Suborbital Flight Opportunities for Cubesat-Class Experiments Aboard NLV Test Flights

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San Luis Obispo, CA

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Nanosat Launch Vehicle (NLV) Development Flight Tests Provide Opportunities for Manifesting CubeSat Payloads

- distinct and separate from OCT Flight Opportunities Program

Initial Operational Capability (LEO)

50 kg to 450 km,
surge capability
$2M to 5M per flight

20 kg to 450 km ("20/450")
serial production, launch
$2M to 5M per flight

P-6 / -8

P-7A/B/C/D

P-9

P-11 / -12

P-18A/B/C

P-W Enabler / Pathfinder

P-Y, … Suborbital Demonstrators

NLV

20 kg to 250 km

10 kg to 250 km ("10/250")
serial production, launch
$1M to 2M per flight
former baseline

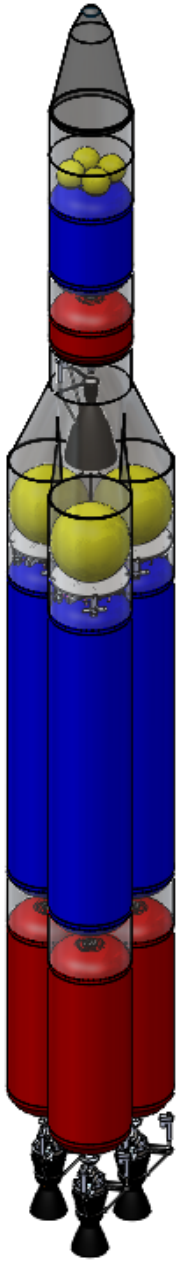
Potential Vehicle Evolution

P-9

P-W

Core Stage

10/250

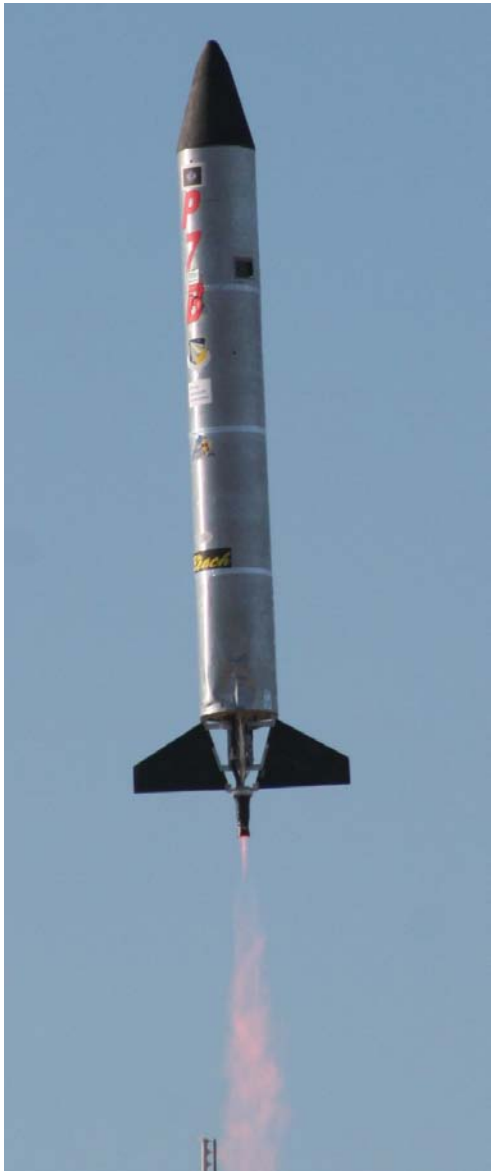


20/240

Background

- Garvey Spacecraft Corporation (GSC)
  - small California aerospace R&D company with “old space” perspective
  - team experience includes DC-X/XA, Delta II/III/IV, Sea Launch, Land Launch and several other launch initiatives
  - started flight testing in 1998
  - SBIR RLV demonstration project with AFRL/RZ and SMC/XR
- California State University, Long Beach (CSULB)
  - hosts current vehicle development activities
  - focus on liquid propulsion technology
  - students participate in all aspects of each project
  - **Prof. Eric Besnard** is the director (AIAA faculty advisor of the year)
- “CALVEIN” Partnership established in 2001
  - pursuing launch vehicle technology development while also providing hardware experience to future engineers
  - since 2003, we have focused on NLV development
  - 14 joint vehicle projects, 23 flight tests
  - numerous technical firsts in the field of liquid propulsion
    - flight testing of composite LOX tanks
    - first flight of student-developed liquid propellant aerospike engine
    - first in-flight use of LOX/methane
    - first in-flight use of LOX/propylene
    - application of wireless data networking for stage-to-stage communications

