Development of UAV for Community Needs

Dr. Anjaiah Madarapu(Professor)[1], CH Akash[2], D Manideep[3] , G Pushyanth Sai[4], N Harsha Vardhan[5]

Department of Mechanical Engineering

Guru Nanak Institutions Technical Campus, Hyderabad

---***---

Abstract - An Unmanned Aerial Vehicle (UAV), commonly known as a drone, is an aircraft that operates without a human pilot onboard and is controlled either remotely or autonomously. UAVs serve various applications, from defence to civilian purposes, and are categorized into fixed-wing, rotary-wing, hybrid, nano, tactical, target, and commercial drones. For this project, we selected a quadcopter due to its versatility, stability, and efficiency, making it ideal for applications like surveillance, aerial photography, emergency response, and environmental monitoring. The prototype is modeled in Fusion 360 for precise design and analyzed using ANSYS to assess structural integrity and durability under varying load conditions. The UAV frame is fabricated using lightweight materials such as carbon fiber and integrates key components like brushless DC motors, LiPo batteries, GPS modules, and a Pixhawk flight controller. Advanced features such as real-time data acquisition, autonomous flight capabilities, and efficient payload handling enhance its functionality. Additionally, 3D printing is used for custom parts, ensuring an optimized weight-to-strength ratio. To validate performance, the UAV undergoes simulation of flight dynamics and control systems using SolidWorks, followed by extensive ground and flight testing. The results demonstrate reliable performance in real-world scenarios such as medical supply delivery, environmental condition monitoring, and disaster relief efforts. By leveraging artificial intelligence, real-time data processing, and robust communication networks, this project contributes to the advancement of UAV technology, providing a cost-effective, efficient, and sustainable solution for public services and community needs.

Key Words: Unmanned Aerial Vehicle (UAV), Quadcopter, Prototype Development, Structural Integrity, Environmental Monitoring.

1.INTRODUCTION

Drone technology, or Unmanned Aerial Vehicles (UAVs), has revolutionized multiple industries by providing autonomous or semi-autonomous flight. These flying robots, equipped with sensors like GPS, altimeters, and accelerometers, can be remotely piloted or follow pre-programmed paths. Initially developed for military applications, drones have expanded into agriculture, cinematography, surveillance, disaster management, and delivery services. Technological advancements, such as lightweight materials, enhanced batteries, and advanced sensors, have made drones increasingly viable for commercial and civilian use, transforming how industries operate by reducing labor and improving accessibility.

The History of Drones

The idea of unmanned flight dates back to the 19th century, with one of the earliest uses being unmanned balloons filled with explosives in 1849. The Kettering Bug, introduced in 1918 by the U.S. Army, was the first true unmanned aerial vehicle and a precursor to future UAV designs. During WWII, the British Royal Navy developed the Queen Bee, a radio-controlled aircraft for training anti-aircraft gunners, and the term "drone" was coined. Drones became critical for surveillance and reconnaissance during the Cold War, and by the 1980s, Israel demonstrated UAVs' full combat potential. These early developments laid the foundation for modern drones.

Modern Drone History

The 2000s saw the mainstream adoption of drones in military and civilian sectors. Following the September 11 attacks, UAVs like the MQ-1 Predator became vital to U.S. military operations, conducting surveillance and eliminating high-value targets. Drones began to see broader applications in border security and domestic surveillance around 2006, with agencies like the U.S. Customs and Border Protection taking the lead. By 2012, consumer drones entered the market with companies like DJI, revolutionizing fields like photography, videography, and surveying. In 2013, Amazon announced Prime Air, a drone-based delivery service, marking the start of commercial drone applications.

2. LITERATURE REVIEW

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have emerged as transformative technologies in surveillance, environmental monitoring, disaster response, and logistics. Their ability to operate autonomously or under remote control has made them vital for modern public service applications. With advancements in lightweight materials, artificial intelligence (AI), real-time monitoring, and efficient power management, UAVs continue to evolve to meet the growing demands of security, patrolling, and logistics operations (16).

