Design, Analysis and making of RC Controlled Stealth Aircraft Working Model

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Abstract - *The project focused on the design, construction, and testing of a working model of an RC controlled stealth aircraft. A multidisciplinary approach was adopted, incorporating aerodynamics, electronics, materials, and control systems to achieve the desired performance. The aerodynamic design of the model involved careful consideration of the shape, contours, and surfaces. The goal was to minimize radar reflections and reduce the infrared signature, leading to the incorporation of smooth and streamlined surfaces, blended wing profiles, and carefully shaped edges.RC channel mixing was implemented to coordinate the movements of control surfaces. This allowed for synchronized actions of ailerons, elevators, rudder, and flaps, facilitating precise maneuvering and stability during flight. By combining input signals from multiple control channels, the model's control surfaces operated seamlessly, emulating the behavior of larger stealth aircraft. The construction process focused on assembling a lightweight yet sturdy airframe using appropriate materials. Structural integrity was ensured to withstand the aerodynamic forces encountered during flight. Extensive testing and fine-tuning were conducted to optimize the model's performance, including stability, responsiveness, and stealth characteristics. The completion of the project resulted in a fully functional RC controlled stealth aircraft model.*
***Keywords**: Stealth Aircraft, RC Model.*

I INTRODUCTION

A radio-controlled aircraft, commonly referred to as an RC aircraft or RC plane, is a small flying machine that is operated remotely by a ground-based operator using a hand-held radio transmitter. This transmitter sends signals to a receiver within the aircraft, which then relays the commands to servomechanisms, known as servos. The servos, in turn, move the control surfaces of the aircraft based on the position of the joysticks on the transmitter. These control surfaces, such as the ailerons, elevator, and rudder, directly influence the orientation and maneuverability of the plane. The popularity of flying RC aircraft as a hobby has grown significantly since the 2000s, thanks to advancements in motor technology, battery efficiency, and electronic components. These advancements have led to improvements in the cost, weight, performance, and capabilities of RC aircraft, making them more accessible to enthusiasts. There is now a wide variety of models and styles available, ranging from beginner-friendly trainers to advanced aerobatic planes and scale replicas of real aircraft.

Furthermore, RC aircraft have found applications beyond recreational flying. Scientific, government, and military organizations utilize RC aircraft for various purposes, including conducting experiments, gathering weather data, developing aerodynamic models, and performing tests. These remote-controlled aircraft provide a safe and cost-effective platform for research and data collection in diverse fields. Overall, the development and use of RC aircraft have revolutionized the hobbyist flying experience while also serving as valuable tools for scientific and practical applications. The continual advancements in technology are likely to further enhance the capabilities and possibilities of RC aircraft in the future.

Stealth technology, originally developed for military purposes, focuses on reducing the radar, infrared, and acoustic signatures of an aircraft, rendering it difficult for adversaries to detect and track. RC controlled stealth aircraft integrate these stealthy attributes, incorporating radar-absorbing materials, aerodynamic shaping, and advanced electronics to achieve a similar level of elusiveness in the RC world. The aerodynamic design of RC controlled stealth aircraft plays a crucial role in their stealth capabilities. Smooth, streamlined surfaces, blended wing profiles, and carefully designed edges help minimize radar reflections and maintain a low infrared signature. These design features allow the RC aircraft to fly undetected or, at the very least, reduce the range at which they can be detected by radar systems.

Moreover, RC controlled stealth aircraft often utilize advanced propulsion systems, such as ducted fans or electric turbines, to enhance their performance and maintain a low acoustic signature. These powerplants provide efficient and quiet operation, enabling the aircraft to approach and maneuver with reduced noise emissions, just like their real-world counterparts. The control systems of RC controlled stealth aircraft are equally impressive. Integrated radio systems, equipped with advanced frequency-hopping spread spectrum technology, offer reliable and secure communication between the pilot and the aircraft. This ensures precise control over the aircraft's movements, allowing for intricate maneuvers and maintaining the element of surprise during flight.

