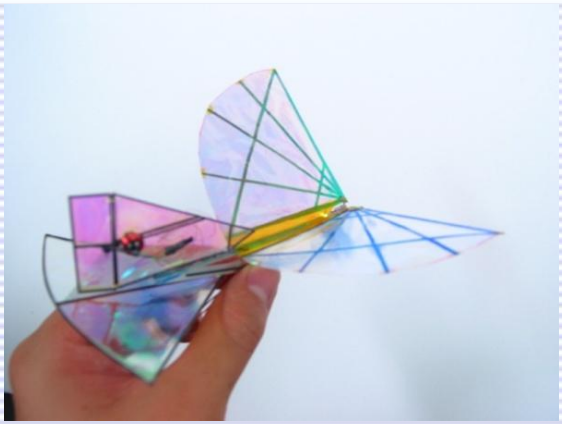
Flapping MAV

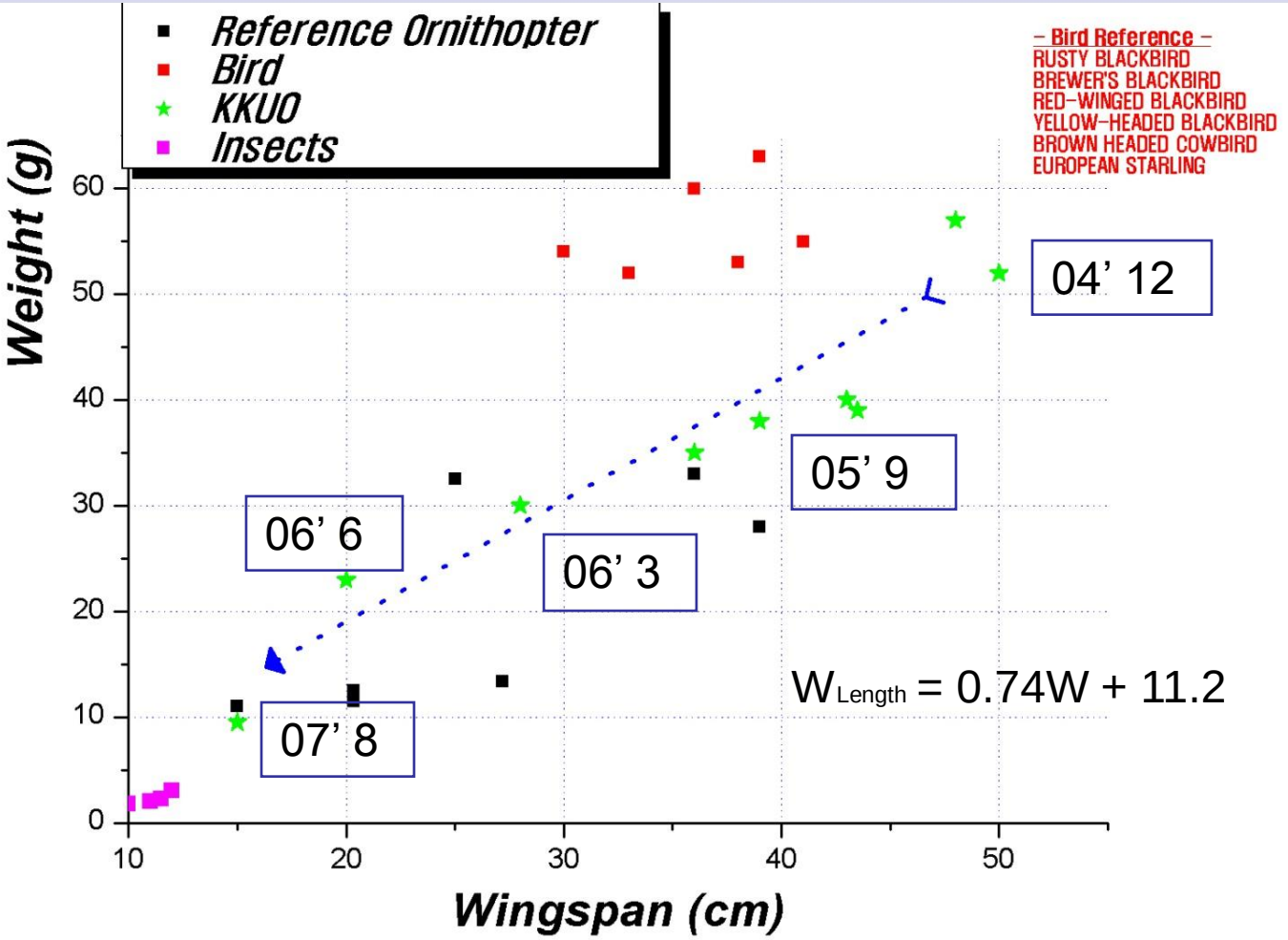


Park Joon Hyuk, Kim Hyung Jin,
Kwang Joon Yoon
Smart Robot Center
Dept. of Aerospace Information Eng.
Konkuk University
Seoul, Korea

