Blimpin' ain't easy

Exploration of Blimp as Robotics Platform

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State of the art: UAVs

Blimp (LTA, Hybrid)	Quadcopter/Multirotor	VTOL	Fixed Wing
• Maneuverable • Versatile • Good flight time • High payload • Good take off/land • Safe • Challenging Controls	• Maneuverable • Versatile • Predictable (complex) control • Fast • Poor Flight Time • Quick Decision Making • Limited Payload • Loud	• Strong Flight Time • Good take off/land • Some Maneuverability (better than FW) • Cumbersome • Nuanced Contro • Limited Payload	• Best Flight Time • Explored discipline • High payload • Clumsy at low speed/altitude • Difficult Takeoff/Land

Historical/Background

- Academia had 2 distinct periods
  - Prior related to
    - general aerospace/flight
    - Materials
    - Computering
- Design and Application: ~96’ - 03’
  - Focus on application, not platform development
  - Utility as sensor platform (sensing/mapping)
  - Development alongside robotic algorithm branches (state estimation/visual servoing
- Control Optimization: ~04 - ‘11
  - Application proved to be useful → need to develop platform for outdoors
  - Machine Learnt controllers
  - Trajectory optimization based off object
  - Navigation in environment

Harvesting Innovation Planted 10 years ago

- Research Field/Constraint in before subsidence of Blimp
  - Algorithm Design
    - Data driven/Robotics Approaches
    - Trajectory optimization (drone movement)
      - Computation speed + capabilities
    - Policy/decision making (dealing with environment)
      - Reinforcement Learning
- Limitations in ~11’ have loosened up
- Adjacent fields grown
  - Manufacturing
    - Power systems
    - Control Architecture
  - Materials

Modern Applications

Industrial Areas	Application Example
Environment	. Greenhouse gas emission detecting and climate change monitoring.
Disaster Rescue	. Monitoring and rescue services in inaccessible environment.
Infrastructure	. Working platform for spiderman.
Astro Exploration	. Monitoring and service for planet exploration.
Transportation	. Big carriages and low costs for the long distance transports.
Telecommunication	. Relaying the communication signals in remote areas.
Military Operation	. Monitoring and weapon platform in tactics tasks.
Security	. Mobile monitoring guard and anti-terror attack.
Science and Research	. Astro and environmental research.

Modern Applications

- Non-invasive monitoring (earth/natural)
- Olfactory Sensing/mapping
- High fidelity imaging
- Entertainment
- Disaster Relief