The popularity of RC controlled stealth aircraft has grown steadily in recent years, with hobbyists embracing the challenge of flying these elusive machines. From casual pilots seeking a new level of excitement to serious hobbyists participating in competitive races or aerial combat simulations, RC controlled stealth aircraft offer a unique and exhilarating experience. The working of RC controlled stealth aircraft involves a combination of advanced aerodynamics, electronic systems, and control mechanisms. These components work together to achieve the elusive and stealthy characteristics of these remarkable miniature aircraft. The aircraft's shape and contours are carefully engineered to minimize radar reflections and reduce the infrared signature. Smooth and streamlined surfaces, along with blended wing profiles and carefully designed edges, help deflect or absorb radar waves, making the aircraft less detectable to radar systems. These design features also aid in reducing the heat signature emitted by the aircraft, making it more difficult to be detected by infrared sensors.

RC controlled stealth aircraft often incorporate radar-absorbing materials, such as composites or coatings, which further reduce the radar signature. These materials are designed to absorb or scatter incoming radar waves, minimizing the aircraft's radar cross-section and making it harder to detect. The propulsion system plays a crucial role in the working principle as well. Many RC controlled stealth aircraft utilize ducted fan or electric turbine propulsion systems. These systems offer several advantages, including improved efficiency, reduced noise emissions, and a lower acoustic signature. By using quieter propulsion systems, the aircraft can fly with reduced noise, minimizing the chances of detection by acoustic sensors.

The electronic systems integrated into RC controlled stealth aircraft also contribute to their working principle. Advanced radio systems equipped with frequency-hopping spread spectrum technology ensure secure and reliable communication between the pilot and the aircraft. This technology allows for precise control over the aircraft's movements, enabling the pilot to execute intricate maneuvers and maintain control even in challenging flight conditions. Additionally, onboard electronic systems may include gyroscopes, accelerometers, and flight controllers. These components help stabilize the aircraft, making it more maneuverable and responsive to the pilot's commands. Flight controllers can also incorporate advanced features like autonomous flight modes or stabilization systems, further enhancing the aircraft's performance and control.

In this era of rapid technological advancements, the world of RC aviation continues to evolve, pushing the boundaries of what is possible. RC controlled stealth aircraft exemplifies the marriage of stealth technology and remote-controlled flight, captivating enthusiasts with their sleek design, stealth capabilities, and precise control. Whether you're an aviation enthusiast, a technology enthusiast, or simply someone looking for an exciting new hobby, RC controlled stealth aircraft offer an immersive and thrilling experience that combines innovation, skill, and the joy of flight.

The primary objective of stealth technology in aircraft design is to render the airplane undetectable by radar systems. Achieving invisibility involves two main approaches. Firstly, the aircraft's shape can be carefully designed to redirect or scatter radar signals away from the radar equipment, minimizing their reflection back to the source. This shaping technique is known as radar cross-section (RCS) reduction. Secondly, the aircraft's surfaces can be coated with specialized materials that absorb or attenuate radar signals, preventing their reflection and subsequent detection.

Stealth aircraft are designed to excel in six key disciplines to maintain their stealth capabilities:

Radar Stealth: The aircraft's shape, angles, and surfaces are optimized to minimize its radar signature, making it difficult for radar systems to detect and track the aircraft.

Infrared Stealth: The aircraft incorporates technologies to reduce its infrared signature, such as using heat-resistant materials and employing cooling systems to minimize the heat emitted from engines and exhausts. [2]

Visual Stealth: The aircraft's design takes into account visual signatures, aiming to reduce its visibility to the naked eye and make it harder to detect visually.

