Design Alternatives and Software Flowchart- Deadline: 10/26/2022

EE/CpE 4812 – ECE Capstone Design I

Fall 2022

Instructor: **Johnathan Votion Ph.D.**

Team name: **D2R**

Team members: **Ehab Afsoonko, Conrad Obeng, Lexi McMinn, Mark James Jr., Matthew Moubray**

Description: **Alternatives to design choices analyzed, and software flowchart created.**

1. Critical Components
    A. VTOL Module Attachment Mechanism
        a. Wing stability
        b. Firmware
        c. Cost
        d. Module Compatibility with Drone
        e. Attachment process
        f. Propeller Attatchment
    B. Foldable Arms
        a. Aerodynamics
        b. Weight
        c. Cost of small motors
        d. Center of gravity
        e. Durability
        f. Actual folding mechanism
    C. Rover-Drone Auto Switching Mechanism
        a. Wireless switching
        b. Weight
        c. Microcontroller Signal To Fold/unfold Wings
        d. Adding Switching functionality to RC inputs
        e. Firmware flashing capability
        f. RC Directional Control of Drone vs Rover
    D. Firmware Loading to Flight Controller
        a. Storage
        b. Microcontroller accepts RC signal for mode swap
        c. State Control (Flight vs Rover)
        d. Read current mode from flight controller
        e. Cost of memory
        f. Type of memory
2. Design Alternatives
    A. VTOL Module
        a. Multiple smaller modules
        b. No Propeller
        c. Flaps for control
    B. Foldable Arms
        a. Fold another direction
        b. Pull into body of drone
        c. Not folding at all
    C. Rover-Drone Switching
        a. Propellers and wheels powered at the same time

b. Dedicated button for each mode as opposed to swapping
c. Button to swap to rover lands and swaps to rover

D. Firmware Loading
   a. One large firmware with different transportation modalities
   b. Changing parameters as opposed to flashing new firmware
   c. Have multiple firmwares already flashed on to the Flight Controller

Pugh Matrices:

Pugh Matrix VTOL Module Attachment Mechanism

Critical Component	*Weight*	All-in-One VTOL Module	Multiple Smaller Modules	No Propeller	Flaps for Control
Wing Stability	15	7	3	1	10
Firmware Compatibility	28	9	3	4	10
Cost	10	8	6	10	4
Drone-Module Compatibility	13	8	3	7	8
Attachment Process	14	9	2	9	9
Propeller Attachment	20	9	10	1	9

Summary Table

Total	847	456	464	880

Firmware Loading to Controller

Critical Components	*Weight*	Microcontroller Loads Firmware	One Large Firmware	Change Parameters	Flight Controller has all firmware
Storage	10	9	8	3	10
Microcontroller signal to switch	30	10	0	10	0
State Control	30	10	10	10	10
Read Current Mode	15	10	10	10	10
Cost of Memory	10	9	8	3	0
Type of Memory	5	5	5	5	0

Summary Table

Total	955	635	835	550

Rover-Drone Auto Switching Mechanism Pugh Matrix					
Critical Quality:	*Weight*	Rover-Drone Auto Switching Mechanism	Propellers and wheels powered at the same time	Dedicated button for each mode as opposed to swapping	Button to swap to rover lands and swaps to rover
Wireless switching	21	9	1	9	9
Weight	24	9	9	9	9
Microcontroller Signal To Fold/unfold Wings	10	8	8	8	9
Adding Switching functionality to RC inputs	11	9	1	9	5
Firmware flashing capability	17	7	1	4	8
RC Directional Control of Drone vs Rover	17	8	4	8	8