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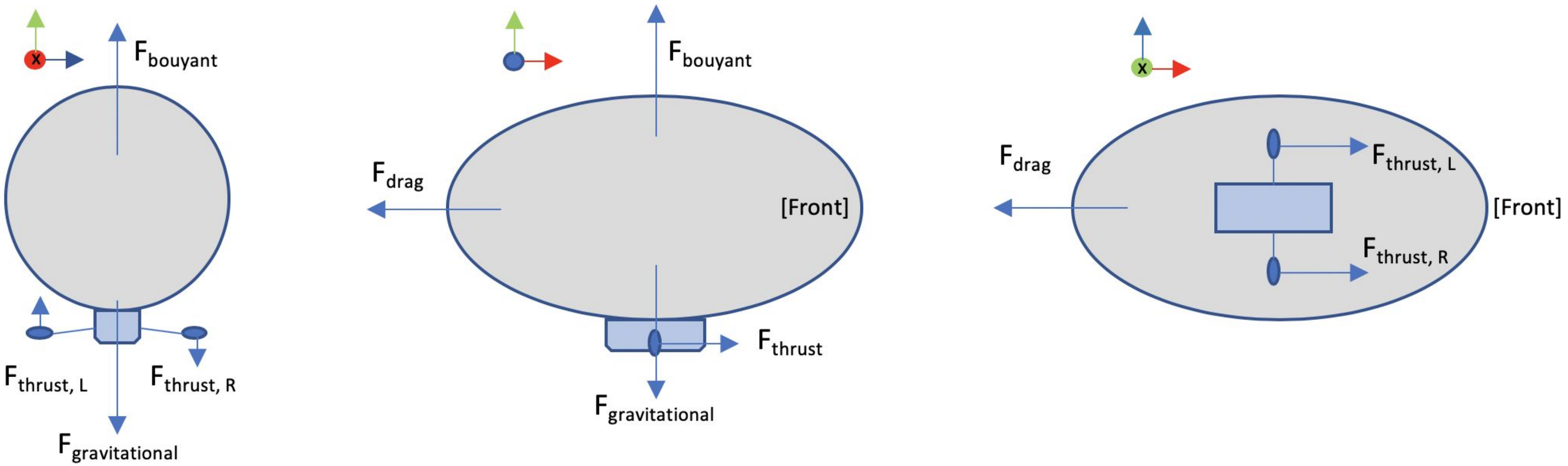
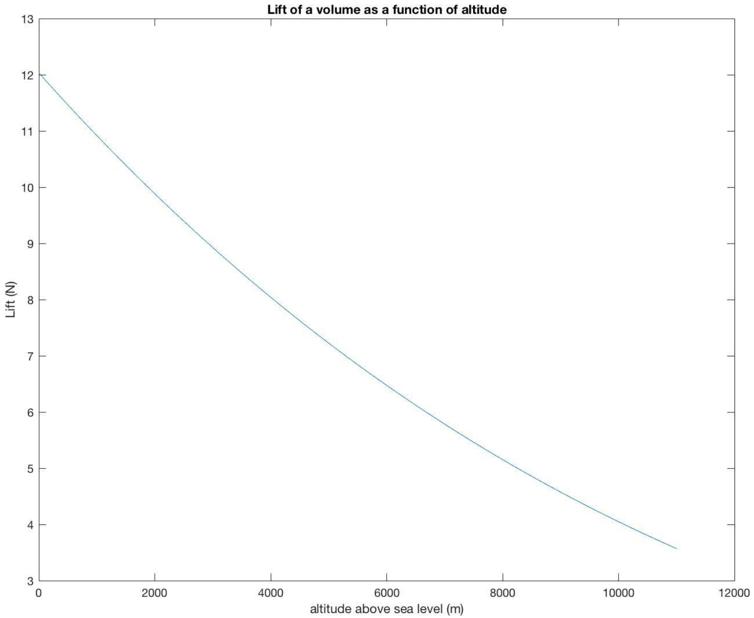
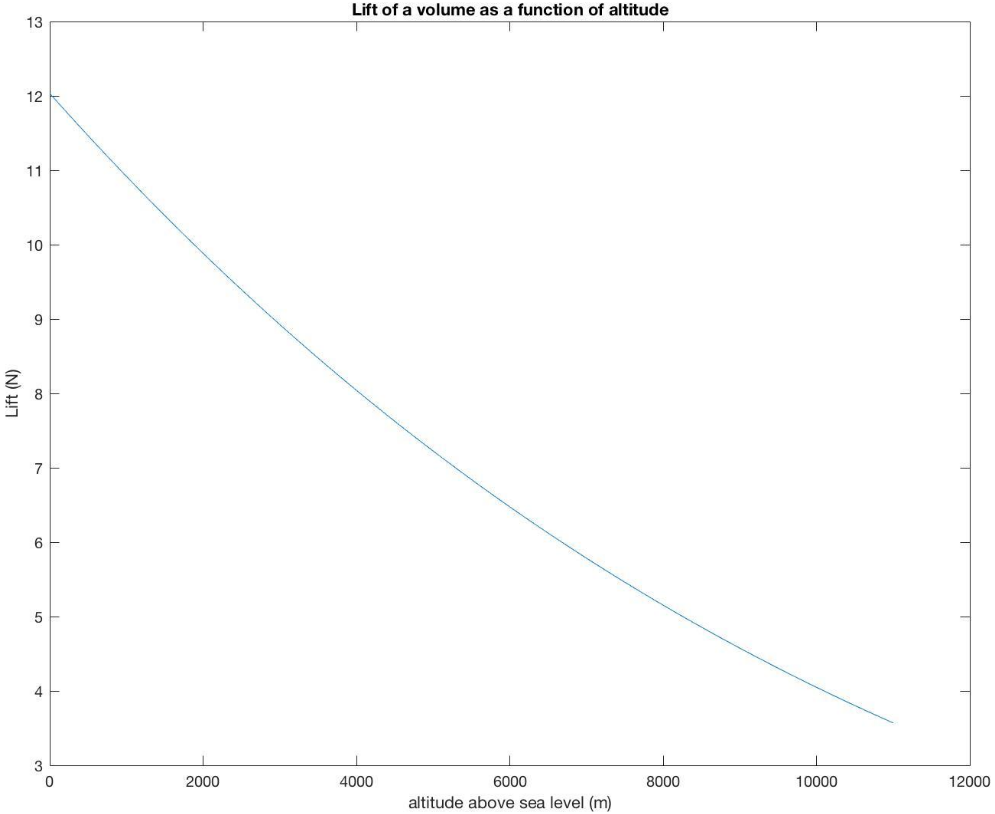
Platform Description



