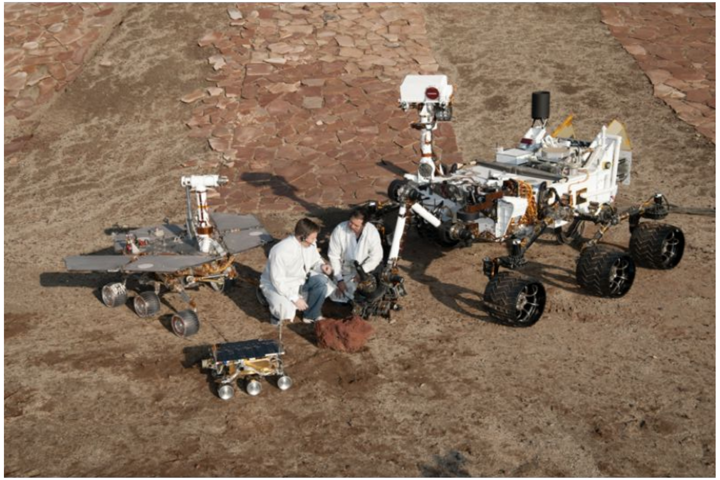
Designing a Mars Survey Unmanned Aerial Vehicle

Bode Wildgrube

Background

- Current missions to Mars: Car-sized rovers
  - Pro: easy to design, can make measurements on the soil
  - Con: need to roll over difficult terrain, only sees from surface
- Proposed design: Unmanned aerial vehicle (UAV)
  - Pros: can move around freely, make accurate maps from above.
  - Cons: Mars has 0.6% the atmosphere of earth



Sizes of mars rovers: (small to large) Sojoner, Opportunity/Spirit, Curiosity

Background: Drone Flight

- Each blade operates on Bernoulli's Principle (fig 1)
  - Faster flow on top to reach point B
  - Airspeed (approx.) inversely proportional to pressure
  - More pressure on bottom to provide lift force
- Each blade creates end turbulence (figure 2)
  - Vortices on end create inefficiencies in lift
  - Can disrupt blades below it (figure 3)
- Lift to weight ratio:
  - Higher Lift/weight ratio = better ability to fly
  - Lift needs to be higher that weight

Figure 1

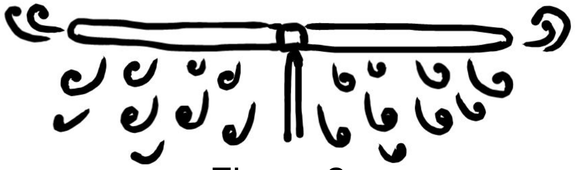


Figure 2

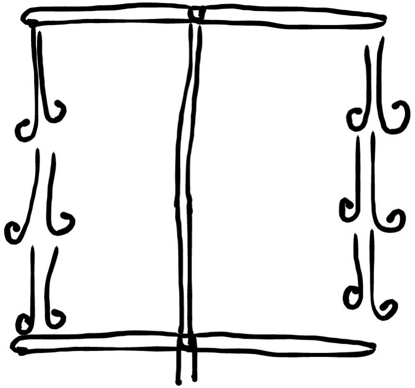


Figure 3

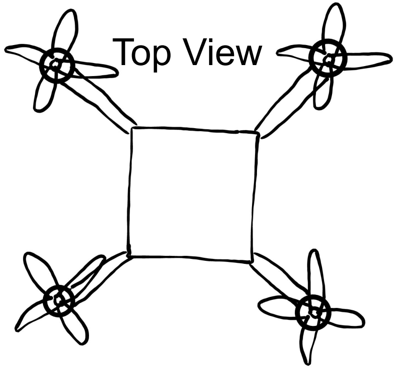
Engineering goal:

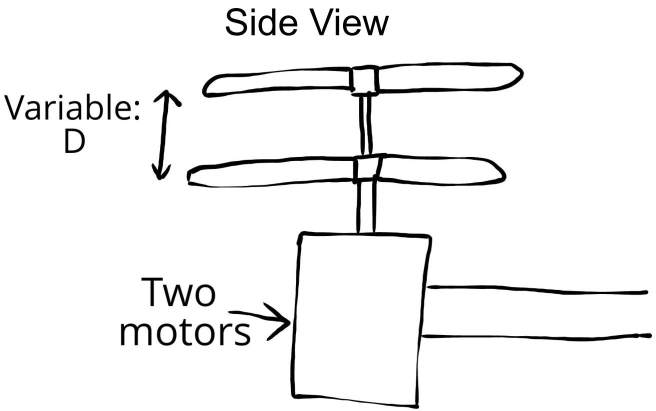
Design a functional drone that can fly in Mars atmosphere