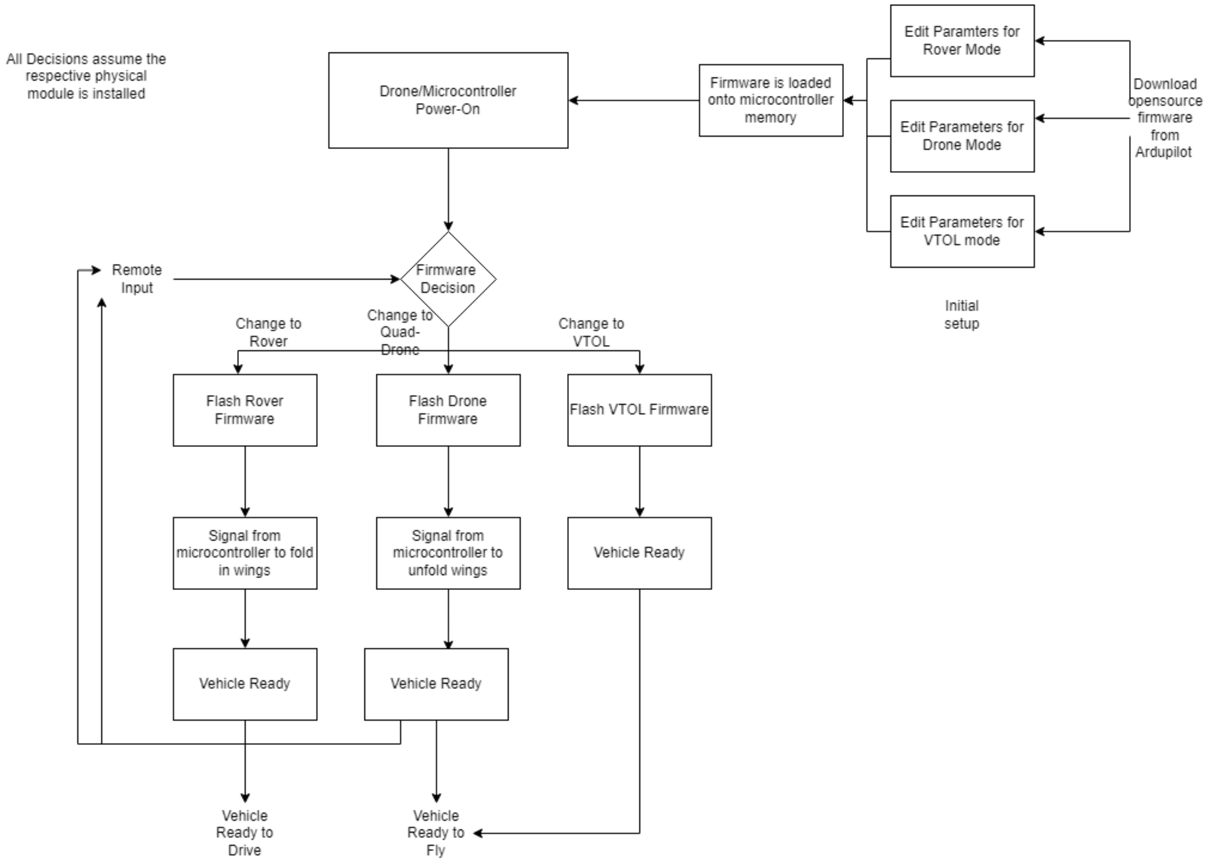
Summary Table				
Total	839	413	788	822

Foldable Arms

Critical Quality	*Weight*	Fold another direction	Parallel Folding	Non Folding Wings	Pull Into Body
Aerodynamics	25	10	3	1	10
Weight	15	7	7	7	6
Cost of Small Motors	5	7	6	10	7
Center of Gravity	20	8	2	2	10
Durability	10	5	5	1	9
Actual Folding Mechanism	25	10	8	1	6

Summary Table				
Total	850	500	255	815

Software Flowchart



Conclusion

In the VTOL Module Pugh Matrix, it was determined that firmware compatibility was the most important component, followed by the propeller attachment for forward motion, wing stability, the ease of the attachment process, and the cost being the least important. Firmware compatibility was determined to be the most important because without it, the drone will not be able to utilize the module for the VTOL Fixed-Wing mode. The propeller attachment was weighted next, due to the need for forward motion to be provided. Without the propeller, the fixed-wing attachment would only provide gliding capability, which would decrease flight time. Ease of attachment process was determined for customer considerations. If the Fixed-Wing module becomes too laborious to attach to the drone, customers will be far less likely to utilize it. Cost was determined to be least important, as it will generally only come into consideration with 3d printing filaments and the various attachments, which will be relatively inexpensive as compared to the rest of the drone. From the Pugh Matrix, using flaps for control slightly edged out having an All-in-One VTOL module, however the complexity of using flaps is prohibitively high, making the All-in-One VTOL module the final choice. The no propeller and multiple smaller module options ranked lowly, as they either performed poorly in the key criteria, or did not address them at all.

