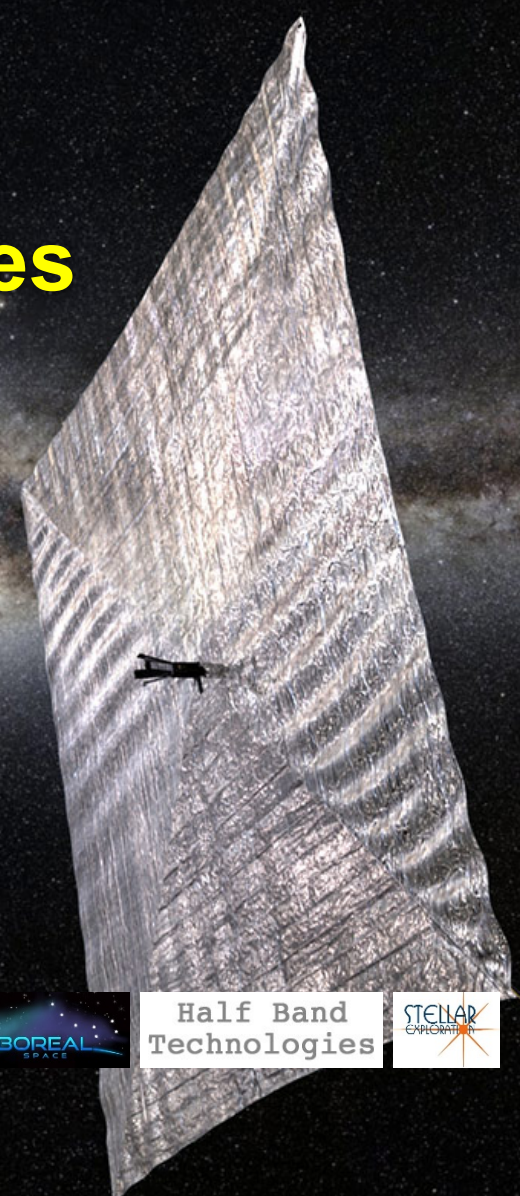


# LightSail Program Status: On Track for Two Launches

Rex Ridenoure, CEO  
Ecliptic Enterprises Corporation  
Pasadena, CA  
... and the LightSail Team

Spring CubeSat Workshop  
San Luis Obispo, CA  
2015 Apr 22-24



# LightSail Program Scope



- **Privately funded by members of The Planetary Society**
- **Principal objectives**
  - Demonstrate feasibility of solar sailing from 3U CubeSat in Earth orbit
  - Serve as pathfinder for future solar sail missions
- **Mission plans**
  - LightSail A (2015 launch on Atlas 5)
  - LightSail B (2016 launch on Falcon Heavy)
  - Mission-control ground segments in California and Georgia

