Software Requirements Specification
for
Drone Flight Path Simulator

Version 1.4

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Revision History

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		from Liaison, New Information Added, More Structural Detail to Requirements, Revisions by Liaison	Thaddeus Owens Sergio Maradiaga Sergio Valadez Alex Alcazar Alex Gaetz Francisco Brito Alberto Gonzalez Helen Dam Kevin Tang

1. Introduction

1.1 Purpose

Our project aims to design, implement, and test a 3D visualization architecture that allows operators in small military units to plan, visualize, and revise drone flight paths over a specific terrain to fulfill the mission success criteria of effectively utilizing sensors over an area while minimizing detection, and possibly susceptibility to countermeasures.

This document outlines the specifications for the Drone Flight Path Simulator (D.F.P.S.), a tool designed to optimize drone flight paths for stealth operations in various environmental conditions while utilizing sensor properties (effective range and limits) to successfully complete mission tasks. The D.F.P.S. will assist drone mission planners with planning and simulating drone missions to avoid detection and provide a plug-and-play architecture so future detection, or other mission or environmental, parameters can be added. This document will contain information regarding the project's requirements, programs needed to run D.F.P.S. efficiently, and other tools to implement this project.

1.2 Intended Audience and Reading Suggestions

This document is intended for Army Research Lab personnel and university professors, developers, and any others involved in the project, including those that were involved in the creation and revisions of the software and its design.

1.3 Product Scope

The D.F.P.S. will be a comprehensive tool for simulating and optimizing drone flight paths under various conditions, including weather effects, potential threats, airspace restrictions, and audio/visual or other sensors. The system will provide mission efficiency/risk data and suggestions to enhance the stealth capabilities of drones for future missions. The tool is envisioned to provide an architecture to integrate, and display in an intuitive manner, mission-relevant data to aid decision making, primarily during planning, with the possibility to support decisions during mission execution in the future.

1.4 Definitions, Acronyms, and Abbreviations

- **3D**: Three Dimension
- **A.R.L.**: DEVCOM Army Research Laboratory
- **D.F.P.S.**: Drone Flight Path Simulator
- **O.T.A.**: Over-The-Air
- **S.U.A.S.**: Small Unmanned Aircraft System

1.5 References

- "Drone Security Features." *AltiGator Drone & UAV Technologies*, 16 Nov. 2017, altigator.com/en/features-of-our-drones/security-features/.
- Nelson, Tom. "How Invisible Geofences Know Where You Are." *Lifewire*, Lifewire, 10 Nov. 2021, www.lifewire.com/what-is-geofencing-4161274.

2. Overall Description

2.1 System Analysis

DFPS is a military mission planning tool that can assess a given drone's mission flight path success, helping Warfighters understand SUAS-relevant mission considerations and optimally position their SUAS during missions. DFPS will allow a user to adjust a number of different mission parameters such as the type of drone used in the mission, environmental effects, and different geographical landscapes and terrain considerations. These will be the factors that can affect the mission success rate of not being detected, destroyed or debilitated while still effectively using the onboard sensors to accomplish mission tasks. Based on this feedback, and feedback presentation, a user can explore and adjust the planned flight path in order to try and achieve a higher mission success rate.

2.2 Product Perspective

DFPS is purely a simulation program that provides a statistical probability for a mission's success rate. While DFPS is primarily a standalone simulation tool, it plays a vital role within the larger mission planning and analysis framework. Its scalability allows it to handle varying mission complexities, and the extensibility of the software ensures that future updates and enhancements (such as additional variables or weightings) can be seamlessly integrated to meet evolving mission requirements.

2.3 Product Functions

Provide a simulation environment

Integrate environmental factors that affect detectability

Integrate sensor factors that represent SUAS capabilities to conduct mission tasks

Determine maximum ranges at which a drone can be perceived

Produce likelihood of detection estimates given environmental conditions

Data collection to determine the likelihood of mission success

2.4 User Classes and Characteristics

The type of User Classes and Characteristics this document addresses are:

- US military personnel, drone operators, mission planners
- Designers of the software
- Developers
- University Professors
- Others who are either:
    - Involved in the Project
    - Interested in the Project

2.5 Operating Environment

US Military personnel will use the flight simulation in almost any environment where the drone is needed. Such settings include:

- Barren Areas such as:
    - Deserts
    - Desolated Areas

    - Wastelands
- Woodland Areas such as:
    - Forests
    - Plantation
    - Jungles
- Urban Areas such as:
    - Major Cities
    - Suburban
    - Rural Areas

It is envisioned that the primary use environment for the intended users will depend on the unit, mission, logistical requirements of the SUAS in use, and mission tasks being supported. Mission planners can be expected to use the tool in a more protected environment, which can be field environments such as a tent or other structure, or in a more stable environment such as a building. This environment might allow for more time to consider factors and also larger display surfaces and computing power. The Warfighters executing the mission might be operating in more rugged and dynamic environments, including use while moving on foot or in vehicles and with the risk of compromise due to noise or light emissions from the DFPS tool. For these Warfighters the decision support information would have to be displayed on smaller devices and in a less complex and more tactical interaction manner.