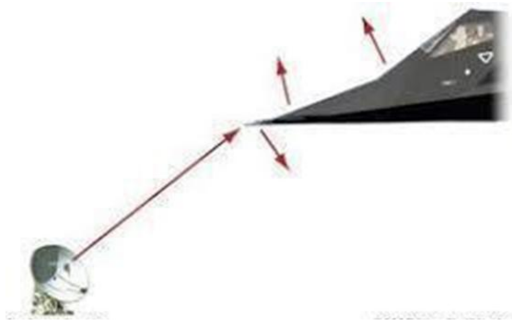
Acoustic Stealth: Noise reduction techniques are employed to minimize the aircraft's acoustic signature, making it less detectable by sound-based sensors and human hearing.

Smoke Stealth: Techniques are employed to minimize the aircraft's smoke or vapor signatures, reducing the visibility of exhaust trails and preventing the emission of distinctive visual indicators.

Electromagnetic Emissions: Measures are taken to minimize the emission of electromagnetic signals from the aircraft's electronics and communication systems, reducing the chance of detection through electronic surveillance.

By excelling in these six disciplines, stealth aircraft aim to remain undetectable or significantly reduce their detectability across multiple sensing technologies. This capability is crucial for military applications, enabling aircraft to operate covertly and gain a tactical advantage by avoiding detection and tracking by hostile radar systems [3].

Figure 1 a) Radar to big aircraft



b) Radar to Flight f117 (Image Adapted from Internet)

RC Channel Mixing

RC channel mixing is an essential feature in the control system of RC controlled stealth aircraft. It plays a crucial role in achieving precise and coordinated movements of the various control surfaces, enabling the aircraft to perform complex maneuvers and maintain stability during flight. RC channel mixing involves combining or "mixing" the input signals from multiple control channels to achieve specific control outputs. In the context of RC controlled stealth aircraft, this feature is particularly important for controlling the aircraft's control surfaces, such as the ailerons, elevators, rudder, and flaps, in a coordinated manner.

One common application of RC channel mixing in stealth aircraft is the implementation of differential thrust or vectoring. By combining the throttle and yaw control channels, the aircraft's propulsion system can be manipulated to provide differential power to different motors or nozzles. This enables the aircraft to execute precise turns, yaw movements, or even perform complex maneuvers like hovering or vertical take-off and landing. Another use of RC channel mixing is in the implementation of flaperons or elevons. Flaperons combine the functions of ailerons and flaps, while elevons combine the functions of elevators and ailerons. By mixing the input signals from the aileron and elevator channels, the control surfaces can be deflected in a coordinated manner, allowing the aircraft to roll and pitch simultaneously. This capability enhances the maneuverability and responsiveness of the aircraft during flight.

Additionally, RC channel mixing can be employed to implement other specialized control functions. For example, in advanced RC controlled stealth aircraft, mixing can be used to create a "thrust vectoring to pitch" or "thrust vectoring to roll" feature. By combining the throttle and elevator or aileron channels, the aircraft's thrust vectoring system can be synchronized with the pitch or roll control, providing enhanced maneuverability and control authority. The specific implementation of RC channel mixing in RC controlled stealth aircraft varies depending on the aircraft's design and the preferences of the pilot. Modern RC transmitters often feature programmable mixing options, allowing pilots to configure and customize the mixing parameters according to their needs and flying style.

In conclusion, RC channel mixing is an integral part of the control system in RC controlled stealth aircraft. By combining input signals from multiple control channels, this feature enables precise coordination of the control surfaces, facilitating complex maneuvers and maintaining stability during flight. Whether it's implementing differential thrust, flaperons, or other specialized control functions, RC channel mixing enhances the maneuverability and control authority of RC controlled stealth aircraft, offering pilots an exhilarating and immersive flying experience.

Method

The primary objective of this project was to design, analyze, and construct an RC plane, encompassing an understanding of aerodynamic forces, motor selection, controller systems, and achieving successful flight. To accomplish this, a comprehensive literature review was conducted to determine the necessary parameters for building the plane. Design targets were established, and the appropriate geometry was selected to optimize performance.

