Inflatable Antenna for CubeSats at X-Band: results of the experimental tests

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Outline

- Introduction
- Spherical Design
- Feed Design
- Deployment
- Inflation and rigidization
- Dynamic
- Conclusion and future work

Introduction

- Cubesats are now becoming a new way to explore space. They are designed to be smaller, with high stowing efficiency, and they are fabricated at a lower cost and faster development schedule than traditional spacecraft.

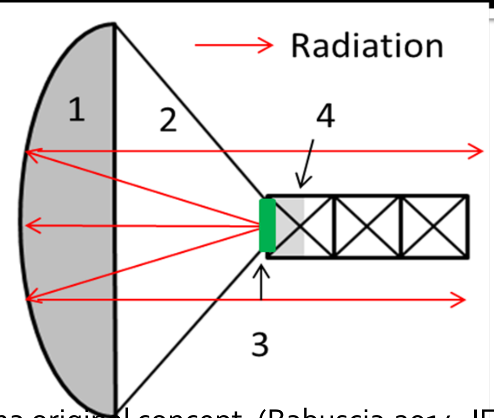
- As CubeSats are becoming a way to explore deep space in a more affordable way than traditional spacecraft, new needs emerge: propulsion systems, thermal and radiation protection and telecommunication systems that can sustain a severely increased path loss.

- Different communication technologies are in development to approach this problem and to support interplanetary exploration with CubeSats and small satellites.

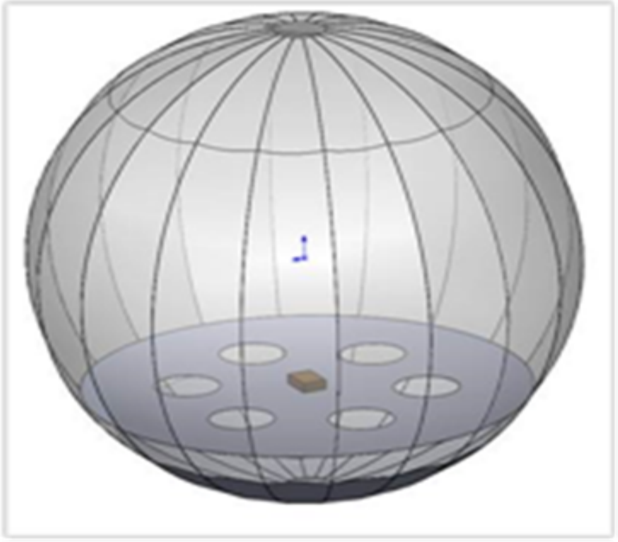
- The inflatable antenna is unique as it provides an extremely high stowing efficiency (20: 1), low mass (<0.5 Kg), scalability and inflation with sublimating powder.

Spherical Redesign

- The original inflation concept was based on the idea of using sublimating powder to inflate into a parabolic shape.
- Many experiments with photogrammetry shown that when the membrane is inflate, the final shapes tends to deviate from a parabola→ the gas tends to inflate the structure into a sphere.
- A new design was conceived: the inflatable antenna is now a sphere with only a portion reflective, while the rest is transparent.
- Challenges are:
  - Feed placement inside the reflector
  - Reflector size is reduced from 1 m to 71.3 cm in diameter.
  - Manufacturing

