

# DESIGN AND MODELLING OF SURVEILLANCE AIRCRAFT

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## **Keywords:**

Surveillance Aircraft, Aerodynamic Optimization, Unmanned Aerial Vehicle (UAV), Payload Versatility and Advanced Sensor Systems

## **Introduction:**

The project on the "Design and Modeling of Surveillance Aircraft" is situated within the growing field of aerospace engineering, particularly focusing on the development of unmanned aerial vehicles (UAVs) that are crucial for modern security and reconnaissance efforts. Surveillance aircraft are integral to various applications, including border patrol, environmental monitoring, disaster management, and urban surveillance each of which is increasingly pertinent in today's complex global landscape.

As technological advancements continue to reshape aviation, the demand for efficient, reliable, and adaptable surveillance platforms has surged. This project aims to address these needs by exploring innovative design principles and cutting-edge tools to create an aircraft tailored for endurance, efficiency, and functionality. The project leverages a systematic design approach that integrates aerodynamic optimization, structural integrity, and payload adaptability, ensuring that the aircraft can effectively gather and relay real-time data across diverse operational scenarios.

The significance of this project lies not only in its contribution to the field of aerospace engineering but also in its potential to enhance situational awareness and decision-making capabilities in critical situations. By incorporating advanced sensor technologies and communication systems, the designed aircraft can provide insights that are vital for security operations and disaster response.

## **Objectives:**

1. Enhance Situational Awareness
  - Enable real-time data acquisition for improved operational decision-making.
2. Extend Flight Endurance
  - Design for long-duration missions with minimal need for refueling or recharging.
3. Ensure Cost-Effective Design
  - Focus on economical use of materials and manufacturing.
  - Support both military and civilian applications to increase versatility and market potential.
4. Develop a Versatile Payload System
  - Create a modular design to accommodate various surveillance equipment (e.g., optical, infrared, and communication sensors).

## **Methodology:**

### 1. Design Methodology

**CAD Tools:** The primary design phase utilized CAD software, specifically CATIA V5, to create optimized models of the aircraft. This allowed for precise shaping of key components such as the aerofoil, wings, fuselage, and tail assembly.

### 2. Aerodynamic Design

**Aerofoil Selection:** The NACA 23012 aerofoil was selected for its favourable lift-to-drag ratio, providing stability and efficiency essential for surveillance missions. High aspect ratio wings inspired by glider designs were incorporated to enhance endurance and fuel efficiency.

**Stabilized Tail Configuration:** This design feature was crucial for improving balance and maneuverability during surveillance operations.

### 3. Structural Optimization

**Material Selection:** The aircraft was constructed using lightweight and durable materials, primarily high-density (HD) foam for the frame, reinforced with glass fibre tape to improve strength and environmental resistance.

**Software Simulations:** Structural analysis and load-bearing simulations were conducted using software like ANSYS to ensure the aircraft could handle operational stresses while minimizing weight.

#### 4. Payload Versatility

The design included a modular payload section that could easily accommodate interchangeable sensors, cameras, and other surveillance equipment, allowing for customization based on specific mission requirements.

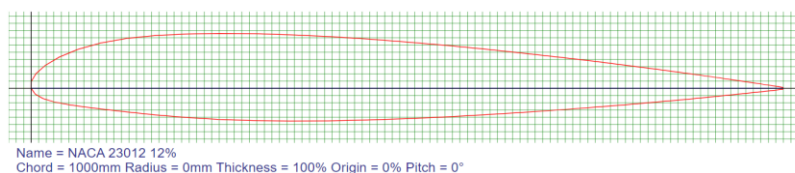
#### 5. Prototype Development and Testing

**CFD Simulations:** Computational Fluid Dynamics (CFD) were employed to test aerodynamic performance digitally, ensuring that the design met efficiency targets before physical fabrication.

**Building Materials:** The model was fabricated from high-density foam to keep overall weight low while ensuring structural integrity for sustained flight performance.

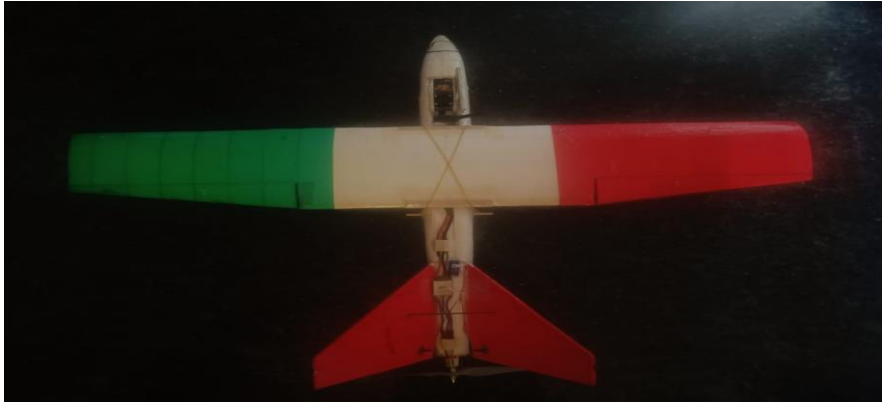
#### Diagrams and Visual Aids:

1. **Aerofoil Geometry:** Illustration of the NACA 23012 aerofoil showcasing its profile to explain its aerodynamic advantages (refer to Fig. 1.0).