Contents

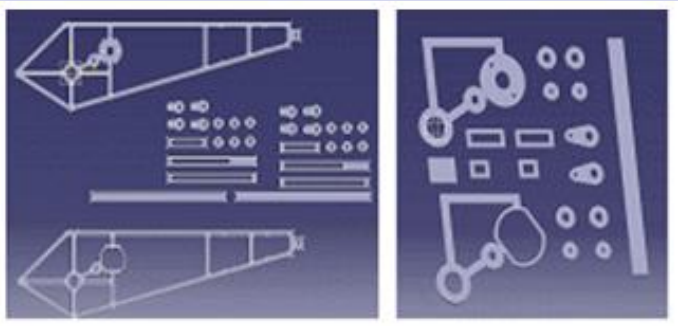
- **Characteristics**
  - Materials
  - Research on wing structure motivated by insect wing
- **36cm Flapping MAV**
  - capable of vision sensing and Take-off/Landing
- **28cm Flapping MAV**
- **15cm Flapping MAV**

History


Reference Ornithopter
Bird
KKUO
Insects
– Bird Reference –
RUSTY BLACKBIRD
BREWER'S BLACKBIRD
RED-WINGED BLACKBIRD
YELLOW-HEADED BLACKBIRD
BROWN HEADED COWBIRD
EUROPEAN STARLING
Weight (g)
Wingspan (cm)
0
10
20
30
40
50
60
10
20
30
40
50
04' 12
05' 9
06' 3
06' 6
07' 8
W_Length = 0.74W + 11.2

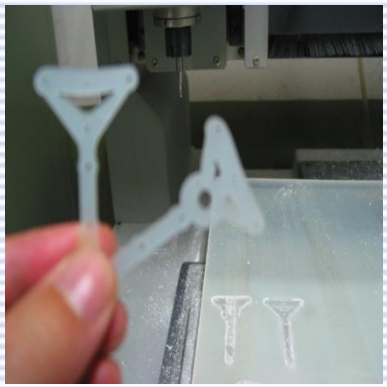
Characteristics - materials

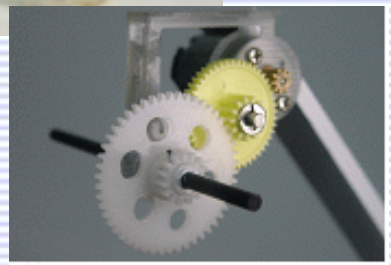
- Designed using CATIA



- Materials
  - Body : glass/epoxy
  - Wing frame & shaft : carbon rod
  - Wing skin : epoxy film