In the Foldable Arms Pugh Matrix, the actual folding mechanism and the aerodynamics of the drone were determined to be the two most important components. Which are then followed by the center of gravity, the weight of the arms, the durability, and the cost of the small motors. The aerodynamics of the wings was determined to be the one of the most critical components because the aerodynamics of the wings are important for the air flow and air pressure on the wings. A good aerodynamics design will result in less air pressure on top of the wing which will help the drone move up and at high speeds. Non-folding wings will actually help the aerodynamics because there wouldn't be a need for an extra motor to be able to fold the wings. The direction the wings fold is not really important for the weight and durability of the drone. Similarly the parallel folding will also not really affect the weight and durability of the drone as compared to the non-foldable wings. The non-foldable wings will help with the cost of the small motors, aerodynamics, weight, durability, and center of gravity. With the non-foldable wings the actual folding mechanism would not be needed. The pull into the body wings is good for the durability, center of gravity, and aerodynamics of the drone. The pull into the body wings will affect the weight of the drone and increase the cost since we would be using more small motors to be able to fold the wings.

The Rover-Drone Switching Mechanism Pugh Matrix shows that the weight is the most important functional requirement, followed by wireless switching, firmware flashing capability, RC Directional Control of Drone vs Rover, and finally the Microcontroller signal to fold/unfold wings. In regards to the Rover-Drone Auto Switching Mechanism the addition of weight increases the power requirement to take off and maintain flight. As the switching mechanism will require the addition of motors to fold the wings, this additional weight will be crucial to take into consideration in order to increase flight duration and reduce battery consumption. The second most important concept was the wireless switching requirement. This requirement will be vital among 3 of the 4 choices, without it the Rover-Drone switch will not be able to transfer modes. The following requirement was the firmware flashing capability and how to flash the rover mode to the flight controller without this the flight controller will not be able to control this function without the proper firmware. Which leads to the next functional requirement: the RC directional control of the drone versus the rover. Setting up a separate control function for each of the rover and drone modes in order for the operator to accurately control the vehicle. In the drone mode the operator will need to control the vehicle's acceleration, pitch, yaw, and roll, while in the rover mode the operator only needs to control the acceleration and yaw.

The Firmware Loading Pugh Matrix ranked the critical components from most to least important as the microcontroller signals to switch between the modes and state control as equal importance, then reading the current mode, storage and cost of memory as equal importance, then the type of memory as the least important component. The Microcontroller signal to switch between modes and state control were set to the highest importance because they will be used to determine if/when a mode can be switched to, and the ability to actually switch between the modes, which is the core functionality of the component. Reading the current mode was the next most important due to the fact that knowing the current state will be needed to switch between ground and driving if the mechanism for switching is not separated into different buttons. Storage and cost of memory were next, as having a place to hold the firmware and said cost of storing the firmware are both key points when determining the ideal method. Finally, the type of memory storage used was least important, since it should only matter if the firmware flashing method fails. The top choice was determined to be having a Microcontroller load the firmware, as it hits the most crucial components. The runner-up choice was having the parameters be changed in the firmware, rather than flashing new firmware. This would add undue complexity and present possible issues, as changes would need to be made to parameters that would include value changes, adding new parameters, and removing some parameters altogether in order to ensure correct functionality. Having one large firmware drastically increases storage concerns, as the flight controller would most likely not have the capability of storing that size of firmware. Having the flight controller have all the firmware has the same type of issue, as there will not be enough storage space to hold the separate firmware.

Terminating Sheet

Role	First and Last Name	Contribution (%)
Engineering Manager	Conrad Obeng	20%
Secretary	Ehab Afsoonko	20%
Systems/Software Engineer	Lexi McMinn	20%
Financial Officer	Mark James Jr	20%
Hardware Engineer	Matthew Moubray	20%

Date: 26 October 2022

Assignment: Design Alternatives and Software Flowchart