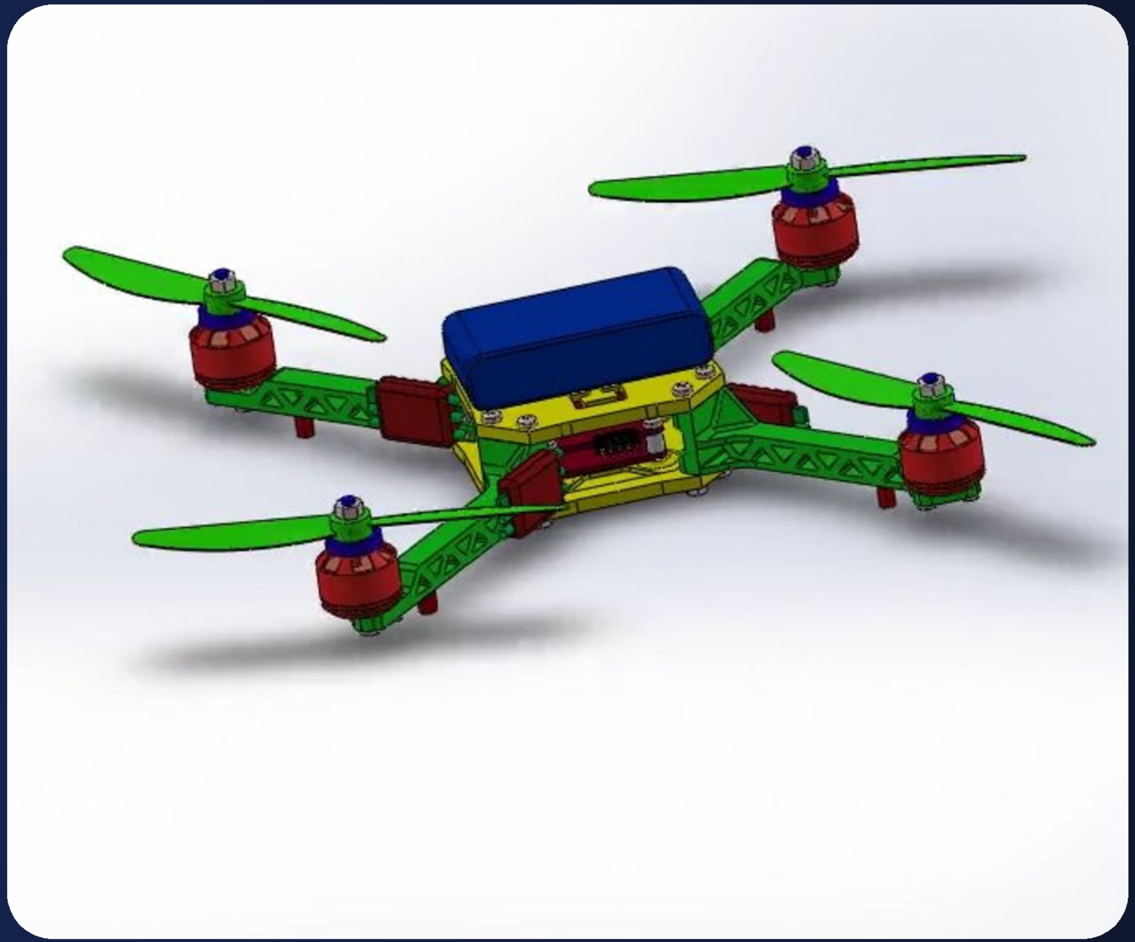
MicroQuad-X250: Modular UAV Platform for Engineering Applications

SolidWorks Design Project for Educational Applications

DESIGN OVERVIEW

What is MicroQuad-X250?

- A 250mm quadcopter design concept created in SolidWorks
- Features color-coded modular components for easy identification
- Designed around the principle of component accessibility
- Targets educational markets where students need hands-on learning
- Emphasizes design-for-assembly methodology



Why This Matters

- Modular architecture allows individual component replacement
- Color-coding system simplifies component identification
- Standardized fasteners reduce tool requirements
- Symmetric X-frame configuration for balanced performance
- Educational focus prioritizes learning over peak performance

Design Challenge: Making Complex Technology Accessible

How Modular Design Addresses Educational Needs

The Problem with Current Educational Drones

Sealed enclosures prevent students from accessing components.

When one part fails, entire units need replacement.

Complex assembly procedures discourage hands-on learning.

Students can't see how individual systems work together.

Repairs require specialized knowledge and tools.

