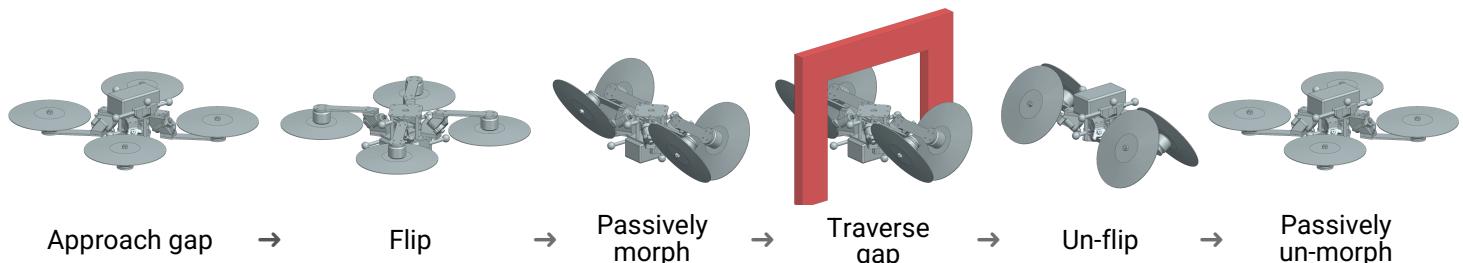
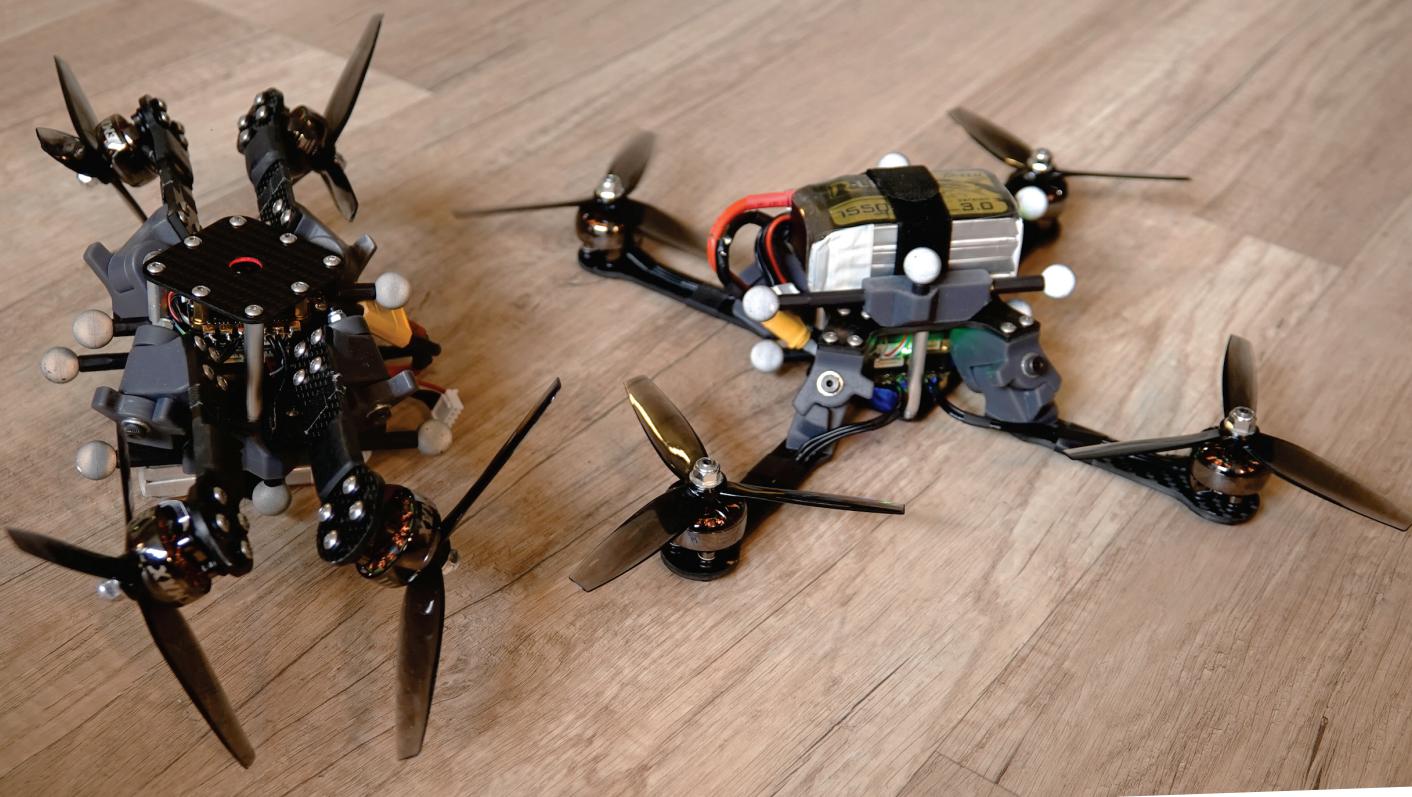


