DOI: 10.13009/EUCASS2019-712

HIGH ALTITUDE PLATFORMS WITH WIND UNCERTAINTY:

SIMULATION AND DYNAMICAL ANALYSIS

N. Garcia Pereira, M. Miguel Robledo, D. Sanchez-Biezma, D. Sanchez Garcia, M. Sanjurjo Rivo
Balloons Team, Cátedra UC3M - SENER, Universidad Carlos III de Madrid
Av. de la Universidad 30, 28911, Leganés, Madrid, Spain

uc3m | Universidad Carlos III de Madrid

Introduction

- The Catedra UC3M-SENER was first initiated in January 2017, defining the following objectives:
  - Planning algorithm testing.
  - Control algorithm testing.
  - Atmospheric prediction inclusion.
  - Commercial Orbital Transportation Services (COTS) hardware trials.
- 3 end-of-degree projects have already been produced under this brand.
- Empirical data obtained by several balloon launching in Spain and Mexico (International Collaboration).
- 3 new end-of-degree projects (ongoing) with the following objectives:
  - Platform testing (cameras, tracking).
  - Attitude control flight test (ADCS).
  - Glider control system flight test (aerodynamic control). Limited by regulation
  - Simulator test.

Ongoing Projects

- Simulator
  - Habhub: simulation with optimization capabilities.
  - Integrate 6 DoF.
  - Customization of payload.
  - Possibility of including super-pressure.
- CDF Integration
  - Goal: CDF for balloon mission design.
  - Framework: coordination with Team MBSE. Installation of SW. Definition of needs or additional codes.
- Platform
  - Goal: Consolidate a UC3M platform in order to get an open - high altitude platform.
  - Framework: Communications, thermal, structural and integration testing.
- ADCS
  - Goal: Operate Attitude Determination and Control Systems in a balloon. Consolidate onboard computer based on Raspberry-Pi.
  - Framework:
    - Build reaction wheel.
    - Explore different control schemes.
- Glider
  - Goal: Design, implement and test a glider with aerodynamic control capabilities.
  - Framework:
    - Explore different options and test actuators.
    - Controller design & processor in the loop.

Results

- The following image shows a comparison between the simulator results and data from a suborbital flight provided by the experimental module SADM-1 that was onboard the platform CSM: Carga de Servicio Mexicana.

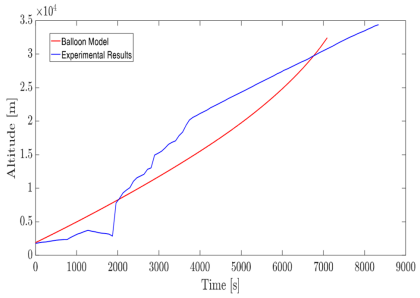


Figure. Altitude

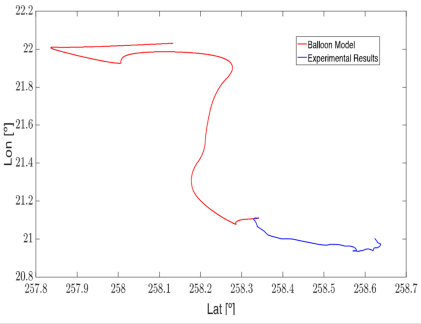


Figure. Position

- The next image tries to reduce uncertainty produced by the amount of Helium contained in the balloon. For that, several conditions spanning from a lower amount of gas (-10 and -20%) to a higher amount (+10 and +20%) were simulated. As expected, a higher amount of Helium leads to a higher weight and therefore a slightly smaller rate of climb and therefore a longer mission life.

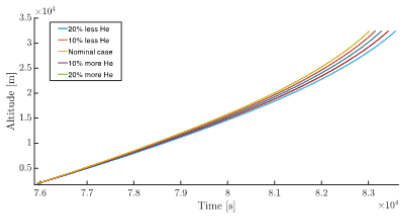


Figure. Filling Uncertainty. Altitude

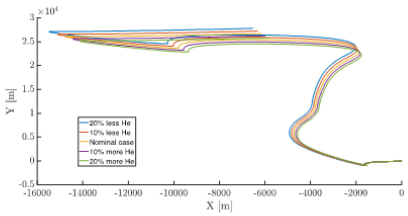
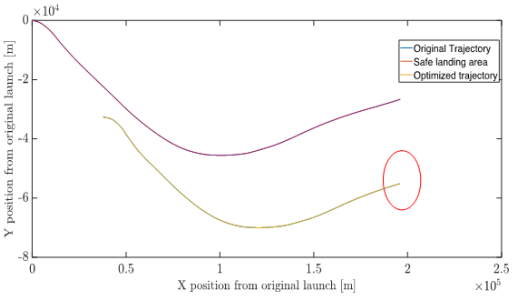
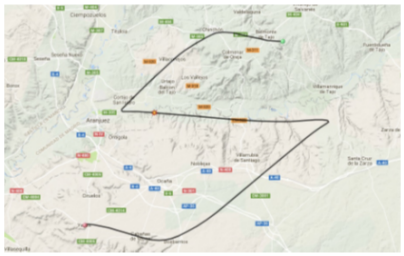


Figure. Filling Uncertainty. Position

- Together with the simulation, an optimization was developed in the horizontal plane and the following image (left) presents the result, including an indication of the safe landing area. In the right side an expected trajectory has been drawn.





- Onboard Instrumentation:
  - Accelerometer
  - Gyroscope
  - GPS
  - SIM card antenna
  - Arduino board
  - HD camera

Control & Wind Data

- Control: Project Loon system composed of three main parts:
  - Gass Pressure Chamber:
    - Compressor-valve combination.
    - Pump air into balloon to increase altitude.
    - Extract air from the envelope to reduce altitude.
  - Fuel Cell:
    - Hydrogen generation and pumping into baloon to increase altitude.
    - Hydrogen extraction to reduce altitude and generation of power and water.
  - Radiation Absorptive Paint:
    - Half balloon painted with refractive paint, the other half with absorptive.
    - Rotating the balloon to face the Sun changes the altitude.
- Wind Data:
  - Provided by the National Oceanic and Atmospheric Administration (NOAA).
  - Delivery of accurate forecasts of 120 variables in a 3D mesh around the globe.
  - 129 forecasts everyday within a range from 3 hours up to 384 hours between each other.
  - In order to take into account uncertainty, NOAA provides information about ensembles: 21 different predictions in total that have different initial parameters and hence develop different trajectories.