

Assignment 1 - System Categorization

System Description

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1 System Description

1.1 AeroTech Industries and the X9 Drone System

In 2005, Dr. Emily Carter and Dr. Michael Patel founded AeroTech Industries to provide aerospace and defense solutions through the design, development, and manufacturing of unmanned aerial vehicles (UAVs). The company began with the mission to revolutionize aerial solutions by providing cutting-edge UAV technology that enhances efficiency, safety, and decision-making across industries. The earliest drones produced by AeroTech were used for agricultural monitoring, and the company's focus remained primarily on the commercial market until 2020.

AeroTech's progression in drone technology is evident in its product timeline. In 2015, they released the AeroTech X5, which became an industry benchmark for reliability and performance in the commercial sector. The potential for border security, surveillance missions, and emergency services in later models attracted the interest of government agencies as well.

The AeroTech X9, introduced in 2023, is the company's most advanced drone system to date. The X9 emphasizes modularity and adaptability, allowing it to meet diverse mission requirements for government, commercial, and emergency services stakeholders on a global scale. It offers integrated advanced artificial intelligence for autonomous navigation and decision-making. The lightweight and durable materials developed through AeroTech's materials science research protect the aircraft, while state-of-the-art cybersecurity protocols safeguard operations and data integrity.

AeroTech Industries has a global presence with offices and facilities in North America, Europe, Asia-Pacific, and the Middle East, supporting the X9's worldwide operational capabilities. The company continues to invest heavily in research and development, focusing on artificial intelligence, materials science, energy solutions, and cybersecurity to maintain its position at the forefront of UAV technology.

1.2 Purpose and Capabilities

In rural areas, Aerotech drones have provided assistance to many users in the commercial sector since 2008, and the X9 will only improve upon the services previous versions provided. Farming with the X9 becomes a considerably more precise operation. The X9 can be fitted with multi-spectral and thermal sensors to monitor crop health, optimize resource use by identifying areas needing irrigation or fertilization improving yields and reducing cost. Automated drones flights can survey large fields of crops identifying pests and plant disease much earlier than traditional methods minimizing crop damage. In more urban areas, the Aerotech X9 will be used for building, bridge, powerlines, and other critical infrastructure inspections, and the remote monitoring of difficult to reach places like the tops of electrical towers to minimize expensive manual inspections. The X9 will be used for forest health and wildlife monitoring, pollution detection, rapid and efficient delivery in cities, and remote deliveries to locations within rough terrain areas. The capabilities of the X9 in commercial industries is limited only by the imagination of the user.

Outside of commercial and agricultural purposes, the Aerotech X9 is ideal for government agency reconnaissance, border security, surveillance, law enforcement, and disaster response. Border control is a major issue in today's political landscape, and has become increasingly dangerous work. The X9 can provide detailed surveillance and monitoring capabilities on the front lines of border security without endangering border security personnel. The X9 produces real-time transmission of information to data centers including Ai-Powered threat detection and identification. The drone's high-resolution imaging, video, and long-range flight capabilities are ideal for collecting intelligence even in the most challenging environments. The X9 also offers support for law enforcement in the form of Crowd monitoring and management in large events, Aerial support for crime scene investigation and suspect tracking with rapid deployment for emergency situations. The AeroTech X9's utility extends further into the realm of emergency services, providing crucial support for search and rescue operations through its thermal imaging capabilities, enabling the location of missing persons across vast and varied terrains. The drone's ability to execute autonomous flight patterns ensures efficient search routes, maximizing coverage and minimizing response times. For firefighting efforts, the X9

delivers real-time monitoring of fire spread and intensity, offering invaluable guidance to firefighters on the ground and facilitating the safe and effective deployment of resources. Furthermore, the X9's capacity for rapid medical supply delivery ensures that critical medications and equipment reach remote or inaccessible areas promptly, potentially saving lives in emergency situations. The integration of AI and robust security measures across all applications enhances the X9's operational effectiveness while safeguarding sensitive data, and the availability of global support services ensures its reliable performance in diverse environments.

