Micro Airplane Operation/Assembly Manual

Team Final Approach
20F12: A2 Aero Micro

April 16th, 2021

Tyler Darnell
Colton Farrar
Zachary S. Kayser
Thomas O'Brien
Daniel Varner

NAU NORTHERN ARIZONA UNIVERSITY

Table of Contents

Introduction

The purpose of this document is to instruct how to manufacture and assemble the 2021 SAE Aero Micro capstone project's micro airplane. Following the manufacturing and assembly guide, the operation manual and how to control the airplane during flight will be explained. Maintenance and troubleshooting sections will also be included for potential failures and how to mitigate them.

Manufacturing/Assembly

This section will explain how to manufacture the micro airplane from the first step. It is assumed that all necessary materials have already been acquired and the LightBurn files for the various foam board pieces are accessible (along with a laser cutter).

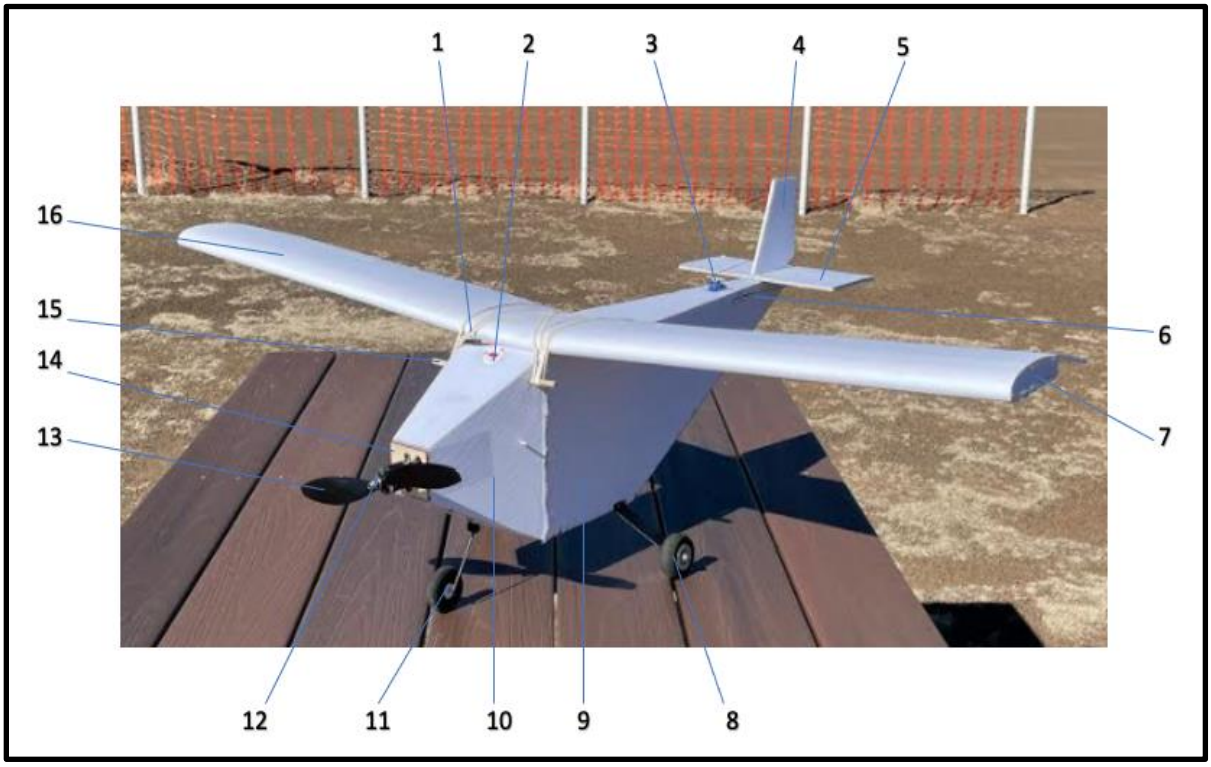

Figure 1 - Micro airplane external components.

