DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

PROJECT CHARTER
CSE 4316: SENIOR DESIGN I
FALL 2024

VERMINATOR
WASP DRONE

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Revision History

Revision	Date	Author(s)	Description
0.1	10.01.2024	TN	Document creation
0.2	10.05.2024	TN, IM	Complete draft
1.0	04.29.2025	TN, RY	Official release

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1 Problem Statement

Wasps pose a risk to many people and can range from simple stings to life-threatening allergic reactions. In many cases, wasp nests can be situated in hard-to-reach areas, making traditional removal methods risky. The goal of this project is to design and build a remote-controlled drone that can assist in the safe removal of wasp and hornet nests.

2 Methodology

For our senior design project, we are developing an integrated system consisting of a drone, remote controller, sprayer system, and desktop camera application to eliminate wasp nests without requiring human contact. The drone is equipped with a low-light, forward-facing camera that transmits a real-time video feed to a ground station. A manual-controlled targeted insecticide delivery system enables the user to neutralize nests from a distance. The system is designed to prioritize safety and environmental responsibility by minimizing collateral impact on non-target species and surrounding areas.

3 Value Proposition

The value proposition for our wasp-killing drone project offers significant benefits to multiple stakeholders. Our primary stakeholder are homeowners, hobbyists, and small-operation farmers. Commercial drones designed for aerial spraying are prohibitively expensive. In this project, we aim to propose a low-cost alternative using standard, off-the-shelf components that makes it ideal for this type of stakeholder.

Larger, commercial sponsors and stakeholders may also benefit from this project. For applications requiring precise applications of insecticides, this drone's low-cost and small size allows it to fulfill the role of a precision sprayer that complements much larger and expensive agricultural drones. Academic and industry sponsors can also benefit from this project because it is a modular platform that can be extended to fulfill a wide range of missions.

By supporting this project, sponsors will contribute to the development of a practical, open-source, and low-cost system that addresses important safety concerns.

4 Development Milestones

- Project Charter First Draft - September 2024
- System Requirements Specification - September 2024
- Architectural Design Specification - September 2024
- Obtain Major Hardware Components for Drone Platform - December 2025
- Construction of Modular Drone Platform - January 2025
- Detailed Design Specification - February 2025
- Design of Hardware Sprayer Module - February 2025
- Implementation of Hardware Sprayer Module - March 2025
- Implementation of Software Sprayer Module - March 2025
- Design of Live Camera Viewing Software - March 2025
- Implementation of Live Camera Viewing Software - April 2025
- Final Project Demonstration - April 2025

5 Background

The current methodology for removing wasp nests in homes or small businesses involves soaking the nest in insecticide or using foaming sprays at the opening of the wasp nest. This can pose several issues. First, wasp nests can be located in hard-to-reach areas, requiring the use of ladders, which can be risky for those attempting to remove wasp nests. Second, both methods require someone to be within close proximity to the wasp nest which raises safety and health concerns. This project seeks to address these challenges by providing a solution that allows customers to safely remove wasp nests from a distance.

This project is sponsored by Dr. Shawn Gieser and Dr. Chris McMurrough. The target customers are exterminators, homeowners, businesses, and drone hobbyists. The motivation behind this project arises from health concerns and general dislike of being stung by wasps. There is an existing relationship between the development team and potential customers, as the team members themselves could serve as early adopters of this product.

6 Related Work

There are few commercial solutions to remove wasp nests using drones; however, the idea of using a drone as a spraying platform is not new. In recent years, drones have been used in the agriculture industry to spray pesticides, herbicides, and fertilizers on crops. DJI, a Chinese company known for designing drones and cameras, have a lineup of agricultural drones for this purpose [1]. DJI went on to publish an industry report noting the potential for growth in their agricultural drone business with over 300,000 units sold [2]. Moreover, large heavy-lift drones has been demonstrated as successful in academia. The Freyr Drone project by Spoorthi et al. have demonstrated the feasibility of drones to distribute pesticides and fertilizers in crop fields [3].

Previous Fall 2023 senior design 1 team at the University of Texas at Arlington worked on a drone for the Raytheon Drone Competition. The project involved developing an autonomous drone (UAV) to identify and target unfriendly ground vehicles (UGVs) using water blasts. The UAV used LiDAR and computer vision to achieve this. Their system specifications are outlined in their project charter.

Our product will be adjacent work to products similar to DJI's agricultural drones, but instead of focusing on the agricultural application of drones only, we aim to investigate applications for homes and businesses with a much more affordable price point.