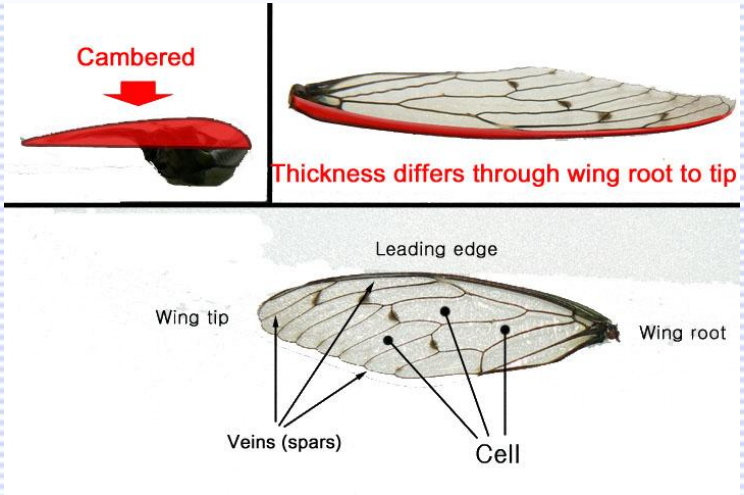
- Manufacture by CNC machine



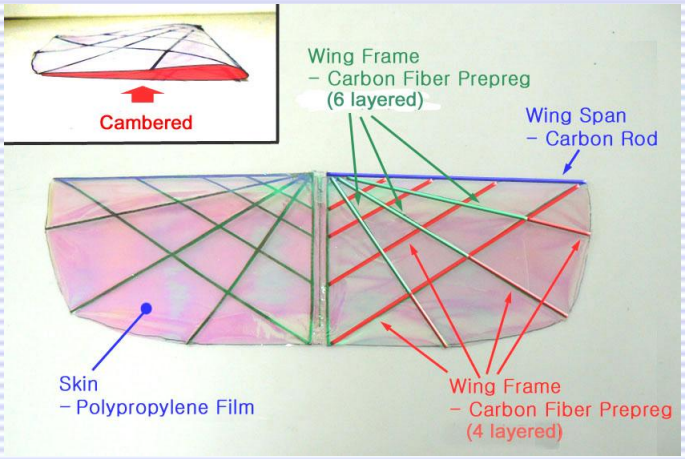


Characteristics – wings

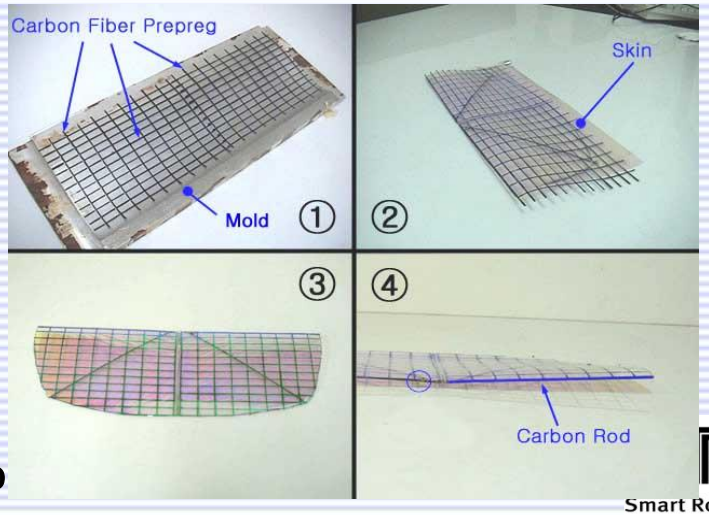
- **Wing Shape Configuration**
- Insect wing(cicada) analysis



- Bio-mimetic wing design



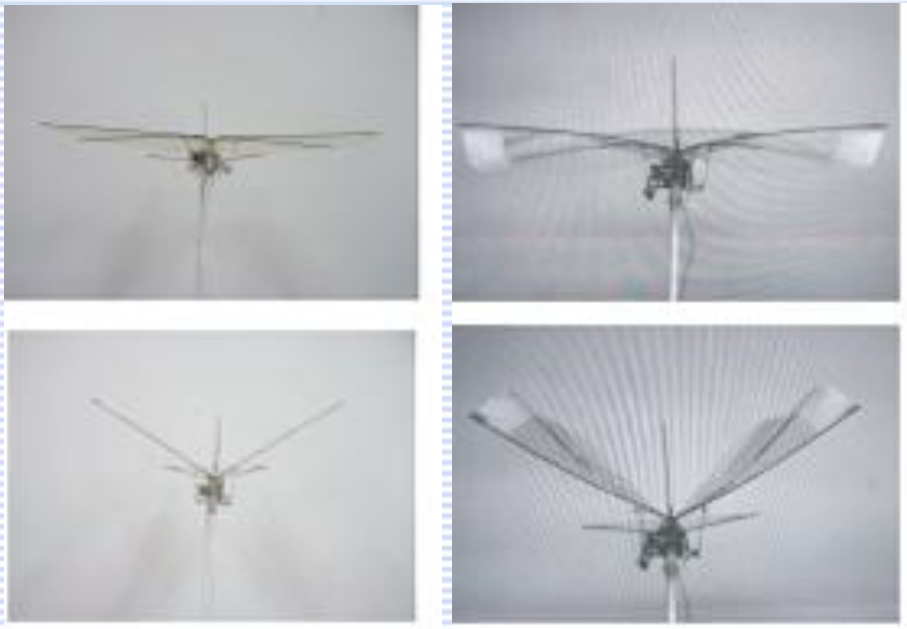
- Procedures



- Characteristics of insect wing
  - Cell-type wing
  - Camber wing on both spanwise and chord direction