# LightSail Team



- Overall program direction; funding; outreach



- Program management



- Lead system contractor; system I&T



- Mission management; system analyses; mission ops



- Launch integration; environmental test; mission ops



- Systems engineering; ACS; flight software



- Systems engineering; system I&T support



- CubeSat design; initial construction; I&T support

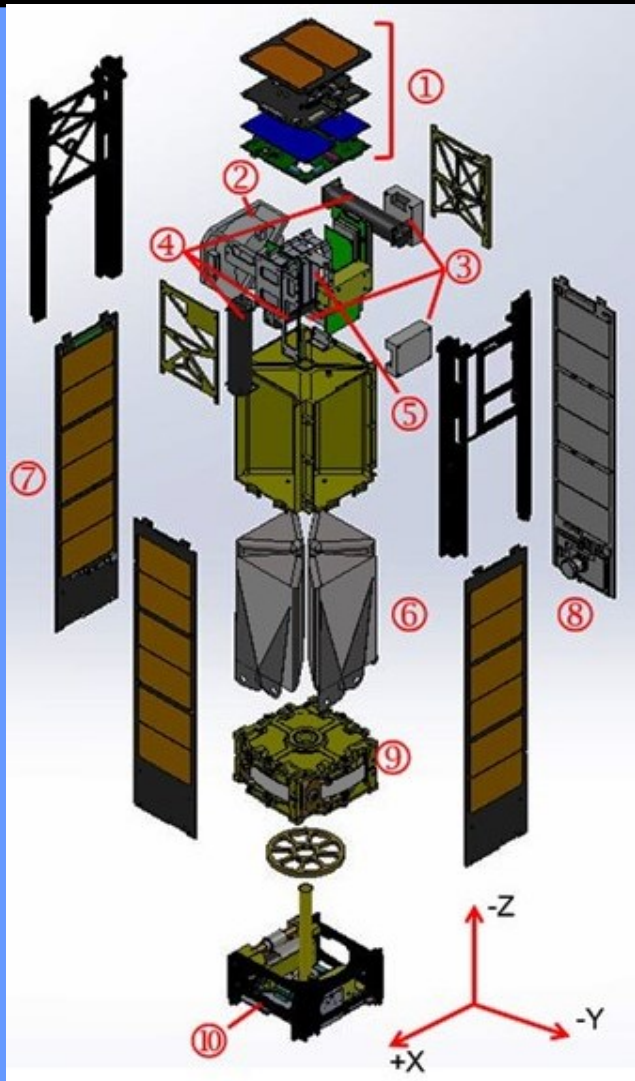
# LightSail History



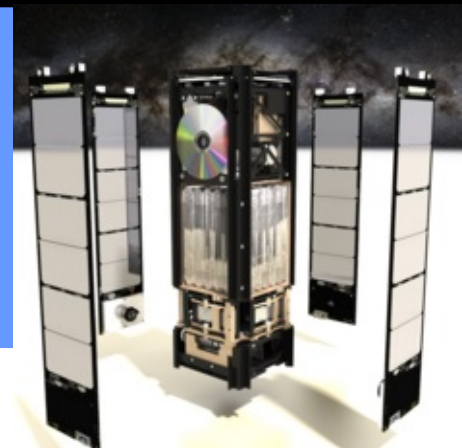
- **Follow-on to previous solar sail mission attempt by TPS**
  - Cosmos 1 (2005)
- **3U CubeSat concept defined 2009-2011**
  - Two spacecraft constructed by end of 2011 (one partly tested)
- **~18-month program pause 2012-2013**
- **Program resumed late 2013**
  - Two launch opportunities secured (LightSail-A and LightSail-B)
  - New program and technical management team
- **LightSail-A I&T completed late 2014**
- **LightSail-B I&T to be completed late 2015**

# LightSail Spacecraft

LIGHTSAIL



No.	Subsystem
1	Avionics
2	Momentum Wheel Mass Model
3	Gyros
4	Torque Rods
5	Battery Module
6	Stowed Solar Sail
7	Solar Panel
8	Camera
9	Sail Deployer
10	Antenna



## Avionics

Torque rods, momentum wheel, circuit boards

## Sail storage

Four Mylar sails, 32 square meters (344 square feet) total

## Boom storage

Four Triangular Rollable and Collapsible (TRAC) booms—the 'tape measures'

## Payload

Boom deployment motor, antenna

# LightSail A: 4.93 kg

# LightSail-A Spacecraft

(Mostly stowed)