Among different UAV configurations, quadcopters have received significant attention due to their versatility, stability, and efficiency in both controlled and dynamic environments. Unlike fixed-wing UAVs, quadcopters provide vertical takeoff and landing (VTOL) capabilities, making them suitable for confined and urban spaces (1). The integration of AI-driven flight control, autonomous navigation, and advanced imaging systems has further enhanced their use in real-time surveillance and security enforcement (17). These drones can perform continuous campus patrolling, live video streaming, and automated file delivery, improving security operations and logistical efficiency (3).

A key aspect of UAV research focuses on structural optimization and material selection to enhance flight performance and endurance. Studies have shown that carbon fiber reinforced composites (CFRP) reduce UAV weight while maintaining high strength-to-weight ratios, resulting in improved efficiency, aerodynamics, and durability (19). The use of Finite Element Analysis (FEA) through ANSYS has been applied to evaluate stress distribution, deformation, and load-bearing capacities, ensuring UAV reliability under operational conditions (14). Additionally, the adoption of 3D printing techniques for UAV component fabrication has enabled customized and lightweight airframe designs, improving structural balance and performance (5, 6, 10).

The effectiveness of UAVs in surveillance largely depends on their flight control and autonomous navigation. Modern UAV systems utilize advanced flight controllers, GPS modules, and sensor fusion techniques to achieve precise and stable autonomous operations (15). The Pixhawk flight controller, widely applied in UAVs, facilitates waypoint navigation, altitude control, and real-time data acquisition (7, 9). Furthermore, the use of brushless DC motors (BLDC) with high-density LiPo batteries supports efficient power management, ensuring longer endurance and improved energy utilization (18).

Artificial intelligence has significantly improved UAV surveillance, data processing, and security assessments. AI-driven UAVs are capable of identifying threats, monitoring restricted areas, and assisting in law enforcement or campus patrolling (2). UAV-based monitoring systems are also being developed for automated file transport, ensuring secure and timely delivery of sensitive documents in institutions or corporate environments (3, 13).

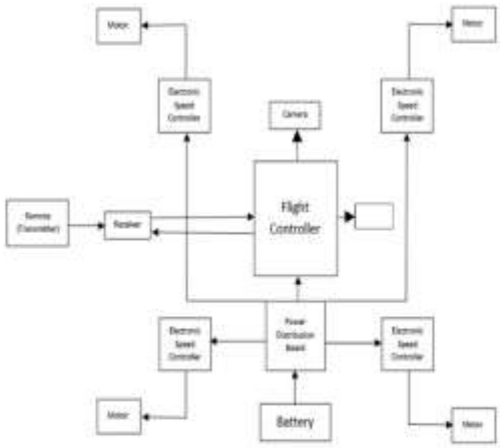
Beyond security, UAVs play an important role in public service applications such as disaster relief, medical supply delivery, and environmental monitoring. UAVs equipped with thermal imaging, LiDAR, and multispectral sensors have been deployed for search-and-rescue missions, reducing response time (12). In environmental monitoring, UAVs assess air quality, wildlife habitats, and detect early forest fires, providing cost-effective and scalable solutions (13).

Our project builds on these advancements by developing a multi-functional UAV system optimized for campus patrolling, real-time video streaming, and secure file delivery. By integrating lightweight carbon fiber structures (19), AI-based flight control (2, 17), and efficient energy management (18), our UAV aims to provide a scalable, autonomous solution for modern surveillance and public service operations.

3. Body of Paper

Block Diagram & Components Description

Block Diagram



Components Description

- **T-Motor Air Gear 450 II KV920 Motor Combo & 1045 Propellers**

The T-Motor Air Gear 450 II KV920 Motor Combo is a high-performance brushless motor combo meant for multirotor drones, with efficient power, smooth flight, and greater durability. It is optimized for aerial photography, survey, and FPV racing. The 1045 propellers included provide outstanding thrust efficiency and stability for a range of UAV applications. The combo consists of Brushless motors, propellers and esc

- **AIR2216 KV880 Brushless Motors**

The AIR2216 KV880 brushless motor is a high-performance outrunner motor commonly used in drones, RC aircraft, and multirotor applications