1.3 System Components

1.3.1 Airframe

- Lightweight, durable materials (developed through AeroTech's materials science research)
- Modular design for adaptability and customization
- Carbon fiber composite structure with military-grade materials for increased resilience
- Enhanced environmental sealing against dust, moisture, and electromagnetic interference

1.3.2 Propulsion System

- Electric Motors (Brushless DC): U8II Lite Efficiency Type Multirotor UAV Motor KV100
 - Specification: Stable operation, 1000 hr life, Competitive performance, 256g, 9.1kg thrust, 36 power ratio, Industrial grade, Waterproof, dustproof, low noise, large bearings
- Propellers: NS18*6 Prop-2PCS/PAIR
 - Specification: Very large, 18" super lightweight and durable, 17g, lifts 5kg per propeller
- Electronic Speed Controllers (ESCs): FLAME 80A 12S V2.0 Multi-Rotor UAVs ESC
 - Specification: Built for tough conditions, Built-in protection features, High-performance processor, 109g

1.3.3 Navigation & Control Hardware

- GPS Module: Collins AeroSpace Navstrike (SPS GPS Receiver)
 - Specification: Fifth-generation SAASM-based design, All-in-view tracking and navigation, No need for active antenna electronics, Field-reprogrammable software, Designed for high-g vibration and shock, High-speed serial interface, Field clock recalibration for extended storage
- Inertial Measurement Unit (IMU): Honeywell HG1930
 - Specification: Ideal for unmanned vehicles, Easy integration with SPAN receivers, Ideal for size-constrained applications, Small size and light weight, 10-30 VDC power input, 100 Hz data rate
- Flight Controller Board: UAV Navigation VECTOR-600
 - Specification: Automatic actions on waypoints: suitable for cargo drop or camera shots, Transponder ADS-B IN for UTM (Unmanned Traffic Management), Compact Unit, Easily Configurable, Multi-UAV Operations, Integrated ADS, Dual High-end CPU, Tactical grade ADAHRS, Flare and parachute activation for target drones
- Transmitter/Receiver (for remote control): CrysaliTMs Tactical GCS
 - Specification: Back-Packable, 20 km range, 10 min setup, 3.9 kg Android OS, Swappable battery, Compatible Antennas: pDDL, Standard Range Antenna, ERA
- MicroController Unit: STM32

- Specification: Very high performance, real-time capabilities, digital signal processing, low-power / low-voltage operation, and connectivity, while maintaining full integration and ease of development.

1.3.4 Onboard Computing

- GPU & CPU: NVIDIA Jetson Orin Nano
 - Specifications: CUDA-enabled for parallel processing, Supports machine vision with time-synchronized IMU and cameras, Enhances processing speeds for Dense Matching and 2D Products steps
- In-line Memory Encryptor: NXP SE050
 - Specifications: Hardware secure element, CC EAL 6+ certified, Supports AES and 3DES encryption/decryption, RSA and ECC asymmetric algorithms, Secure key storage, I2C interface, Temperature range -40°C to 105°C
- NVMe: Seagate Firecuda 530 NVMe SSD
 - Specifications: Speed Reigns. Pure performance, absolute power, the most advanced components, and unrivaled endurance. At up to 7,300MB/s you can harness the full power of PCIe Gen4 speeds. Built for sustained, pro-level gaming and accelerated content creation with transfer speeds up to 2× faster than PCIe Gen3 NVMe SSDs and up to 12× faster than SATA SSDs. Built with a Seagate-validated E18 controller and the latest 3D TLC SSD NAND to provide the most advanced speed and durability. Up to 5100TB TBW means you can write and delete 70% of the drive capacity, every day, for five years. Up to 4TB capacities and transfer speeds of up to 7300MB/s. Rescue Services. Three years of Rescue Data Recovery Services, offering an industry-leading 95% success rate against unexpected data loss.

1.3.5 Power System

- High-Capacity Battery (LiPo or similar): Back-up Batteries for MALE UAS
 - Specification: Flexible design and form factors addressing complex geometries, High energy density: 250 Wh/kg, High power density: 3,000 W/kg, Long life cycle – supporting hundreds of missions with a single battery, Cold and hot weather operability
- Power supply: TATTU G-tech
 - Specifications: Capacity: 41000mAh, Voltage: 23.7V/6S, Max Constant Current: 60A, Max Peak Current: 100A, Net Weight(±20g): 3790g, Size: 230x104x70mm, Discharge Connector Type: XT90-S, Balancer Connector Type: G-Tech-7P, Discharge Wire: 8# 150mm, Charge Wire: 22# 75mm. Technical Features: High Energy Density: 280Wh/kg, High Voltage: 4.45V/cell, Safety Performance: Voltage range of 4.45V to 3.0V per cell when the State of Charge (SOC) is from 100% to 0%. Cycle Life of Pack: 300+ cycles, with 80% of the initial capacity retained after those cycles.
- Voltage Regulators: Texas Instruments LM138QML
 - Specification: Manufactured and Tested per Texas Instruments Military Grade Flow, Specified 7-A Peak Output Current, Specified 5-A Output Current, Wide Temperature Range -55°C to 150°C, Adjustable Output Down to 1.2 V, Specified Thermal Regulation, Current Limit Constant With Temperature, Output is Short-Circuit Protected