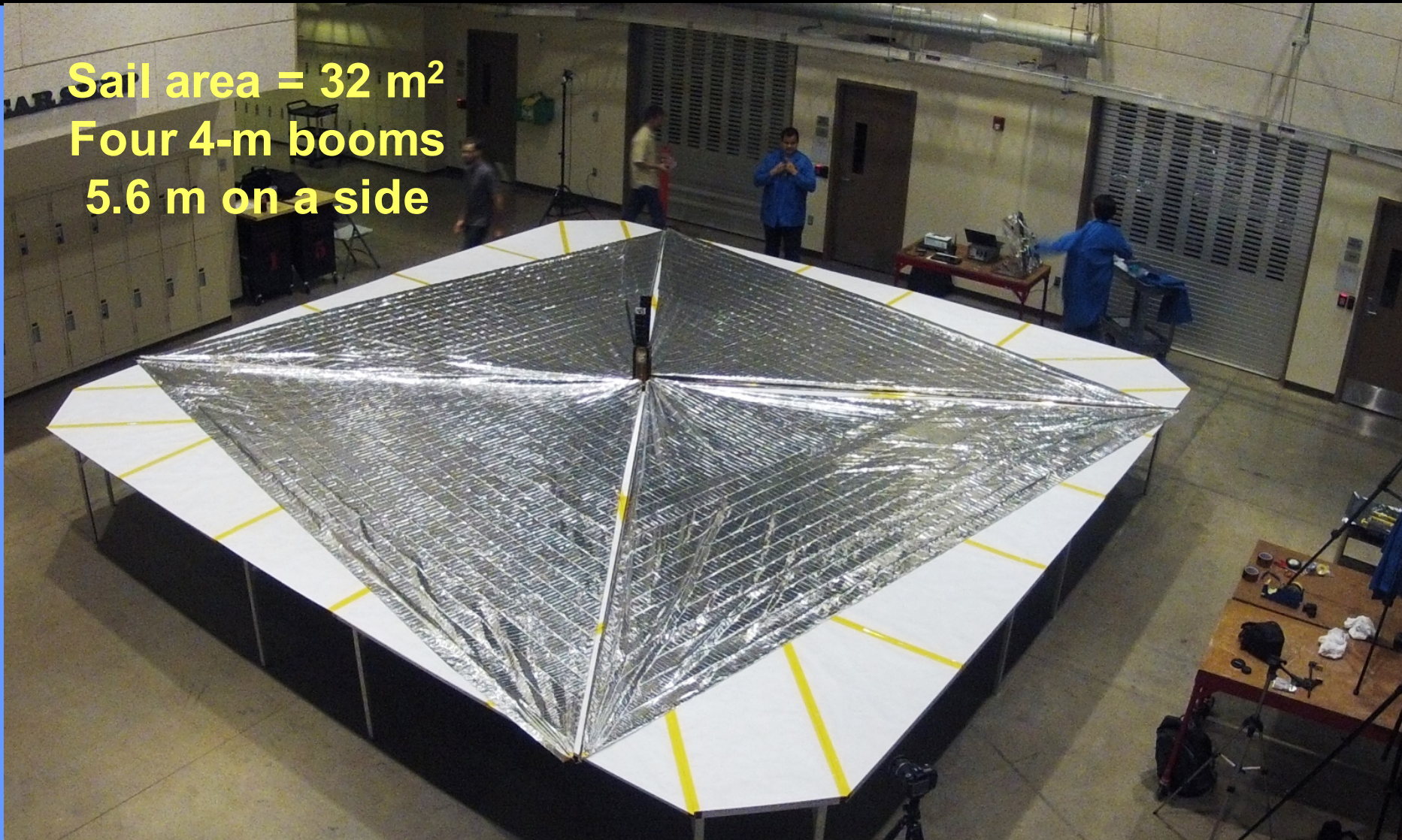


# LightSail-A Spacecraft

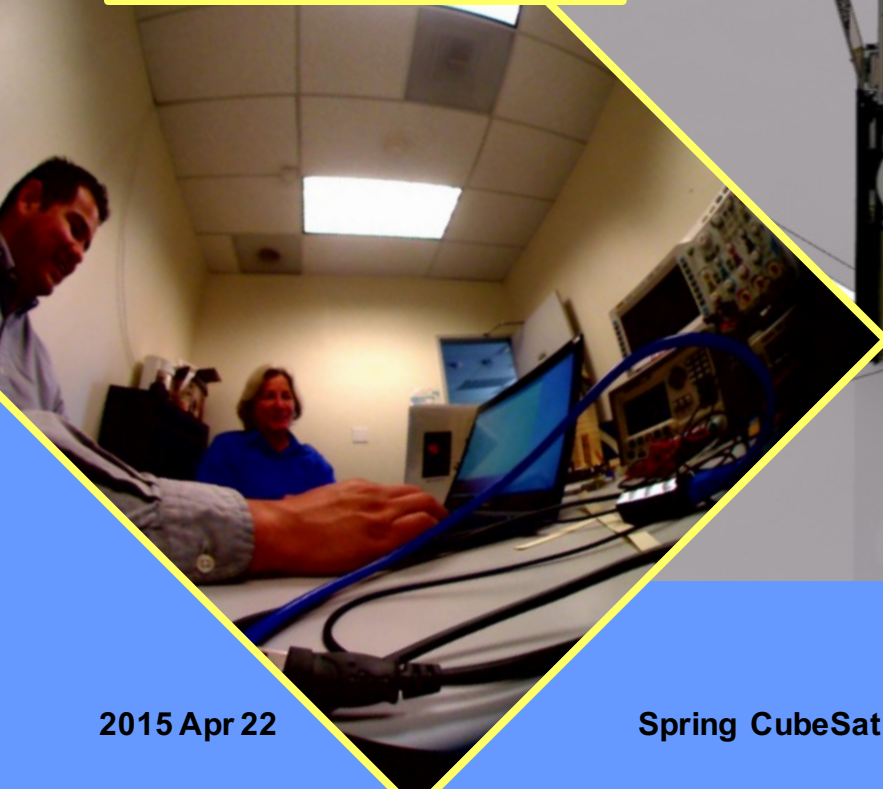
