Space Science Program Around Communication Engineering with High Achieving Undergraduate Cadres (SPACE HAUC): UMass Lowell's CubeSat mission


University of Massachusetts, Lowell

7th Nano satellite Symposium, Kamchia, 2016
Outline

• An Introduction to UMass Lowell and the group
• The USIP program
• SPACE HAUC
UMass Lowell Overview

• 17,000 students
  – Enrollments increased by 47% since 2007
  – SAT scores increased 79 points since 2008
  – Retention and Graduation rates improved

• More than 120 undergraduate, 39 masters
  and 33 doctoral degree programs in 6 colleges

• 1000+ faculty

• $63M+ in research expenditures

• Urban campus with polytechnic focus
New Models for Industry-University-Government Partnerships

Co-location catalyzes innovation, strengthens cluster development, and enhances workforce development

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LoCSST: Objectives

- Train next generation of space scientists, technologists, teachers, business leaders and policy makers
- Involve industry partners in curriculum, research and proposals/business development
- Provide a home for space science and technology research activities on UMass Lowell campus
We are toolmakers

A full-waveform lidar for quantitatively assessing forest structure, sequestered carbon

A high-resolution echelle spectrometer for round-the-clock space-weather studies
We observe from balloons

Pictures of Balloon flight from Hyderabad in 2010
Two new flights coming up in 2017 and 2019
PICTURE rocket: Direct Imaging of Exoplanet environment

Launched October 8, 2011
Demonstrated 5 milli-asec pointing

Launched again in November 25, 2015
Demonstrated 3 milli-asec pointing
Our LITES instrument flies aboard the ISS in early 2017

LITES: Limb-imaging Ionospheric and Thermospheric Extreme ultraviolet Spectrograph
SCIENCE PROGRAM AROUND COMMUNICATION ENGINEERING WITH HIGH ACHIEVING UNDERGRADUATE CADRES (SPACE HAUC)

And now....
Undergraduate Student Instrumentation Project (USIP)

USIP Project Goals

The two goals of this USIP SFRO are:

• To provide a hands-on flight project experience to enhance the science, technical, leadership, and project skills for the selected undergraduate student team.

• To fly a science and/or technology investigation relevant to NASA strategic goals and objectives on a suborbital-class platform.

September 2016 USIP-II Kickoff Meeting

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### Organizational relationship

**NASA/GSFC/Wallops**
- **David Wilcox** Provides Mission Management support/help to teams; Arranges review support; Coordinates launch services; Coordinates vehicle Interfaces; Coordinates reports (monthly, final) & conference/poster sessions

**USIP Teams**
- **Principal Investigators:** Guide/train/mentor students/ NASA Grant Reporting
- **Grad Students:** Serve as mentors
- **Undergrad Students:** Lead Project (T/C/S) Design, Build, Test Conduct Reviews; Status GSFC/Wallops; Coordinate Launch readiness

**NASA/HQ/Space Grant & SMD**
- **David Pierce** Provides Technical Assistance
- **Lenell Allen & Mary Sladek** Provide Grant Management

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NASA will provide launch services for USIP through CSLI

**CSLI and USIP**

- The NASA CubeSat Launch Initiative (CSLI) will be the means of providing all 23 USIP Cubesats access to space.
- Step 1: Submit USIP proposal to CSLI (Nov 22, 2016)
- Step 2: Selection to USIP (~ Feb 2017)
- Step 3: Manifesting on a particular launch (~ time of I&T)
- Step 4: Launch and mission operations.
- The 2016 CSLI solicitation can be found at:
- More information about the CubeSat Launch Initiative is available at: [http://go.nasa.gov/CubeSat_initiative](http://go.nasa.gov/CubeSat_initiative).

**CubeSat Launch Initiative**

NASA’s CubeSat Launch Initiative (CSLI) provides launch opportunities to educational institutions, non-profit organizations and NASA Centers who build small satellite payloads that fly as auxiliary payloads on previously planned launches, commercial missions or as International Space Station deployments.

More information about the CubeSat Launch Initiative is available at: [http://go.nasa.gov/CubeSat_initiative](http://go.nasa.gov/CubeSat_initiative).
SPACE HAUC Objectives

- Demonstrate practicality of high-data rate, high frequency communications on a CubeSat
- Achieve rapid beam steering for dynamic pointing of X-band uplink/downlink
- Use phased array of patch antennas
- Camera will take high-res images of Sun to transmit back to Earth

See: https://www.uml.edu/Research/LoCSST/Research/spacehauc/about.aspx
The students have formed teams (with minimal “adult supervision”)

- Project management
- Systems engineering
- Beam Steering
- Antennas
- Telemetry
- Deployables
- Power system
- Attitude determination and control
- Thermal
- Structures
- Command & Data Handling
- Ground Station
- Promotion Management

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Organization examples
(student slides from first organization meeting)

How to Get Started

• Accept invitation to CubeSat group (university Office 365) and file repository (Workbench)
• **SUBSCRIBE TO THE GROUP FOR ANNOUNCEMENTS**
• Research CubeSats and satellite subsystems (you should already have been doing this)
• Sort yourselves into teams, schedule meetings with each other

Some Places to Start your Research...