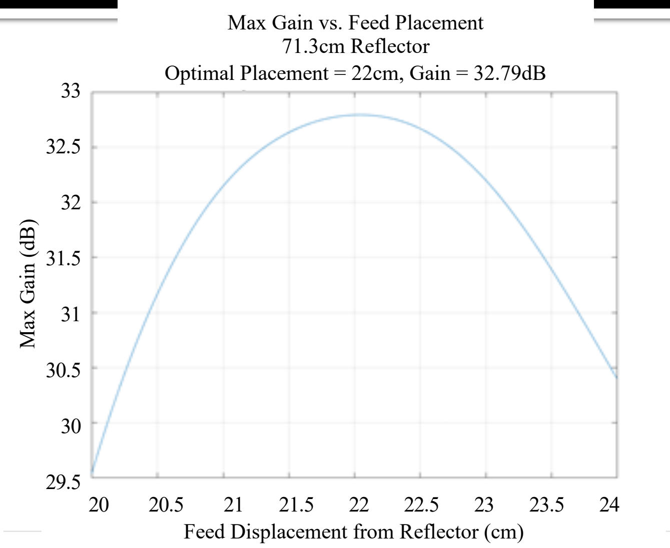


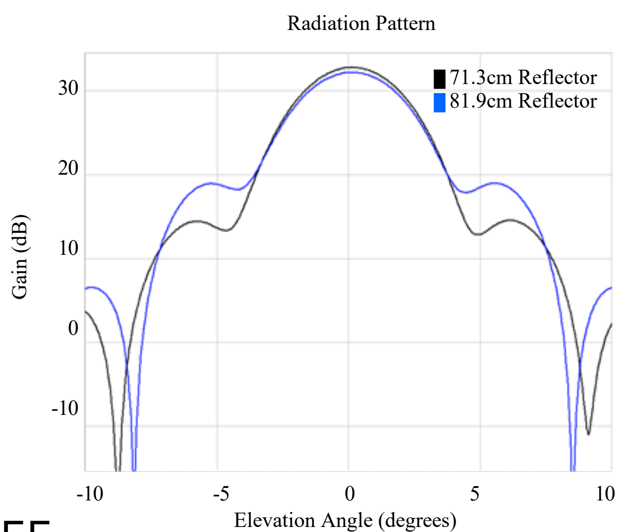
Inflatable antenna original concept, (Babuscia,2014, IEEE)


New design (Babuscia et al., 2017, IEEE)

Feed design

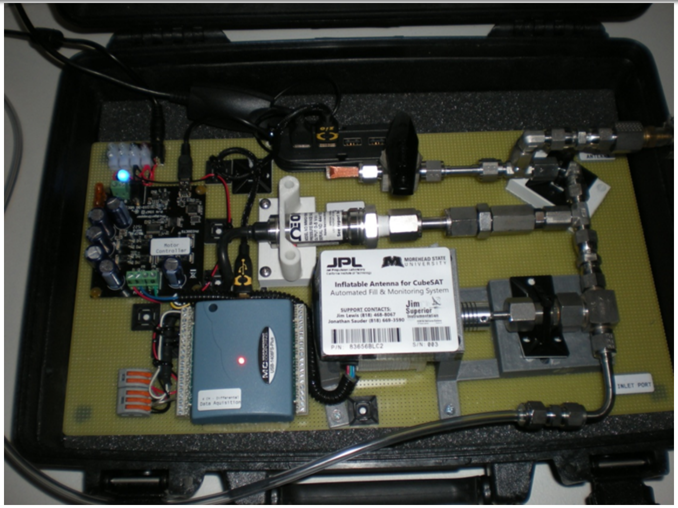
- A single RHCP patch was selected as the feed for the inflatable reflector (Feed gain: 7.16 dBi).
- Two reflector-feed configurations were considered and evaluated with TICRA GRASP:
  - The first design prioritized gain maximization→ Gain is a function of both feed placement and reflector diameter and is maximum when reflector diameter is 71.3 cm and feed placement is 22 cm from the reflector.
  - The second design constrained the feed placement so that the seam of the feed support structure was co-located with the reflector seam for easier manufacturing→ The seam constraint caused feed placement to be a function of reflector diameter. Therefore, gain was only a function of reflector diameter and was maximum with a reflector of 81.9 cm.
- The first design was selected because of higher gain, lower sidelobes and the increased manufacturing complexity which is non-consequential. .

