CUBE-PRO

Enterprise UAV Service Management System

System Architecture & Technology Stack Snapshot

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Framework:	Python Flask with SQLAlchemy ORM
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1. Architecture Overview

Core Technology Stack

CUBE-PRO is a comprehensive enterprise-grade UAV service management system built on modern web technologies. The system employs a Model-View-Controller (MVC) architecture pattern using Python Flask as the primary framework, providing scalable and maintainable code structure through Blueprint-based modular design.

Component	Technology	Version	Purpose
Backend Framework	Python Flask	2.3.3	Web application framework
Database ORM	SQLAlchemy	3.0.5	Object-relational mapping
Authentication	Flask-Login	0.6.3	User session management
Forms	WTForms + Flask-WTF	3.0.1 + 1.1.1	Form handling and validation
Database	SQLite/PostgreSQL	Latest	Data persistence
Frontend Framework	Bootstrap	5.3.2	Responsive UI components
JavaScript	Vanilla ES6+	Native	Client-side interactions
Charts	Chart.js	Latest	Data visualization
Icons	Font Awesome	6.x	Icon library
Analytics	Plotly + Pandas	5.17.0 + 2.1.1	Advanced reporting

2. Database Architecture

Core Models (22 Total)

The system employs a comprehensive database schema with 22 interconnected models, providing complete coverage for enterprise UAV service management operations.

Category	Models	Purpose
User Management	User, Role	Authentication and authorization
Work Orders	WorkOrder, WorkOrderActivity, WorkOrderPart	Service ticket management
Products	Product, ProductCategory, ProductSpecification, ProductImage, Company	UAV catalog management
Inventory	InventoryCategory, InventoryItem, InventoryTransaction	Parts and stock management
Service Management	ServiceCategory, ServiceIncident, ServicePart, ServiceActivity, ServiceSoftwareUpdate, ServiceTemplate	Comprehensive service workflows
Reporting	SavedReport, ReportSchedule, ReportExecutionLog	Analytics and reporting
Support Tables	Priority, Status, Category	Reference data

Key Relationships

- **One-to-Many:** Users → Work Orders, Categories → Products, Companies → Products
- **Many-to-Many:** Work Orders ↔ Inventory Parts through WorkOrderPart junction table
- **Complex Workflows:** Service Incidents with 8-step workflow tracking and status management
- **Audit Trails:** Activity logging for all critical operations with timestamp tracking

3. Application Modules

8 Primary Modules

Module	Route Prefix	Primary Functions	Key Features
Authentication	/auth	Login, logout, password management	Session handling, role-based access
Main Dashboard	/	Overview, statistics, navigation	Real-time updates, analytics widgets
Work Orders	/workorders	CRUD operations, status tracking	Activity logging, assignment management
Inventory	/inventory	Parts management, stock tracking	UAV-specific categories, cost tracking
Service Management	/service	UAV service incidents, workflow	8-step process, template management
Products	/products	UAV catalog, specifications	Company management, technical specs
User Management	/users	Admin, role management	Bulk operations, user analytics
Reporting	/reporting	Custom reports, analytics	Scheduled reports, multiple formats

Additional Modules

• **Email Management (/email-management):** SMTP configuration, template management, notification system
• **API Endpoints:** Real-time dashboard updates, data synchronization, mobile app support

4. Frontend Architecture

Responsive Design

The frontend architecture is built on modern web standards with a mobile-first approach, ensuring optimal user experience across all device types and screen sizes.

Component	Technology/Approach	Implementation Details
Responsive Framework	Bootstrap 5.3.2	Mobile-first grid system, utility classes
Theme System	CSS Variables + JavaScript	Light/Dark mode toggle with localStorage persistence
Color Scheme	Enterprise Blue/Grey Palette	Professional corporate identity with accessibility compliance
Typography	Inter Font Family	Modern, readable typeface with multiple weights
JavaScript Architecture	Vanilla ES6+ Modules	No framework dependencies, modern browser APIs
Real-time Updates	AJAX + Fetch API	30-second dashboard refresh, live statistics
Interactive Elements	Bootstrap Components	Form validation, modals, tooltips, progress bars
Chart Integration	Chart.js	Dynamic data visualization with responsive design
Icon System	Font Awesome 6.x	Comprehensive icon library with consistent styling
Loading States	Custom CSS + JavaScript	Professional UX feedback with spinners and animations

Template Structure

- **Base Templates:** base.html and base_new.html providing consistent layout and styling
- **Modular Components:** Reusable blocks for forms, tables, navigation, and data display
- **Jinja2 Features:** Custom filters, macros, template inheritance for maintainable code

5. Advanced Features

Service Management System

The service management system provides a comprehensive 8-step workflow for UAV maintenance and repair operations, with built-in quality control and progress tracking at each stage.