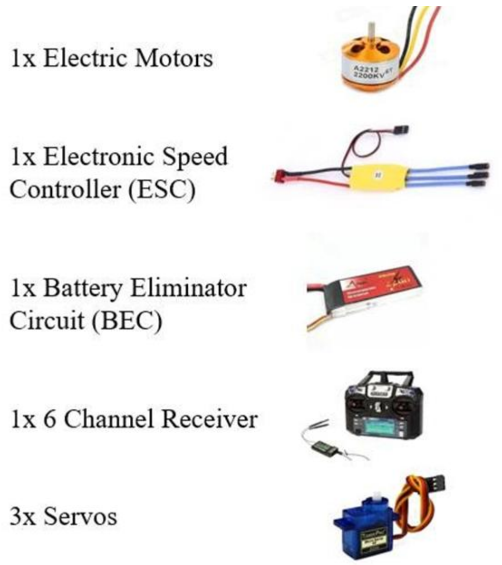
The project involved the optimization of various parameters to achieve the best possible flight characteristics. Stress points and critical areas on the wing and fuselage were identified, such as the neutral point on the wing, and were considered during the design process. The fuselage, wing, elevator, and other components were designed using appropriate airfoil profiles. The structure was analyzed for its structural integrity and performance parameters, and adjustments were made as necessary through iterative design iterations. [7]

The selection of electronics played a crucial role in the project. Motor and battery combinations were chosen to provide sufficient thrust and flight time. An Electronic Speed Controller (ESC) capable of handling the motor's Amperage draw was selected. For this aircraft, a single motor was chosen, providing approximately 860g of thrust with a 6-inch propeller (totaling 1720g) and drawing about 12 Amps. The flight time was calculated using the equation: Flight Time (minutes) = Battery Capacity (Ah) / Motor Amp Draw (Amperes) * 48.

In addition to motor and battery selection, control options were considered. Elevons, flaps, and throttle control were desired, requiring a minimum of 5 channels. Therefore, a 5-channel receiver was chosen, with an additional channel for flexibility and future expansion, resulting in the selection of a 6-channel receiver. By following these procedures and considerations, we aimed to design and construct an RC plane that met the desired performance goals, resulting in a successful and enjoyable flight experience.

Figure 2 Electronics used

After selecting all electronics, we can add up their weight and be sure to add in a large margin for the weight of the model itself. The different types of electronics user are shown in Figure 2 (The total weight could be 2 to 4 times the weight of all your electronics).



1 motors 80g each x 1 = 80g

1 ESC 35g each x1 = 35g

1 2200mAh Batteries 200g each x 1 = 200g

1 Receiver = 15g

3 Servos 25g each x 3 = 75g

Total Electronics Weight = 405g
405g x 2.5 (margin for aircraft weight) = 1012.5g Total

Now that we have a total weight estimate, we can use the desired flight handling (affected by Wing Loading) to calculate the total amount of wing area We need for our plane to fly. Using Computer-Aided Design (CAD) software, created a precise 3D model of the aircraft and the 2D top view and side view is represented inFigure 3. During design, incorporated stealth-inspired features such as smooth surfaces, blended wing profiles, and carefully shaped edges. Once the design was finalized, began constructing the airframe and control surfaces and paid close attention to aligning and balancing the components properly to optimize the model's flight characteristics. [4]

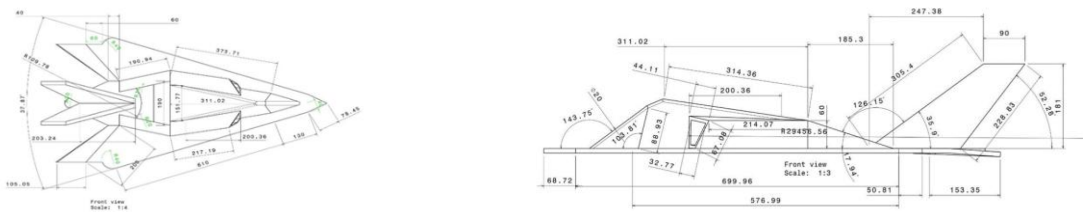


Figure 3 a) Top View **b) Side View of RC Aircraft**

Figure 4 Isometric View of RC Aircraft

After having a scale drawing of a design, we can translate those plans over to the Dephron and the Figure 4 repreesents the 3D top and iso view of the RC aircraft. We had used dephron to construct our RC plane since it is very easy to work with and glue together. We added all the electronics that go in the fuselage andattached the ESC and the attachments of all the electronics used for the RC aircraft is shown in Figure 5. We glued the receiver with hot glue inside the fuselage and glued in Velcro strips onto a raised deck in the fuselage that will hold the batteries inplace.

