



# 16.485: VNAV - Visual Navigation for Autonomous Vehicles

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Lecture 6



based on slides by Markus Ryll

# Agile Navigation with Aerial Vehicles

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# Agile Navigation with Aerial Vehicles

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Quadrocopter Pole Acrobatics

Raffaello D'Andrea et al.  
@ETH



**ETH** zürich

Vijay Kumar et al.  
@Penn



# Agile Navigation with Aerial Vehicles

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Video of Lockheed Martin AlphaPilot AI Drone Innovation Challenge

# Design Concepts

- Single rotor



- ⊕ ✓ Good Controllability and maneuverability
- ⊖ - Complex mechanics
- ⊖ - Large rotor

- Tandem rotor



- ⊕ ✓ Good Controllability and maneuverability
- ⊖ - Complex mechanics
- ⊖ - Large size

- Coaxial rotor



- ⊕ ✓ Compactness
- ⊕ ✓ Simple mechanics
- ⊖ - Complex aerodynamics

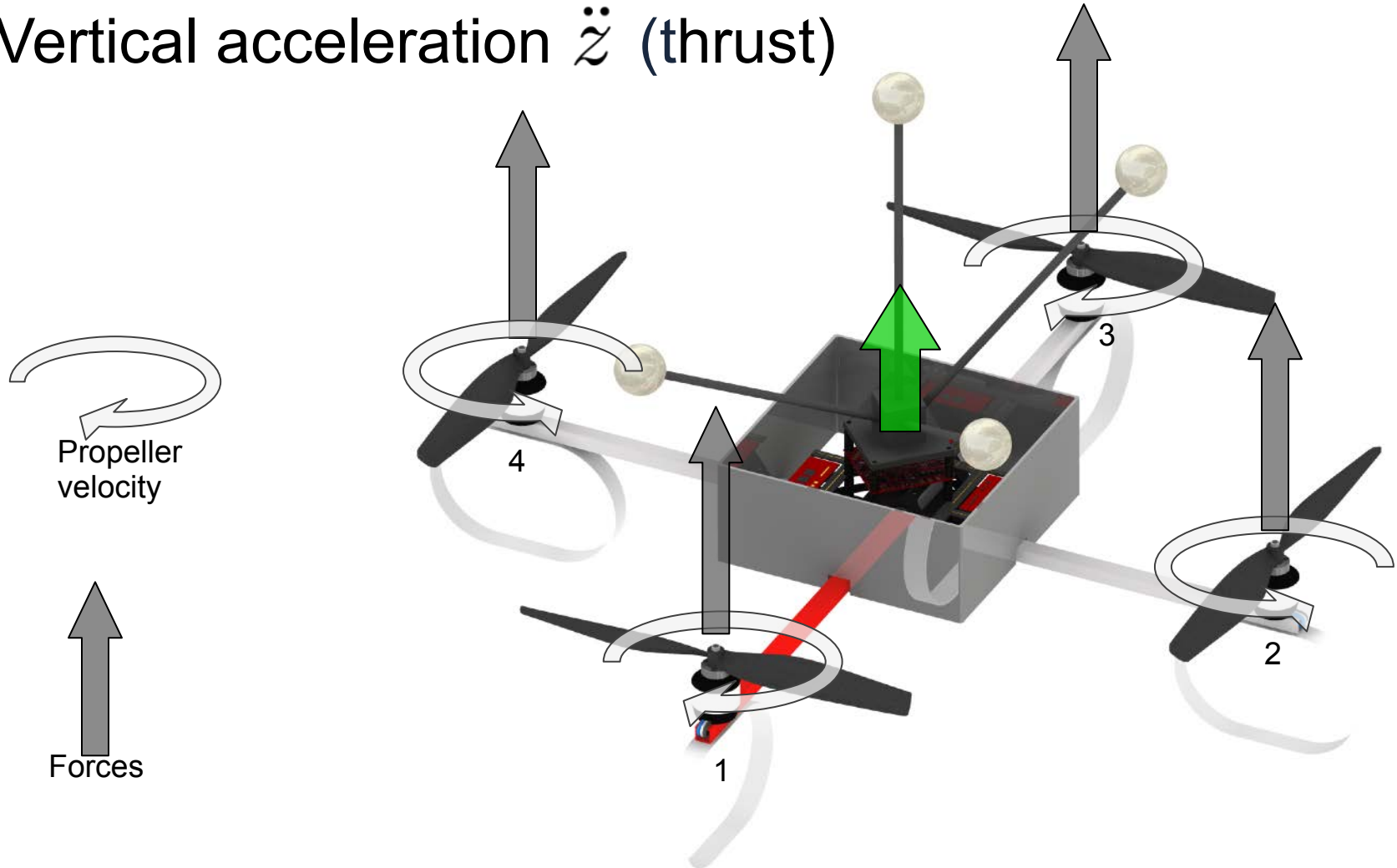
- Quadrotor



- ⊕ ✓ Good maneuverability
- ⊕ ✓ Simple mechanics
- ⊕ ✓ Big payload
- ⊖ - High energy consumption

