Providing a Unique STEM Education Opportunity with a Five Day ELEO Mission

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New Spacecraft & Launch Program
Launch Costs vs Orbit Life

- **SS ELV**: 5 Years, $150k
- **ELV**: 2 Years, $125k
- **ISS**: 6 Months, $80k
- **2nd Stage**: 5 Days, $10k

Launch Cost vs Orbit Life:

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  - $150k
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## Spacecraft Costs vs Orbit Life

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<tr>
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<tbody>
<tr>
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### File Types
- ThinSat
- PocketQube
- CubeSat
- Small Sat
Spacecraft Costs vs Orbit Life

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Spacecraft Costs

$10k
$35k
$100k
$1M
Is there a need for a short orbit life?

- STEM education attention span
- Low Cost
- Rapid repeat missions
- Getting through the mission cycle
- Scheduling
New Spacecraft & Launch Program
Planned Program

Using the Antares Cygnus ISS Supply Mission

Atlantic Ocean

Flame Duct
Planned Program

Release from Second Stage

Ascent Profile

Mission Parameters:
- Orbit Altitude: 250 km x 303 km
- Inclination: 51.6°

Antares Launch Mission

1. Stage 1 Ignition
   - Time (s): 0
   - Orbit Altitude (km): 0

2. Lift Off
   - Time (s): 2
   - Orbit Altitude (km): 0

3. MECO (Main Engine Cut-Off)
   - Time (s): 230
   - Orbit Altitude (km): 107

4. Stage 1 Separation
   - Time (s): 319
   - Orbit Altitude (km): 184

5. Fairing Separation
   - Time (s): 483
   - Orbit Altitude (km): 255

6. Stage 2 Ignition
   - Time (s): 328
   - Orbit Altitude (km): 189

7. Stage 2 Burnout
   - Time (s): 603
   - Orbit Altitude (km): 255

8. Payload Separation

Release of ThinSats at 200km-250km
Planned Program

Release from Second Stage

Antares Expanded View

Available Space for ThinSats
Planned Program

Release from Second Stage

- REMOVE BEFORE FLIGHT HARDWARE AND EXTERNAL ACCESS REQUIRED
- BLUE AREA SHOULD BE ABLE TO USE WITHOUT PROBLEMS
- FLIGHT TERMINATION LINES - MAY BE POSSIBLE TO USE WITH APPROVAL
- STATIONARY CABLES MATED DURING STAGE 2 ASSEMBLY. POSSIBLE TO CROSS OVER WITH APPROVAL

Containerized Satellite Dispenser
Planned Program

Release from Second Stage

Four Canisterized Satellite Dispensers Here
Figure: Twenty one Thin-Sats are flipped sequentially for space optimization with antennas and for centering the center of mass.
Four 3U CSD fastened together. Isolators fastened to the base
Planned Program

21 ThinSat/CSD released in groups of seven, connected together with stiff nitinol wire
Advantages of Antares Launch

• Release PicoSat at an altitude of 200 km – 250 km

• Orbit life of approximately 5 days

• No lasting orbital debris
Target Customers

• STEM K-12

• Jr Colleges

• University Lower Division

• ELEO Research
Mission Objectives

• Get DATA
• You build your sensor board
• All Hardware Provided – ThinSat
• Communications with GlobalStar
Other Research Payloads

PocketQube

POPACS

TU-POD

Mixed Payload

CubeSats
Repeatable Launches

Antares ISS Resupply Missions
ThinSats burn up in the atmosphere after approximately five days on orbit.

ThinSat link and ground segment data verified down to reentry region.
Conclusion

• Low Cost

• Repeatability

• Available Hardware and Launches
Question?
Backup Slides
Planned Program

Mothership
GPS - Camera

Power Support
Daughtership

Standard Sensors
- Temperature
- Voltage
- Currents
- Accelerometer
- Magnetometer
- Gyro
- Light Sensors
- Radiation

Options Sensors/experiments
- Energetic Particles & Dose
- Spectrum Filters
- Plasma Density, Ionosphere
- Reentry temperature and accelerations
- Radio Coverage Mapping
- Tether Motions
- Thermosphere
- GPS at 7 km/s
- Aurora and South Atlantic Magnetic Anomaly
- Ion (Magnet) versus Electron Radiation and Energy
- Thermosphere Drag for Thin-Sat swarms
- Attitude aerodynamic stabilization
The three Phases of this mission provides a STEM program that allows the students over a 9-12 month period make meaningful measurements of the environment correlated with the National Science standards for K-12.
### Phase 1

10 Satellite kits  
2 large party balloon launch kits  
1 ground station with Wi-Fi Database and dashboard  
Teacher training  
Activity – build and run weather stations, launch 1 on a balloon as a test, launch a 2\textsuperscript{nd} one on Earth Day with everyone else. Collect and analyze.

### Phase 2 Tentative Plans

- Near Space Launch  
- Data comms link  
- Database and dashboard  
- Teacher feedback session on missions  
Activity – build weather satlites based on learning in Phase 1. Launch to near space, collect data and analyze.

### Phase 3

- Prototype a ThinSat from what we have in our class kits  
- Commission ThinSats build  
- If permitted, elect one learner to attend launch event  
- Launch ThinSats collect data over 5 days  
Activity – design and launch our own satellite into space. Analyze the data collected.
Phase 2 Experiments: 4 Balloon Launches

- 1000g, 25ft. Balloon
- 6ft Parachute + 100g Balloon
- EyePod Mini, 900 MHz
- Command Pod: STX2, STX3, ABC Stamp, Duplex, Cut Down, Batteries
- Payload 1: PQ Camera, Sun Camera (IR/UV Filter), Telephoto Lens, 5.8 GHz, Batteries
- 7 Deployed PQs
- 120° FOV Sun Camera
- PQ/Shadow Camera
- Payload 2: Deployed PQ’s, IMU, Spectrometer (2), PIN Diode, Pyro, Temp, 900 MHz, Batteries
Planned Program

Orbital ATK CRS-8
- WiseCounty-1
- Addington-5
- Union-6
- Twiggs-1
- SetonStars
- Raider-1
- Langley-2
- NOAA-12

Orbital ATK CRS-9
Orbital ATK CRS-10
Orbital ATK CRS-11

Search
- Sensor
- Satellite

XINABOX

14th Cal Poly CubeSat Workshop
April 27, 2017
Phases 2 and 3

xCHIPS are incorporated into the ThinSat using a payload motherboard and connectors.

Data transferred by Global Star radio to the same dashboard at the schools.
Option Configurations

Option 1: All 21 ThinSats separate by single burn-wire

Option 2: 7 sets of 3 ThinSats each separate by individual burn-wires

Option 3: 3 1U size sets of 7 ThinSats each separate by individual burn wires