 3
4. Mach number (M) = 0.05

Using a cambered plate, the following results were obtained;

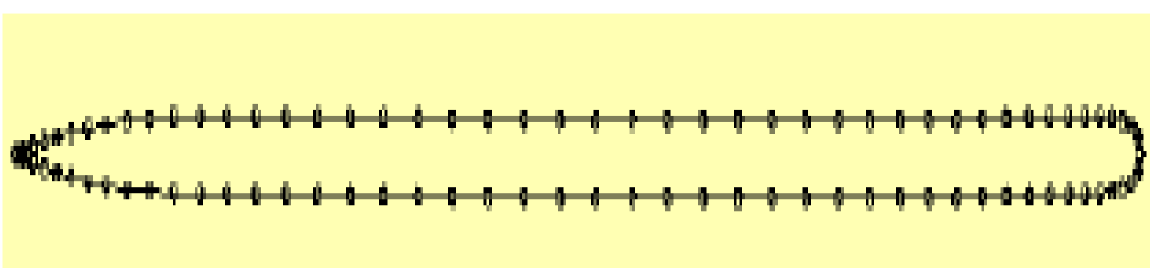

Fig.5. Airfoil Geometry

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Figure 5 shows the airfoil geometry for a cambered plate developed by JAVA foil for a thickness-to-chord ratio (t/c) of 0.03 and the design coefficient of lift (Climax) of 0.22. The lift has been defined as the net force developed perpendicular to the relative wind. The aerodynamic force of lift on an airplane results from the generation of pressure distribution on the wing.

The typical airflow patterns exemplify the relationship between static pressure and velocity, as defined by Bernoulli. Any object placed in an airstream will have air impact or stagnate at some point near the leading edge. The pressure at this stagnation point will be an absolute static pressure equal to the total pressure of the airstream. As the flow divides and proceeds around the object, the increases in local velocity produce decreases in static pressure. The pressure distributions and flow patterns shown in Fig.6 and 7 best illustrate this flow procedure.

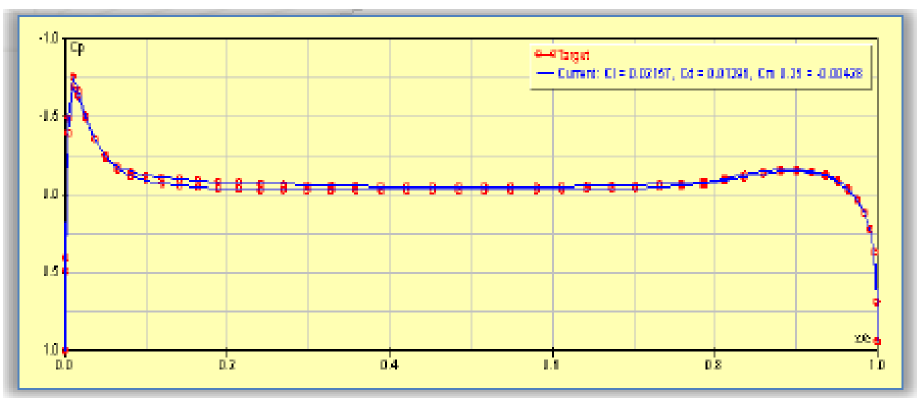

Fig. 6. Pressure Distribution

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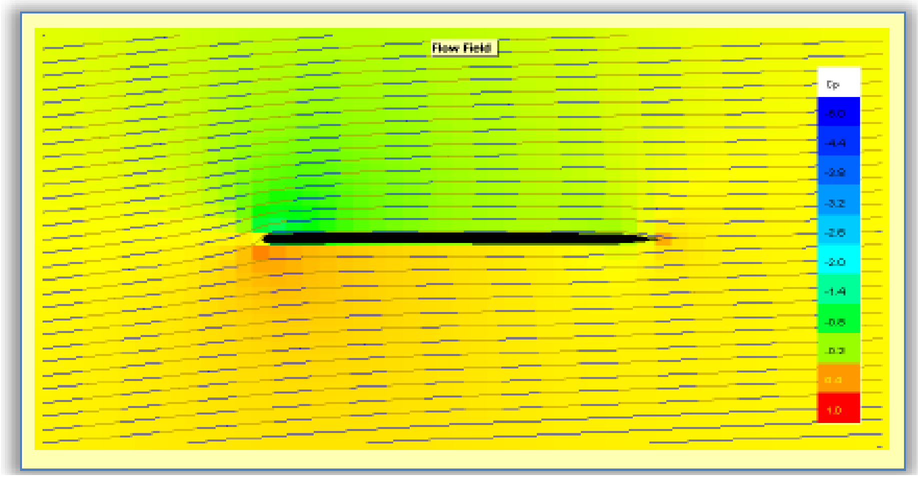