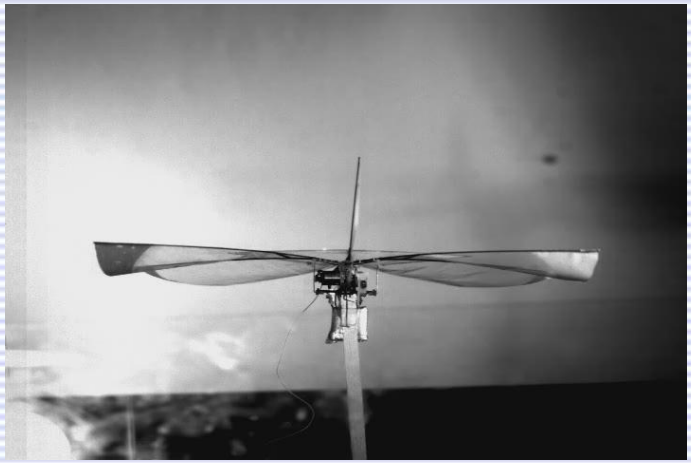
Characteristics – wings

- **Wing Shape Configuration**
- The deformed shape of ornithopter wings during the flapping motion



  - Different flapping shape due to the elasticity in chord direction

- The deformation of wings of ornithopter and cicada



36cm Flapping MAV

INVEST
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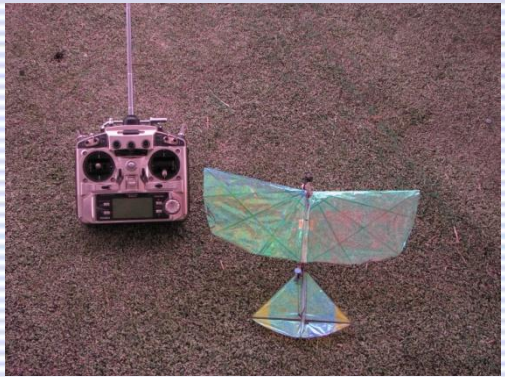

- Landing gear
- Camera attached

Component Part	Mass	Product	Specification
Motor	6.09 g	B2C Motor	Input Voltage (V) 5
Battery	10.0 g	210mA	Output Voltage (V) 8.4
Speed Controller	1.22 g	Falcon HF ESC	
R/C Receiver	2.04 g	GWS Receiver	
Fuselage and Gear Box	6.44 g		Glass plate
Wing Structure	3.27 g		Carbon rod
Camera &transmitter	+6.05 g		
Total Mass	44.60 g(+6.05g)		

36cm Flapping MAV

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- Take off

- Landing

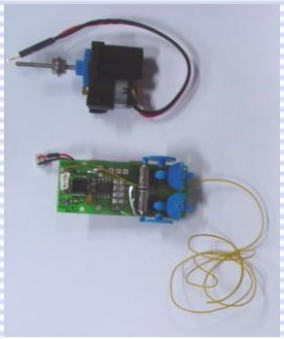
Wing Span	36 cm	Gear Ratio	28:1 reduction
Wing Area	432 cm^2	Frequency	20 Hz
Weight	50 g	Up Stroke ˚	35°
Wing loading	0.115g/cm^2	Down Stroke ˚	0 °
Fuselage	23 cm	Flight Duration	15 min

36cm Flapping MAV

- Flapping and Gliding

- Vision data from camera

28cm Flapping MAV

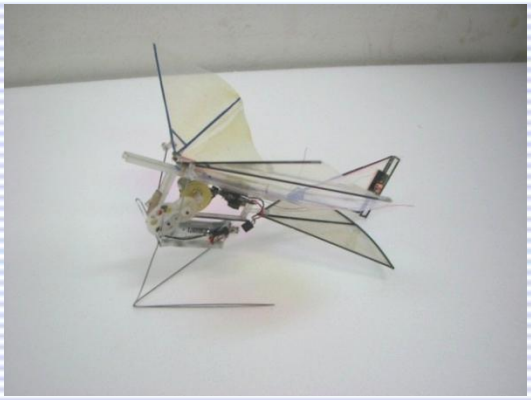


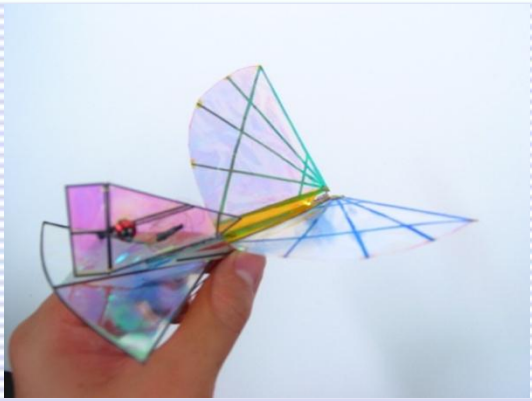
Component Part	Mass	Product	Specification
Motor	6.09 g	B2C Motor	Input Voltage (V) 5
Battery	7.94 g	145mA battery	Output Voltage (V) 8.4
Speed Controller	1.22 g	Falcon HF ESC	
R/C Receiver	2.04 g	GWS Receiver	
Fuselage and Gear Box	6.44 g		Glass plate
Wing Structure	3.27 g		Carbon road
Total Mass	30.60 g(+3.05g)		