Our Design Approach

Modular architecture: Every major system can be separated.

Color-coded organization: Visual system for component identification.

Standardized connections: Common fasteners throughout the design.

Accessible layout: Components positioned for easy access.

Symmetric design: Reduces complexity and part count.

Design Methodology

Started with component identification and color-coding system | Designed frame structure to accommodate modular electronics.
Created standardized mounting interfaces for all systems | Developed an assembly sequence that builds the grasp progressively.

The Goal

Create a drone design that teaches engineering principles through its construction process, not just its operation.

Why Current Educational Drones Don't Work Well

The Challenge of Learning with Complex Technology

THE PROBLEM WITH CURRENT DRONES

What's Wrong Today

- When a drone crashes, the whole thing might be ruined
- Students can't see or touch the important parts inside
- Repairs are expensive and take weeks
- Assembly instructions are too complicated for beginners
- One broken part means buying a whole new drone

Our Solution: Think Like Building Blocks

- Every major part can be removed and replaced separately
- All parts are color-coded so you know what goes where
- Only need one simple tool (like a screwdriver) for everything
- If the motor breaks, just replace the motor - not the whole drone
- Students learn by actually handling each component

Performance and Capabilities Overview

What You Can Expect from This Drone

The Five Main Systems:

- <u>GREEN Parts:</u> The frame and body structure
- <u>RED Parts:</u> The motors and propellers (makes it fly)
- <u>BLUE Parts:</u> The "brain" and sensors (keeps it stable)
- <u>YELLOW Parts:</u> The battery and power system
- <u>GRAY Parts:</u> All the screws and connectors

Flight Performance

- Flies for 10-15 minutes on one battery charge
- Can carry small cameras or sensors (about 80 - 140 g)
- Flies up to 30 mph in sport mode
- Stable in winds up to 15 mph
- Can hover precisely in one spot
- Range: About 300 feet from the controller

Real-World Applications

- Photography and videography training
- Search and rescue simulation
- Agricultural monitoring practice
- Basic autonomous flight programming

What Makes It Special:

- Each colored system can be removed separately
- All parts connect with standard screws
- No special tools needed - just one hex key
- Built-in safety features prevent dangerous flying
- Designed to survive crashes and keep working

Five-System Modular Architecture

Color-Coded Design for Component Organization

GREEN System - Frame Structure: - X-frame configuration with lattice-pattern arms - Integrated landing gear design - Motor mount plates with vibration consideration - Central battery compartment with secure retention - Quick-release arm attachment points

RED System - Propulsion: - Four 2204 brushless motor mounts - Integrated propeller mounting system - Motor wire management channels - Thrust-optimized motor positioning - Counter-rotating propeller configuration

BLUE System - Flight Control: - Protected flight controller housing - IMU sensor integration design - Vibration isolation mounting - Accessible programming interface - Antenna placement optimization

YELLOW System - Power Management: - Dual-compartment electronics housing - ESC integration with thermal considerations - Power distribution board mounting - Battery management system interface - Overcurrent protection design

GRAY System - Hardware: - M3 stainless steel fastener specification - Standardized hex key requirement (2.5mm) - Consistent torque specifications throughout - Minimal fastener count for simplicity - Strategic fastener placement for accessibility

Design Integration: All systems connect through standardized interfaces, enabling independent component access while maintaining structural integrity and electrical connectivity.

Frame Design and Material Considerations

Balancing Strength, Weight, and Educational Access

Frame Geometry Design: - X-configuration provides optimal motor placement - Diamond-pattern lattice arms balance strength and weight - Integrated landing gear eliminates separate components - Symmetric design reduces manufacturing complexity - Recessed battery compartment lowers center of gravity

Material Selection Considerations: - Polymer composite frame for educational durability - Aluminum electronics housing for electromagnetic shielding - Stainless steel fasteners for corrosion resistance - Design accommodates various material options - Weight optimization through strategic material placement

Structural Features: - Vibration isolation between motors and electronics - Stress distribution through lattice arm design - Impact protection for critical components - Modular arm design enables easy replacement - Integrated cable management throughout structure

Design Specifications: - Frame diagonal: 250mm (motor centerline to centerline) - Overall height: 85-95mm including landing gear - Arm length: 125mm from center to motor mount - Component count: 14 primary assemblies - Total design weight target: 335-445g

CAD Design Benefits: - Parametric design allows easy dimension modifications - Assembly constraints ensure proper component fit - Design visualization helps identify potential issues - Material properties can be easily modified - Assembly sequence can be optimized through CAD analysis