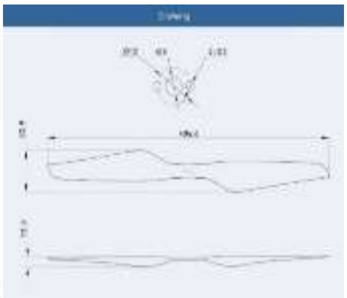
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 09 | Sept - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Performance Parameter-AIR2216

KV	920	Rated Voltage (Lipo)	3-4S
Idle Current (10V)	0.4A-0.6A	ESC Recommendation	AIR 20A
Peak Current (180s)	16A	Propeller Recommendation	T1045
Max Power (180s)	260W	Motor Weight (Incl. Cable)	65±2g
Internal Resistance	119.4±15mΩ	Lead Length	40-50mm

- **Propellers:**

This is 1045(10×4.5) SF Propellers Black 1CW+1CCW-1pair-Normal Quality They have wide and thin blades in their size category which makes them much flexible in crash conditions where they do not break easily. 1045(10×4.5) SF Props have high-quality propellers specially designed for multi-copters. 1045(10×4.5) SF Props has 15° angle design in the end of the propeller to avoid whirlpool multi-copter flying.



Performance Parameter-T1045

Plastic Propeller	10" *4.5 (260mm×30mm)	Working Temp	-10℃ - 40℃
Weight (Single Propeller)	17g	Storage Temp	10℃ - 35℃
Material	Nylon+Glass fiber	Storage Humidity	65±20%RH
Surface Treatment	Matte Technology	Optimum RPM	6000-7000 RPM/min
Propeller Type	Polymer Propeller	Thrust Limitation	1.2kg

- **ESC (electronic speed control) :**

The AIR20A is an Electronic Speed Controller (ESC) designed for brushless motors, commonly used in drones, RC airplanes, and other hobby-grade electric aircraft. TheAIR20A ESC is a lightweight, high-performance 20A brushless motor controller, ideal for RC drones, airplanes, and multirotor applications. It is designed for 2S–4S LiPo battery setups and provides reliable power management for brushless motors

Performance Parameter-AIR 20A

Size(L×W×H)	53x22x7mm	Rated Voltage (Lipo)	3-4S
Con. Current	20A	BEC	NO
Peak Current(10s)	30A	Weight (Incl. Cable)	21g
Banana Plug	3.5mm	Throttle Signal Frequency	50Hz-600Hz

- **Pixhawk 2.4.8 Basic Flight Controller kit with GPS Module Combo Kit**

The Pixhawk 2.4.8 is an open-source flight controller widely used in drones, UAVs, and robotic applications. It is a cost-effective alternative to the Pixhawk 1 and is compatible with PX4 and ArduPilot firmware. This combo kit typically includes the Pixhawk 2.4.8 Flight Controller, GPS Module, and other essential accessories.

- **Pixhawk 2.4.8 Flight Controller :**

The Pixhawk 2.4.8 is an open-source, autonomous flight controller used in multirotors, fixed-wing aircraft, VTOLs, rovers, and boats. It is based on the PX4 and ArduPilot firmware, offering high precision, stability, and expandability for drones and UAV applications.

Specifications

1. Processor
   a. 32-bit ARM Cortex M4 core with FPU
   b. 168 MHz clock speed
   c. 256 KB RAM, 2 MB Flash
   d. 32-bit failsafe co-processor
2. Sensors
   a. MPU6000 as the main accelerometer and gyroscope
   b. ST Micro 16-bit gyroscope
   c. ST Micro 14-bit accelerometer/compass (magnetometer)
   d. MEAS barometer
3. Power
   a. Ideal diode controller with automatic failover
   b. Servo rail supports high power (7V) and high current
   c. Over-current protection for all peripheral outputs
   d. ESD protection for all inputs
4. Interfaces
   a. 5x UART serial ports (1 high-power capable, 2 with HW flow control)
   b. Spektrum DSM/DSM2/DSM-X Satellite input
   c. Futaba S.BUS input (output not yet implemented)
   d. PPM sum signal input
   e. RSSI input (PWM or voltage)
   f. I2C, SPI, 2x CAN, USB
   g. 3.3V and 6.6V ADC inputs
5. Dimensions
   a. Weight: 38 g (1.3 oz)
   b. Width: 50 mm (2.0”)
   c. Height: 15.5 mm (0.6”)
   d. Length: 81.5 mm (3.2”)