Buoyancy Force

- Buoyancy Force = $\oiiint_{cv} \rho\, g$ (N)
  - $\oiiint_{cv}$ is the total volume displaced by the object of interest
  - ρ is the density of the the fluid displaced
  - g is the acceleration due to gravity
- The values of ρ, g change with altitude





The lift force in Newtons for $1m^3$ volume of displaced Earth atmosphere as a function of altitude in meters

Drag Force

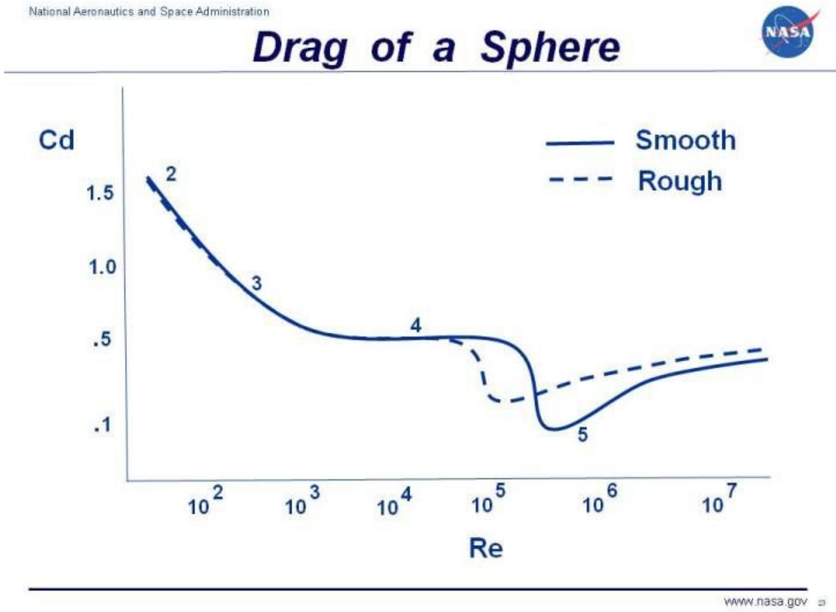
- Drag Force = 0.5 ρ v^2 A C_d
    - ρ is the density of the fluid the object is moving through
    - V is the airstream velocity
    - A is the reference area
    - C_d is the drag coefficient

Blimp Design and Assumptions

- Required values for Blimp design include:
  - Mass is 10kg
  - Altitude of flight is 450m
  - Velocity of the airstream is 2m/s and the air is assumed to be still
  - For the drag calculations the Blimp is going to be assumed a sphere

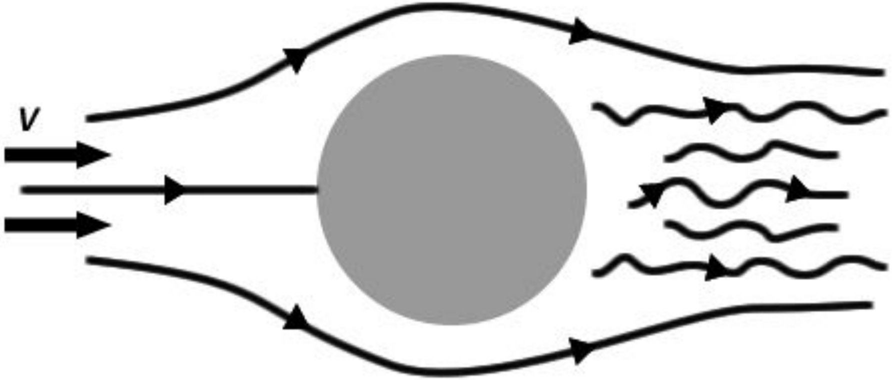
Blimp Design Calculations

- The required volume to create a buoyancy force equal to the weight is $8.52m^3$
- From this volume the diameter can be calculated to be 3.712m
- From the value of the diameter the Reynolds number can be calculated which is used to determine the coefficient of drag. Re = $2.044*10^6$



Blimp Design Calculations

- From the previous chart the coefficient of friction can be found to be about 0.45
- From all the calculated values the value of the drag force can be found to be 17N.



https://s2.smu.edu/propulsion/Pages/dragmain.htm

Further Applications: School of Earth + Space Exploration

- Application for exploration on other planets where the
  - atmosphere density
  - Weigh (*m* * *g*) ratio falls