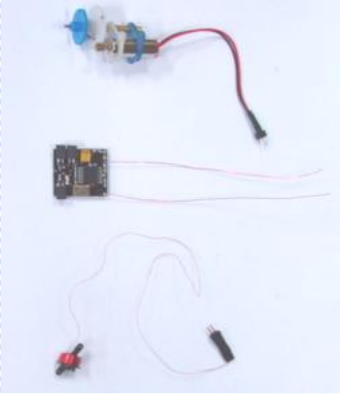
28cm Flapping MAV

Wing Span	28 cm
Wing Area	280 cm^2
Weight	30.6 g
Wing loading	0.109g/cm^2
Fuselage	23 cm
Gear Ratio	19:1 reduction
Frequency	24 Hz
Up Stroke ˚	30°
Down Stroke ˚	5 °
Flight Duration	8 min

15cm Flapping MAV







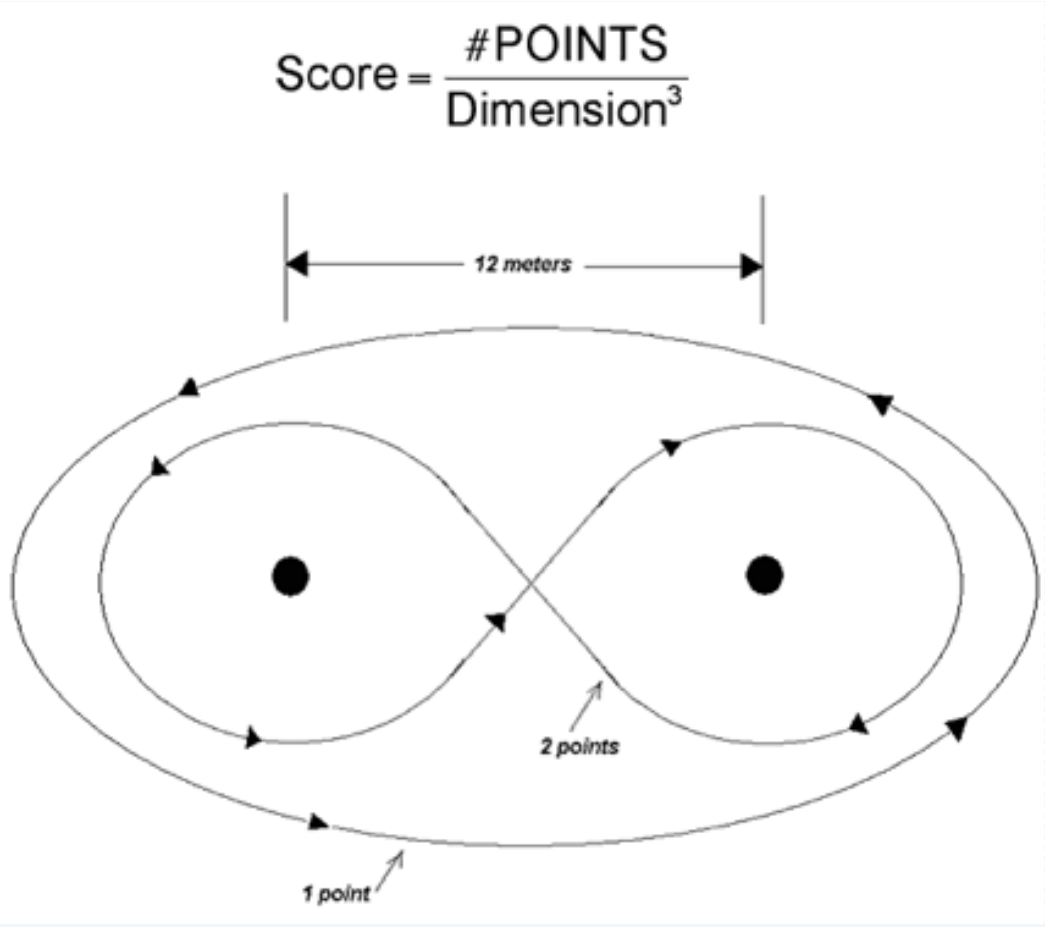
Component Part	Mass	Product	Specification
Motor	1.6 g	Pager motor	Input Voltage (V) 1~3
Battery	1.3 g	60mA battery	Output Voltage (V) 3.7
Speed Controller R/C Receiver	0.8 g		
Fuselage and Gear Box	0.8 g		Glass plate
Wing Structure	6.44 g		Carbon road
Total Mass	8.7 g		