Fig. 7. Flow pattern

Performance Indices

Table 2 gives the figures for the various performance indices generated by the software from the above curves based on the design specifications stipulated.

Table- 2 Performance Parameters

α°	Re	C_l	C_d	C_m 0.25	L/D	A.C	C.P
-10	506641	-0.321	0.08828	-0.001	-3.633	0.26	0.248
-8	516024	-0.305	0.06702	-0.001	-4.548	0.256	0.247
-6	565334	-0.254	0.04977	-0.001	-5.1	0.255	0.246
-4	673278	-0.179	0.03611	-0.002	-4.959	0.266	0.241
-2	861742	-0.109	0.00815	-0.003	-13.383	0.262	0.219
0	2010000	0.012	0.00962	-0.004	1.196	0.253	0.585
2	788448	0.132	0.00899	-0.004	14.681	0.242	0.282
4	644591	0.198	0.03658	-0.002	5.404	0.236	0.262
6	549262	0.272	0.05045	-0.002	5.39	0.248	0.258
8	504662	0.322	0.06803	-0.002	4.736	0.25	0.257
10	492627	0.339	0.08901	-0.002	3.803	0.201	0.257
12	504767	0.318	0.11472	-0.002	2.772	0.243	0.258
14	538030	0.28	0.14561	-0.003	1.92	0.243	0.259
16	585941	0.236	0.16874	-0.003	1.401	0.242	0.263
18	643164	0.196	0.20289	-0.003	0.967	0.242	0.267
20	708092	0.162	0.22279	-0.004	0.726	0.242	0.272

These values were then plotted using the Excel sheet to produce the following trends;

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a. Lift characteristics

The following equation describes this lift force:

$$\text{Lift (L)} = 1/2\ \rho V2SCl \qquad (1)$$

The lift coefficient used in this equation is the ratio of the lift pressure and dynamic pressure and is a function of the shape of the wing and angle of attack. Plotting the lift coefficient of the aircraft wing plan form versus the angle of attack (α˚) produces the graph in Fig.8.

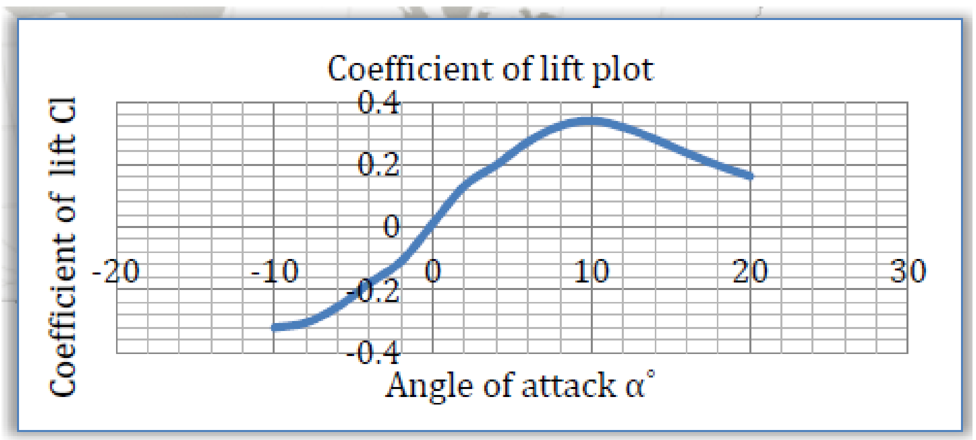

Fig. 8. Coefficient of Lift Plot

Since the coefficient form eliminates the effects of speed, density, area, weight, altitude, etc., an indication of the true lift capability is obtained. Each angle of attack produces a particular lift coefficient since the angle of attack controls the pressure distribution. The lift coefficient increases with the angle of attack up to the maximum lift coefficient (Climax). As the angle of attack is increased beyond the maximum lift angle, the airflow cannot adhere to the upper surface. The airflow then separates from the upper surface, and a stall occurs.