1. Place foam board into laser cutter and cut fuselage [9], front cone [10], vertical stabilizer [4], horizontal stabilizer [5], and 24 ribs [7].
2. Glue ribs [7] 2" apart from one another on and place balsa wood spars (1x rectangular and 2x circular) in the appropriate rib holes.
3. Combine two sections of ribs and spars with the 3D printed dihedral section and glue all pieces together (center section should measure around 6" in length).
4. Cut 2 foam board pieces [16] of size 23" x 13.5" and remove a 3" x 12" section on any corner of each foam board section.
5. Remove one layer of foam board paper and roll over the edge of a table to make folding easier.
6. Fold the foam board [16] around the rib and spar wings, ensuring the cut section

is on the bottom outside edge of wings.

7. Use hot glue to secure the outer foam board section [16] to the rib and spar wing section.
8. Cut a 45° slit on the bottom of the cut foam board [16] to allow hinging for the aileron.
9. Glue a 9g servo [3] to the bottom side of wings and attach a connecting rod [6] to the 9g servo and the provided connecting horn placed on the hinging aileron section.
10. Repeat steps 5-9 for opposite side wings.
11. Create a 45° slit in the vertical stabilizer [4] to create a hinging rudder section.
12. Create a 45° slit in the horizontal stabilizer [5] to create a hinging elevator section.
13. Place the vertical stabilizer [4] into the slot on horizontal stabilizer [5] and glue the two together.
14. Fold and glue fuselage [9] via the dedicated fold lines.
15. Place vertical [4] and horizontal stabilizer [5] into the slot found on top of the rear fuselage [9] section, glue pieces together.
16. Glue 9g servo [3] on top of fuselage [9] and place connecting rod [6] between servo and provided connecting horn glued to the vertical rudder.
17. Glue 9g servo [9] on inside of fuselage [9] and place connecting rod [6] between servo and provided connecting horn glued to the bottom side of the horizontal elevator (it is necessary to cut a slit in the side of the fuselage to allow the connecting rod to move freely).
18. Place ¼” plywood into the bottom section of the fuselage [9] and hot glue into place.
19. Drill 2 holes in the plywood to allow ¼” bolts to fit through plywood.
20. Secure rear landing gear [8] by using 2 ¼” bolts and nuts placed through the holes in the landing gear and plywood.
21. Fold and glue nose cone [10] via the dedicated fold lines.
22. Glue a ½” thick piece of plywood in front section of the nose cone [10] and drill a ⅛” hole through the plywood (location is not critical).
23. Place front landing gear [11] through ½” plywood and secure in place with the provided locking nut.
24. Glue a 9g servo [9] to the inside wall of the nose cone [10] and connect a connecting rod [6] to the servo and the locking nut on top of the front landing gear [11] (this will allow for ground control).
25. Cut ½” hole in the top section of the nose cone [10] and glue red arming plug [2] into place as seen in the above figure.
26. Glue/tape ¼” plywood section [14] in front opening of the nose cone [10] with precut holes.
27. Glue and screw in motor [12] onto the plywood section [14], ensuring the wires are placed in the front section of the nose cone [10].
28. Plug all wires from servos and motor into receiver and ESC, and secure battery and all avionics into place inside the nose cone [10].
29. Glue nose cone [10] and fuselage [9] together, ensuring the place the provided bulkhead between the two to increase its structural integrity.
30. Use the provided nut to secure propellor [13] onto the motor [12], ensuring the

direction of the propellor is correct for forward flight.

31. Place 2 ¼” dowels [15] through the fuselage [9] spaced 6” apart from one another (refer to above figure to see location).
32. Place the completed wing section on top of the fuselage [9] and use 4 rubber bands [1] to secure completed wings to the plane (ensure 2 rubber bands cross sides to increase securing strength).

*Note: Disassembly can be completed by doing these steps in reverse.

Operation

The Aircraft described by this manual utilizes a standard Transmitter (Tx) configuration. This means that the vertical axis of the left toggle of the Tx is used to control **throttle**, the horizontal axis of the left toggle controls the aircraft’s **YAW**, the vertical axis of the right toggle controls the aircraft’s **pitch**, and the horizontal axis of the right toggle controls the aircraft’s **roll**. This aircraft is also equipped with a steerable front landing gear that is integrated into the **YAW** control system; this allows for seamless control of the aircraft when transitioning from the air to the ground. It is important to be aware that this aircraft will fail-safe to all inputs at zero position if the aircraft is to lose signal.

