The University Nanosat Program from Concept to Flight: What Works and What Does Not
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A Dual Student / Program Perspective:

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Aerospace Workers

[Bar chart showing the number of aerospace workers from 1989 to 2002]
U. S. Undergrad Enrollments in Aerospace Engr
Is this accurate? What are we doing about it?

• Trends of the “big boys” may not reflect small spacecraft business

• Many small companies and opportunities

• Opportunities strengthened by new talent

• How to discover and foster the talent?
Satellite Industry: Changing perspective

Today:
• Most small satellites are built for a specific purpose (unique)
• Reinventing the wheel is typical when interfaces don’t line up
• Must figure out how to fit puzzle together between disciplines

Tomorrow? Who knows. University Nanosat Program is an experiment:
• Lay down a set of requirements within a competition setting
• University that delivers working sat closest to requirements wins
• Universities pick their own missions / purposes
• Sat bus development over time becomes routine
What is the University Nanosat Program?

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
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<tr>
<td>NS X</td>
<td>I&amp;T</td>
<td>Launch</td>
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<td>NS X+1</td>
<td>Kickoff / Design</td>
<td>Design</td>
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<td>NS X+3</td>
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<td>Kickoff / Design</td>
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NANOSAT-1/2
Arizona State
New Mexico State
U Colorado-Boulder
Stanford
Boston
Carnegie-Mellon
Utah State
Virginia Tech
Washington

NS-2 Delivery
3-Cutter Sat
January 2002

NS-2 Launch
Delta IV Heavy
December 2004

NS-3 Delivery
Summer 2006

NS-4 Downselect
March 2007

NS-5
Kickoff February 2007

<<Your Name Here>>
Nanosat Program and University Tie-in

Unique UNP initiatives:
• Dedicated USAF personnel (and invited industry guests) as guides
• The goals are on purpose too lofty (survival environment)
• Aggressive two-year timeframe
• Organized competition with 5 reviews and 3 formal workshops

Program Self-sufficiency and sustainability:
• Former UNP students (2500 +)
• Feedback from participants evolves program
University Risks

Harsh personnel turnover
• Students typical change every year, no corporate memory

Budgets can never meet demand
• Unpaid volunteer student engineers
• AFOSR Grant funds never enough (can never be)

Short duration between initiation and completion
• Required w/in degree timeframes
• Risk of expert personnel loss if not within timeframe

Inexperience
Program Risks (From Gov/AFRL side)

- High yield education versus tight budget/schedule constraints
- Quality versus quantity

- Combine this with student turnover
- = difficult task getting from concept to spacecraft
Technical Risks

Lack of concept tracking
• Documentation (Oh BOY!)
• Configuration management
• Reliance on that the past designer was correct

Lack of systems engineering
• Parts not working with the whole
• Interface issues
• Model / Analyses not accurate to reality
• Requirements and Mission not defined well enough up front
A Balancing Act

Creative student design at the expense of delivery and flight

Design risk mitigation:
• Program constraints / standards minimize complexity
• 5 reviews throughout competition
• Workshops
• Web chat board info repository
• AFRL as systems engineering oversight (yea verily, heck no)
• Down-select university that proves best engineering rigor

Delivery risk mitigation
• AFRL full oversight, satellite becomes AFRL’s
SHOT – Student Hands-On Training Workshop

High Altitude Balloon Payload Workshop

Colorado Space Grant
University of Colorado
Boulder, CO

First Year:
Standard Kit Payloads

Second Year:
Nanosatellite Subcomponent Payloads
(e.g. sensor, comm box, etc)
UNP Satellite Fabrication Class

**Hands-on standard sat-fab practices**
- Aerospace Engineering Facility (AEF) at Kirtland
- Taught entirely by AEF personnel
- Soldering, wire harnessing, mechanical assembly
- Safety practices, cleanliness / handling

**Approximately 40-50 students participate**
- Three workshops over three weeks
- 3-4 different universities attend each week
- Universities send 3-4 students each

**Design and testing discussions**
- “Round table” type discussions w/ UNP office
- Program / mission requirements
- Test Facility tours and discussion
What is gained by students

Design Phase:
• Acceptance of real engineering responsibility
• Empowerment of students to make the real decisions
• Systems engineering rigor
• Design reviews are serious (in this program)

Flight Phase:
• Again, the above
• This is for real, not just a “project” anymore
• Scrutiny increases 10X !! (Both University and Gov)
• You might become famous! (well, as much as an engineer can)
• You might not finish school when you thought you would!

Regardless:
• You WILL learn MORE and will get a real job (eventually…)}
What has not worked

So, you want to design, build, test, fly a satellite in two years with nothing but unpaid part time temp volunteers that might have something better to do?

Thou shalt not:

• Create over-complex missions
• Have or try to sell unrealistic goals / progress / expectations
• Have a do-it-all satellite (slice, dice, shred and mix)
• Assume you will get a flight when the program schedule ends
• Assume everything past launch is not the university’s responsibility
• Assume ANYTHING before launch is not the university’s responsibility
• Assume when you win, you’re done
• Assume when you lose, you’re done
What has not worked

Unbridled Optimism: *We can do everything, and it will be awesome!* However,

- Designing, testing, and machining a lift-bracket could take months
- Lack of focus can lead to disaster
- There is much more to it than engineering
What has not worked

Unfamiliar with the design cycle: *Are we there yet?*

- Design, testing, prototype, redesign, testing, integration, redesign, etc. etc.

- Poorly defined requirements lead to a quagmire in testing and integration

- Documentation: the demons of turnover and configuration management
Keys to success

Establish systems engineering processes early
• Capture design reasoning process
• Capture requirements correctly and who they effect
• Identify communication protocol / processes

Establish relationships
• Identify and foster personnel depth, talent and regeneration
• Work at opening doors with industry
• Seek feedback on own accord to sponsors / stakeholders
• Educate public and university on the “coolness” of your project

THEN, get away from the paper, and start to get dirty!
Assume the road is longer/harder than you expect
Keys to success

- Eventually started to get the hang of it
- Industry help
- A creative environment with the freedom to try new and sometimes crazy ideas
- Developed great relationships
- Received a first rate design/development/build education
Keys to success

• Had a blast!