7 System Overview

At a high level, the major components of the product will include the drone platform, a desktop application to capture video stream from a first-person camera on the drone, custom firmware to control the water sprayer, and the hardware components that make up the sprayer itself. The user will control the drone using a remote controller, and the desktop application will be used to receive and display the video feed from the first-person camera. These components are organized into the following systems:

- Avionics System
- Controls System
- Sprayer System
- Camera Application System
- Power and Propulsion System
- Camera System

7.1 Avionics System

The Avionics System serves as the "brain" of the drone. All commands for the drone and sprayer are first sent to the Avionics System for processing. This processing occurs at the flight controller. The chosen flight controller is a Pixhawk-compliant CubePilot Cube Orange+ running the PX4 Autopilot Firmware. After the flight controller processes commands, the messages, signals, or other commands are sent to other hardware components to perform a task. The Avionics Systems also contains other subsystems in charge of telemetry, positioning of the drone, and ensuring the drone can communicate with ground station software.

7.2 Controls System

The Controls System allows the user or pilot to interact with the drone. The Controls System allows the user to use both a command-line interface or RC controller. The RC controller interacts directly with the hardware through the flight controller and dedicated RC receiver. The command-line interface allows the drone to be configured to operate programmatically, enabling future automation if desired.

7.3 Sprayer System

The Sprayer System will be the first payload device designed for the Verminator Wasp Drone platform. With the Sprayer System attached, the drone's mission is to spray insecticides at wasp nests. This will be carried out using a liquid pump and spray nozzle. The liquid pump is to be toggled with a PWM-controlled switch. The PWM-controlled switch is operated by the flight controller. An onboard software module in the firmware toggles the switch programmatically, or the RC controller can toggle the switch through the RC receiver and flight controller directly.

7.4 Camera Application System

A software application to display the live video feed from the drone's camera will be developed alongside the drone. The purpose of this application is to provide the user with information overlays, a targetting crosshair, and live video. This system will allow the user to fly the drone in tight spaces, or in spaces that are outside the line-of-sight of the user.

7.5 Power and Propulsion System

This system will provide the drone with necessary thrust to lift itself and its payload to fulfill its mission. The drone is designed as a 3S LiPo system giving it a wide-range of hardware to pick from. Other functions of the Power and Propulsion System is to provide sufficient power to other components of the drone and payload.

7.6 Camera System

The Camera System will provide the Camera Application System with a wide-angle, low-light capable, first-person view from the drone's perspective. This will allow the user to fly the drone in a wide-range of conditions, times, and continue to fly when the drone is out of the pilot's visual field.

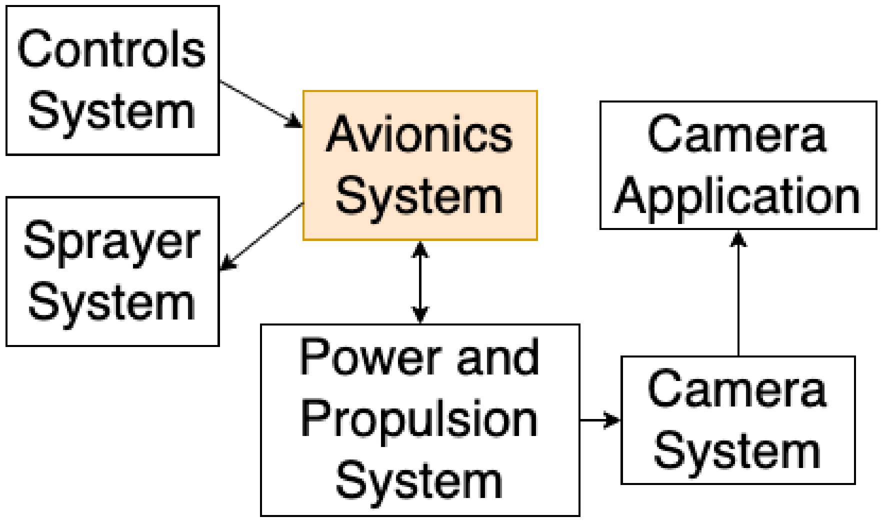

Figure 1: Overall system diagram showing major systems and their interactions.

8 Roles & Responsibilities

The stakeholders for this project are Dr. Shawn Gieser and Dr. Chris McMurrough. The point of contact will be Dr. Gieser.

The team members are Isaac Medrano, Luis Narez, Tyler Nguyen, Nishchal Shrestha, and Rajesh Yaksho. Tyler Nguyen will be the product owner and scrum master for the duration of the project. The following list lists the role of each team member with regard to their project contributions:

- Tyler Nguyen: Team lead, software engineer, hardware engineer
- Isaac Medrano: Software engineer, artist
- Rajesh Yaksho: Software engineer
- Luis Narez: Software engineer
- Nishchal Shrestha: Softrware engineer

The software engineers on the project are tasked with developing the live camera application. The hardware engineers are responsible for the design and construction of the drone, and implementing firmware modifications. The artist is tasked with producing images to overlay for video processing and the team logo.