- Conditions on Mars:
  - Lift force is reduced (lower pressure)
  - The weight is reduced (lower gravity)
- Success if drone works in adjusted conditions

Design

- Current design: Mars Ingenuity
  - Helicopter UAV
  - Box with a single propeller stack
- Proposed designs: Four propeller stacks
  - Each propeller stack: two motors
  - Different distances will be tested
  - Optimal distance avoids the turbulence





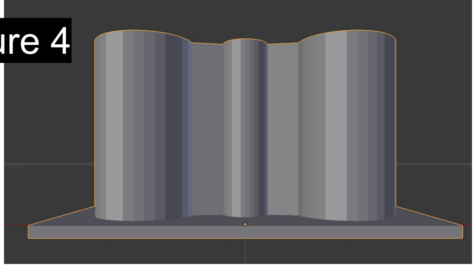


Figure 4

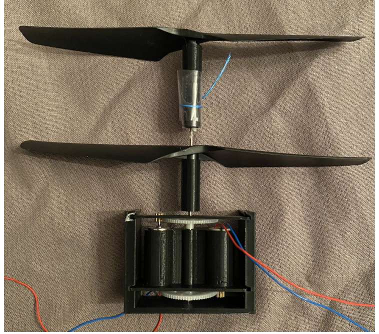


Figure 5

Procedures

1. Design a single gearbox for preliminary testing.
   a. Model (fig 4) and 3D print the gearbox (fig 5) in Blender
   b. Wire an Arduino to power two DC brushed motors (fig 6)
2. Test at Earth Atmosphere
   a. Hang a force sensor from a bar and attach the propeller contraption (fig 7)
   b. Run the propeller at three different distances

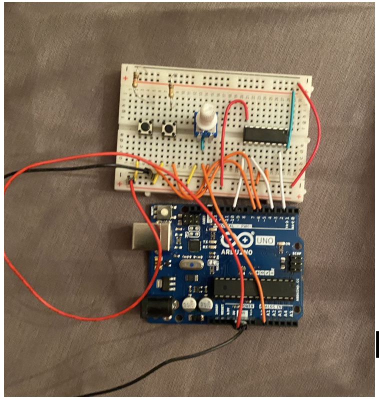
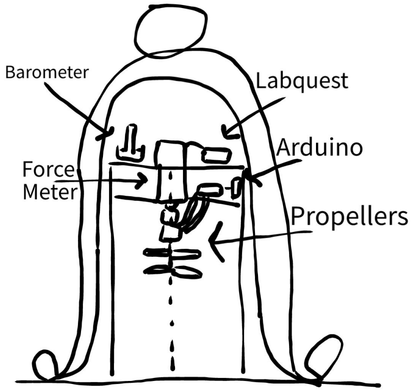


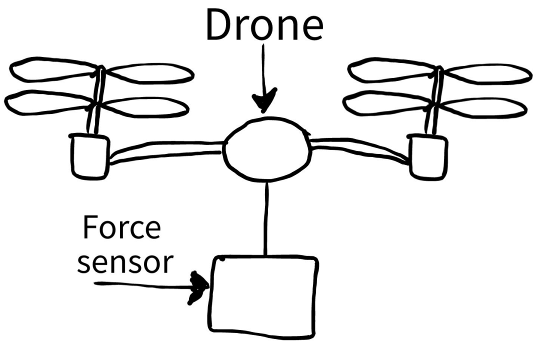
Figure 6

Figure 7

Procedures cont.

3. Test Gearbox in Bell Vacuum Chamber
    a. Mount sensor, electronics, batteries, and testing apparatus in the chamber
    b. Run the propeller at three distances at different pressure
4. Build drone
    a. Design 3d print a body + three more gearboxes
    b. Wire and assemble the parts of the drone
5. Test the drone
    a. Attach the model drone to the testing apparatus
    b. Run the drone at different percentages of full power and record the force





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