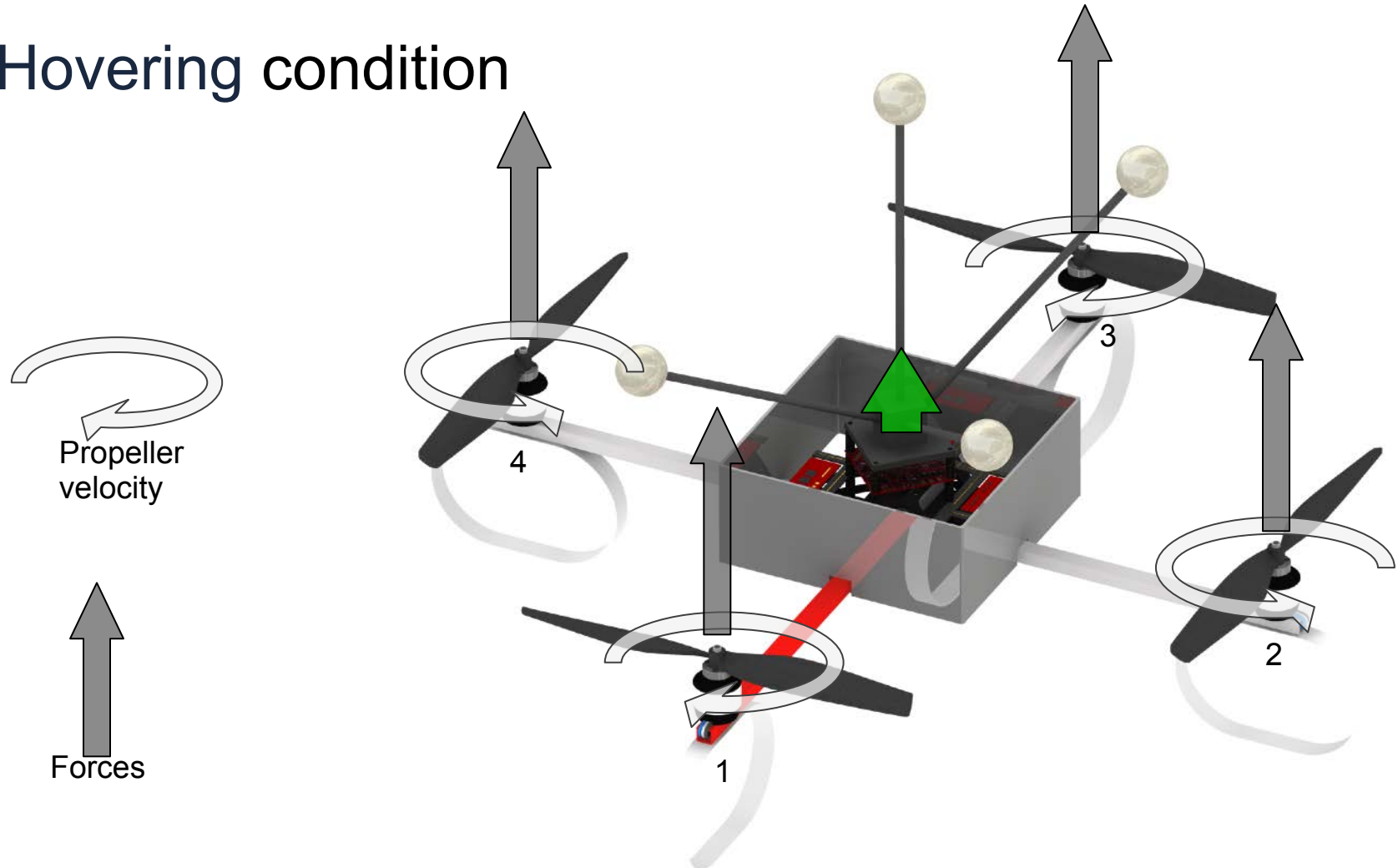
# Design Concepts

Vertical acceleration  $\ddot{z}$  (thrust)