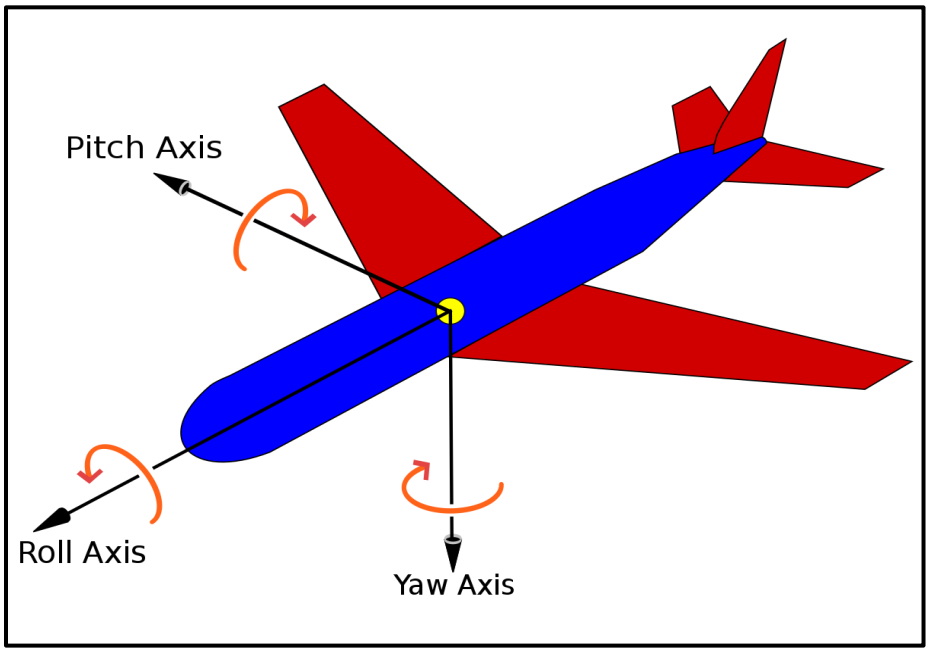

Figure 2 - Airplane axis [1].

Use the following steps to arm the aircraft for flight:

1. Verify that the aircraft’s Red Arming Plug is **removed** from the fuselage.
2. Power ON the Spektrum 8e Transmitter (Tx).
3. Plug power supply battery into the Electronic Speed Controller (ESC).
4. Place the battery securely in the nose of the fuselage.
5. Plug the airfoil servo wire located in the middle of the wing into the unconnected wire inside the fuselage leading from the receiver (Rx) aileron channel near the front of the aircraft.

6. Fasten wing atop the aircraft fuselage using a **minimum** of 4 rubber-bands (two going front to back along each side of the fuselage and two crossing over the fuselage forming an "X").
7. Verify that the Transmitter (Tx) has **throttle** toggle in zero position (The Tx will have given a verbal warning if they are not when it was turned on "switch warning" or "throttle warning," **BUT** the toggles may have moved positions since then so be sure to check again).
8. Insert Red Arming Plug into the red receiving fuselage port (At this point the aircraft is armed and will respond to any inputs given by the Transmitter (Tx)).
9. Perform preflight check to verify systems are working properly.

Maintenance

For maintenance every key aspect of the aircraft should be inspected pre and post flight to ensure every subsystem and component is in proper working order. For inspection follow these steps.

1. Check to make sure the battery has been charged to full capacity.
2. Check controller for full charge.
3. Inspect servo rods for cracks or deformations.
4. Inspect the landing gear frame for cracks or deformations, check the wheels to ensure proper rotation.
5. Inspect the wing for damage. If peeling away from the ribs, add more glue to secure it.
6. Inspect the propellor and motor for damage and ensure the rotational shaft is clear of any debris.
7. Ensure the structural integrity of the fuselage by inspecting for major slashes, crashes, or other issues that could cause failure. Repair minor damage if possible, replace if necessary.
8. After connecting the battery ensure the controller and receiver are communicating.
9. Check to make sure all the servos and motor are bound to the proper controls on the controller:
    a. Make sure the control surfaces are moving to the proper position.
    b. Check to make sure the propeller is rotating the proper direction.
    c. Test the motor by accelerating and decelerating.
10. Inspect the foam board joints on the control surfaces to ensure structural integrity, if needed add a thin layer of hot glue to reinforce the joint.