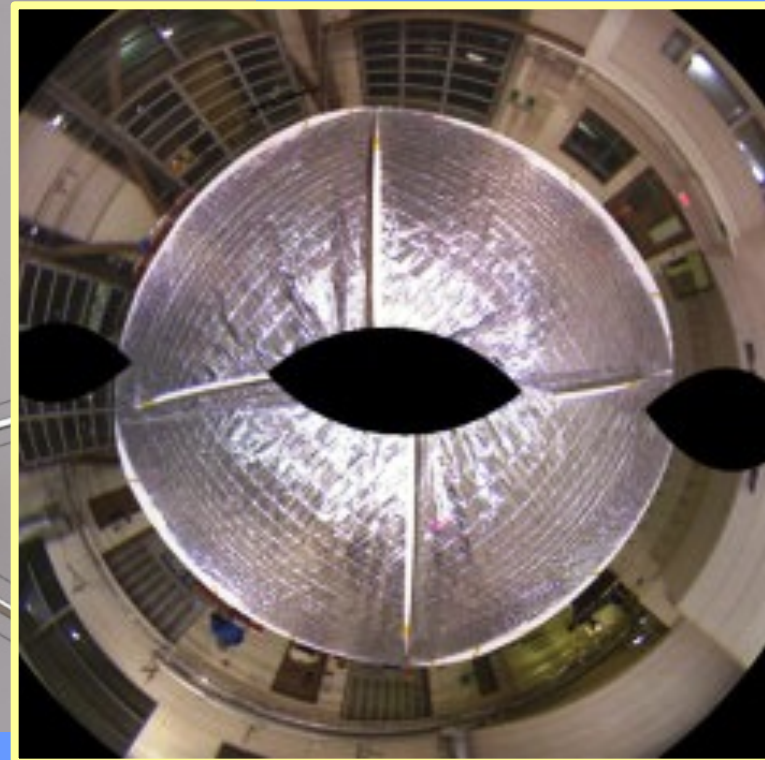
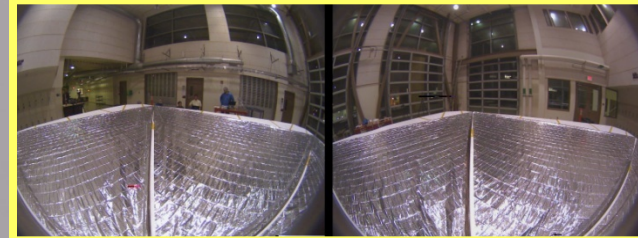
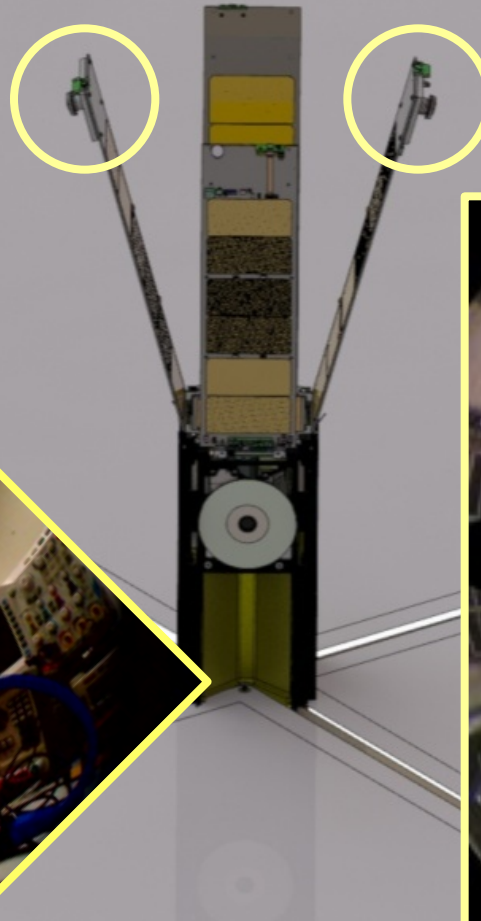
(Fully deployed)



