

2. DESIGN REQUIREMENTS

Air Mail is a new delivery system that will be implemented through the use of an UAV. The UAV will be given its mission coordinates at the ground station via a USB connection from a computer to the flight controller. Once the coordinates have been loaded onto the device, it will be disconnected from the computer and will be ready for take-off. Air Mail is completely autonomous but will have the ability to be overridden via transmitter. Once the destination has been reached, the onboard camera will take pictures and will perform various image processing techniques in order to locate the landing zone. If the landing zone is not detected, Air Mail will return back to its home base.

2.1 Technical Design Constraints

In order for Air Mail to function properly, the following criteria in Table 2.1 must be satisfied.

Table 2.1: Technical Design Constraints

| Constraint | Description |
|-------------------------------|---|
| Weight | The UAV must weigh less than 3 kg without load |
| Payload | The max weight of the payload must be 450 grams |
| Motors | Motors must provide a combined thrust of at least 7 kg |
| Battery Life | Battery must last for at least 15 minutes |
| Mission | UAV must be able to make a 2 mile roundtrip from takeoff to landing |
| UAV Speed | UAV must fly at least 8 m/s to complete trip in 15 minutes or less |
| Camera | Camera must be able to capture an image at a speed of at least one frame per second |
| Image Processing System (IPS) | The IPS must be able to process 10 images in 10 seconds and identify the landing location in at least 60% of the images |

2.1.1 Weight

In order to have maximum lift, the UAV must weigh under 3.5kg without a load. In order for the UAV to have maximized mobility the hover throttle must be between 45 and 50 percent.

2.1.2 Payload

UAV must be able to carry a 450 gram payload.

2.1.3 Motors

The motors of the UAV will need to provide a maximum combine thrust of 7kg. Since we are using a hex-copter this means that each motor will need to provide a lifting trust of

approximately 1.16 kg each.

2.1.4 Battery Life

Since the approximate flight time of mission will be around 15 minutes the battery life will need to sustain the flight time.

2.1.5 Mission

For the proof of concept the design will need to make a 2 mile round trip. This includes takeoff, delivery of the payload, and the return back to the mission base.

2.1.6 UAV Speed

In order for the UAV to make a mission in 15 minutes of a 2 mile round trip, the flight speed must be greater than or equal to 8 meters per second.

2.1.7 Camera

The camera must be able to capture an image at a speed of at least one frame per second in order to capture enough images for the Image Processing System (IPS).

2.1.8 Image Processing System

The IPS must be able to process 10 images in 10 seconds in order to accurately distinguish the landing zone from the surrounding area.

2.2 Practical Design Constraints

Practical design constraints are also required and can be found in Table 2.2

Table 2.2: Practical Constraints

| Name | Description |
|-------------------|---|
| Economic | Air Mail will need to have high quality parts to safely carry out missions. Parts can be customized based on customers needs. |
| Environmental | Air Mail will use a battery. Proper disposal will need to be done when the battery is at it's end life. |
| Sustainability | The batteries that run the systems on Air Mail will need to be easily rechargeable. |
| Manufacturability | While the hardware will be customizable, the firmware that runs Air Mail will be the same for any size UAV. This will need to be easily testable on new builds. |

| Name | Description |
|-------------------|--|
| Ethical | Any operations must meet the countries federal requirements for UAV use. |
| Health and Safety | Measures must be taken when testing the UAV to ensure the Air Mail will not cause safety issues to the public. |
| Political | In the US, FAA regulations restrict the use of commercial UAV operations. Special permits are required for a business who wishes to use one for commercial operations. |

2.2.1 Economic

The control systems for Air Mail will be adaptable for any size UAV. This will allow for customers to customize the size of their Air Mail UAV to meet their payload and distance needs. UAV parts come in a wide range of motor sizes, frame sizes, and propeller sizes. For the Air Mail prototype a budget of \$1500 will be sufficient.

2.2.2 Environmental

Air Mail will be powered by a battery. LiPo, NiCd, and NiMH batteries all have proper disposal requirements when the battery's life has ended. These requirements must be followed.

2.2.3 Sustainability

It is unlikely that a battery that drives the motors will last longer than one mission. Therefore, a customer will need to be able to easily replace and recharge the main drive battery for Air Mail. The likely solution will be for a customer to complete a mission, replace the battery, and start another mission while the replaced battery is charging. Consideration will need to be taken when designing where the battery is placed, and how it is attached so the customer can easily remove and replace it.

2.2.4 Manufacturability

Though Air Mail will be adaptable, the firmware that runs the instruments will be the same. Each Air Mail system will need to be assembled by hand. The firmware will need to be easily testable on a new system to ensure proper operation before the system is delivered to the customer.

2.2.5 Ethical

Air Mail must be operated to meet all federal regulations in the country of operation. Some people might have a concern that a UAV will be used for the purpose of spying. Air Mail will need an on-board camera in order to identify the landing location. However, the images will only be used for the purpose of identifying a landing location and will not be stored in normal operations.

2.2.6 Health and Safety

Air Mail will be a flying object, and could potentially do operations in populated areas. Precautions should be taken before each mission to ensure harm will not occur to anyone in case of flight failure. The pilot that is controlling Air Mail will need to have a good understanding of the local terrain before sending Air Mail on a mission. One example is the height and location of buildings in the area.

2.2.7 Political

In the US the FAA has strict regulations that prohibit the use of an UAV like Air Mail being used in commercial operations. Other countries have different policies. Depending on where Air Mail is being operated, the operator will need to ensure they are abiding by local and federal regulations. For instance, if a business wishes to operate Air Mail in the US they will need a permit by the FAA.