# Design Concepts

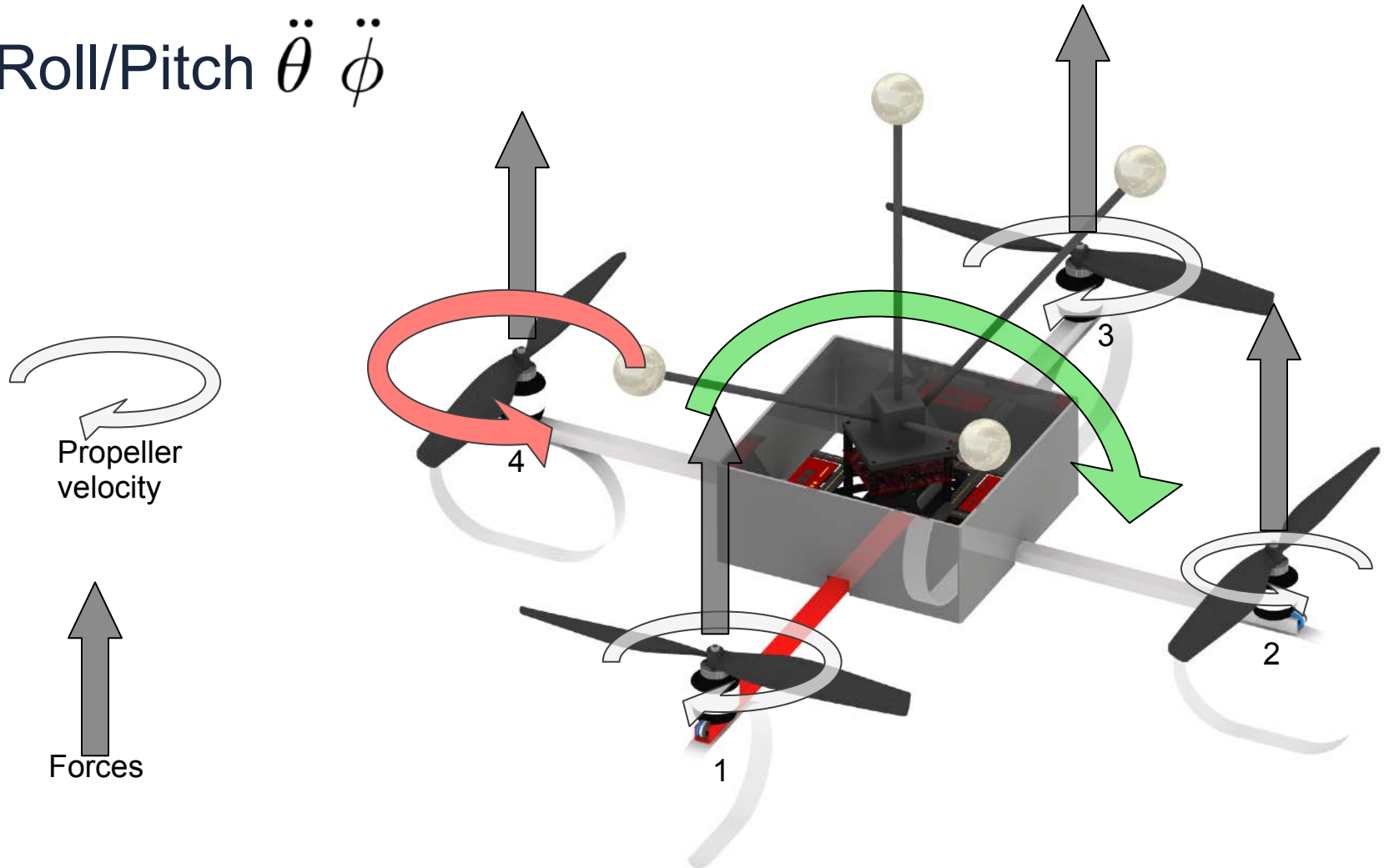
## Hovering condition





# Design