**Fig. 1.0. Geometry of NACA 23012**

2. **Model Fabrication:** Photographs of the prototype showing top and side views of the aircraft, highlighting design features and electronic components (refer to Fig. 1.1 and Fig. 1.2).



**Fig. 1.1. Top View of Model**



**Fig. 1.2. Top View of Model with Electronics**

3. Flight Testing: Images from initial flight tests demonstrating the aircraft's performance at various altitudes, providing visual confirmation of its stability and operational effectiveness (refer to Fig. 4.1 and Fig. 4.5).



**Fig. 4.1. Flight is flying above 30-meter (approx) ground level**



**Fig. 4.5. Flight is flying above 350-meter (approx) ground level capturing the images from FPV camera**

### **Results & Conclusions:**

The project focused on the design and modelling of a surveillance aircraft, successfully achieving its objectives through a systematic approach that integrated advanced design methodologies and technologies. Key findings and observations from the project include

1. **Design Effectiveness:** Utilizing CAD tools like CATIA V5 allowed for the creation of optimized models that enhanced the aircraft's aerodynamic performance. The choice of the NACA 23012 aerofoil contributed significantly to the aircraft's stability and efficiency in flight.
2. **Structural Integrity:** Lightweight materials, particularly high-density foam reinforced with glass fibre tape, were essential in maintaining durability while minimizing weight a crucial factor for endurance in surveillance operations. Structural optimization through software simulations ensured the design could withstand operational stresses.
3. **Aerodynamic Performance:** CFD simulations validated the aerodynamic efficiency of the aircraft design, showcasing converging results in key performance indicators such as lift and drag coefficients. These simulations were critical in identifying and refining design features to improve flight capabilities.

4. **Payload Versatility:** The modular design allowed for easy customization of the payload section, facilitating the integration of various sensors and cameras for diverse surveillance applications. This versatility enhances the operational flexibility of the aircraft across different mission scenarios.
5. **Successful Flight Tests:** Initial flight tests demonstrated the aircraft's ability to achieve controlled and sustained flight. Photographs from these tests (e.g., Fig. 4.1 and Fig. 4.5) illustrated the aircraft's stability and performance at altitudes of approximately 30 meters and 350 meters, confirming its operational effectiveness.

## **Conclusions**

The project successfully designed, modelled, and tested a surveillance aircraft that meets contemporary requirements for stability, efficiency, and functionality in various operational environments. The innovative approach and findings highlight the feasibility of integrating advanced technologies, such as modular payload systems and lightweight construction materials, into the design of Unmanned Aerial Vehicles (UAVs). Future enhancements could involve integrating AI-driven sensors for real-time analysis, expanding camera ranges for broader coverage, and implementing night vision capabilities for 24/7 surveillance.

## **Visual Aids**

While the current summary does not include actual photographs or graphs, it is essential to reference:

- **Photographs from Initial Flight Tests:** Including images like Fig. 4.1 that capture the aircraft in flight provide visual confirmation of its design success and operational capabilities.
- **CFD Results Graphs:** Graphs showcasing the convergence of lift and drag coefficients over iterations would illustrate the aerodynamic performance validation achieved during simulations.

## **Project Outcome & Industry Relevance:**

The project on the design and modelling of a surveillance aircraft has several practical implications and contributions to the field of UAV technology and surveillance systems:

1. **Enhanced Surveillance Capabilities:** The developed aircraft can be utilized for various surveillance applications, including border patrol, urban monitoring, environmental tracking, and disaster response. Its ability to provide real-time data collection and situational awareness is critical for security and emergency services.
2. **Modular Payload Integration:** The modular design allows for easy adaptation of different payloads, such as cameras, sensors, and communication devices. This flexibility makes it suitable for diverse operational requirements across industries, including military, agriculture (for crop monitoring), and wildlife conservation.
3. **Data Collection and Analysis:** The integration of high-resolution sensors and real-time data transmission capabilities enables the collection of valuable information. Industries can leverage this data for improved decision-making, resource management, and enhanced operational efficiency.
4. **Cost-Effectiveness:** The lightweight construction and optimized design promote fuel efficiency and prolonged flight duration, reducing operational costs. This aspect makes the aircraft an attractive option for organizations with budget constraints while requiring advanced surveillance capabilities.
5. **Research and Development Contribution:** The project's findings support further research in UAV design and highlight the importance of integrating advanced technologies like AI and machine learning in future applications. This can drive innovations in automated surveillance systems, predictive analytics, and smart monitoring for various sectors.
6. **Applications in Urban Planning and Management:** City planners and management departments can utilize the aircraft for regular monitoring to assess urban development, traffic patterns, and infrastructure health, allowing for more informed urban development decisions.
7. **Environmental Monitoring:** The aircraft can be employed in monitoring environmental changes, tracking wildlife movements, and assessing the impact of natural disasters. This capability supports conservation efforts and provides critical data for environmental scientists.

8. **Integration with Smart Technologies:** The potential integration of AI-driven features suggests applications in smart cities and IoT (Internet of Things) frameworks, where the aircraft can autonomously monitor and report on various environmental and situational parameters.

### **Working Model vs. Simulation/Study:**

The project involved the development of a physical working model of the surveillance aircraft. While it incorporated theoretical aspects and simulations (such as aerodynamic optimization and structural analysis using CAD tools and CFD simulations), it ultimately resulted in a tangible prototype that was constructed and tested in real-world flight conditions. This hands-on approach allowed for the evaluation of the aircraft's performance in practical scenarios, demonstrating its capabilities and effectiveness in surveillance applications.

### **Project Outcomes and Learnings:**

The key outcomes of the project on the design and modelling of a surveillance aircraft include:

1. **Successful Prototype Development:** The project culminated in the creation of a physical working model of the surveillance aircraft, demonstrating its ability to achieve controlled and sustained flight. This was validated through initial flight tests, showing the aircraft's operational effectiveness.
2. **Enhanced Design Insights:** The project highlighted the importance of integrating aerodynamic optimization and structural integrity in aircraft design. It involved careful selection of design components, such as the NACA 23012 aerofoil, which contributed to optimal aerodynamic performance.
3. **Real-time Data Acquisition Capabilities:** The inclusion of high-resolution sensors and cameras was crucial for achieving the project objectives related to effective surveillance. The successful integration of an FPV camera allowed for clear data capture and real-time monitoring, essential for various surveillance applications.
4. **Performance Evaluation and Optimization:** The iterative process of testing and optimizing the design through simulations provided valuable data. The project

emphasized performance metrics such as range, endurance, and the aircraft's operational effectiveness in diverse scenarios.

5. **Interdisciplinary Learning:** The project facilitated learning across various domains, including mechanical engineering, aerodynamics, software usage (e.g., CATIA V5 for CAD modelling), and data analysis (through the results from CFD simulations). This interdisciplinary approach enhanced technical skills and understanding of complex aircraft systems.

From the process of designing, implementing, and analyzing the project, several important lessons were learned:

- **Importance of Practical Testing:** Engaging in hands-on building and testing reinforced the theoretical knowledge gained during design. It illustrated the discrepancies that can arise between simulation predictions and real-world performance.
- **Collaboration and Teamwork:** Working as a team on a project underscored the value of collaboration and communication among team members, essential for overcoming challenges and achieving project goals.
- **Problem-Solving Skills:** Addressing various design challenges, such as optimizing battery consumption and ensuring structural integrity, enhanced problem-solving capabilities and adaptability.
- **The Need for Continuous Improvement:** The project underscored that engineering is an iterative process. Feedback loops from testing and analysis are vital for refining designs and enhancing system performance.

### **Future Scope:**

Potential future directions for the surveillance aircraft project encompass several avenues for research and development:

1. **Advanced Image Processing and AI Integration:** Utilizing AI for real-time analysis enhances target detection and tracking, boosting mission effectiveness.

2. Enhancing Night Vision Capabilities: Integrating infrared or thermal imaging would enable 24/7 monitoring in low-light conditions, broadening operational applications.
3. Hybrid Propulsion Systems: Exploring hybrid technologies can improve fuel efficiency and operational range, incorporating renewable energy sources for sustainable operations.
4. Modular Payload Systems: Developing customizable payloads for specific missions would increase the aircraft's adaptability for various applications, from environmental monitoring to disaster response.
5. Data Integration and Cloud Computing: Syncing captured data with cloud platforms enhances storage, analysis, and sharing capabilities, improving emergency response and decision-making.
6. Drone Swarm Technologies: Researching collaborative operations with multiple drones can ensure comprehensive coverage, including algorithms for coordinated flight.