2.6 Design and Implementation Constraints

The current limitations and constraints that this software may have are that it:

- Can’t predict how the opposing forces will move while creating the simulation
- Can’t rapidly adjust the flight path whenever a detection sensor changes focus
- Will not contain data on all SUAS sensors
- Will not contain data on all environmental factors

2.7 User Documentation

The User will have the following access for documentation:

- Software Requirements Specification (SRS) document
- Software Design Document (SDD)
- Any User Manuals that may be created or implemented for this project

2.8 Assumptions and Dependencies

This section of the document addresses the following Assumptions and Dependencies that this project has:

- Accurate environmental data is available for simulation purposes.
    - If not available, allow the User to input those data inquiries.
- Users possess the requisite knowledge to operate the simulation software.
- Under the assumption that the military personnel will use the simulation on a mobile device.

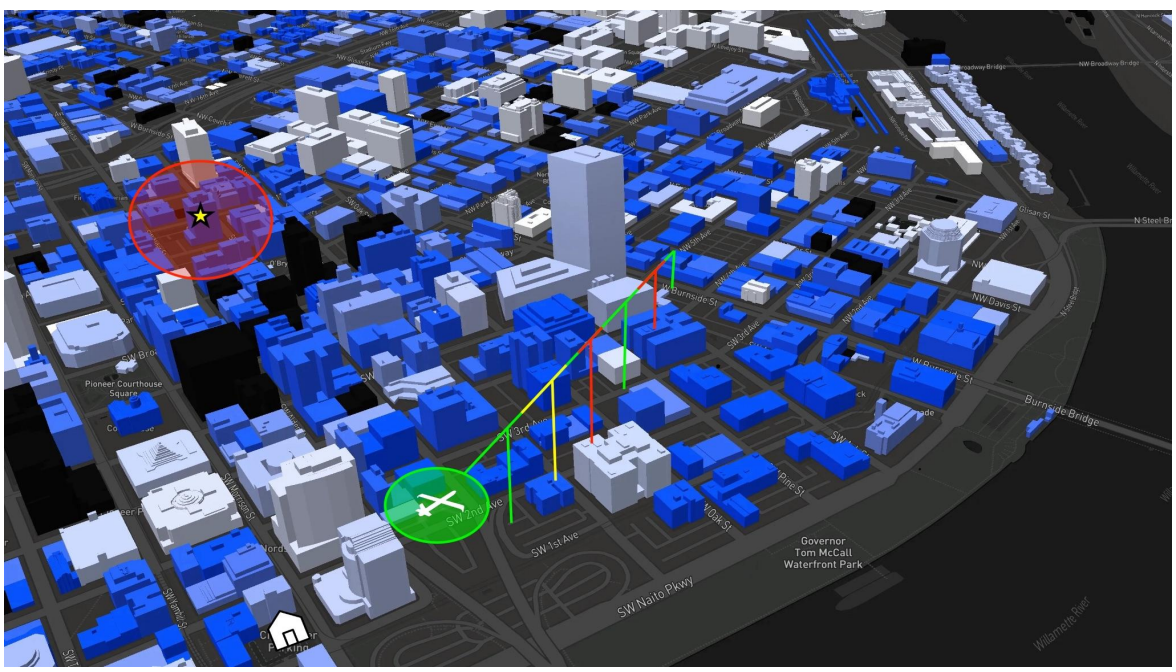
2.9 Apportioning of Requirements

- The option to have the simulator determine the best path for the drone based on the chosen settings of:
    - “Fastest path,” which will come at the cost of stealth
    - “Least detection,” which can arrive at the expense of time and speed
        - This mode will be by default for the created program.

3. External Interface Requirements

3.1 User Interface

The user interface will show a map indicating the chosen flight path and will give visual cues for the detectability of the drone along the flight path. The flight path will be created by the user either by uploading a pre-made path, or drawing a line with the start and end of the line being the start and end points of the flight. Colors will be used to indicate how well the drone will avoid detection, with green being excellent, yellow being moderate, and red being poor. Along with the line indicating the drone's flight path, additional lines will go from the flight path to the ground to indicate the drones altitude and will follow the same color code guideline. The drone on the map will also feature a circle around it to indicate its noise level and will change colors based on how likely it is to be heard along the path provided. The target area the drone is scouting will be indicated on the map with a yellow star surrounded by a red circle.



*Example of what the map could look like

3.1.1 User Interface Display Information

The user interface will give users information about the flight including what type of drone is being used, the altitude of the drone on any given point of the flight path, the distance to target, the distance the drone is from base, the estimated duration of the planned flight, the total distance of the planned flight path, the total time/distance the drone can fly given its current battery level, the compass and degree direction of the drone on the flight path, and the designated airspace the drone must fly in.

3.1.2 User Interface Input Fields

The user interface will have input fields that the user can use to provide further information about the drone's detectability during the flight and any other mission considerations such as airspace constraints, or known locations of risks and critical target areas. These input settings include weather options such as overcast or sunny, the start and end points of the flight path, the option to add points to the current flight path, the time of day the flight will take place, the drone's battery level, the altitude the drone will be flying at, the target location and size, and the location of home base.

