Lorena Calvente Roldán
Study of the folding of the GRIFFIN Project wing
January 27, 2021
1. PREVIOUS STATE IN CATIA

TOTAL dimensions (connected whole wing)
Longitudinal x wingspan in mm:
- Unfolded: 454 x 1600
- Folded: 751 x 330, travel of 79° (21° ornithopter axis)
Difference: +65% x -79%
Max. heigh: 57 mm
2. CURRENT STATE IN CATIA

TOTAL dimensions (connected whole wing)
Longitudinal x wingspan in mm:
• Unfolded: 442 x 1500
• Folded: 701 x 349, travel of 62°
  (28° ornithopter axis)
Difference: +59% x -77%
Max. heigh: 51 mm
Study of the folding of the GRIFFIN Project wing
3. IMPROVEMENTS IN DESIGN

Alignment of the bars to improve movement transmission

Redistribution of bars to reduce the exposed parts

Reduction of weight
  - Reduction of the diameter of two bars
  - Reduction of pieces in thickness and size
  - Reduction of the length of two bars to have a halfwing of 750 mm.

Fabric tensioner

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Study of the folding of the GRIFFIN Project wing
3. IMPROVEMENTS IN DESIGN

Different material: Two pieces PLA → One piece TPU 95A
Rib Ø 2 mm → Ø 1.5 mm (curvature)

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Study of the folding of the GRIFFIN Project wing
Initially: gear transmission

Each wing can be folded independently when the ornithopter is perching or during flight for any angle of flapping (this gives problems, higher angle more difficult to move).
1. An engine on a support connected to the bird axis
2. Two supports with connecting rods to hold the rod L1
3. A gear transmission between the engine and the rod L1
Finally: alignment of gearmotor to L1

Gears aren’t enough reliable to stay in the same plane due to displacement of bar L1. Updated connection to:

1. An engine on a new support connected to the bird axis but aligned to rod L1
2. Two supports with connecting rods to hold the rod L1

Slider: 74 mm of travel
5. MASS & PIECES

Elements of the mechanism itself per halfwing

Total
71.5 g
84 pieces

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Study of the folding of the GRIFFIN Project wing
### 5. MASS & PIECES

<table>
<thead>
<tr>
<th>PIECES</th>
<th>NUMBER</th>
<th>MODELS</th>
<th>Nº PIECES IN HALFWING PER MODEL</th>
<th>PRODUCTION</th>
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</table>

**Lorena Calvente Roldán. January 27, 2021**

Study of the folding of the GRIFFIN Project wing
5. MASS & PIECES

The extra elements per halfwing
Total 55.7 g
23 pieces

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Study of the folding of the GRIFFIN Project wing
5. MASS & PIECES

Total mass of the whole system of folding per halfwing

124.24 g
107 pieces

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Study of the folding of the GRIFFIN Project wing
Mass and number pieces increase respect to non-folding mechanism

78 grams 90 pieces
### 5. MASS & PIECES

#### Mass of both wings

<table>
<thead>
<tr>
<th>Part</th>
<th>Mass (g)</th>
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<td>Front holder</td>
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<td>Flapping pieces</td>
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**TOTAL: 247.08 g (123.54 g/halfwing)**
6. CURRENT STATE

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Study of the folding of the GRIFFIN Project wing
7. EXPERIMENTS. Folding

60° angular travel (the leading edge reaches about 30° with the main axis)

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Study of the folding of the GRIFFIN Project wing
7. EXPERIMENTS. Unfolding

Problems due to deformation of L1, along which the slider B moves parallel to ornithopter axis
2.56 Hz reached maximum
7. EXPERIMENTS. Flapping

3.58 Hz reached maximum

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Study of the folding of the GRIFFIN Project wing
7. EXPERIMENTS. Flapping

4 Hz reached maximum – December 2020

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Study of the folding of the GRIFFIN Project wing
Solving the fact of the bar L1 along which the slider B moves

New design
• Assembling the new design for the right wing
• Substituting ribs of 2 mm Ø with 1.5 mm Ø

Experiments
• Able to resist the whole wing a frequency of about 3 Hz
• Able to fold and unfold for every flapping angle → a more powerful motor

Connecting the engine with the station
With a driver to change the sense (extending/folding)

Improving aerodynamics
• Introducing curvature to the wing:
  • Half rib in the two nearest ribs to the ornithopter axis
  • Complete rib in the two furthest ribs.
• Ensuring the tightness of the fabric