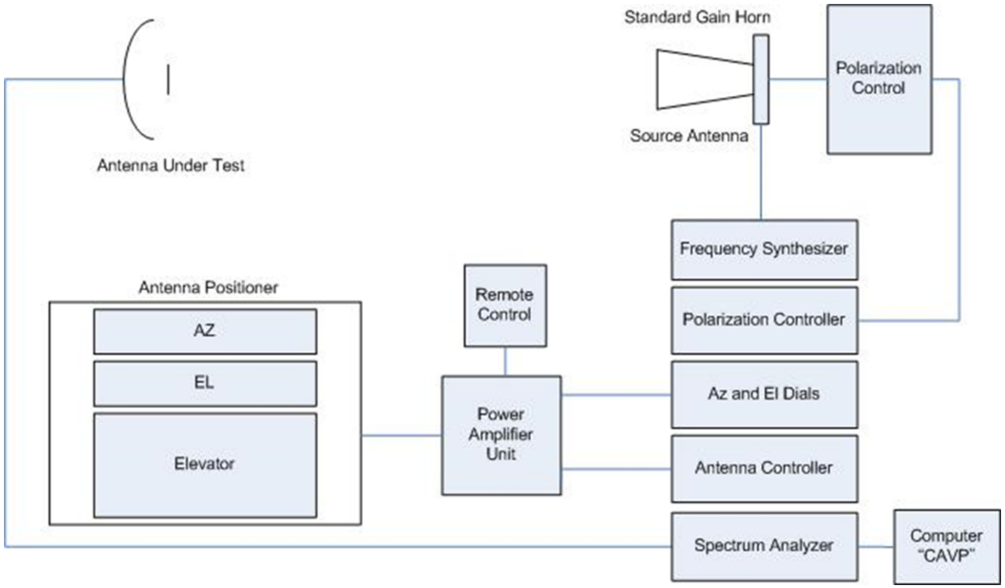




Babuscia et al., 2017, IEEE

Anechoic Chamber Test: Setup

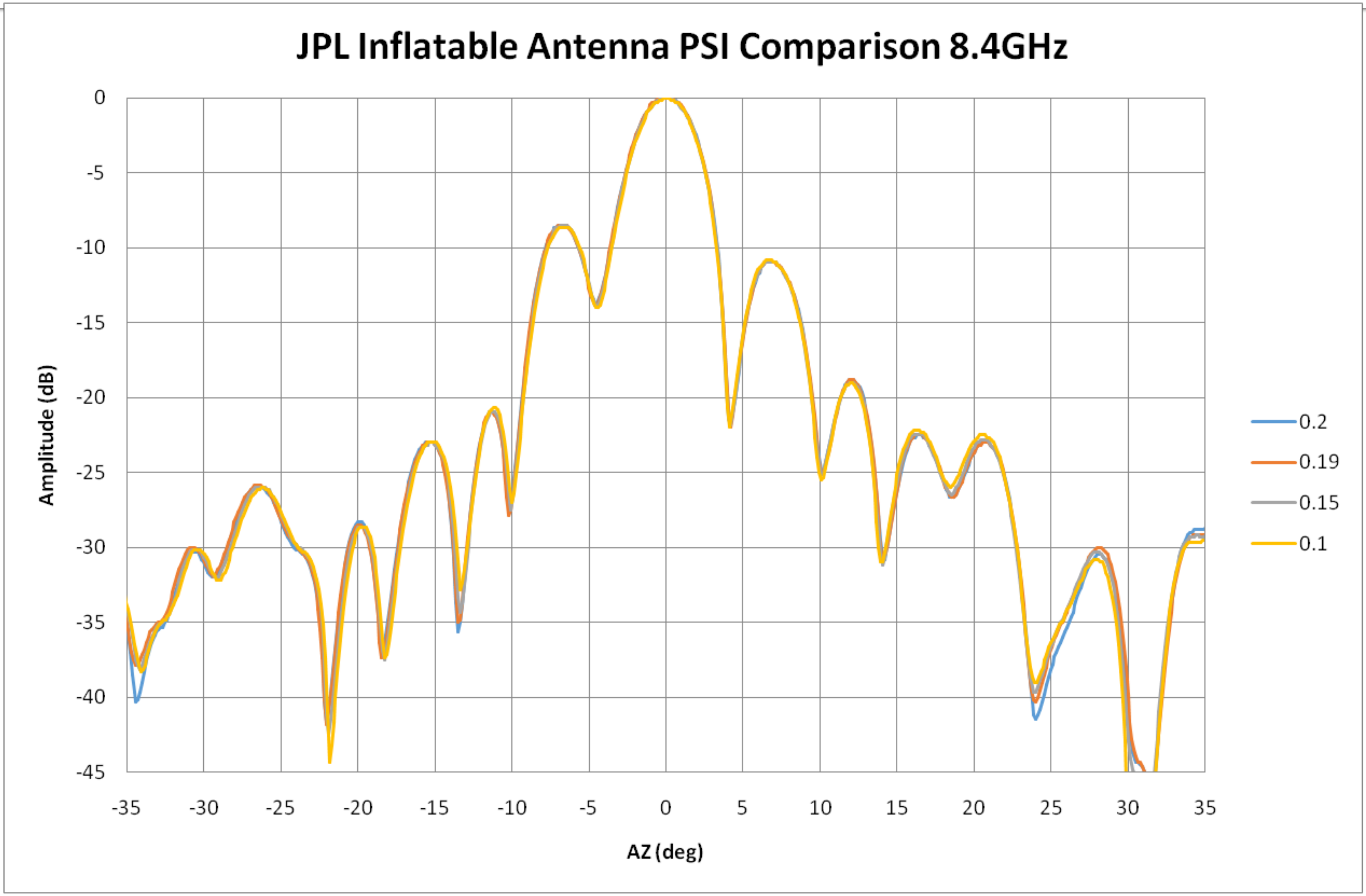




Anechoic Chamber Tests Results

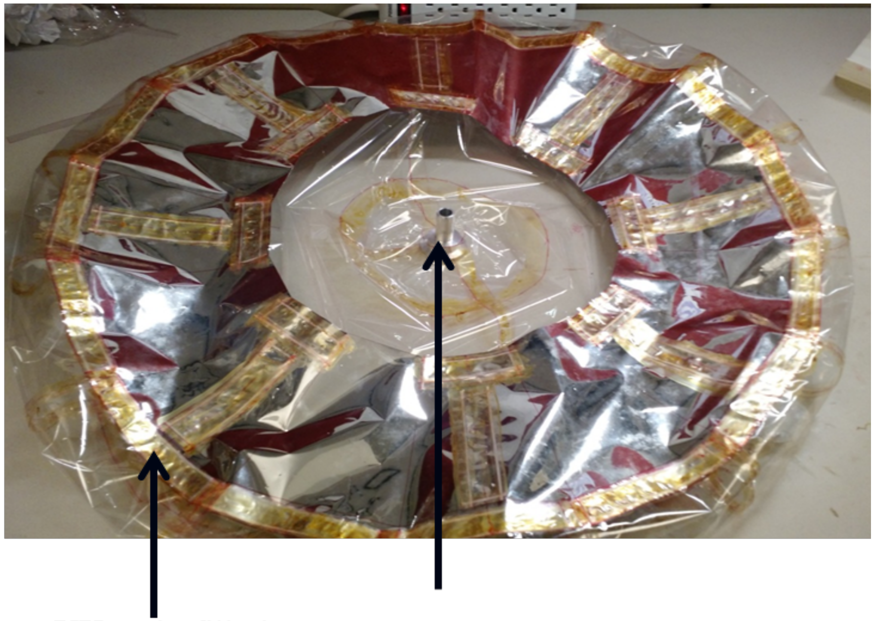
JPL Inflatable	19 Dec	Pattern				Estimated
Freq GHz	**N2 Pressure PSI**	**Integrated Gain dBi**	**3 dB Beam Width**	**10 dB Beam Width**		**3/10 Gain dBi**
7.145	0.20	28.67	4.922	12.74		29.64
7.19	0.20	28.70	4.926	12.66		29.65
7.235	0.20	28.74	4.789	12.54		29.85
8.4	0.20	29.68	4.212	11.17		30.93
8.45	0.20	29.28	4.081	11.06		31.15
8.5	0.20	28.82	4.214	11.12		30.94