- **NEO-M8N GPS Module**

- Receiver type 72-channel Ublox M8 engine.
- GPS/QZSS L1 C/A, GLONASS L10F, BeiDou B1.
- SBAS L1 C/A: WAAS, EGNOS, MSAS.
- Galileo-ready E1B/C (NEO-M8N).
- Nav. update rate1 Single GNSS: up to 18 HZ.
- Concurrent GNSS: up to 10 Hz.
- Position accuracy2 2.0 m CEP.
- Acquisition2 Cold start: 26 s.
- Aided starts: 2 s.
- Reacquisition: 1.5 s.
- Sensitivity2 Tracking & Nav: –167 dBm.
- Cold start: –148 dBm.
- Hot starts: –156 dBm.
- Assistance AssistNow GNSS Online.
- Assist Now GNSS Offline (up to 35 days)3.
- Assist Now Autonomous (up to 6 days).
- OMA SUPL & 3GPP compliant
- Oscillator TCXO (NEO-M8N/Q).
- Crystal (NEO-M8M).

- **Radiomaster Pocket Radio Controller CC2500 - Transparent**

The RadioMaster Pocket is a small, lightweight radio that packs a big punch. MPM CC2500 version is come preinstalled with EdgeTX firmware. The Pocket is also equipped with removable stick ends and a foldable antenna, making it easy to transport and store. It is compatible with 18650 batteries, which provide long battery life for hours of fun.

- **GenX 14.8V 4S 8000mAh 40C / 80C Premium Lipo Lithium Polymer Battery**

The GenX Power Premium Lipo batteries are the gold standard for performance in the High Discharge Lipo Battery Segment. The 8000 mah Batttery is a 40C discharge rating cell which has a burst current of upto 80C. With the best energy density and weight to energy ratio available in the market, the GenX Power Premium Lipo Batteries are the most compact cells in the segment and stand out from the other available batteries.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 09 | Sept - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

The GenX Power Premium 14.8V 4S 8000mAh 40C Lipo Battery with XT90S Connector is a 4s1p battery pack with a nominal Voltage of 14.8V. This battery pack has 4 cells connected in series with a capacity of 40C continuous discharge. The nominal capacity of the battery pack is 8000mah.

- **ISDT PD60 60W/6A Portable 1-4s Li-Po Balance Charger**

This is a ISDT PD60 60W/6A Portable 1-4s Li-Po Balance Charger. It's Compatible with QC 2.0/3.0 and USB PD 2.0/3.0. It supports 5-20V Voltage Input.

characteristics of ISDT PD60 60W/6A Portable 1-4s Li-Po Balance Charger.

- USB-C Power input
- Support USB interface to upgrade firmware – Connecting the computer through the USB-C interface, upgrade to the latest firmware Always maintain the advanced performance and features.
- Natural convection, silent heat dissipation – The all-aluminum radiator combines a honeycomb radiator and a hidden air inlet to quietly take away heat by natural convection.
- Compactable, Easy to hold – Small size, coupled with PD and QC fast charging protocol, can be easily put in the bag whether in daily life or during travel.
- Specification

No. of Cells	[illegible]
Input Voltage (V)	[illegible]
Output Voltage (V)	[illegible]
Input Current (A)	[illegible]
Charging Power (W)	[illegible]
Balance Current	[illegible]
Battery Type	[illegible]
Operating Temperature (°C)	[illegible]
Storage Temperature (°C)	[illegible]
Connector	[illegible]
Length (mm)	[illegible]
Width (mm)	[illegible]
Height (mm)	[illegible]
Weight (g)	[illegible]
Additional Specs	[illegible]

- **100A PDB Power Distribution Board:**

The 100A Multirotor ESC Power Distribution Battery Board For Quadcopter is a lightweight distribution board that will power your multi-rotor aircraft easily.These boards are great for smaller multirotor builds. They're compact and lightweight and offer large solder pads – making them easy to work with.

These boards can handle some serious current – up to 20A per output for a quadcopter build or drop that down to 10A each for an octocopter.