First Prototype sRLV – P-7
- Two Flights within 3.5 hours -

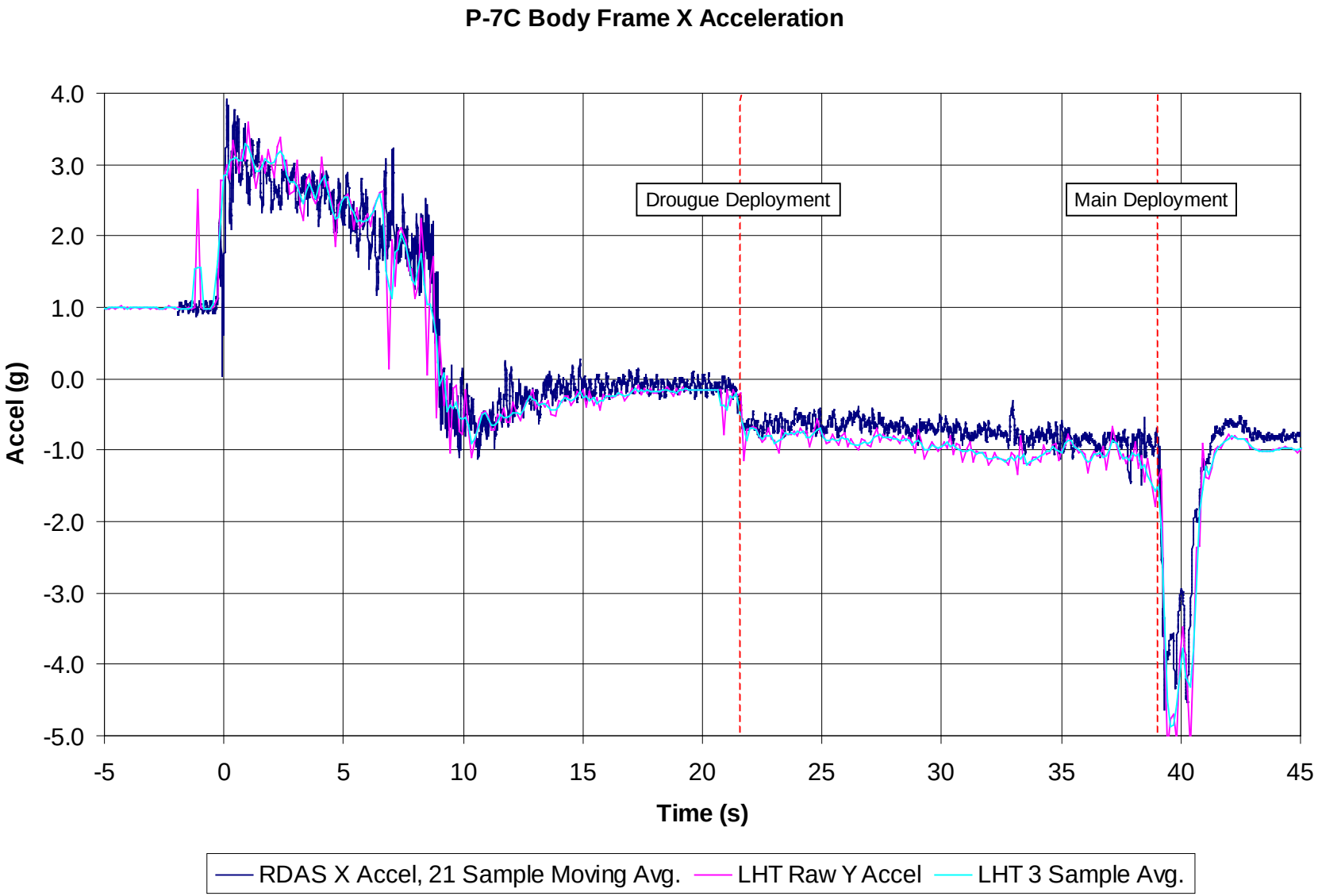


Students Integrating the CP SLO P-POD CubeSat Deployer Into the P-7 Interstage

P-7C Prototype RLV with the Launch Hardware Tracker Experiment

- **Commercial RLV mission**
- Sponsored by The Aerospace Corporation and SMC
- 3rd of 4 flights of precursor RLV developed for AFRL/RZ
- Early evaluation test of Re-entry Break-up Recorder (REBR) concept
  - full-up REBR just flew on Japanese HTV-2
- Assessed GPS and Iridium data links
- Fourth flight for MSU data logger
- Pathfinder for responsive launch ops

LHT Data


P-7C Body Frame X Acceleration
Drougue Deployment
Main Deployment
Accel (g)
Time (s)
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-5
0
5
10
15
20
25
30
35
40
45
RDAS X Accel, 21 Sample Moving Avg.
LHT Raw Y Accel
LHT 3 Sample Avg.

P-11 Wireless Technology Demonstrator

- developed and flown under a Phase I SBIR with NASA
- refurbished and flown as the P-12 for CSA

P-9 Next Generation Test Vehicle

2011

P-18 Vehicle Developed at CSULB with GSC Direction and IRAD Funding is Now Being Configured to Provide Nanosat Suborbital Launch Services for NASA Launch Services Program after 3 check-out flights