1.3.6 Payload Interfaces

- Standardized mounting points: 12mm Rail Payload Mount Kit (Alta X)
 - Specifications: Compatible with payload mounting brackets using 12mm rails, Machined aluminum and carbon fiber for lightweight, rigid payload mounting, Weight in use: 6.6 oz / 186 g, Quick-release levers for easy adjustment, Includes fasteners and driver for installation
- Power and data connections for various sensors/payloads:
 - Mouser Electronics provides most connectors that might be necessary, and these will be included as needed.
- Cameras: VEGA Ultra Long-Range Multi-Sensor PTZ Camera
 - Specifications: 6.8 kg, 15.4–2075mm HD IR-Corrected Zoom Lens (with IZE doubler), 27°–0.2° Horizontal Field of View gives a 135X Zoom Range, 550X Zoom Ratio with 110° Wide-Angle Spotter Camera, 1280×1024 or 640×480 Cooled Thermal Imager, Thermal Lens Options Available with up to 1400mm 125° to 0.39° Thermal HFOV, Depending on Lens and Sensor, Optional ZLID™ Illumination for up to 6km of High Definition, NIR Imaging in Complete Darkness, Endless 360° Rotation Pan/Tilt with Speeds up to 0.001–100°/s, Up to 0.00036° Resolution Pan/Tilt with Low Backlash, Rugged IP66/67 and -50° to +65°C with Anti-Corrosion Finish
- Payload Delivery Unit: Tarot Payload Quick Release System
 - The electronic quick release electronic drop system is made of 6063 aviation aluminum and 304 stainless steel through CNC machining and assembly. The structure adopts the design principle of mechanical lever, which can reduce the output power required by the driving mechanism and make the throwing device volume. It is compact and the hinged structure of the lever will not be stuck due to the heavy weight of the load (the limit measured load is 43KG and the load can be smoothly retracted). You can mount multiple electronic drop systems of this series according to the usage scene environment, and can independently control the order of the throwing devices.

1.3.7 Communication System

- 5G Receiver: Telit FN990 Fixed wireless access
 - Specifications: Enterprise routers and gateways, Indoor and outdoor CPE, Professional broadcasting and surveillance Opt. 3a/3x and Opt. 2 for full network compatibility, Latest generation 4G and 5G Rel 16 4G Cat 20 up to 7xCA for FN990A40 4G Cat 19 up to 5xCA for FN990A28, Intra-band and interband UL CA supported on 4G networks for improved throughput performance for uplink-centric applications (e.g., surveillance cameras and 4K/8K video streaming), 3G HSPA+ Rel 8 for fallback to legacy networks, Support for PCIe Gen 3 and USB 3.1 Gen 2 for maximum application design flexibility, Dedicated/shared (switchable) RF path/connector for GNSS L1 to allow total flexibility in the design phase and low losses whenever high sensitivity is required, Internal GNSS L1 LNA allows the use of less expensive passive antennas, lowering the total cost of ownership.
- RF transmitter/receiver: RadioMaster XR3 Multi-Frequency RF Transceiver
 - High-Performance MCU, Advanced Transceiver, Additional UART Port, Antenna Diversity, Secondary Port, Castled Pads

1.3.8 Software Components

1.3.9 Flight Control Software

- Stabilization algorithms
- Navigation algorithms (GPS-based, autonomous)

- Mission planning and execution software
- Real-time control algorithms
- Modular architecture for updates and customization
- Autonomous navigation with AI algorithms for real-time path planning and obstacle avoidance
- Flight mode management and conversion of user inputs into appropriate control parameters