Sail area = 32 m<sup>2</sup>  
Four 4-m booms  
5.6 m on a side



# LightSail Cameras





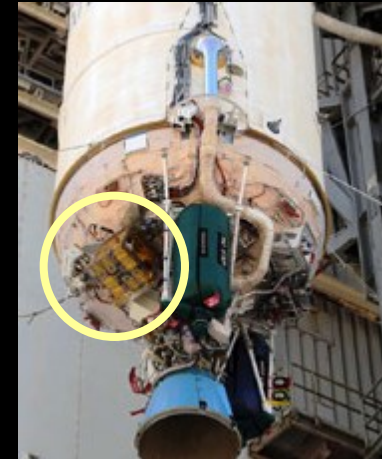
# LightSail Launches

LIGHTSAIL



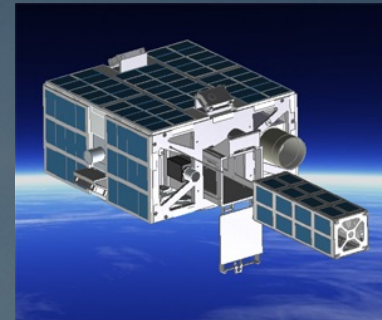
- **LightSail-A**

- Atlas 5 / AFSPC-5 payload; from CCAFS; 2015
- NASA ELaNa slot on ULTRASat (NPS CuL Lite)
- Low elliptical orbit
- 2015 ~ May 20



- **LightSail-B**

- Falcon Heavy / STP payloads; from CCAFS
- Embedded target for Prox-1 spacecraft
- ~720-km LEO orbit
- 2016 2Q-3Q



# LightSail Mission Objectives



- **LightSail-A objective**
  - Successfully deploy solar sail from 3U CubeSat in Earth orbit and demonstrate key spacecraft functions (i.e., show design is sound)
- **LightSail-B objectives**
  - Successfully deploy solar sail
  - Successfully control attitude before and after sail deployment
  - Observably change orbit parameters (e.g., inclination)
  - Capture engineering and CONOPS data relevant to future CubeSat-class solar sail missions

- **Mission collaborations**

- NEO Scout
- Lunar Flashlight



- **Plus other program objectives of TPS ...**



# LightSail-A Mission Operations



- **LightSail-A**

- ~Launch+1 hr: Eject from ULTRASat
- Eject+15 sec: Boot-up complete; ACS ON
- Eject+55 min: RF antenna deploy; start beacon TLM
- Eject+4 days: Gyros and camera checkout
- Eject+28 days: Deploy solar panels, solar sails; image sail deployment and download images
- Sail deploy+2 to 10 days: Enter atmosphere