15cm Flapping MAV

Wing Span	15 cm
Wing Area	85 cm^2
Weight	8.7 g
Wing loading	0.102 g/cm^2
Fuselage	15 cm
Gear Ratio	16:1 reduction
Frequency	30 Hz
Up Stroke °	40°
Down Stroke °	5 °
Flight Duration	1 min

Thank you …

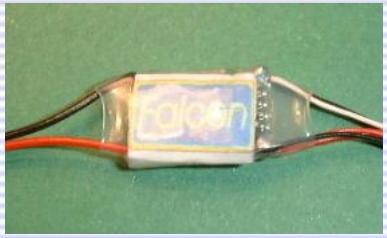
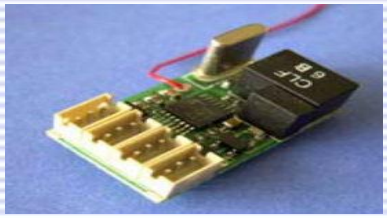
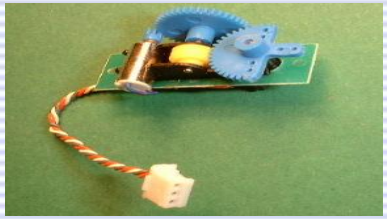
Ornithopter mission



Ranked 4th Place at
9th Int. MAV Competition
2005. 6. Seoul Korea

Ranked 2nd Place at
10th Int. MAV Competition
2006. 5. BYU Utah USA

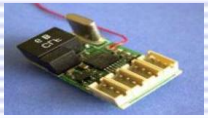
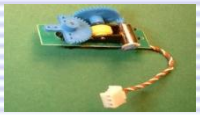
Component Specification

Speed Controller		**Falcon HF ESC for 2 Li-poly cells** **The Falcon High Frequency 100kHz** 2 cell ESC is designed to work with 2 Li-poly cells. The ESC incorporates a 5v BEC to power the radio. Data: **1.45g** complete with all onnectors and wire. Dimensions: 11mmx15mmx3mm BEC: 5v easily handles 3-4 servos.
Receiver		**Gws Rx with JST plugs** GWS Rx with JST 4.8 - 6 V Dimensions: 15 x 25 x 10mm Range approx. 150m 4.3g with micro crystal **3.8g** without housing
Actuators		**Falcon 1.7g Servo** Falcon Coreless digital **1.7g** servo with JST connectors, **Torque 25+grams** Operating voltage 3.3 - 5v Length .....26mm Width.....13mm Height.....14mm For models up to approx150gms

Development Background

- **Conceptual Design**
- Component Mass

Component Part	Mass
Motor	6.09 g
Battery	7.94 g
Speed Controller	1.22 g
R/C Receiver	2.04 g
Fuselage and Gear Box	6.44 g
Wing Structure	3.27 g
Total Mass	30.60 g