Concepts

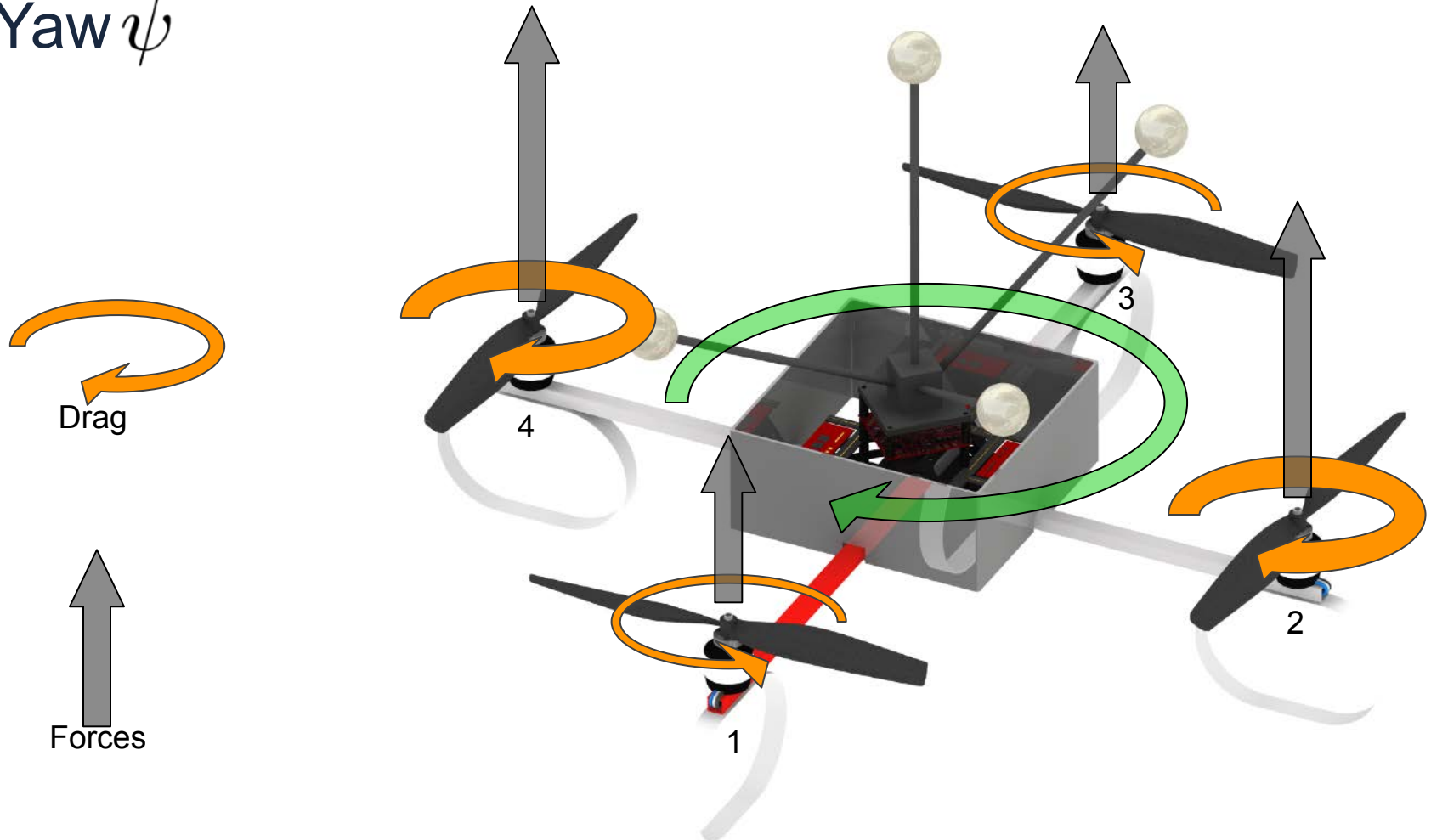
Roll/Pitch  $\ddot{\theta}$   $\ddot{\phi}$