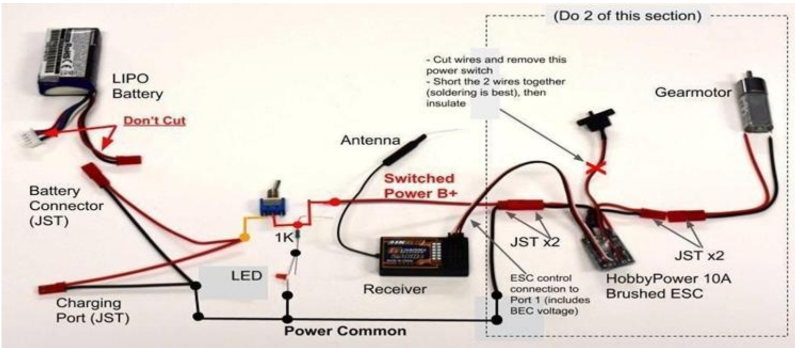


Figure 5 Attachments of Electronics (Image Adapted from Internet)

We fabricated a versatile firewall using 2mm aircraft grade plywood [5]. The firewall was designed to accommodate almost any motor, as it had precut holes and could be mounted on either side. To ensure the motor mount's strength and prevent it from ripping off during operation, we used a robust wooden motor mount. The motor mount was securely attached to the fuselage using strong adhesive and the wooden motor mount used is shown in the Figure 6. Once the glue dried, we proceeded to attach the motor onto the popsicle sticks, creating a sturdy and reliable motor mount.

Next, we determined the center of gravity for the fuselage to determine the ideal wing placement. By placing the batteries in a neutral position, we allowed for slight adjustments by moving them a few inches forward or backward. Using our fingers, we carefully balanced the fuselage until it leveled out. We marked this balanced spot, which needed to align with the 30% mark of the wing chord. To find the exact location on the wing chord, we measured the wing chord length and calculated the corresponding position in relation to the wing.

Next, we need to transfer the movement of the servo to the movement of the control surface. Cut of the extra pushrod wire and unscrew the servo arm. Push the pushrod through theservo arm, and the control horn, and then screw the servo arm back onto the servo. The servo which is connected to the flaps is shown in Figure 7.

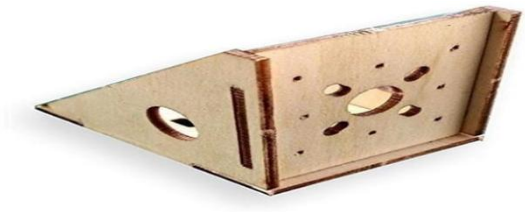


Figure 6 Strong Wooden Motor Mount

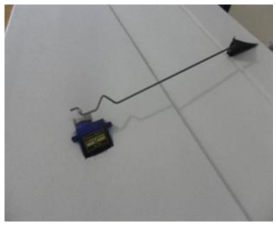


Figure 7 Servo Attached to Flaps

During the fabrication process, we opted for the tricycle style landing gear configuration, where two wheels were positioned at the back and a small tail wheel or skid at the front. To create the landing gear structure, we used 1/16-inch piano wire, which we bent into a triangular shape. The pointed end of the wire was secured onto a popsicle stick using a zip tie. Prior to this, the popsicle stick had already been glued onto the fuselage, with a hole on each side. To bend the wire effectively, we drilled a small hole in a wooden workbench and inserted the wire, bending it over to give us the necessary leverage. This method ensured a sturdy and reliable landing gear structure.