b. Drag characteristics

Drag is the net aerodynamic force parallel to the relative wind, and its source is the pressure distribution and skin friction on the surface. The primary drag equation is as follows:

$$\text{Drag (D)} = 1\ 2\ \rho V2SCd \qquad (2)$$

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The force of drag is shown as the product of dynamic pressure, surface area, and drag coefficient (Cd). The drag coefficient in this equation is similar to any other aerodynamic force coefficient. It is the ratio of drag pressure to dynamic pressure. Plotting the drag coefficient of the aircraft versus the angle of attack (α˚) produces the graph shown in Fig.9.

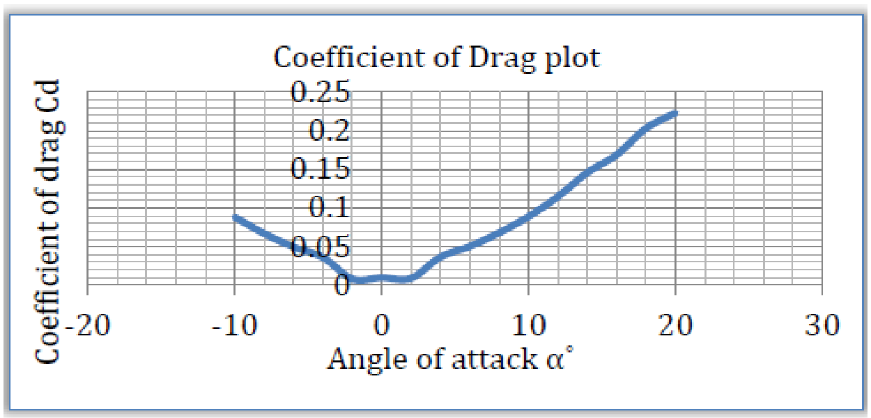

Fig.9. Coefficient of Drag Plot

At low angles of attack, the drag coefficient is low, and small changes in the angle of attack create only slight changes in the drag coefficient. At higher angles of attack, the drag coefficient is much greater, and small changes in the angle of attack cause significant changes in drag. As stalls occur, a large increase in drag takes place.

c. Moment characteristics

The moment about the aerodynamic center has its source in the relative pressure distribution and requires applying the coefficient form of expression for proper evaluation. The following equation expresses the moment of the aerodynamic center:

$$Ma.c = Cm\ a.c\ 12\ \rho V2S \qquad (3)$$

Where, Ma.c – Moment about the aerodynamic center (a.c),

Cm a.c – Coefficient of the moment about the aerodynamic center,

S – Wing area, C – Chord

A graph of the coefficient of the moment about the aerodynamic center against the angle of attack is shown in Fig.10.

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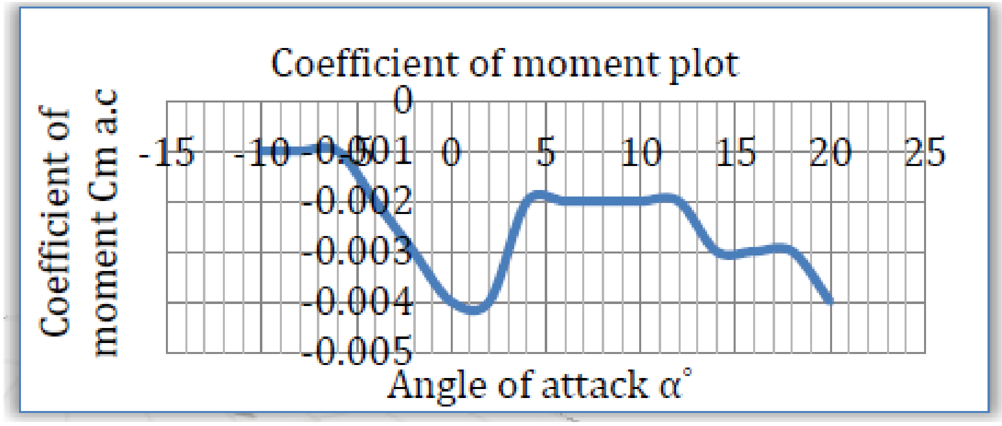