# FLIFO: A passively morphing drone for small gap traversal



Drones with large propellers are typically more efficient than drones with small ones. This can lead to design trade-offs when a drone is required to fit through small gaps. Morphing drones manage to sidestep this trade-off by temporarily morphing into smaller and less efficient configurations to traverse gaps. Here, a novel morphing drone design is presented that manages to shrink by an unprecedented 50% in width while maintaining full controllability. All without requiring any additional actuators.



## Showcase video

[youtu.be/km4emnqCqzE](https://youtu.be/km4emnqCqzE)



## 40x Slow-mo video

[youtu.be/oOH2R4ZKw6I](https://youtu.be/oOH2R4ZKw6I)



## Crash reel

[youtu.be/bIH9VZyr2X4](https://youtu.be/bIH9VZyr2X4)

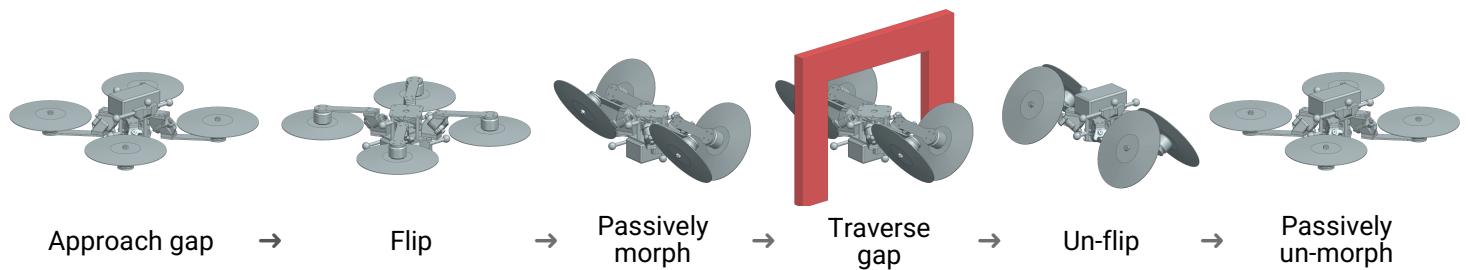


## Project website

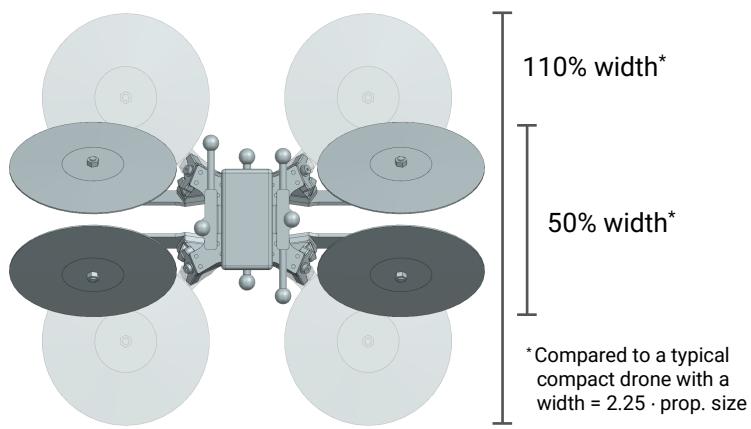
[marcoruggia.ch/flifo](http://marcoruggia.ch/flifo)