05 Mar 2011

16 Apr 2011

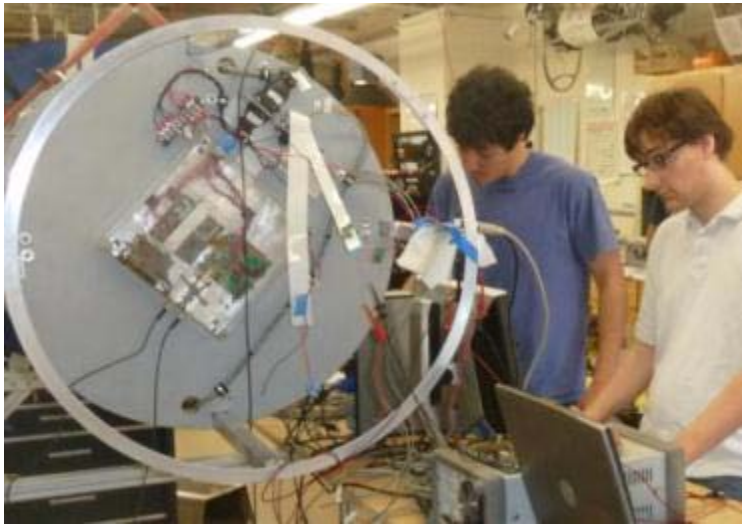
20 Aug 2011

In Addition, P-16 Launch with ORBITEC Vortex Engine was 4th Flight in 7 months

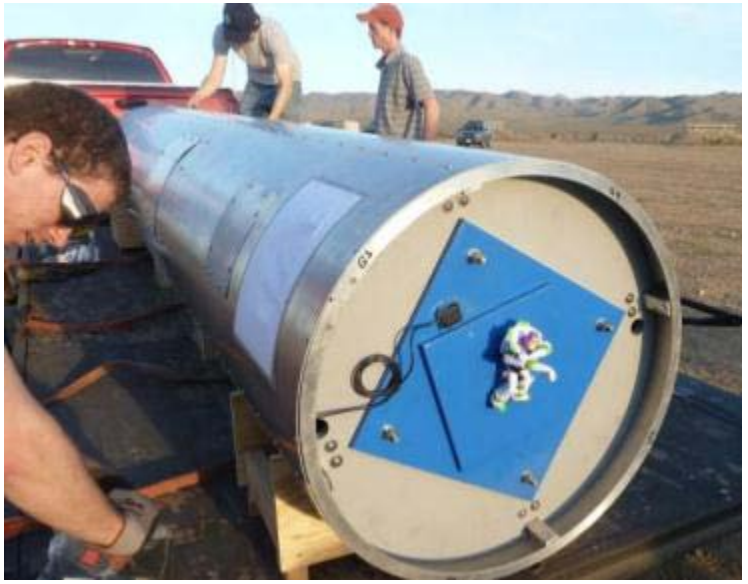
24 Sep 2011

P-18 Features Parachute Recovery