Fig.10. Coefficient of Moment

The sign convention applied to moment coefficients is that the nose-up moment is favorable. The aircraft will tend to nose-down since the plot shows a negative trend.

d. Lift to Drag Ratio

With the lift and drag data available for the airplane, the proportions of Cl and Cd can be calculated for each specific angle of attack.

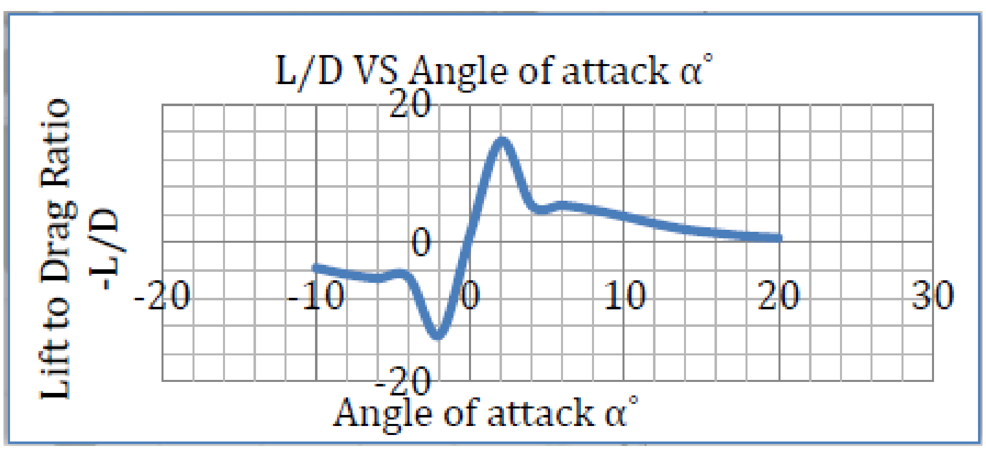

Fig.11. Plot of the lift-drag ratio with the angle of attack

The resulting plot of the lift-drag ratio with the angle of attack in Figure 11 shows that L/D increases to some maximum and then decreases at the higher lift coefficients and angles of attack. The $(^L/_D)_{max}$ occurs at one specific angle of attack and lifts the coefficient. The total drag is minimal if the airplane is operated in steady flight at (L/D) max. Any

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angle of attack lower or higher than that for $(^{L}/_{D})_{max}$ reduces the lift-drag ratio and increases the total drags for a given aircraft lift.

e. Aerodynamic center (A.C)

The aerodynamic center is the point on the chord where the coefficients of the moment are the constant point where all lift changes occur. If the two symmetrical airfoils are subject to an up gust, the lift will increase at the aerodynamic center (A.C). If the center of gravity (C.G) is ahead of the aerodynamic center (A.C), the lift change creates a nose-down moment about the C.G, which tends to return the airfoil to the equilibrium angle of attack. This stable, “weather cocking” tendency to return to equilibrium is an essential feature in any airplane. If the C.G. is aft of the A.C., the change in lift due to the up takes place at the AC and creates a nose-up moment about the C.G. This nose-up moment tends to displace the airplane farther from the equilibrium and makes the aircraft unstable. The aircraft is similar to a ball balanced on a peak. Hence, to have a stable aircraft, the C.G must be located ahead of the helicopter A.C. Since the aerodynamic center (A.C) in Table 2 has a maximum of 50% and a minimum of 20 % chord, the aircraft center of gravity (C.G) has to be placed forward of 20% chord for the aircraft to have longitudinal stability.

Advantages of Drone Technology

The presented design of the mini UAV and its commuting power can also be engaged to process spectral data in real-time and any data processing based on artificial neural networks, especially for neural comparative navigation methods.