Anechoic Chamber Tests Results



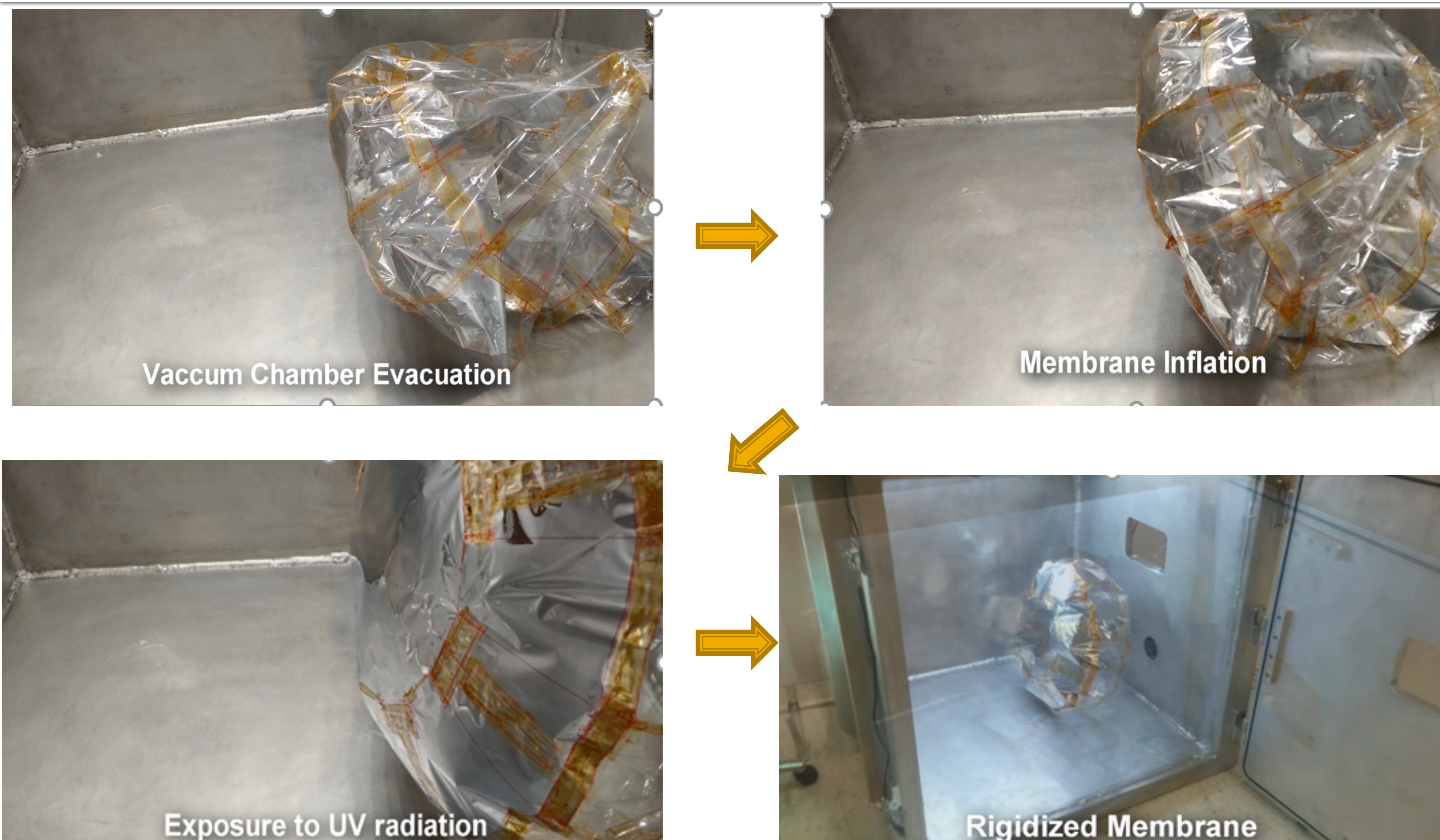
UV Rigidization

- One of the critical aspects of the inflatable antenna design is its resistance to environmental phenomena, especially temperature fluctuations and micrometeoroids
- Rigidization would allow the antenna to still maintain its shape even in case of puncturing and loss of pressure in the membrane.
- Rigidization of the antenna structure right after deployment to avoid these temperature-driven shape fluctuations.
- During this past year, the first attempt to rigidize the entire antenna shape was carried on and tested at Arizona State University.



Babuscia et al., 2017, IEEE

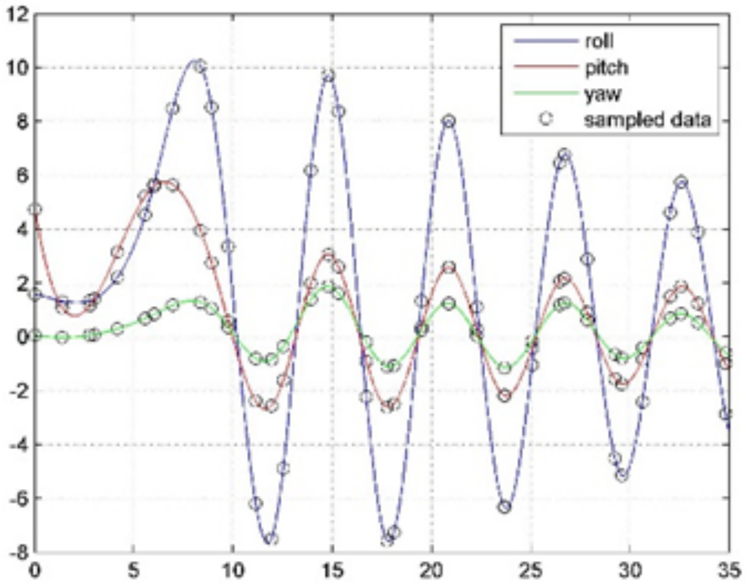
Rigidization Experiment



Babuscia et al., 2017, IEEE

Dynamic Test on JPL Airbearinf platform: Results

- Test results showed that the inflated antenna is controllable with state of the art reaction wheel systems for CubeSats.
- The disturbances induced on the system by the oscillations of the antenna coupled with a flexible material were found to be negligible, and therefore compatible with foreseen mission profiles and selected hardware configurations.



Stabilized behavior

Babuscia et al., 2017, IEEE

Conclusions and Future Work

- This presentation describes the test results for the inflatable antenna for CubeSat project.
- Measurements showed between 29.6-31.2 dBi gain depending on gain integration method, pressure, frequency. They do not take into account cable loss (approx. 1 dB)
- Progresses have also been made in the process of rigidizing the antenna to increase its lifetime. A full scale rigidization experiment was carried on at Arizona State University.
- Finally, an effort to investigate dynamic effects was carried on through tests at the JPL small satellite dynamic testbed.
- Future work includes the fabrication and test of the deployment system

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Thank you!

Questions?

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