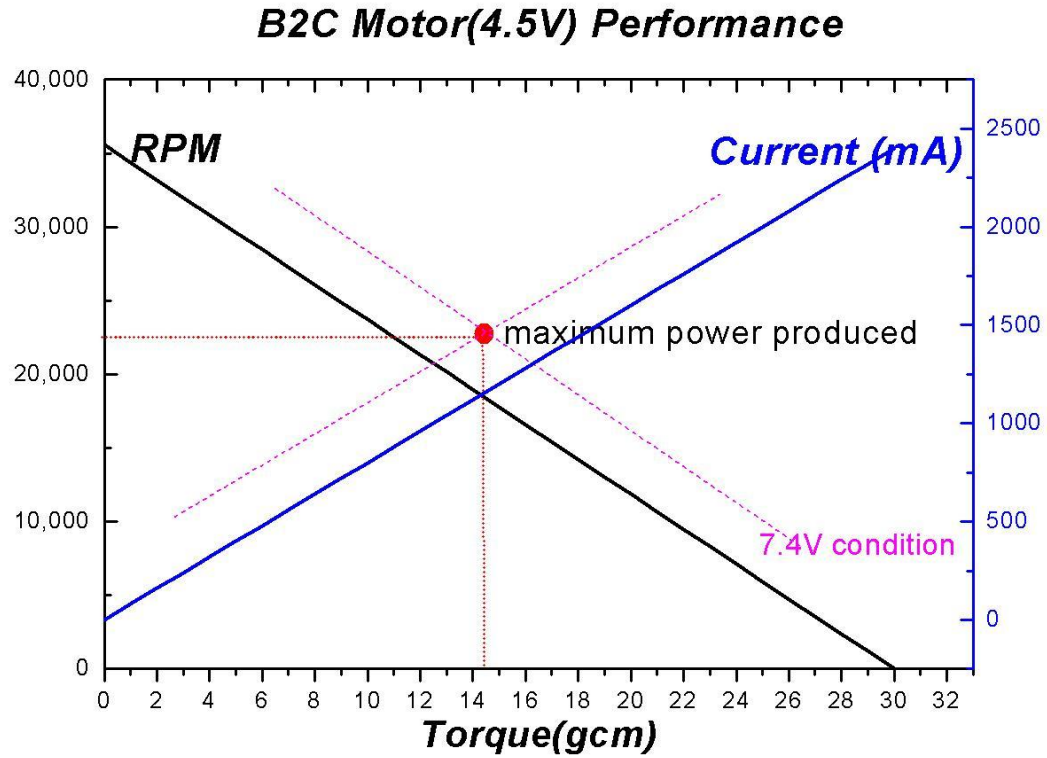
$W_{Length} = 0.74W + 11.2$

- Design Requirement
  - Wing Span : 35cm
  - Weight : max 35g
  - Flight endurance : 15 min.
  - Remote control range : max 100m
  - Materials : composite materials
  - Propulsion : electric motor
  - Flight control : rudder, elevator

- Maximum assuming weight : 35g
  - Require Wingspan Length = 35cm

Development Background

- **Power System**
  - Torque value related to RPM & Amp



  - Torque loaded on the wing : min 350 g·cm^2
  - Maximum torque produced : 15 gcm
  - Gear reduction ratio : 23:1
  - Selection of Motor :
    - B2C Motor

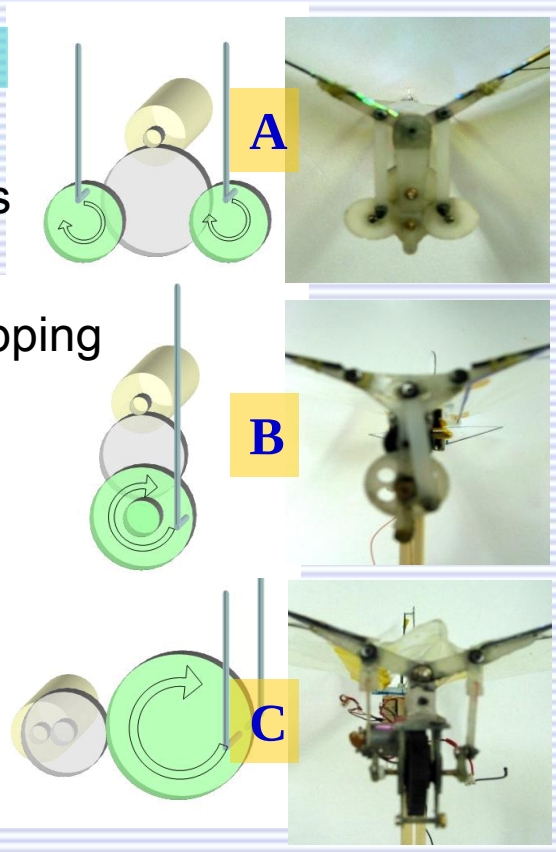
Norminal Voltage (V)	4.5
Weight (g)	5.6
RPM (No load)	25500
Stall Torque (g•cm)	130