3.1.3 User Interface Accessibility and Settings

The user interface will have accessibility options and settings that can be modified. These include labels that the user can expand and minimize to display or hide information, the option to change text size, text color, and the measurement system being used to indicate distances, and a help menu that will provide basic information needed for the user to be able to use and understand the program.

3.2 Hardware Interfaces

Program will not be interacting with any hardware as it is a pre plan flight path simulator.

3.3 Software Interfaces

The program will use Python as the coding language to write the application and Django as the web framework to build the application. Specifically Geo Django will be used as it provides the framework needed to display the map data for the drone's flight path. Mapbox Maps API will be used to customize the map being displayed in the application to provide better detail and a 3D visualization. React Redux will be used to help build and manage the components of the UI.

3.4 Communication Interfaces

HTTPS will be used to securely handle requests and responses coming to and from the application.

4. Requirements Specification

4.1 Functional Requirements

4.1.1-1 D.F.P.S. shall have a plugin that allows for a fixed base audio detection range

4.1.1-2 D.F.P.S. shall have a plugin that allows for a fixed base visual detection range

4.1.1-3 D.F.P.S. shall provide a testing sample flight path

4.1.1-4 D.F.P.S. shall allow users to create and edit flight paths

4.1.1-5 D.F.P.S. shall allow users to delete existing flight paths

4.1.1-6 D.F.P.S. shall provide a reasonable (readable) map as a starting point

4.1.1-7 D.F.P.S. shall allow users to set the system's settings to default

4.1.1-8 D.F.P.S. shall provide users the distance from the start point

4.1.1-9 D.F.P.S. shall provide calculations for the SUAS' battery life

4.1.1-10: D.F.P.S. shall have a plugin that allows real-time weather data to be obtained and incorporated for the chosen flight path.

4.1.1-11: D.F.P.S. shall allow users to save and load flight plans for future use.

4.2 External Interface Requirements

Drone:

The drone needs to be built for silent operation to reduce the chance of being discovered. Furthermore, the drone has to be able to move in order to optimize its flight paths for intelligence, surveillance, and reconnaissance needs.

Ground station computer:

The computer shall be able to process and handle the computation of the drone data and program

4.3 Logical Database Requirements

To be Determined by May of 2024.

4.4 Design Constraints

The quality of the visual data that the drone's camera captures determines the mission's success. Upgrading or changing hardware may be restricted by compatibility with current gear. Weather and terrain are two examples of environmental variables that the system must adjust to. Accurate noise and visibility signature models and human vision and auditory perception models are essential for minimizing detection risks. Ensuring the effectiveness of the system requires accurate models that represent these aspects.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

DFPS aims to ensure seamless and prompt operations, delivering optimal conditions to users even in high-pressure situations. Leveraging the security of the US military, the Over-The-Air (OTA) approach will serve as the primary method for software updates and scheduled maintenance to uphold software/firmware integrity. Implementing a plug-in architecture will facilitate new development, while efficiently managing multiple users on individual systems and offering real-time map data.

5.2 Safety Requirements

No requirements are necessary as the system is purely software-based.

5.3 Security Requirements

5.3-1 D.F.P.S shall use a Profile Method for selecting Authorized Users

5.3-2 D.F.P.S shall use Two Factor Authorization to safely secure a sign-in method for Users

5.3-3 D.F.P.S shall use TCP/IP for transferring data between drone and user

5.3-4 D.F.P.S must have an alert system to warn of important matters like altitude limits and battery life

5.3-5 D.F.P.S must have an emergency failsafe so if battery life reaches a critical limit, it will perform an automatic emergency landing

5.3-6 D.F.P.S shall have geofencing to create a virtual boundary to prevent the drone from leaving the operational airspace

5.3-7 D.F.P.S shall display forbidden flight zones to warn against unauthorized airspace entry

5.3-8 D.F.P.S shall have flight data logging for post-flight analysis such as flight time, position, speed, and altitude

5.4 Software Quality Attributes

Incorporate a 3D web-based application to deliver measurements to the user. By having the user input their current coordinates into the program we are able to display a map of the current area as well as the location of the drone. The drone will provide measurements for both auditory and visual detection ranges and relay this data back to the user.

5.5 Business Rules

N/A (Not Applicable), as the software is intended for military use only.

6. Legal and Ethical Issues

DFPS will be used as a means to assist Soldiers in combat planning by providing the most viable drone flight path in order to minimize risks, detection, and to better ensure mission success.

We are not aware of the full extent of the military use that our software will be involved in, only that it will be used primarily for reconnaissance and planning. Regardless, the DFPS does not aim to increase or exacerbate any harm on any sides of a conflict and in fact is intended to decrease it. Part of our system involves avoiding detection which will preserve the safety of the users. Having increased knowledge of the area via drone reconnaissance will also allow for more precise missions which will decrease collateral damage both to property as well as any non-combatants that could be in the area. In addition, that increased precision will decrease military casualties on both sides.