Design for Assembly Methodology

CREATING INTUITIVE BUILD PROGRESSION

Step 1: Frame Assembly (Green Components)
- Central frame pieces connect with visible fasteners
- Arm attachment points clearly marked
- Landing gear integrated into frame structure
- Battery compartment becomes immediately apparent
- Foundation for all other systems established

Step 2: Propulsion Integration (Red Components)
- Motor mounts attach to arm terminations
- Propeller attachment points clearly visible
- Motor wire routing becomes apparent
- Thrust vector alignment designed into geometry
- Counter-rotation requirements become clear

Step 3: Electronics Housing (Blue/Yellow Components)
- Dual-compartment design separates systems
- Flight controller protection clearly demonstrated
- Power management system organization visible
- Wiring harness routing designed for clarity
- Component accessibility maintained throughout

Step 4: Hardware Integration (Gray Components)
- Standardized fastener approach becomes apparent
- Single tool requirement demonstrated
- Torque specifications consistent throughout
- Assembly mistakes minimized through design
- Maintenance access points clearly identified

Step 5: Final Integration and Balance Check
- Component weight distribution becomes apparent
- Center of gravity optimization visible
- System integration demonstrated
- Troubleshooting access points clear
- Overall system operation becomes understandable

Design Benefits
- Each step builds on previous knowledge
- Assembly sequence reinforces engineering principles
- Mistakes are minimized through design constraints
- Students understand function through construction
- Modular approach enables easy modifications

Performance Parameters and Design Targets

ENGINEERING CALCULATIONS BEHIND THE DESIGN

Physical Design Parameters:
- Frame diagonal: 250mm (optimized for stability vs. portability)
- Overall height: 85-95mm (includes integrated landing gear)
- Component weight distribution designed for balance
- Center of gravity positioned for stable flight characteristics
- Modular design adds minimal weight penalty

Power System Design:
- Four motor configuration for redundancy and control
- Power consumption estimated at 200-280W continuous
- Battery integration designed for 1500mAh 3S LiPo
- Power distribution optimized for efficiency
- Thermal management considerations built into housing design

Performance Design Targets:
- Thrust-to-weight ratio: 2.5:1 minimum design target
- Flight duration: 10-15 minutes with standard battery
- Payload capacity: 100-150g for educational sensors
- Operating envelope: Designed for indoor/outdoor use
- Control range: 300 feet for educational applications

Weight Distribution Analysis:
- Frame structure: 65-85g (optimized polymer composite)
- Propulsion system: 120-160g (four brushless motors)
- Electronics package: 135-175g (dual-compartment design)
- Hardware: 15-25g (stainless steel fasteners)
- Total design weight: 335-445g (battery dependent)

Design Validation Approach:
- SolidWorks mass properties analysis
- Center of gravity calculations
- Component interference checking
- Assembly constraint validation
- Design rule checking for manufacturability

Educational Design Considerations:
- Assembly time target: 25-35 minutes
- Tool requirement: Single 2.5mm hex key for 85% of operations
- Fastener count: 20-25 pieces total
- Component count: 14 primary assemblies
- Disassembly/reassembly cycles: Designed for repeated use

Design Summary and Recommendations

MICROQUAD-X250 DESIGN PROJECT CONCLUSIONS

DESIGN OBJECTIVES ACHIEVED

Primary Design Goals:

✓ Modular architecture successfully implemented
✓ Color-coded component organization system developed
✓ Standardized assembly methodology established
✓ Educational accessibility prioritized throughout design
✓ 250mm form factor maintained within specifications

Key Design Features:

- Five-system modular architecture
- Single-tool assembly requirement (2.5mm hex key)
- 14 primary assemblies with standardized interfaces
- Target weight: 335-445g including battery
- Symmetric X-frame configuration for balanced performance

RECOMMENDATIONS

Design Validation:

- Prototype development recommended to validate design concepts
- Component interface verification required
- Assembly sequence optimization through physical testing
- Material selection confirmation for educational environments

PROJECT DELIVERABLES

Complete CAD documentation including:

- Full assembly model with all components
- Individual part drawings and specifications
- Exploded assembly views for documentation
- Bill of materials with component specifications
- Assembly sequence documentation

Future Enhancement Opportunities

- Advanced sensor integration capabilities- Payload interface standardization
- Manufacturing cost optimization- Alternative material configurations

CONCLUSION

The MicroQuad-X250 design successfully demonstrates the application of modular design principles to educational UAV applications. The SolidWorks design provides a comprehensive foundation for prototype development and further refinement.