Safety Memo of KU-BATwing

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In this paper, development of fixed wing MAV(Micro Air Vehicle) with electric motor system is presented in detail. Electric motor system has been adopted due to its lower noise level than that of engine system. Flying MAV is very difficult due to inherent characteristics even though design and manufacturing of MAV are successful. The MAV named "KU-Batwing" has a 11cm wing span, 43g weight. It has successfully flown for 7 minutes at the flight test.

We introduce the following notations :

n Life time in amount of charge / discharge cycle
e Endurance (h)
h Cruise Altitude (m)
L/D Lift-to-Drag ratio
ws Wind speed (m/s)
as Air speed (m/s)

1. System properties

The Vehicle

Name : KU-Batwing
Weight : 43g
Wingspan : 110mm
Propulsion : 1 Electric Brushless engine
Endurance : 7 minutes

Transmission system

- 2.4GHz analog transmitter for the video downlink. (80mW)
- 72MHz RC transmitter for safety RC Link. (100mW)

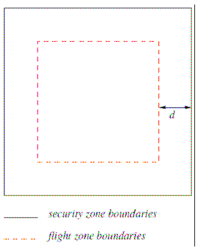
2. Flight Zone Computation

The fall distance without wind is : $L/D \times h$

The fall duration is : $\frac{\sqrt{h}}{\;}$

The wind effect is : $\frac{\sqrt{h}}{\;} \times ws$

Therefore, we have (see figure 4): $d = L/D \times h + \frac{\sqrt{h}}{\;} \times ws$



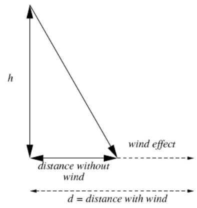


Figure 4 : distance between the Security zone and the Flight zone.
Figure 5 : How the previous distance is computed

The KU-Batwing cruise speed is approximatively 13m/s. At this speed the maximum. Lift-to-Drag ratio is 1.3 with a nose-down attitude. In the worse case, we consider that the wind speed is 15m/s. The Li-Po battery commonly used have a 500 charge and discharge cycle, and provides a 7 minutes endurance. Therefore we have a distance:

d=96 meters

3. Probability to exit a given flight zone

To prevent Micro Air Vehicle from causing accidents we need to classify flight failure and provide maneuvers and failsafes to prevent this failures to be responsible for an accident. To do so a Micro Air
Vehicle mustn't exit a given flight zone with the probability of 10−4 per flight hour.

Power supply failure

A power supply failure will automatically and immediatly cause a crash of the MAV. We define the following events, which are indepent:

The battery of the Micro Air Vehicle is out of order.
The Micro Air Vehicle crash outside of the borders of the flight zone.

P(A) = = 2.3 per hour

d = L/D × h + $\frac{\sqrt{h}}{}$ × ws

= 96m

P(B) = $\frac{\text{surface(stripe within distance d of t}}{\text{surface(flight zone)}}$

= 0.125

P(A B) = P(A) × P(B)

= 2.875 × per hour

To simplify the computation of the surface we considered that the flight zone was a 900 meters square.

References

[1] Nicolas Albert. Certification du code embarqu´e d'un micro-drone. Master's thesis, University of Toulouse, 2005.
[2] P. Brisset, A. Drouin, M. Gorraz, P.-S. Huard, and J. Tyler. The Paparazzi solution. In MAV2006, Sandestin, Florida, November 2006.

[3] N. Halbwachs, P. Caspi, P. Raymond, and D. Pilaud. The synchronous data-flow programming language LUSTRE. Proceedings of the IEEE, 79(9):1305–1320, September 1991.