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<th><strong>Title</strong></th>
<th>UAV with hybrid fixed and rotary wing capabilities</th>
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<td><strong>Author(s)</strong></td>
<td>Chao, Joshua Jang En</td>
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**1. Introduction**

Helicopters can hover and maneuver well while planes can fly fast and efficiently. A hybrid UAV will be tapping the potentials of both systems.

**2. Objectives**

- To design and develop a tilt rotor UAV.
- To implement fully autonomous features.
- To investigate and optimize transition flight.

**3. Prototype development**

Ardupilot Mega (microprocessor and sensor) is used to stabilize the UAV during hovering and forward flight using its 3-axis gyroscope and accelerometer.

**4. Autonomous**

In order to carry out missions, autonomous capabilities are required for flights out of visual range. Below is the behavior in autonomous mode.

**5. Transition at constant altitude**

During transition flight, the role of lift generation is transferred from motor to wing. This occurs when the tilt mechanism activates, rotating the upward pointing motor to the forward position. The challenging part is that thrust is constantly varying to ensure a constant total lift even when the wing starts to provide lift. This lift increases with velocity.

The formulas below and a few other equations are used to develop the mathematical model. Graphical methods are used to find the time interval and thus time for the acceleration and velocity obtained.

\[
\theta_{\text{max}} = \cos^{-1}\left(\frac{mg - \frac{1}{2}pV^2SC}{T_0}\right)
\]

Where

- \(\theta_{\text{max}}\) = Max tilt angle
- \(m\) = Mass
- \(V\) = Forward velocity
- \(C_L\) = Lift coefficient
- \(C_D\) = Drag coefficient
- \(V_i\) = Instantaneous velocity
- \(a_i\) = Instantaneous acceleration
- \(T_0\) = 80% of max total thrust

The mathematical model outputs the six instantaneous flight properties for every 0.1sec since the start of transition. This generates the angle of tilt required at a particular instant for optimized transition.