- **915Mhz 100mW Mini Telemetry Kit :**

This is a 915Mhz 100mW Radio Telemetry Kit that is based on the 3DR Telemetry kit and is 100% compatible as it runs the same firmware onboard. This firmware used by 3D Robotics is completely open-source which is, of course, the reason we are able to use it on our own version at Unmanned Tech.

The Unmanned Telemetry Kit is compatible with Ardupilot or Pixhawk-based systems and allows you to easily add a two-way telemetry connection between your drone and ground station. This product comes with our full support and warranty as we are confident in the functionality and reliability of this item.

- **1/3″ CMOS 1500TVL Mini FPV Camera 2.1mm Lens PAL / NTSC With OSD**

This 1/3″ CMOS 1500TVL Mini FPV Camera support both PAL and NTSC where PAL is slightly sharper and clearer text display on the screen and NTSC is used for slightly higher frame rate, and it helps with smoother FPV video playback also the lens can be tilted up to 158 degrees. The night-vision starlight camera is small in size but it has an Illumination of 0.001Lux/1.2F.

This camera uses a high-performance 1/3" CMOS camera with a 2.1mm lens for exceptional clarity and resolution. It provided an excellent picture quality in all light conditions and Wide Dynamic Range (WDR) and 3D Noise Reduction (3DNR) combine to give superb image clarity and definition. This Type of FPV camera is used for many of the same applications like Aerial photography and cinematography, remote inspections, security, Military, and other entertainment purposes.

- **5.8G UVC OTG Android AV Phone Receiver**

5.8G UVC OTG Android Phone Receiver is a new receiver that you can connect to your smartphone directly instead of a heavy monitor and is good for those who feel dizzy when wearing FPV goggles.

It has low latency of around 100ms 150CH auto search allows covering all 5.8G frequency bands.

- **TS835 Fpv 5.8G 600Mw 48Ch (2-6S) Wireless Av Transmitter :**

This TS835 FPV 5.8G 600MW 48CH (2-6S) Wireless AV Transmitter is perfect for the small budget multi-rotor. Works brilliantly in an atom and because of its low price you have no worries about throwing it around the sky.

A good little mod you can do is to simply solder a length of the single core wire to the SMA as this gives you more than enough range without the long hefty antenna.

Features :

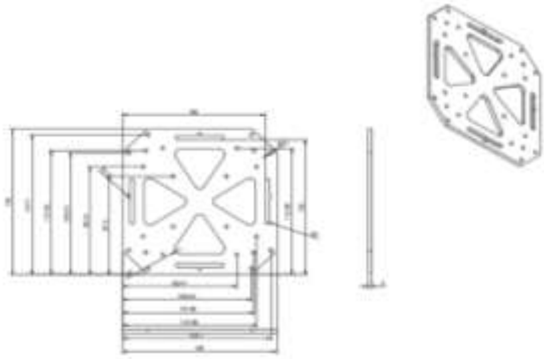
1. 48 channels choice to get the best transmitting quality.
2. Compatible with A, B, E, and F frequency bands
3. Smaller size with lighter weight.
4. 48 CH compatible with all FPV 5.8g receivers.
5. 5.8G 600mW 40 Channels AV wireless FPV transmitter
6. Super small 200mA current for 600mW wireless transmitter power.
7. 600mW transmitter power assure 5KM distance in open area,
8. 5-8 KM is available if work with the bigger gain antenna.

Connector: transmitter module side RP-SMA jack, antenna RP-SMA plug

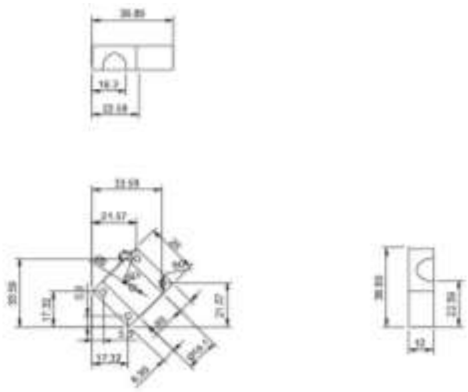
➢ MODELING OF DRONE

- **Introduction to Fusion 360**

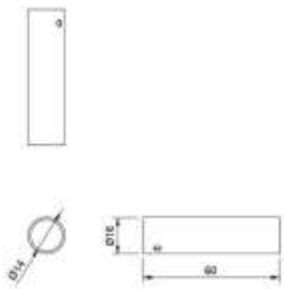
Fusion 360 is a cloud-based 3D modelling, computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) software developed by Autodesk. It runs on Windows and macOS platforms and is known for integrating design, engineering, and manufacturing workflows into a single tool. Fusion 360 supports collaborative work, allowing teams to work on the same design project in real time.