After conducting a successful flight and landing one should make sure to check the airfoil, landing gear, foam board joints and servo rods to make sure they did not sustain any damage. Should any of the components sustain damage you can either completely replace or repair the component depending on the level of damage and type of component.

Troubleshooting

With the complexity and delicacy of some of the sub-components of the aircraft, troubleshooting will likely be required for any user to resolve any technical issues that may arise with this system. The nature of the tasks in which the craft is designed to perform will likely result in damage to the aircraft due to crashes and faulty electro-mechanical connections.

The most common error that was found during testing was the connection of the servos to the controller and their direction of motion. To resolve any issues with this, follow these corrective actions:

1. Ensure that all servo motors are properly secured and connected to the main battery.
2. Check to be sure that the battery is fully charged and is providing an electrical output.
3. Check to make sure the remote controller is charged and functioning.
4. Ensure that the signal from the motors to the controller is not obstructed by anything (e.g. between an object, wrapped in metal).
5. Check to make sure that the frequency on the motor set by the manufacturer matches the frequency set on the controller.
    a. Do not use different motors that require different frequencies for connection.
6. A proper connection between the motors and the controller will be indicated by a beeping noise from the controller.
7. Once connections have been reestablished, clarify that the motors are turning in the correct direction.
    a. The propeller must be turning in a clockwise direction in order to provide the correct direction of thrust.
    b. Ensure motors on other components such as the ailerons, rudder, and front wheel are moving in the correct direction.

Another component of the aircraft that was discovered to have issues was the alignment of the positions of the servo motors for the equal range of motion for components such as the aileron and the rudder. Misalignment of these motors can cause increased difficulty in the steering of the plane during flight and can lead to potential crashes. The misalignment of the motors can occur after multiple trials of flight with the craft or after a crash where the motors are subjected to outside forces from the crash that throw their alignment off. To resolve any issues with the alignment of the servo motors, the following steps should be taken:

1. The servo motors are already pre-programmed to begin at 0° when they are powered on.
2. Ensure that the components attached to the motors are in the correct 0° position once powered on.
3. If the alignment is off, remove coverings to access servo motors and remove the set screw attaching the control rod to the servo motor.

a. Adjust accordingly the angle of the connecting rod to the servo.

4. Reattach connecting rods between the servo and component and reexamine the position to ensure it is in the correct position.

The team has provided a Q&A list of other simple troubleshooting questions that may occur during use and operation of the aircraft. This list is not exhaustive, thus, issues that cannot be resolved using this troubleshooting guide should be addressed by researching the answer online, contacting the faculty or other advisors, and finally by contacting the Aero Micro team.

Q: Why does nothing have power?

A: The red arming plug ensures the plane does not turn on when not intended. Ensure the red arming plug is connected when ready to fly.

Q: Why is the receiver not connecting to the remote?

A: Ensure that the Transmitter and Receiver are bound together. See Transmitter manual for instructions on binding transmitter to the receiver.

Q: Why won't the plane make it off the ground?

A: If the motor operates at full capacity and the plane cannot make it off the ground, the aircraft is likely overloaded, or the wing is struggling to produce lift. Ensure the plane has the lightest load possible by removing unnecessary payload. If this does not resolve the issue, inspect the wing to ensure it is not damaged, and replace the wing if necessary.

Q: Everything binds, but the servos move super slowly, and the propeller barely spins, what is wrong?

A: Check to ensure the battery has a full charge. If the battery is fully charged, ensure that all electrical connections are stable.

Q: Why does the landing wheel turn the opposite direction as expected?

A: The servo connection is likely backwards. Try reversing the servo connection or changing the side on which the servo is connected.

Q: Why are the servos making noise when I am not pressing the controls?

A: The servos are likely under a forced load; ensure they have no tension or compression on them before starting the system. The issues should not cause any harm to the plane.

Conclusion

The instructions provided in this manual should provide sufficient information pertaining to the operation, assembly, and maintenance of the aircraft. Any material not explicitly covered should be considered at the discretion of the operator. The Aero Micro team, Northern Arizona University, and any subsidiaries are not responsible for injury, damage, or loss of life due to the improper use of the aircraft and its components.

References

[1] "Aircraft principal axes," *Wikipedia*. [Online]. Available: https://en.wikipedia.org/wiki/Aircraft_principal_axes. (Accessed: Apr. 15th, 2021).