1.3.10 AI and Autonomy Software

- Machine learning algorithms for decision-making
- Object recognition and tracking
- Path planning and obstacle avoidance
- Real-time data processing for immediate decision-making based on environmental changes
- Autonomous multi-agent capabilities for complex mission execution
- Edge computing for mission-critical applications in communications-contested environments

1.3.11 Cybersecurity Software

- Encryption protocols
- Intrusion detection systems
- Authentication and authorization mechanisms
- Anti-spoofing measures for enhanced GNSS security

1.3.12 Sensor Data Processing Software

- Image processing algorithms
- Data fusion algorithms (combining data from multiple sensors)
- On-board image processing for real-time analytics
- Sensor-calculation module for converting and transferring data from various sensors
- SPOTR-Edge computer vision software for onboard detection, classification, localization, and tracking of objects

1.3.13 Communication Software

- Telemetry data encoding/decoding
- Command and control protocols
- Communication module for message handling between UAV and Ground Control Station
- Integration with distributed groups of dismounted units in a Mobile Ad Hoc Network (MANET)²

1.3.14 User Interface Software

- Ground control station software
- Mobile app for remote control and monitoring
- Intuitive behavior tree approach for rapid development and adoption of new autonomous missions
- Configuration tools for interacting with the flight controller, tuning parameters, and troubleshooting

1.3.15 Third-Party Components/Services

Advanced Sensor Systems

- LiDAR (Light Detection and Ranging) System:
 - Purpose: Creates highly detailed 3D maps of the environment. Essential for infrastructure inspection, surveying, and environmental monitoring.
 - Example: Velodyne Lidar Puck Series (or similar) - Known for accuracy and reliability.
 - Integration Notes: Requires careful integration with the X9's flight controller and power system. Data processing software is also needed.
- Hyperspectral Imaging System:
 - Purpose: Captures data across a wide range of the electromagnetic spectrum, providing detailed information about the chemical composition of materials. Crucial for precision agriculture, environmental monitoring, and mineral exploration.
 - Example: HAIP Solutions BlackBird V2 Hyperspectral Camera
 - Integration Notes: Includes an integrated 4K RGB camera for simultaneous acquisition of HSI and RGB images. Requires specialized software like PARGE® and DROACOR® for high-precision positioning and atmospheric correction.
- Dual Airspeed and Altitude Pressure Sensor:
 - Purpose: Provides high-accuracy airspeed and altitude measurements in a single compact unit.
 - Example: Amphenol All Sensors AUAV Series1
 - Integration Notes: Utilizes MEMS piezoresistive technology, offers digital I2C outputs, and includes unique serialized addressing for self-test and redundant safety requirements.

Enhanced Communication and Tracking

- Satellite Communication System:
 - Purpose: Enables communication and control of the drone in areas with no cellular or radio coverage. Essential for long-range missions and operations in remote areas.
 - Example: Iridium satellite transceiver module.
 - Integration Notes: Requires a dedicated antenna and integration with the X9's communication system.
- ADS-B Transceiver (Automatic Dependent Surveillance-Broadcast):
 - Purpose: Enhances airspace awareness and safety by broadcasting the drone's position and altitude to other aircraft and air traffic control.
 - Example: uAvionix ping200X.
 - Integration Notes: ADS-B is becoming increasingly important for regulatory compliance and safe drone operations in controlled airspace.

Specialized Payload Delivery Systems

- Precision Drop Mechanism:
 - Purpose: Allows for accurate delivery of small payloads, such as medical supplies or sensors. Useful for emergency services and environmental research.
 - Example: Drone Delivery Systems SureFly (or similar).
 - Integration Notes: The release mechanism must be reliable and controllable from the ground station. Weight and balance are also important considerations.

Enhanced Power Solutions

- Fuel Cell Power System:
 - Purpose: Extends flight time significantly compared to batteries. A good option for long-endurance missions.
 - Example: Intelligent Energy fuel cell systems.
 - Integration Notes: Requires a specialized fuel storage system and safety precautions.

Counter-Drone Technology

- Drone Detection System:
 - Purpose: Autonomous drone defense
 - Example: DroneShield DroneGun Tactical
 - Integration Notes: Requires specialized training and licenses, and should only be used when there is an intrusion from an unknown drone.