Drawing of Base Plate

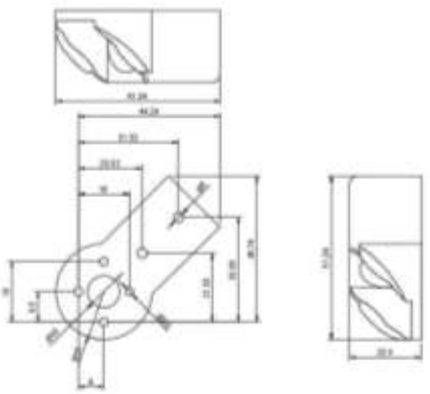


Drawing of 3D Printing Arm Clamp

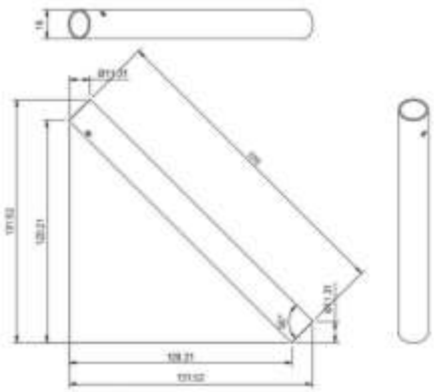


Drawing of Landing Gear Rod

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 09 | Sept - 2025 SJIF Rating: 8.586 ISSN: 2582-3930