• [http://www.cubesat.org](http://www.cubesat.org) → Documents → Papers
• [http://www.polysat.calpoly.edu](http://www.polysat.calpoly.edu) → Team → Published Papers
• Library Databases (IEEE, Science Direct, Wiley)
  – Search terms such as “cubesat” and “nanosatellite”
  – Search for journal articles and conference publications
  – Senior projects and master’s theses are good sources
• [Space Mission Analysis and Design (SMAD)](http://www.cubesat.org) → Space engineering bible
• Textbooks, for basics and fundamentals
• Workbench → Resources → Papers (stuff that I’ve found that is helpful)
• …and of course, Google
One more
(student slides from first organization meeting)

Tips for Involvement

• Be open to criticism → keep long-term goal in mind
• Be proactive → don’t wait around for someone to tell you what to do
• Communicate often.
• Communicate often!
• Communicate often!!!
• In event of:
  – Conflict with a team member,
  – Stress due to work, school, etc,
  – or anything else
• …talk to your team leader or to your program manger → we’ll help

Time Commitment and Example Schedule

• 6 – 8 hours/week
• Work as a team; distribute the work
• You get out what you put in
• Don’t promise what you can’t deliver

<table>
<thead>
<tr>
<th>Day</th>
<th>Amount of Time (hours)</th>
<th>Example of Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON</td>
<td>1</td>
<td>Team meeting, brainstorming</td>
</tr>
<tr>
<td>TUE</td>
<td>2</td>
<td>Informal get-together with team members to brainstorm</td>
</tr>
<tr>
<td>THU</td>
<td>2</td>
<td>Individual work/research</td>
</tr>
<tr>
<td>SAT</td>
<td>1</td>
<td>More individual work/research</td>
</tr>
<tr>
<td>SUN</td>
<td>2</td>
<td>Document progress for next team meeting, write your share of the specifications document</td>
</tr>
</tbody>
</table>

TOTAL: 8 hours

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System design examples

Power

Telemetry

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Thermal analysis example

An orbit assumed, and...

First-cut results

B: Transient Thermal
Type: Temperature
Unit: °C
Time: 25
9/30/2016 10:58 PM

Max: 45.667
33.175
30.602
23.19
15.698
8.2054
0.71308
-5.7792
-14.272
-21.764 Min

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More examples

Beam steering simulation

Flight software organized

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Our planned schedule

Project Initiation
18 MONTHS

Winter Break 2016 - 2017

Conceptual Design

Reserve

Concept Review (CR) 10/14

Preliminary Design

Reserve

Preliminary Design Review (PDR) 11/17

Critical Design

Winter Break 2017 - 2018

Annual Report 2016 12/30

Critical Design Review (CDR) 4/13

Integration and Test

Final Satellite Delivery 12/29
Preparation for Readiness
Mission Readiness Review (MRR) 1/5
Preparation for Launch
Launch 1/12
Mission Ops / Data Analysis

Annual Report 2017 12/29
Our other student-involved work

- **K-12**
  - High school Newton’s Laws experiment
  - Curriculum developed used in several schools in Massachusetts

- **Undergraduate**
  - Involved in all phases of all projects
  - SPECTRE
  - SPACE HAUC (launch 2018)

- **Graduate**
  - 8 Ph. D.s and 11 M. A.s in 15 years
  - Placed in Academia, Government, Private Industry and Private Start ups
Our upcoming space flights

• Science
  • Exoplanet
    • PICTURE balloon 1 – Launch 2017
    • PICTURE balloon 2 – Launch 2019
  • Ground based studies of airglow and aurora (HiT&MIS)
    • Total solar eclipse – “Launch” 2017
  • Space based Ionospheric Studies (ISS/LITES) – Launch: 2017
  • Support for MISTIC WINDS with BAE – aircraft Launch: 2017

• Education and technology demonstration
  – SPACE HAUC – Launch 2018
A symposium announcement

• To commemorate 60 years of space exploration, we will host a symposium on April 21-22 at UMass Lowell entitled

   Domestication: The future of space exploration in the upcoming decade

• Please join – you will help shape the future

https://www.uml.edu/Research/LoCSSTNews/Symposium.aspx