1.4 Stakeholders

The stakeholders for AeroTech Industries begin with its diverse customer base, encompassing farmers, city officials and planners, emergency services responders, and government agencies. Commercial enterprises engaged in agriculture, logistics, infrastructure inspection, and environmental monitoring all benefit from AeroTech Industries' products. These customers seek out AeroTech for high-performance and reliable drone services tailored to their specific needs, appreciating the cost-effectiveness and data security that AeroTech drones provide.

In addition to its global partners and the executive team led by Drs. Carter and Patel, AeroTech employs research and development staff, engineers, manufacturing personnel, and a highly capable cybersecurity division. Employees at AeroTech enjoy job security, career opportunities, and competitive compensation. More importantly, they are part of a team that values ethical and responsible practices, allowing them to find meaningful work within an innovative company.

AeroTech fosters mutually beneficial relationships with its global partners, sharing in the success that AeroTech generates through strong financial returns and consistent company growth. Both locally and abroad, AeroTech has earned the support and engagement of the community by adhering to ethical standards in its drone technology and promoting a positive societal impact.

AeroTech takes its relationships with stakeholders seriously, striving to provide the best experience for all who depend on the company's success. To this end, they have created several engagement strategies, including customer advisory boards that gather feedback to guide product development, employee training programs that enhance skills and promote ethical behavior, and investor relations activities that report company performance and strategy. AeroTech also relies on community support through outreach programs that support local initiatives and build relationships, as well as industry conferences and events to engage partners and network with a wider community of innovators.

1.5 Operational Environment

- Environmental Factors:
 - Weather Conditions
 - * Temperature The X9 is able to operate in harsh climates like those found in high altitudes, the coldest seasons, and the unforgiving climates in middle eastern deserts. The range in temperature for the X9 is between -20 degrees to +55 degrees Celsius (-4 to 131 Fahrenheit).
 - * Precipitation The propellers of the X9 are optimized to maintain lift in moderate precipitation, and all external connectors are waterproof in their design. Each of the electrical components is stored in sealed enclosures with water-resistant coatings. The X9 has an IPX7 waterproof rating, ensuring excellent protection against water and dust.
 - * Wind The X9 is designed to withstand various wind conditions. Its robust construction and advanced flight control systems allow it to maintain stability and perform effectively even in challenging wind environments.
 - * Visibility The X9 is equipped with LED lights that can be adjusted for color, enhancing visibility in low-light conditions. This feature allows for safer operation and easier tracking of the drone in various visibility scenarios.
 - Terrain and Geography
 - * Urban Environments The X9 is well-suited for urban operations, with its compact design and advanced maneuverability. It can navigate through complex urban landscapes, making it ideal for infrastructure inspections and surveillance tasks in city environments.
 - * Rural/Remote Areas With its long-range capabilities and robust design, the X9 is effective in remote and rural areas. It can cover large distances and operate in areas with limited infrastructure, making it suitable for applications such as search and rescue operations in challenging terrains.
 - * Maritime Environments The X9's waterproof design and corrosion resistance make it suitable for maritime applications. It can operate effectively in coastal areas and over water bodies, supporting tasks such as maritime surveillance and offshore inspections.
- Operational Considerations:
 - Regulatory Compliance The X9 is designed to meet various regulatory standards, ensuring it can be operated legally in different jurisdictions. Its advanced features, such as no RF emissions when using a tether, help in complying with strict regulatory requirements.
 - Logistics and Support The X9 is designed for ease of operation and maintenance. Its modular construction allows for quick repairs and replacements, minimizing downtime and simplifying logistics in the field.
 - Safety and Risk Management The X9 incorporates multiple safety features, including power-on self-tests, voltage abnormal protection, current protection, and stall protection. It also provides real-time operational data to the flight controller, enhancing overall system reliability and safety.
- Case Studies:
 - Urban Infrastructure Inspections The X9's high-precision capabilities and stable flight characteristics make it ideal for inspecting urban infrastructure such as buildings, bridges, and power lines, providing detailed imagery and data for maintenance and planning.
 - Rural Search and Rescue With its long operational range and ability to carry various payloads, the X9 has been successfully deployed in rural search and rescue operations, helping to locate missing persons and assess dangerous situations in remote areas.
 - Maritime Surveillance The X9's waterproof design and long-range capabilities have proven effective in maritime surveillance operations, monitoring coastal areas, and supporting offshore security tasks.