Drawing of 3D Printing Motor Arm Clamp

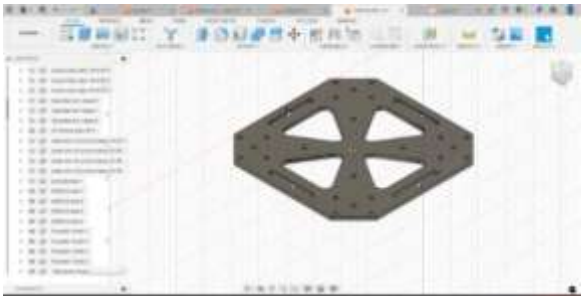


Drawing of Carbon Fiber arm Tube

Drawing of Assembly

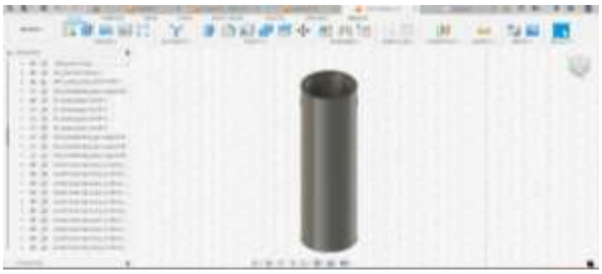
3D Modeling in Fusion 360

Top Plate

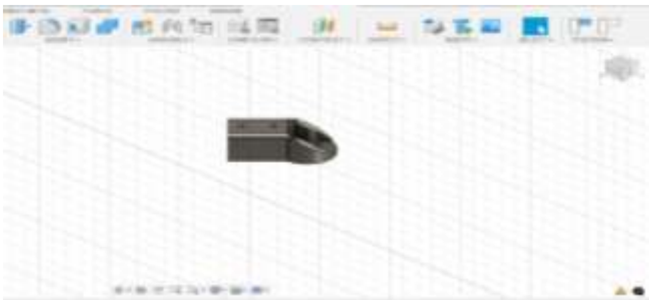


Base Plate

Arm Clamp



Landing Gear Rod



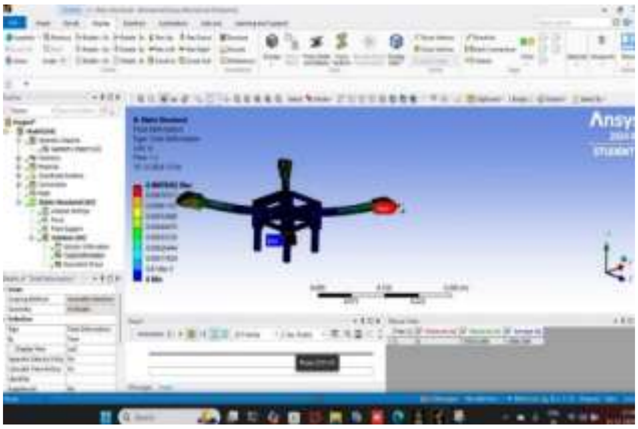
Motor Arm Clamp

Arm Tube

Motor Arm Clamp

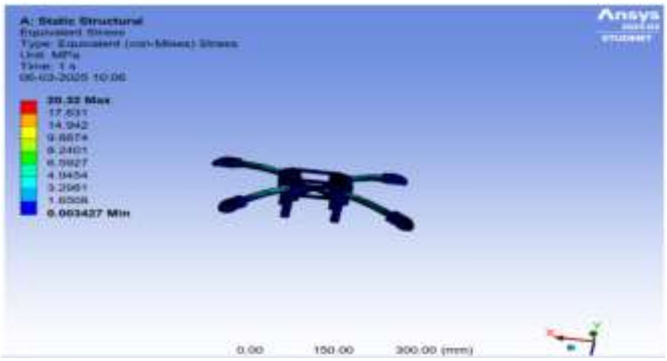
Static Structural

Static Structural Analysis evaluates a structure's response under static loading conditions, assuming loads and boundary conditions remain constant over time. It can handle both **linear** and **nonlinear** scenarios, accounting for material nonlinearities (like plasticity), large deformations, or contact interactions. Typical loads include forces, pressures, moments, gravity, and thermal effects, while boundary conditions such as fixed supports, displacement constraints, or symmetry are applied to restrict motion. The analysis provides results like displacements, stresses (e.g., von Mises), strains, and reaction forces. The workflow involves defining geometry, assigning material properties, creating a mesh, applying loads and constraints, solving the model, and interpreting the results to ensure the design's safety and performance.



Total Deformation

Time [s]	Minimum [Pa]	Maximum [mm]	Average [mm]
1.	0	0.34835	0.19353



Equivalent Stress

Time [s]	Minimum [mPa]	Maximum [mPa]	Average [mPa]
1.	0.003427	20.32	6.5927

RESULTS

The prototype UAV developed in this project underwent systematic design, fabrication, and testing processes to evaluate its feasibility for community-based operations such as surveillance, medical delivery, and environmental monitoring.

Flight Time Performance:

Two scenarios were analyzed for flight duration:

At 75% throttle:

Current consumption: 43A

Flight Time: 15 minutes

At 60% throttle:

Current consumption: 24A

Flight Time: 25 minutes

This demonstrates the UAV's ability to sustain flight for practical use cases when operated under moderate load.

Thrust-to-Weight Ratio:

Maximum thrust (4 motors): 3200g

Total weight (fully equipped): 1928g

T/W Ratio: 1.65

This confirms the UAV has sufficient lift capability, allowing stable flight and payload handling with a margin for maneuverability.

Component Integration:

All subsystems (motors, ESCs, GPS, telemetry, camera, Pixhawk FC) were successfully integrated.
Calibration of accelerometer, compass, ESC, and transmitter confirmed accurate system response and reliable stabilization.

3D Printing & Structural Design:

Custom components were designed using **Fusion 360** and fabricated using **FDM 3D printing**.
Carbon fiber and PLA materials provided strength with weight optimization.
Structural components withstood field testing, validating **ANSYS-based stress analysis**.

System Features Demonstrated:

Manual and autonomous operation via **Mission Planner**.
Real-time telemetry and GPS data acquisition.
Onboard camera for FPV use.
Safe Return-to-Launch failsafe and mode switching.

