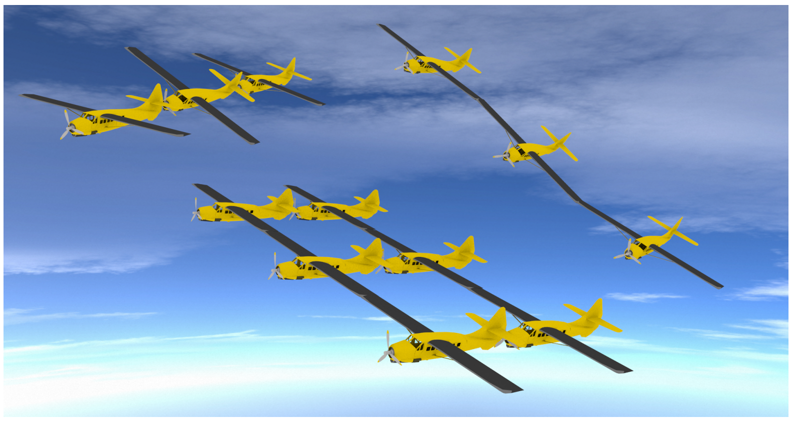
META AIRCRAFT FLIGHT DYNAMICS AND CONTROLS

The field of mobile robotic systems has become a rich area of research and design. These systems can navigate difficult terrain using multiple actuators with conventional ambulation, by hopping, jumping, or for aerial vehicles, using flapping wings, propellers, or engines to maintain aerial flight. Unmanned Aerial Systems(UAS) have been used extensively in both military and civilian applications such as reconnaissance or search and rescue missions. For air vehicles, range and endurance is a crucial design parameter as it governs which missions can be performed by a particular vehicle. In addition, when considering the presence of external disturbances such as atmospheric winds, these missions can be even more challenging. Meta aircraft technologies is one area of research that can increase range and endurance by taking advantage of an increase in L/D. A meta aircraft is an aircraft composed of smaller individual aircraft connected together through a similar connection mechanism that can potentially transfer power, loads, or information.

This presentation explores meta aircraft flight dynamics and controls for a variety of different configurations. First, the dynamics of meta aircraft systems are explored with a focus on the changes in fundamental aircraft modes and flexible modes of the system. Specifically, when aircraft are connected, the fundamental modes change, can become overdamped or even unstable. In addition, connected aircraft exhibit complex flexible modes and mode shapes that change based on the parameters of the connection joint and the number of connected aircraft.



Second, the connection dynamics are explored for meta aircraft where the vehicles are connected wing tip to wing tip using passive magnets with a particular focus on modeling the connection event between aircraft in a practical environment. It is found that a multi-stage connection control law with position and velocity feedback from GPS and connection point image feedback from a camera yields adequate connection performance in the presence of realistic sensor errors and atmospheric winds. Furthermore, atmospheric winds with low frequency gusts at the intensity normally found in a realistic environment pose the most significant threat to the success of connection. The frequency content of the atmospheric disturbance is an important variable to determine success of connection. Finally, the geometry of magnets that create the connection force field can alter connection rates.

Finally, the performance of a generic meta aircraft system are explored. Using a simplified PID controller with scheduled gains, any meta aircraft configuration is adequately controlled in the presence of realistic winds. Using this controller the aerodynamic benefit of different configurations are investigated. Wing to wing tip connected flight provides the most benefit in terms of average increased Lift to Drag ratio while tip to tail configurations drop the Lift to Drag ratio as trailing aircraft fly in the downwash of the leading aircraft.

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