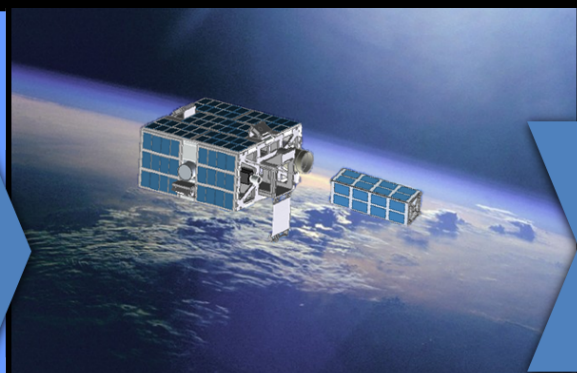
# Prox-1 / LightSail-B CONOPS



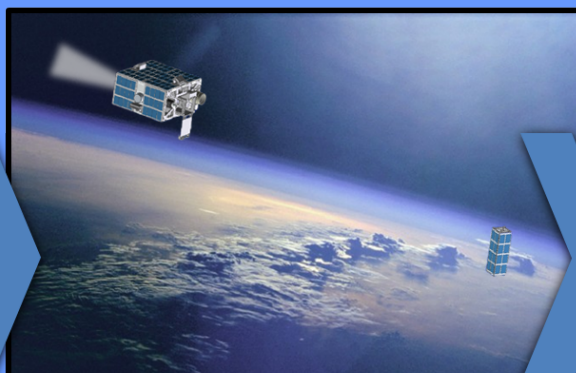
**LV Separation & Detumble**  
(2 hours)

This panel shows a satellite in space, having just separated from its launch vehicle. The satellite is oriented vertically, and the Earth's horizon is visible below.

**Initial Acquisition & System Checkout**  
(1 week)

This panel shows the satellite in space with two yellow lightning bolts striking it, representing the initial acquisition and system checkout phase.

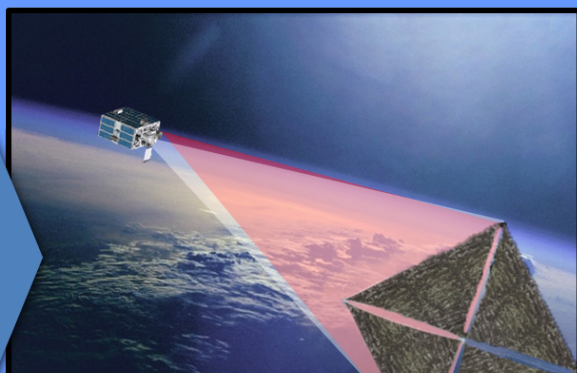
**CubeSat Deployment & Orbit Determination**  
(2 weeks)

This panel shows the main satellite in space with a smaller CubeSat being deployed from its side.

**Rendezvous**  
(1 week)

This panel shows the main satellite in space with the CubeSat in the distance, representing the rendezvous phase.

**Proximity Operations**  
(1 week)

This panel shows the main satellite in space with a red laser beam directed at the CubeSat, representing the proximity operations phase.

**Sail Deployment & Inspection**  
(1 week)

This panel shows the main satellite in space with a large, dark, triangular solar sail being deployed from its side, representing the sail deployment and inspection phase.

# LightSail-A Issues Resolved

(Partial List)



- **Hardware**

- Re-design payload interface board (re-spin)
- Upgrade and mod flight computer board
- Upgrade and mod radio board
- Replace blown radios
- Re-tune/match and replace RF antenna
- Fix camera housing interference
- Stiffen solar panels
- Wire staking
- Fastener staking
- Mod burn wire install
- Mod spectraline routing
- Re-grease motor
- Fix cracked cells
- Fix solar panel switch

- **Software**

- Major re-do of ACS CONOPS and software
- Resolve various telemetry issues
- Work mode transitions
- Fix motor drive counter

- **Test**

- Fix vibe failures of burn wire assembly
- Deployment table facility
- Breakout board issues