Figure 8 shows the landing gear used for the RC aircraft and with the landing gear in place, we were almost ready for flight. We powered on the transmitter and plugged in the battery. It was crucial to check the movement of each stick to ensure that it corresponded to the correct control surface and moved in the intended direction. The receiver, either through a label on the website or directly on the receiver itself, provided information regarding the control assignments for each plug. By following these procedures, we successfully fabricated the tricycle landing gear and ensured proper control surface movement, bringing us closer to the flight-ready state of the RC controlled stealth aircraft working model.

Figure 8 Landing Gear used (Image Adapted from Internet)

II RESULTS AND DISCUSSION

From Ansys flow simulation, it is obtained that this designed RC Aircraft have a lift force of 34.055757 N and Drag force of 10.117772N [1] and the simulation results is represented in Figure 9.

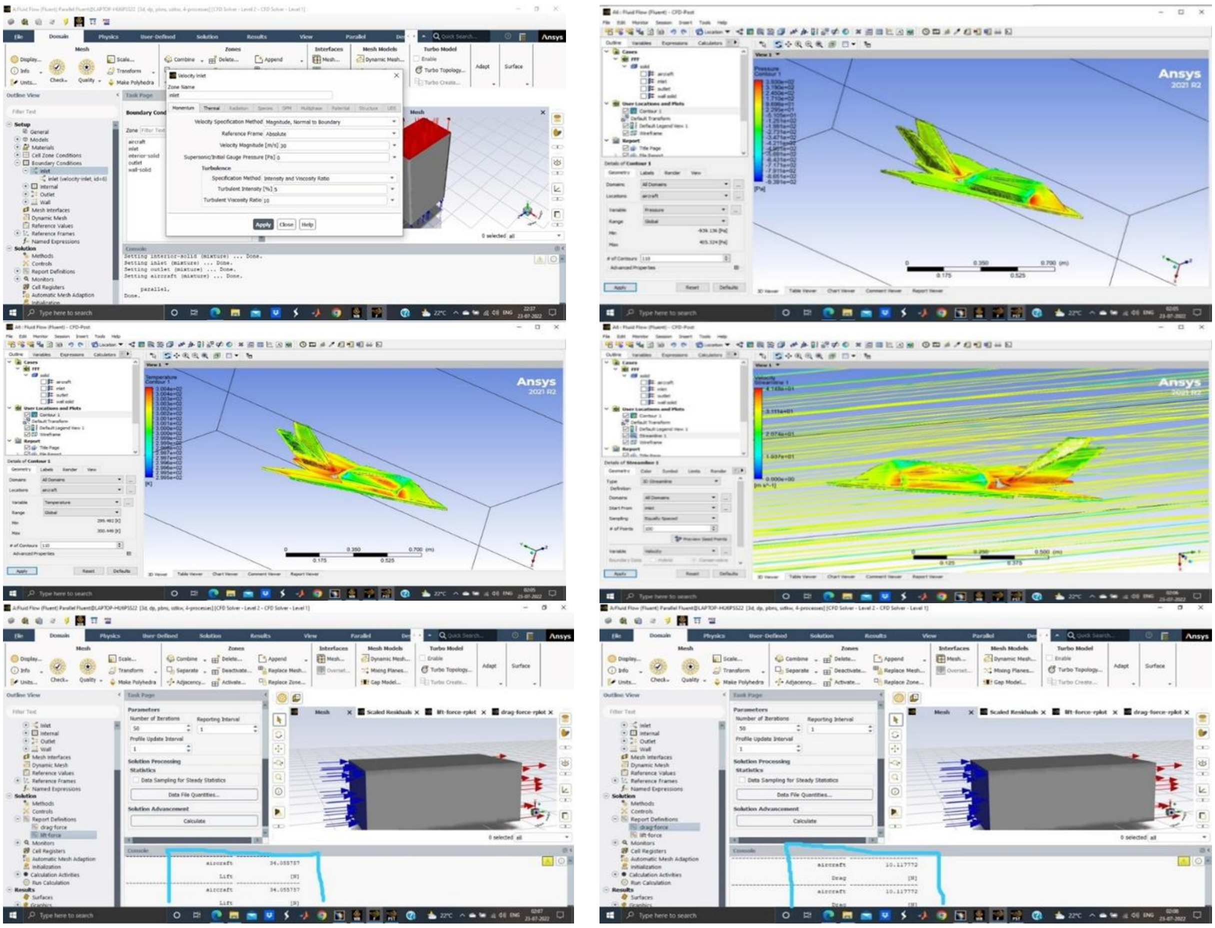


Figure 9 Ansys Flow Simulation

Figure 10 Final Fabricated Model of RC Aircraft

Figure 11 Climbing of RC Aircraft

Figure 10 represents the final fabricated model of the RC aircraft and Figure 11 represents the climbing image of the aircraft. To evaluate the performance of the RC controlled stealth aircraft working model, the following procedures and tests were carried out:

Hand Launch: With the power off, the airplane was hand-launched from shoulder height. The aircraft was gripped at the Center of Gravity (CG) and thrown straight and level. The launch height and distance traveled were measured and recorded for analysis. For example, launch Height (H) was measured at 5 feet, distance Traveled (X) was measured at 45 feet, resulting in a calculated glide ratio (L/D) of 9. [6]

Re-trimming: After the initial launch, re-trimming was performed by either shifting the CG or adjusting the stabilizer. This step was essential to achieve optimal flight characteristics and stability. By making necessary adjustments, the aircraft's flight performance could be improved.

Repeat Launch and Drag Polar Construction: The hand launch was repeated multiple times to gather data for constructing a drag polar. Launch heights, distances traveled, and glide ratios were measured and recorded for each launch. This data would be used to analyze the aircraft's aerodynamic performance and determine its drag characteristics.

