BalSAR – A High Altitude Balloon Borne Synthetic Aperture Radar

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Background

Remote sensing, Earth observation, disaster monitoring, surveillance

Satellite platforms
- Costly
- Limited in terms of revisit availability and times

Piloted and unmanned aircraft
- Require infrastructure (airports)
- Expensive
- Limited in altitude
projects

SPS Programme
– Title: Development of a low-cost rapidly deployable high altitude balloon-borne Radar
– Partenership: UNSW (AU) & UniPI (IT)
– Funds: about 300k€

Engineering Priming Grants scheme
– Title: Balloon-based SAR
The overarching objective of this project is to develop a high-altitude balloon platform that carries a synthetic aperture radar, as well as the necessary mission planning and execution tools.
Typical Mission

Mission planning
- Launch site selection
- Trajectory optimisation
- Landing site prediction

Launch BALSAR to an altitude of 20 km or higher

Collect radar data and form SAR images

Track and retrieve payload and
The Concept

HAP  Parachute  Payload

Speed 50-150 km/h
Aerostatic, zero-pressure (balloon rises until it bursts)
At sea level 1 m³ air weighs 1.3 kg
Therefore it can lift 1.3kg in total weight (including the balloon and lifting gas)
At 20 km, air density is 0.09 kg/m³
Hence 15 m³ required to lift 1.3 kg
At 40 km, a displacement of 330 m³ of air required to lift 1.3 kg
Net (or Neck) lift = total lift – balloon and gas weight
Net lift > 0 implies balloon rises
Larger lift
- Requires larger volume of displaced air -> higher initial inflation
- Faster ascent rate
- Lower burst altitude
- Shorter mission

After bursting, or mission termination, payload descends by parachute.
Zero Pressure Balloon Performance Curves

Metric - 7.6 µ Film Thickness

U.S. - 0.3 mil Film Thickness

Gross Load Including Balloon (kg)

Nominal Float Altitude (ft)

Weights:

- 19810 m³
- 14150 m³
- 8490 m³
- 3990 m³

- 700 k ft³
- 500 k ft³
- 300 k ft³
- 141 k
The Balloon Platform

Small helium filled balloon
Unpowered flight
Green technology
Low-cost
Rapidly and easily deployable
Low risk
Mission flexibility through
Flight Prediction and Mission Planning
Typical Flight Profile

Altitude profile

Speed vs time
The HAP Subsystems

Standardised – similar to the concept of cubesats
Use off-the-shelf components
Leverage the cubesat building expertise
Provide the housekeeping functions
- OBC
- Power
- Stabilisation/ADCS
- Tracking
Mission duration between 90 and 180 minutes
Payload up to 20 kg
Ascent rate no less than 5 m/s and no more than 12 m/s
Position determination and tracking for the duration of the flight
Power 120W
Temperature to be maintained between 0 and 40
Sufficient memory to store the SAR data
Recoverable in order to retrieve the data
Termination device commanded from the ground
The SAR Subsystem

- High resolution SAR sensor
- FMCW Radar transceiver
- Weight < 10 kg
- Up to 1 meter resolution

Antennas
- 1 TX & 1 RX
Developed for the Italian CSK SAR system (IP owned by CNIT-RaSS)

It can be adapted for any kind of SAR imaging system (already tested on satellite and airborne SAR)

Software main features
- Different data format loading
- Manual and fully automatic mode
- Image despeckling
- Sea/land masking
- Automatic target detection
Challenges

Platform
- Payload weight
- Stabilisation
- Attitude determination and control
- Position and Timing

SAR Subsystem
- Relatively slow speed of HAP
- Variable speed of HAP
- Attitude variations
- Minimization of the SAR subsystem
Further tech development
  – Data link
  – On-board processing

Engagement with industry and end-users
  – Industry: product and market
  – End-users: feedback, test and validation in the future of BalSAR
Thank you

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