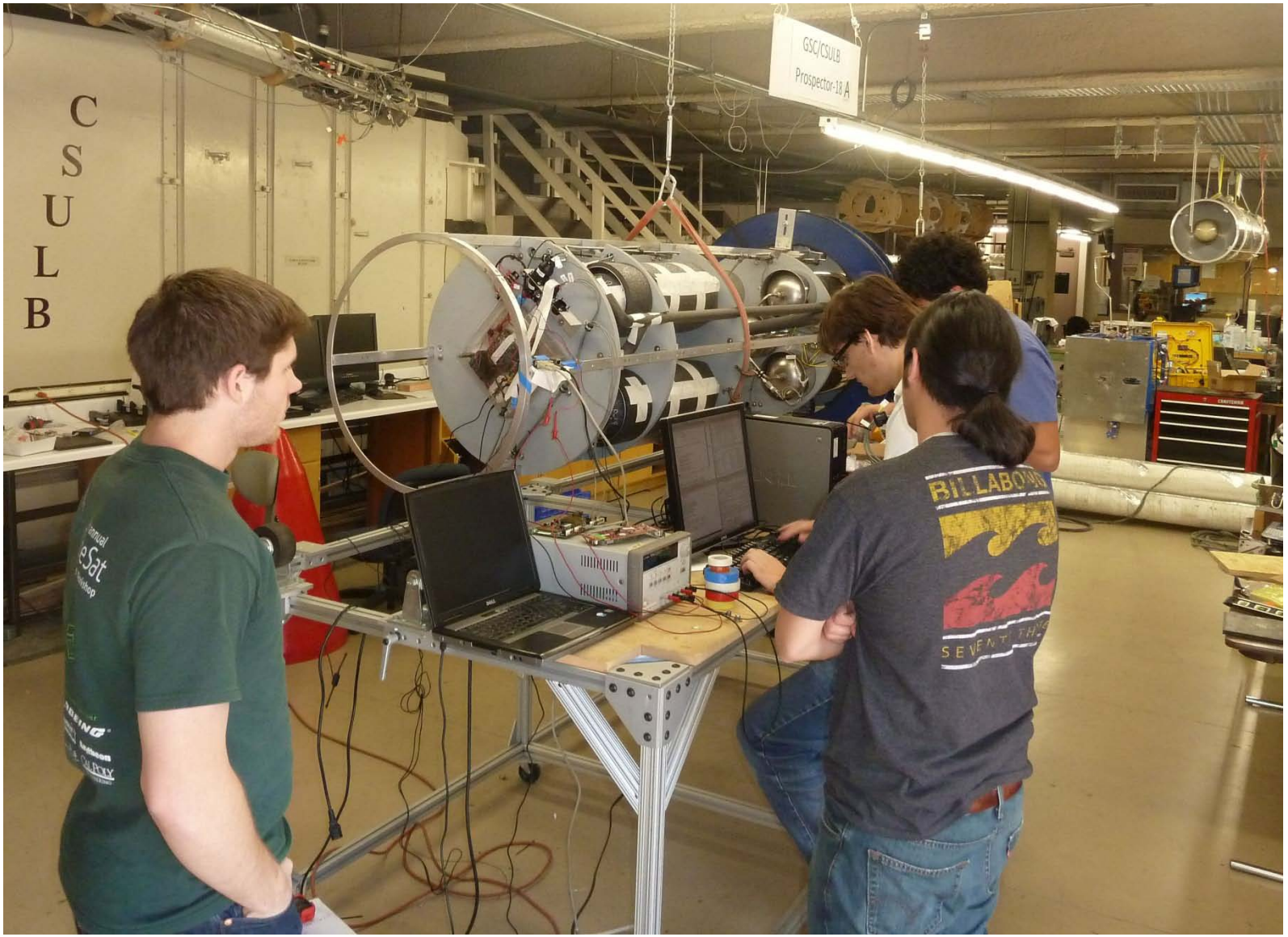
Typical P-18 Payloads



- Cal Poly SLO, prototype CubeSat avionics
- U Maine, wireless telemetry experiment
- NASA CaSGC
- Elementary school STEM payloads
- 50 lb ballast