Testing

The results showcase the UAV's practical applicability in real-world tasks, particularly where rapid deployment and low-altitude monitoring are needed. The balance between performance, cost, and ease of manufacture positions this UAV well for use in educational, rural, and semi-urban contexts.

4. CONCLUSIONS

This project involved the complete lifecycle of UAV development—from concept, design, analysis, and fabrication to functional testing. Key technologies included CAD modeling (Fusion 360), structural simulation (ANSYS), additive manufacturing, and electronic integration.

1. The designed UAV meets the basic requirements for community services such as:
   - **Surveillance and patrolling**
   - **Emergency medical supply drops**
   - **Environmental inspection**
2. The UAV demonstrated stable flight with a good thrust-to-weight ratio and 15–25 minutes of flight time depending on throttle load.
3. Efficient integration of Pixhawk 2.4.8, GPS, and telemetry modules enabled both autonomous and manual control.
4. The use of lightweight materials and modular design ensures ease of replication and maintenance.

Acknowledgments

We would like to express our sincere gratitude to our internal guide, **DR.ANJAIAH MADARAPU** Professor, Department of Mechanical Engineering for his valuable guidance, encouragement, and continuous support throughout the duration of this project.

We are also thankful to Dr. A. RAJ KUMAR, Professor and Head of the Department, Mechanical Engineering for his expert supervision and helpful suggestions, which contributed significantly to the successful completion of this project.

We would also like to thank the faculty members of the Mechanical Engineering and the Lab Technicians for their assistance and cooperation during the practical work of our project.

We are grateful to our friends and well-wishers for their encouragement, collaboration, and useful feedback throughout the project journey.

Lastly, we sincerely thank our parents for their constant support, patience, and motivation, which helped us complete this project successfully.

REFERENCES

[1] Dilshad, N., Hwang, J., & Song, J. (2020). Applications and challenges in video surveillance via drone: A brief survey. *IEEE ICTC*.
[2] Muzammul, M., AlGarni, A., & Ghadi, Y. (2024). Enhancing UAV aerial image analysis: Integrating advanced SAHI techniques with real-time detection models. *IEEE Access*.
[3] Yang, N. K., & San, K. T. (2016). A novel approach for real-time monitoring system to manage UAV delivery. *IIAI International Congress on Advanced Applied Informatics*.
[4] Modh, H., et al. (2014). Comparison of theoretical, analytical, and testing results of various frame cross-sections.
[5] Di Cesar, A., et al. (2012). Weight reduction techniques for autonomous flight UAVs.
[6] Phang, S. K., et al. (2014). Frame shape and thickness optimization for UAV strength.
[7] Pounds, P., et al. (2010). Design and control analysis of a 4kg quadcopter with 1kg payload.
[8] Cutler, M., et al. (n.d.). Performance improvement using variable-pitch propellers for UAVs.
[9] Santos, et al. (2011). Development of a fuzzy controller for UAV flight stabilization.
[10] Park, Y. B., et al. (2011). Stress analysis in composite wings and landing gear of UAVs.
[11] Yuksel, S. (2009). Impact load analysis for UAV belly landing.
[12] F. B., et al. (2017). Use of UAVs for precision agricultural spraying.
[13] Carlsson, J. G., et al. (n.d.). Development of UAV-based dynamic delivery systems.
[14] Akshayraj, N., Kumar, M., & Chandrakant, S. A. (2022). Design and structural analysis of UAV body frame. *IJRAR Research Journal*.
[15] Pawar, A. A., Nalbalwar, S. L., & Deosarkar, S. B. (2019). Surveillance drone and real-time monitoring. *International Research Journal of Engineering and Technology (IRJET)*.
[16] Adorni, E., Rozhok, A., & Revetria, R. (2021). Literature review on drones used in the surveillance field. *International MultiConference of Engineers and Computer Scientists*.
[17] Shetty, S., et al. (2018). Development of an autonomous drone for surveillance application. *International Research Journal of Engineering and Technology (IRJET)*.
[18] Quan, L., et al. (2020). Survey of UAV motion planning. *IET Cyber-Systems and Robotics*.
[19] Aswin Kumar, V., et al. (2021). Structural optimization of UAV frames using carbon fiber composites. *Journal of Physics: Conference Series*.