Step	Status	Activities	Integration Points
1	Received	Initial intake, documentation	Work order creation, customer notification
2	Inspection	Visual and technical assessment	Photo documentation, preliminary diagnosis
3	Diagnosis	Detailed analysis and testing	Parts requirement identification
4	Approval	Customer approval for repairs	Cost estimation, timeline communication
5	Parts	Parts ordering and allocation	Inventory integration, supplier management
6	Repair	Actual repair work	Technician assignment, time tracking
7	Testing	Quality assurance testing	Flight testing, functionality validation
8	Complete	Final delivery preparation	Customer notification, invoicing

Real-time Dashboard Features

• **Live Statistics:** Auto-refreshing work order counts with 30-second update intervals
• **Cache Management:** Intelligent cache-busting to prevent stale data display
• **API Integration:** RESTful endpoints for real-time data synchronization
• **Session Handling:** Automatic database session management for data consistency

Inventory Management

• **UAV-Specific Categories:** Pre-configured for drone components (Motors, Flight Controllers, Sensors, etc.)
• **Smart Stock Tracking:** Minimum/maximum level alerts with automatic reorder suggestions
• **Cost Management:** Comprehensive cost tracking with unit and total calculations
• **Transaction History:** Complete audit trail for all inventory movements and adjustments

6. Data & Analytics

Reporting Engine

The integrated reporting engine provides comprehensive analytics capabilities with custom report building, automated scheduling, and multiple export formats for business intelligence and operational insights.

Feature	Capability	Business Value
Custom Report Builder	Drag-and-drop query interface	Self-service analytics for non-technical users
Scheduled Reports	Automated generation and delivery	Regular business intelligence updates
Export Formats	CSV, Excel, PDF with custom formatting	Flexible data sharing and presentation
Report Templates	Saved configurations and parameters	Standardized reporting across organization
Dashboard Analytics	Real-time KPI monitoring	Immediate operational visibility
Work Order Metrics	Status distribution, completion rates	Performance measurement and optimization
Inventory Analytics	Stock levels, cost analysis, trends	Supply chain optimization
Service Metrics	Workflow tracking, performance KPIs	Service quality and efficiency monitoring
User Activity	Login tracking, role-based usage	System utilization and security monitoring

7. Security & Performance

Security Features

Security Layer	Implementation	Protection Level
Authentication	Flask-Login session management	User identity verification
Password Security	Werkzeug hashing with salt	Strong password protection
CSRF Protection	Flask-WTF token validation	Form submission security
Role-Based Access	Admin, Manager, Technician roles	Granular permission control
Session Management	Secure cookie handling	Session hijacking prevention
Input Validation	WTForms server-side validation	Data integrity and XSS prevention
SQL Injection Prevention	SQLAlchemy ORM parameterized queries	Database security
Audit Logging	Comprehensive activity tracking	Security monitoring and compliance

Performance Optimizations

- **Database Indexing:** Strategic indexes on frequently queried fields for optimal performance
- **Lazy Loading:** SQLAlchemy relationship optimization to minimize database queries
- **Cache Headers:** Browser cache management for static assets and dynamic content
- **AJAX Updates:** Reduced page reloads with targeted content updates
- **Efficient Queries:** Optimized database queries with proper joins and filtering

8. Enterprise Features

Professional UI/UX Design

The system features a professional enterprise-grade user interface designed for productivity and ease of use in demanding business environments.

- **Enterprise Color Scheme:** Professional blue and grey palette for corporate environments
- **Consistent Typography:** Inter font family for modern, readable text across all interfaces
- **Responsive Tables:** Mobile-optimized data display with sorting and filtering capabilities
- **Loading Indicators:** Professional feedback mechanisms for all user interactions
- **Accessibility Compliance:** WCAG guidelines adherence for inclusive design

Business Logic & Operations

- **Workflow Management:** 8-step service processes with automated progression and validation
- **Cost Tracking:** Detailed financial management with labor, parts, and overhead calculations
- **Audit Trails:** Complete activity logging for compliance and quality assurance
- **Multi-tenant Support:** Company-based organization for service bureau operations
- **Integration Ready:** API endpoints for third-party system integration

Deployment Architecture

- **Environment Configuration:** Python virtual environments with dependency management
- **Database Migrations:** Flask-Migrate support for schema evolution
- **Production Ready:** Gunicorn WSGI server configuration for scalable deployment
- **Configuration Management:** Environment variables and secure configuration handling
- **Monitoring Ready:** Structured logging and health check endpoints

File Structure Overview

```
CUBE/
■■■ app/ # Main application package
■ ■■■ auth/ # Authentication module
■ ■■■ main/ # Dashboard and core functionality
■ ■■■ workorders/ # Work order management
■ ■■■ inventory/ # Inventory and parts system
■ ■■■ service/ # Service management workflow
■ ■■■ products/ # Product catalog management
■ ■■■ users/ # User administration
■ ■■■ reporting/ # Analytics and reporting engine
■ ■■■ email_management/ # Email system and templates
■ ■■■ static/ # CSS, JavaScript, and assets
■ ■■■ templates/ # Jinja2 HTML templates
■■■ instance/ # Database and instance files
■■■ requirements.txt # Python dependencies
■■■ run.py # Application entry point
```

System Summary

CUBE-PRO represents a comprehensive, enterprise-grade work order management system specifically designed for UAV service operations. Built on modern web technologies with Flask and SQLAlchemy, the system provides a robust foundation for managing complex service workflows, inventory operations, and business analytics. The 8-step service workflow, real-time dashboard updates, and comprehensive reporting capabilities make this system suitable for professional UAV service centers, corporate fleet management, and multi-tenant service bureau operations. With its modular architecture, security features, and professional user interface, CUBE-PRO provides the scalability and reliability required for mission-critical UAV service management operations.