- **Ops**

- Lower duty cycle of motor drive
- Ground tracking

# LightSail Schedule

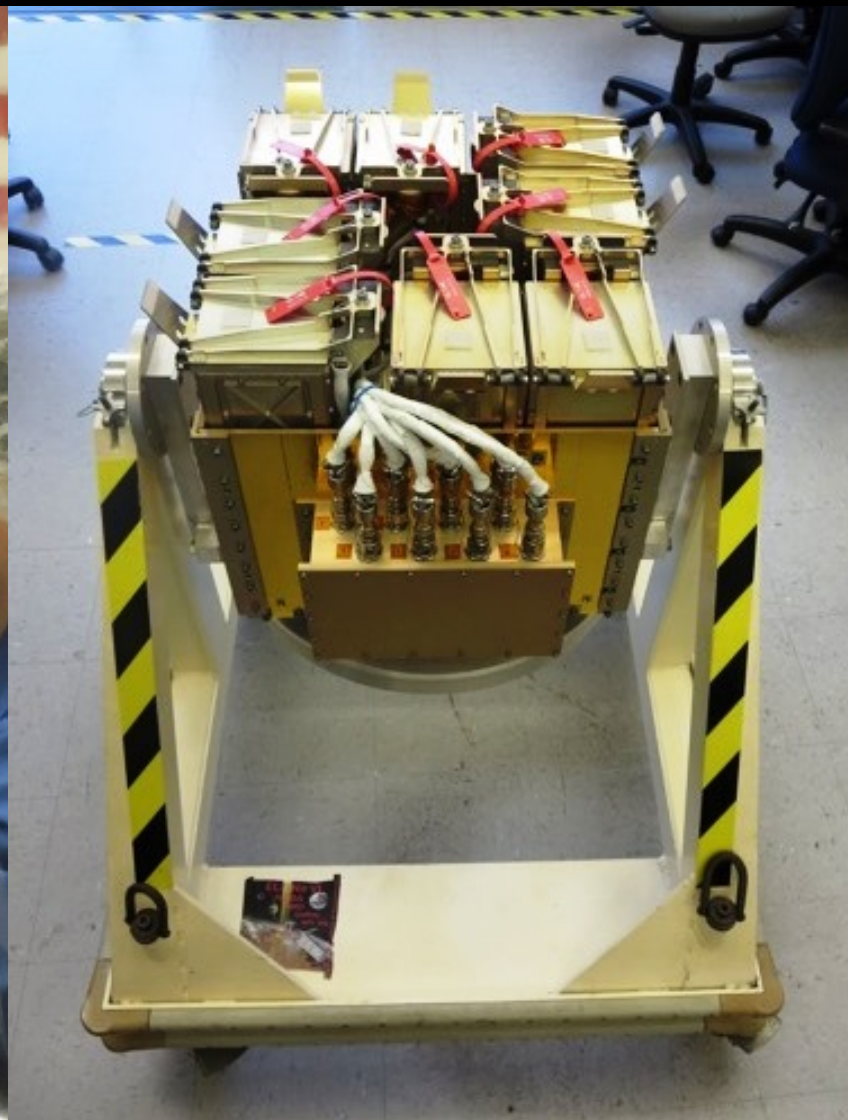
(Since program pause in late 2011)



- 2012 Aug Program resumption assessment
- 2013 Aug Preliminary program review
- 2013 Dec Program review – and resumption
- 2014 Jan-Aug LS-A build-up, mods, functional testing
- 2014 Sep LS-A day-in-the-life test
- 2014 Oct-Nov LS-A system environmental testing
- 2014 Dec LS-A Mission Readiness Review
- 2015 Jan LS-A P-POD/ULTRASat integration; ship to Cape
- 2015 Apr LS-A ORT-1 and ORT-2
- 2015 May LS-A launch (expected)
- 2015 Jun LS-A mission ops
- 2015 Jan-Dec LS-B I&T
- Mid-2016 LS-B launch (expected) and mission ops

# LightSail-A Ready for Launch!

LIGHTSAIL



# LightSail Information



- **Intro**
  - <http://sail.planetary.org/>
- **Solar sail deployment (PSCAM view)**
  - [planet.ly/unfurl](http://planet.ly/unfurl)
- **TPS updates by Jason Davis**
  - <http://www.planetary.org/explore/projects/lightsail-solar-sailing/project-updates.html>
- **And talk to us at the Ecliptic booth!**
  - Rex Ridenoure
  - Barbara Plante (Boreal Space)
  - Alex Diaz (Half Band Technologies)
  - Justin Foley (Cal Poly)
  - SWAG -- !