CP SLO Team During Payload Integration at CSULB



T-30 Minutes

UMaine Wireless Experiment PI's after FT-2

SPACE TRAVEL
EXPLORATION AND TOURISM

UMaine Students Test Wireless Sensors on Rocket

by Staff Writers
Orono ME (SPX) Apr 29, 2011

Five University of Maine students participated in a recent launch process as a rocket loaded with wireless sensors the students developed in a UMaine lab blasted off in California's Mojave Desert.

The launch took place on April 16 at the Friends of Amateur Rocketry test site in the Mojave Desert. The 27-foot, 500-pound Prospector 18B rocket, which was built in part by Cal State Long Beach students under the management and sponsorship of GSC, was launched and reached a height of nearly 2,100 feet before falling back to the earth on a 1,000 square foot parachute. The entire launch took about two minutes. The rocket came down a few hundred feet away from the launch site.

The students, working under UMaine electrical and computer engineering Associate Professor Ali Abedi, collaborated on the NASA-funded project with faculty and student researchers at California State University at Long Beach and Garvey Spacecraft Corporation (GSC), a Long Beach, Calif.-based R and D company that focuses on cost-effective development of advanced space technologies and launch systems.

The UMaine payload, which was integrated into a rocket known as the Prospector 18B, included sets of wireless sensors that detect acceleration

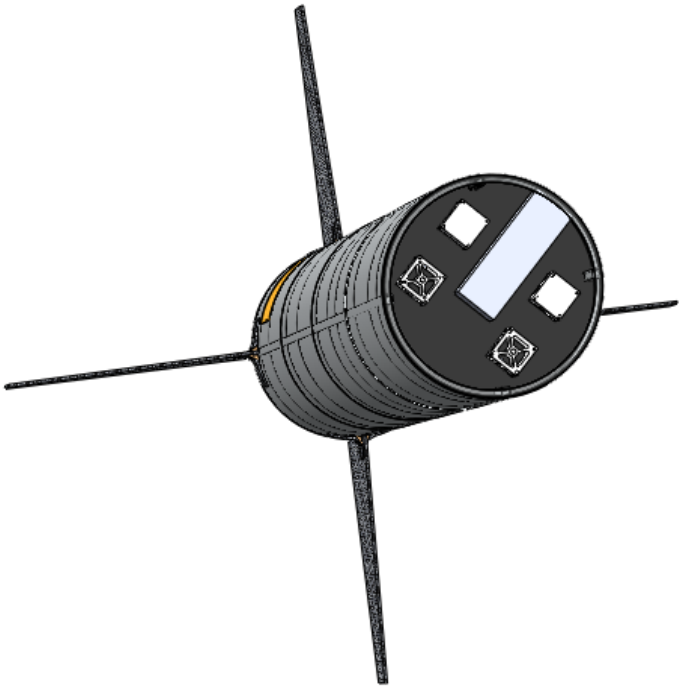
CSULB Student Experiments Play a Key Role in Assessing Vehicle Performance

IMU Data from CSULB Zigbee Telemetry Experiment

Still Images from Video of Main Parachute Deployment



Payload Integration Now Underway for First NASA LSP P-18 Flight Test in September



Summary

- Ongoing NLV development program provides suborbital flight opportunities
  - separate and complementary to OTC Flight Opportunities Program
  - development flights versus operational missions
  - traceable to orbital mission applications
- Flexible payload integration process
  - 25 inch diameter payload bulkhead(s)
- Beginning to draft streamlined payload users guide
- Preparations now underway for 3+ flights in 2012
  - P-18D (NASA LSP)
  - P-15
  - P-3B