9 Cost Proposal

9.1 Preliminary Budget

The majority of the budget will be spent on the drone. Software is free and open source under BSD 3-Clause and MIT Licenses, so no budgeting is required.

Item	Estimated Cost (USD)
500-X4 500mm Quadcopter frame	76
3S 5200mAh 11.1v LiPo battery	35
XT60 battery connectors	9
Deans female to XT60 male adapter	8
XT60 12AWG	9
XT60 14AWG	9
CubePilot Cube Orange+ with ADS-B Carrier Board	385
Here3 GNSS	225
RFD900x U.S. Telemetry Modem Set	130
Readytosky 2212 920KV Brushless Motors CW CCW	40
Diatone Mamba 40A Brushless 4-in-1 ESC F40$_BLSDshot60040A3-6S$	100
1045 propeller pack	17
6-12V DC Water Pump	10
1/4" ID 3/8" OD Silicon Tube	10
3/8" OD Bulkhead Fitting	7
1/4" Barbed Fitting to 1/4" Female NPT Adapter	7
1/4" Male NPT Srpay Nozzle 60 degree Cone Brass	15
DC 5V-12V 20A PWM Switch	9
10oz/300mL HDPE Bottle	13
RunCam Night Eagle 3	70
5.8 GHz 600mW Analog Video Transmitter	34
RC832S 5.8 GHz Analog Video Receiver	28
Analog Video Capture Card	13
450 mAh 3s LiPo Battery	16
FrSky Taranis 2.4 GHz Q X7 Transmitter	124
FrSky Taranis 2.4 GHz X8R Receiver	39
M3 Screws Steel	8
M2.5 Screws Steel 3	12
2.54mm Dupont Connector Set	10
Rubberized Battery Straps	17
12 AWG Wire	13
16 AWG Wire	17
Anti-Vibration Balls	7
3M Adhesive Backed Hook and Loop Fastener	12
Zip Ties	6

Table 1: Preliminary Cost Estimates

9.2 Current & Pending Support

Funding for this project will be provided by the Department of Computer Science and Engineering and the development team. Total support for this project by the CSE department is 800 USD. If more funding is needed, the development team will have to source funding. Additional funding can come from unused budgets from other senior design teams.

10 Facilities & Equipment

The University will provide accesses to Labs 208 and 241 which contain the drone space needed to test drone flight with drone netting for safety, as well as store parts for the drone. The University will also provide the outdoor space needed to field test the drone. We will have to source the venom delivery mechanism and the venom itself. These parts can be bought at local utility stores or online. Existing venom delivery methods include water pumps, venom spray cans, and agriculture drone attachments. We will also require a camera and controller which will be purchased from online sources.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- A safe lab environment will be available for building and testing the drone and its features.
- All necessary sensors and electronic devices will receive approval and be available in a timely manner for integration into the project.
- The power supply and weight distribution of the drone will function as planned, ensuring stable flight and the effective operation of all sensors.
- All the components required for the project will be within our budget.
- All features outlined in the requirements will be completed before the prototype demo.
- Help from professor and lab technician will be available for completion of this project.

12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by May 1st, 2025.
- Testing to be conducted only in a safe lab environment.
- The drone for this project must be built; a pre-built drone cannot be purchased.
- Total development costs must not exceed $800.
- Use of actual insecticides is prohibited.

13 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

Maintenance of the Project Charter will be a shared responsibility among all team members. It will serve as a stable document, subject to be updated only under significant changes such as regulatory modifications, new lessons learned, or substantial alterations in project scope. The initial version is expected by September 23, 2024, and the final version, along with a project demo video, will be delivered at project completion.

Risk description	Probability	Loss (days)	Exposure (days)
Availability of specific drone components from approved vendors	0.50	21	10.5
Delays in shipping of the ordered parts for the drone	0.10	14	1.4
Approval/Registration from FAA if the weight of drone exceeds 250gm	0.20	7	1.4
Compatibility issue between chosen hardware and software requirement	0.40	21	8.4
Problem with weight distribution affecting flight performance	0.40	14	5.6
Issues with battery life limiting drone operation time	0.10	7	0.7
Camera system/targeting mechanism could malfunction	0.20	21	4.2

Table 2: Overview of highest exposure project risks

14.1.2 System Requirements Specification

The SRS will be maintained using Overleaf for collaborative LaTeX editing. There will be updates only if major changes occur in the development process or if new features are required by the sponsor. The first version will be delivered in October 2024, with the final version targeted for November 2024.