Systems Testing: As flight testing is a comprehensive systems test, each subsystem was evaluated to determine how its performance could be assessed and what specific tests should be conducted to gather relevant data while minimizing risks. This included evaluating aircraft handling qualities, performance (endurance, climb, glide, turn), stall and spin characteristics, structural deflection, flutter, thermal performance, operator proficiency, adherence to standard procedures, emergency procedures, system performance, data links, failsafe mechanisms, mission performance, payload capacity, maintenance requirements, and data analysis. [8]

By conducting these tests and evaluations, we aimed to gather comprehensive data on the performance, stability, and functionality of the RC controlled stealth aircraft working model. This information would assist in optimizing the aircraft's design, identifying any potential issues, and refining its performance for enhanced flight capabilities.

III CONCLUSION

The journey of creating and flying the RC controlled stealth aircraft working model has been an exhilarating and rewarding experience. Through meticulous design, construction, and testing, the model successfully emulates the elusive characteristics of stealth technology while offering precise control and stability during flight. The integration of advanced aerodynamics, electronics, materials, and control systems has proven crucial in achieving the desired performance of the model. The aerodynamic design, including streamlined surfaces, blended wing profiles effectively reduces radar reflections and infrared signature, enhancing the stealth capabilities of the aircraft. The implementation of RC channel mixing has further enhanced the control capabilities of the model. By coordinating the movements of the control surfaces, the aircraft exhibits synchronized actions, enabling precise maneuvering, stability, and an immersive flight experience. Throughout the project, extensive testing and fine-tuning were conducted to optimize the model's performance. Flight tests validated the success of the design and construction efforts, demonstrating the model's stability, responsiveness, and stealth characteristics. These tests have provided valuable insights into the behavior and performance of the model, enabling further refinements and improvements. Overall, the fabrication and flight of the RC controlled stealth aircraft working model have showcased the integration of various disciplines and technologies to create a truly captivating and realistic flying experience. The project has not only satisfied the curiosity and passion for aviation but has also expanded the knowledge and expertise in the field of RC aviation.

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