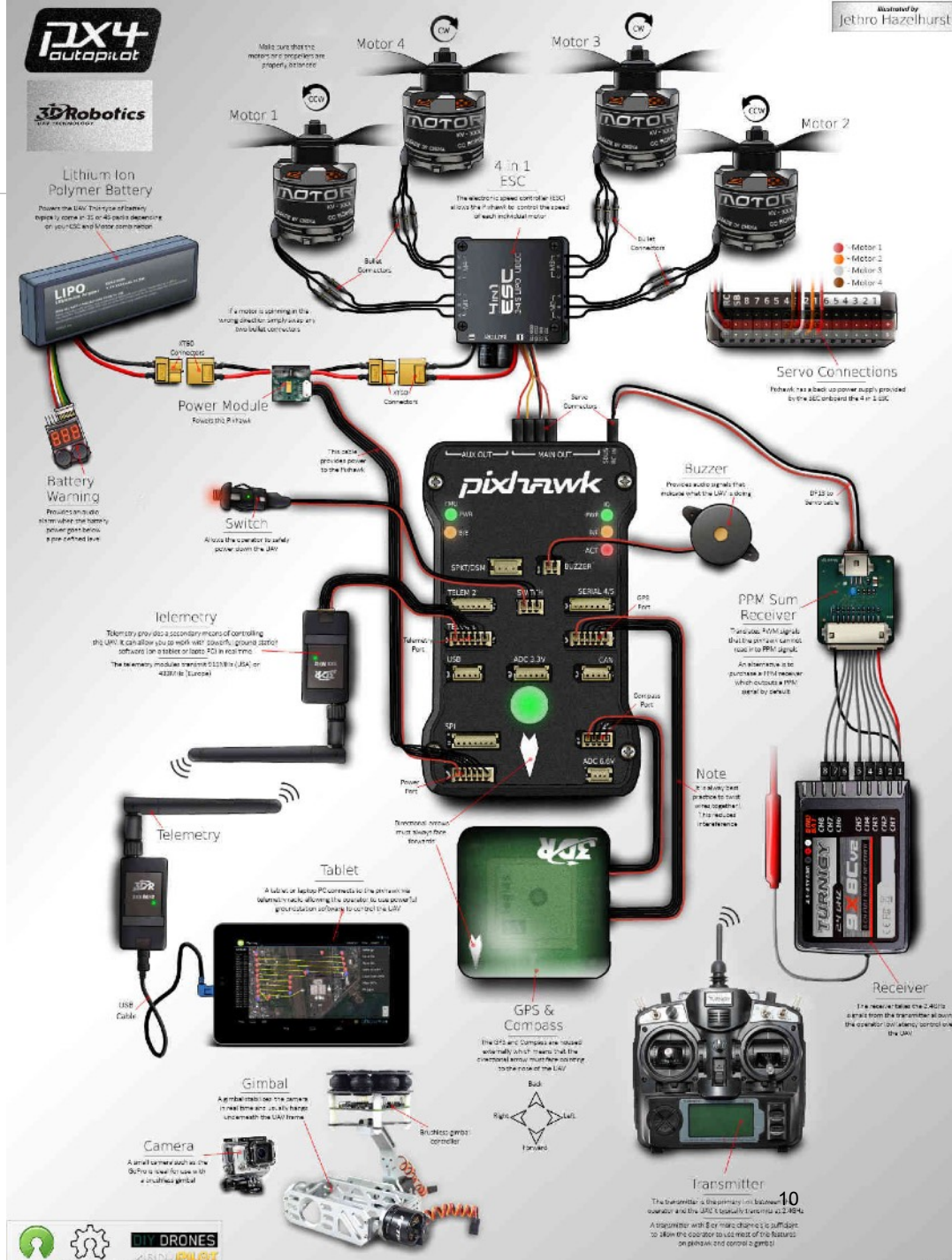


# Design Concepts

Yaw  $\ddot{\psi}$



# System view



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