14.1.3 Architectural Design Specification

Each team member will contribute individually to maintaining the document. Updates will be made regularly as drone improvements and modifications occur throughout the project. The focus will be on key components such as flight control systems, the payload system (water container), and navigation mechanisms that will be operated through a desktop app.

14.1.4 Detailed Design Specification

The DDS will be reviewed and updated after Sprint 3 to ensure alignment with the evolving project and design changes. Significant updates will occur in response to major revisions in technical architecture, drone design, or new requirements from stakeholders. The lead drone engineer will be responsible for updates, under the supervision of the project manager. The first version will be delivered before Sprint 4, and a final version will be delivered closer to project completion.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Backlog items will be derived from the SRS, with additional input from the project team and sponsor. Requirements such as drone autonomy, water deployment, and structural integrity will be broken into Jira tasks and prioritized by the product owner.

14.2.2 Sprint Planning

There will be 6 - 8 sprints, depending on the overall timeline and deliverables. For each sprint, the team will define specific sprint goals, select backlog items, and assign tasks based on team capacity. Feedback from stakeholders will help shape each sprint plan.

14.2.3 Sprint Goal

Sprint goals will focus on achieving milestones such as drone prototype assembly, development of the desktop application, and integration of waster dispensing mechanism. These goals will be refined through regular feedback from instructors and the project sponsor.

14.2.4 Sprint Backlog

Items from the product backlog for each sprint will be selected based on sprint priorities and feasibility. The sprint backlog will include drone hardware components, software modules, and safety testing procedures. Jira will be used to track progress and make necessary updates.

14.2.5 Task Breakdown

Tasks will be claimed by team members at the start of each sprint, with remaining tasks assigned as necessary. Responsibilities will include areas such as hardware assembly, coding the drone control desktop app, and ensuring pesticide safety and containment.

14.2.6 Sprint Burn Down Charts

Sprint progress will be tracked using burn down charts in Jira and the provided Excel spreadsheet, providing a visual representation of remaining work. The team will review these charts at the end of each sprint to adjust plans and timelines.

14.2.7 Sprint Retrospective

At the end of each sprint, the team will conduct a retrospective, led by the rotating scrum master. This will allow for collective feedback, process improvement, and planning for the next sprint.

14.2.8 Individual Status Reports

Each team member will submit a PDF report detailing their sprint goals, completed tasks, time spent, and feedback. This report will be reviewed by the team instructor and sponsor.

14.3 Closeout Materials

14.3.1 System Prototype

The prototype demonstration will feature an unmanned drone deploying water onto a simulated wasp nest. The demo will occur on-site at an approved testing facility. Project acceptance will based on the evaluation of sponsors on drone's accuracy and functionality.

14.3.2 Project Poster

The poster will summarize the goals, methodology, design, and the real-world application of the project. It will be presented during the final demo in April 2025.

14.3.3 Web Page

A GitHub repository will host web page of the project. It will contain a Read-Me, along with a demonstration video of the drone in action, and other documentation. The page will be made public after the project completion.

14.3.4 Demo Video

Two demo videos will be produced: one after the initial prototype is complete and the final video showing the full capabilities of the drone in neutralizing a wasp nest using the app control.

14.3.5 Source Code

The source code for the drone's software, including its autonomous flight controls and water sprayer system, will be stored in a GitHub repository under an MIT license, or other licenses as required by existing open source projects.

14.3.6 Source Code Documentation

All source code documentation will be generated and edited using Doxygen. A final documentation file will be included in the GitHub repository as PDF and HTML.

14.3.7 CAD files

Mechanical designs for various components of the project will be developed using Autodesk AutoCAD. To prototype and test these designs, 3D printing will be used. All CAD files will be provided throughout the duration of this project.

14.3.8 Installation Scripts

Installation instructions will be available in the Read-Me section of the GitHub repository, guiding users through setting up the drone's software environment and the desktop camera application.

14.3.9 User Manual

The user manual, available in the Read-Me, will explain how to configure the drone's environment and launch an unmanned flight for nest elimination using remote controller and the camera app on desktop.

References

[1] DJI. DJI Agriculture.

[2] DJI. Agricultural Drone Industry Insight Report, 2023.

[3] Spoorthi S. et al. Freyr drone: Pesticide/fertilizers spraying drone - an agricultural approach. In *International Conference on Computer and Communications Technologies (ICCCT)*, 2017.