Drone devices are part of unmanned aircraft systems (UAS) capable of flying on the ground. Hence, they are also called Unmanned Aerial vehicles (UAVs). The essential components of these devices are communication systems, a ground-based controller, and unmanned aerial equipment. The controllers of an unmanned aerial vehicle can be either an automated set of computers or a human operator.

To operate the drone, a user launches the device's elevation from the ground through a push-button technology to activate the propeller engine to airlift itself from the ground to reach the vast atmosphere above. The drone can visualize the horizon as it rises higher into the atmosphere while human users control them. When situated at the desired viewing horizon, the fitted infra-red image-capturing device will record ongoing activities and instantly transmit the real-time signals to a configured GSM device at a remote location.

Saves Time and Effort: The small drone device provides better accessibility and convenience than many existing surveillance monitoring devices. Drones are very convenient for users who want to save more time while covering a scene and navigating above the ground. With a button push, users can fly the drone and start recording moving images

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of its surroundings in less time. The recorded media clips are easily transferred to your internal or external data storage units. This ensures that the clips are secured in a storage unit from exploitation or leakage from unauthorized third-party users without wasting time.

Live Streaming: The system provides real-time live streaming of events, and the images captured by the drone can be distributed to blogs, streaming sites, and social media networks.

Disadvantages of Drone Technology

Several concerns that arise from the use of UAV drones are highlighted below:

Shorter Battery Lifespan: Though drones are convenient, their lifetime is shorter than traditional cameras for capturing images or any media file before uploading them to social media, blogs, or documents. The life span is an average of at least four hours, which most drones apply because the battery designs are smaller and do not last for more than four hours. This is a significant drawback of the design.

Vulnerable to Wild Animal Attacks: The device is often considered a creature when flying drones to an area with a large concentration of wild animals. Larger flying animals, such as eagles, are usually the main culprits when they attack or capture drones while navigating the atmosphere and taking essential photos or videos. This could lead to the sudden disappearance of the drone.

The Danger of Hacking: Hackers can easily invade the central control system of drones, replacing the original users as the new drivers or controllers of the device. The network and control systems of drones contain vital information that is essential for hackers to sneak in without the knowledge of the original user. After obtaining private information, the hacker starts to corrupt the file to prevent any traces of the intrusion. When users attach their social media profiles directly to the drone's control systems, all confidential information becomes vulnerable, allowing unauthorized third parties to sneak confidential files.

Spying: There is the risk of criminal elements using drone technology to spy and monitor their victims with felonious intent; their targeted victims are now vulnerable to privacy invasion. The risk of atrocities such as privacy invasion abounds when using the Grind Drone technology.

CONCLUSION

Security is the sine qua non for the sound existence of human beings, a nation, its unity, economic prosperity, and political stability. Security entails the presence of peace, safety, happiness, and the protection of human and physical resources. All threats to human security are also health challenges and detrimental to the individual's physical,

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psychological, and overall well-being. Thus, we note that insecurity leads to illnesses, low life expectancy rates, low quality of life, and even death.

The economy's productive sector, which depends mainly on the availability and regular supply of raw materials, needs to cut off the supply of raw materials and face untold difficulty in marketing finished products. In finance, insecurity has increased security or defense spending as the country and most business organizations now spend a lot on maintaining security outfits. Insecurity has, thus, become a drain on national resources as the resources expended on security could have been otherwise deployed in developing national infrastructure. Finally, and perhaps most importantly to Nigeria, insecurity has significantly affected oil production as a result of kidnappings and the hostage-taking of oil workers, and this has adversely reduced government revenue.

Therefore, this paper suggests that there should be an open dialogue among Nigerians across all ethnic groups to negotiate and offer harmonious ways of living together so that Nigeria can overcome its security challenges.

RECOMMENDATIONS

The UAV combines advanced aerodynamics, structures, materials, stability, and system integration technologies. There are still further design considerations to be studied in the development of this project. At the end of this research, a sound design and model were expected to be implemented to show uniqueness for uninhabited missions, fast and high operation, system and airframe integration, and introduction of new technologies and methods. Wind tunnel testing machines should be employed in the aerodynamic analysis.

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