Wing folding and fuselage

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Content

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• Fuselage (in collaboration with CATEC)
  • First iteration
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Folding wing

Current state
Folding wing

Current state – Dimensions (whole wing)

- Longitudinal x wingspan in mm:
  - Unfolded: 452 x 1500
  - Folded: 701 x 341 travel of 62°
    Difference: +55% x -77%
- Max. height: 51 mm
- Reduction to 1/3 of volume
Folding wing

Curvature

- 12 more pieces
- Fabric less tightened
- More difficult to fold
Folding wing

Current state - Electronics

• Integration of:
  • Flapping
  • Control of tail
  • Folding

• PCB, folding motors, cables: 69 grams

PCB and connections by Jesús
Folding wing

Mass and pieces (mec)

TOTAL: 138 grams

TOTAL: 160 pieces
Folding wing

Mass and pieces (complete wing)

TOTAL: 305 grams

TOTAL: 221 pieces (+ electronics)
Folding wing

Mass and pieces (complete wing)

### Mass (g)
- **Front holder:** 6g; 2%
- **Mechanism:** 138g; 45%
- **Connecting rods:** 4.5g; 2%
- **Flapping pieces:** 34g; 11%
- **Fabric:** 22g; 7%
- **Electronics:** 57g; 19%

**TOTAL:** 305 grams

### Pieces
- **Front holder:** 1; 1%
- **Flapping pieces:** 14; 6%
- **Fabric:** 2; 1%
- **Connecting rods:** 4; 2%
- **Folding elements:** 40; 18%
- **Mechanism:** 160; 72%

**TOTAL:** 221 pieces (+ electronics)
Folding wing

Mass and pieces (complete wing) – added to E-FLAP

**Mass (g)**
- Front holder; 6; 3%
- Mechanism; 93.4; 54%
- Connecting rods; 4.5; 3%
- Flapping elements; 36; 21%
- Electronics; 27; 15%
- Fabric; 0; 0%

Total: 174 g (less than 100 g per half wing)

**Pieces**
- Mechanism; 138; 76%
- Folding elements; 34; 19%
- Connecting rods; 4; 2%
- Fabric; 0; 0%
- Flapping pieces; -4; -2%
- Front holder; 1; 1%

Total: 173 pieces (+ electronics)
Folding wing

Aluminium pieces - CATEC  
Piece redesign after they were broken in flight
Folding wing

Aluminium pieces

FEM analysis by Cristina
Folding wing
Experiments – Bench
Flapping March 2021
This will be submitted to AIRPHARO
Folding wing
Experiments – Bench
Folding April 2021

This will be submitted to AIRPHARO
Folding wing
Experiments – Bench
Unfolding April 2021

This will be submitted to AIRPHARO
Folding wing
Experiments
Flapping April 2021
Folding wing
Experiments
Flapping April 2021
Folding wing
Experiments
Flapping April 2021
Folding wing

Future work

• Submitting paper to AIRPHARO with bench experiments included
• Simplified study of efforts to determine weak points and to have scientific content to publish (with Cristina)
• CATEC:
  • Aluminum pieces
• Adapting to last version of E-FLAP (for future integration)
• Experiments and redesign to be able to fly (with Jesús, Fran, Mar, Ernesto, Cristina, Raphael):
  • Gliding
  • Flapping
  • Flying in automatic with Optitrack
• Publishing in a journal
Fuselage

First iteration with CATEC
October 2019 – October 2020

120 g → 105 g
Fuselage

Recent work

Version with head, without event camera
- More closed
- 130 grams without optimization
- Performing iterations with CATEC
- Considering electronics
- Easily replaceable head
Fuselage

Recent work

Version without head, with event camera
Fuselage

Recent work

• Grooves along the body
• Two pins in the body:
  • One fixed (front zone)
  • The other free (tail zone)
• 2 points of joint with screws each half body to carbon fiber plates of gears
• 4 points of joint with screws in the head to carbon fiber plates of electronics
Fuselage

Future work

• CATEC:
  • Topological optimization or other methods to reduce mass in areas that do not support efforts
  • Manufacture
  • Sending about summer

• Experiments for demonstrate the endurance:
  • Gliding
  • Front impact (in head)
  • Flapping (to assure the ornithopter can fly carrying the fuselage weight).

• Feedback to CATEC
Thanks for your attention

ANY QUESTIONS?