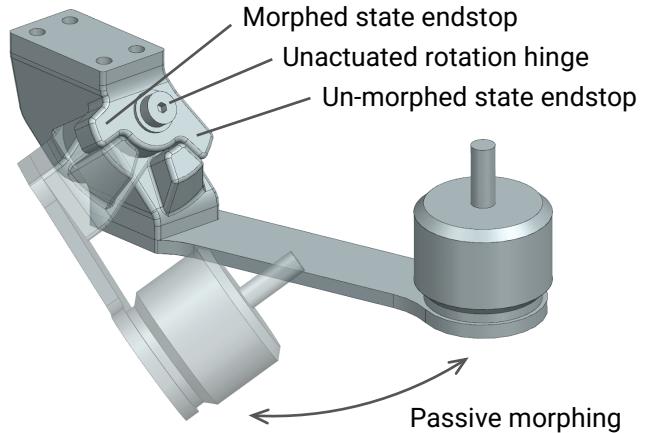
# FLIFO: A passively morphing drone for small gap traversal



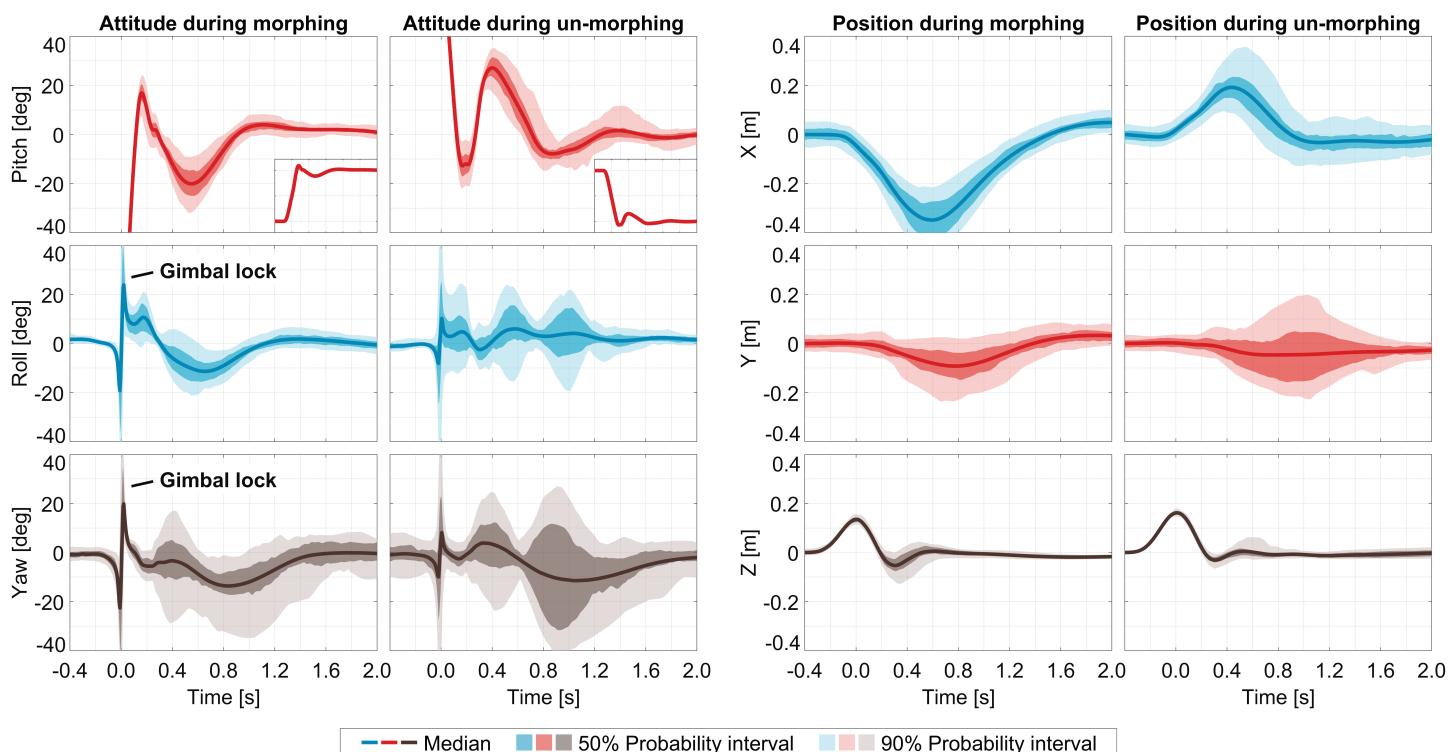
**Width reduction when morphed:**



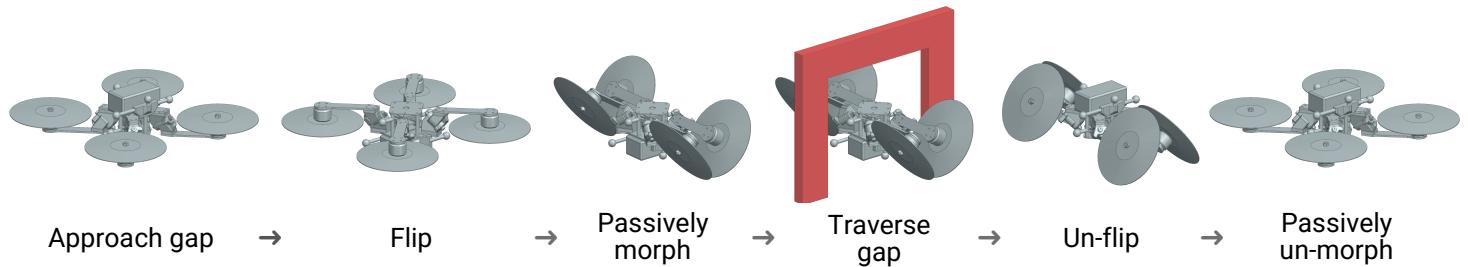
**Passive morphing mechanism:**



**Morphing / un-morphing transition trajectories:**



# FLIFO: A passively morphing drone for small gap traversal



**Control effectiveness in normal flight:**

$$\begin{bmatrix} M_{roll} \\ M_{pitch} \\ M_{yaw} \\ F_{up} \end{bmatrix} = \begin{bmatrix} -1.21 & +1.21 & +1.21 & -1.21 \\ -1.21 & +1.21 & -1.21 & +1.21 \\ +0.17 & +0.17 & -0.17 & -0.17 \\ +13.1 & +13.1 & +13.1 & +13.1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix}$$

(  $M_{roll}, M_{pitch}, M_{yaw}$ : Body torques [Nm]    $F_{up}$ : Body upward thrust [N]    $u_{1-4}$ : Motor throttles [-1 to 1] )

**Control effectiveness in morphed flight:**

$$\begin{bmatrix} M_{roll} \\ M_{pitch} \\ M_{yaw} \\ F_{up} \end{bmatrix} = \begin{bmatrix} -0.36 & +0.36 & +0.36 & -0.36 \\ -0.92 & +0.92 & -0.92 & +0.92 \\ -1.15 & -1.15 & +1.15 & +1.15 \\ +6.75 & +6.75 & +6.75 & +6.75 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix}$$

**Performance of two propeller options:**

(measured on a thrust-stand for propellers rotating both ways)