Development Background

- **Gearbox System Design**
- Type of Gear box

Disadvantage

Advantage



– Heavier than other types

– appropriate to transfer large force

– Non symmetric wing flapping motion
– Structural weakness

– Lighter than others
– Easy to repair

– generates higher body vibration relatively

– Strong structure

Type C was compatible in both weight and performance

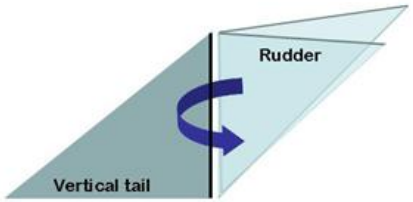
Development Background

- **Tail System Design**
- 2 types of vertical and horizontal stabilizer

Disadvantage

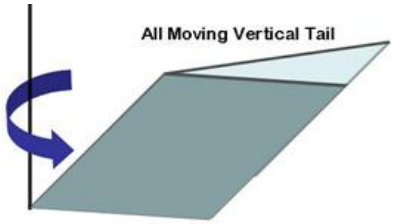
Advantage

delay before turning



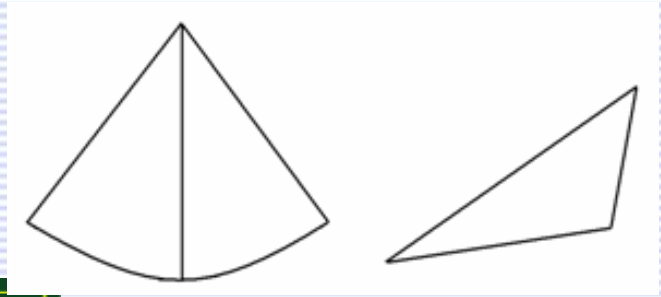
very stable in straight and level flight

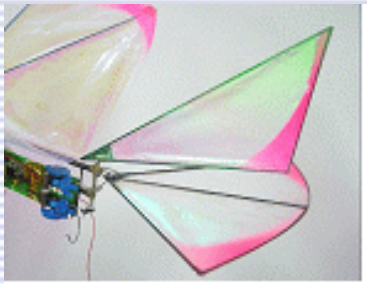
Less stability after turning



rapid direction change

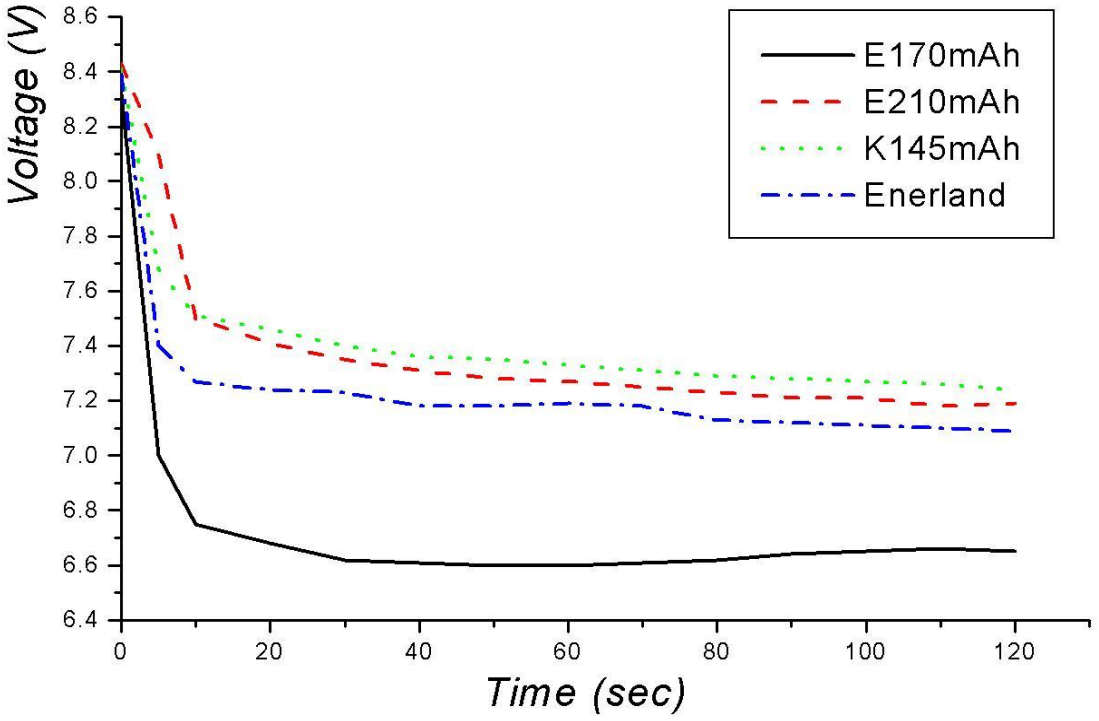
- The designed vertical and horizontal stabilizer of ornithopter





Development Background

- **Battery Configuration**
- Battery discharge performance
  - Battery type : Li-polymer battery (2-cell)
  - Measured with “Micro-Meter Model 100” device



Battery Requirements

- Supply 1Amp for more than 5 min
- Voltage drop rate should be small