



One Company | Customer Focused



Space Systems Company



CubeSats:

Impacts, Benefits, and Challenges Ahead

An Industry Perspective

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Which Industry Perspective?



The Aerospace industry is very diverse field

- Airplane Design
- Rocket Design
- Space Science Research
- Manned Exploration
- New Enabling Technology Developers
- Satellite Design

Many different perspectives on the impact and benefits of CubeSats.

Some business view CubeSats as an cornerstone to some of their products as enabling technology Developers.

The perspective that I will be taking today is from a satellite design company, such as Lockheed Martin.

The CubeSat Connection



- Professor Twiggs
- Lockheed Martin (Sunnyvale) began participation in the Stanford Spacecraft Design Program
- Began annual program participation in 2001
- Purpose: Train company engineers in Systems Engineering
- Idea: Design, build, test, launch, and operate a CubeSat
- Program Goal: Achieve all this in one 1 year

CubeSats: A Proven Platform



- **CubeSats have proven themselves to be a cost-effective platform for conducting short term space science missions for several years now.**
- **One Example: QuakeSat**

QuakeSat:

June 30, 2003

On 30th June 2003 the Multiple Orbit Mission was successfully launched by Eurockot Launch Services from Plesetsk Cosmodrome in Northern Russia.

Europe's small launcher Rockot confirms its reliability by launching 8 satellites into an elliptical and a sun-synchronous orbit.

ROCKOT – Multiple Ignitions into Multiple Orbits

SUCCESS!
Multiple Orbit Mission on ROCKOT

- Design Team of 5 Students
- 1.5 Years to Completion
- Still Operating Today

Direct Impacts:

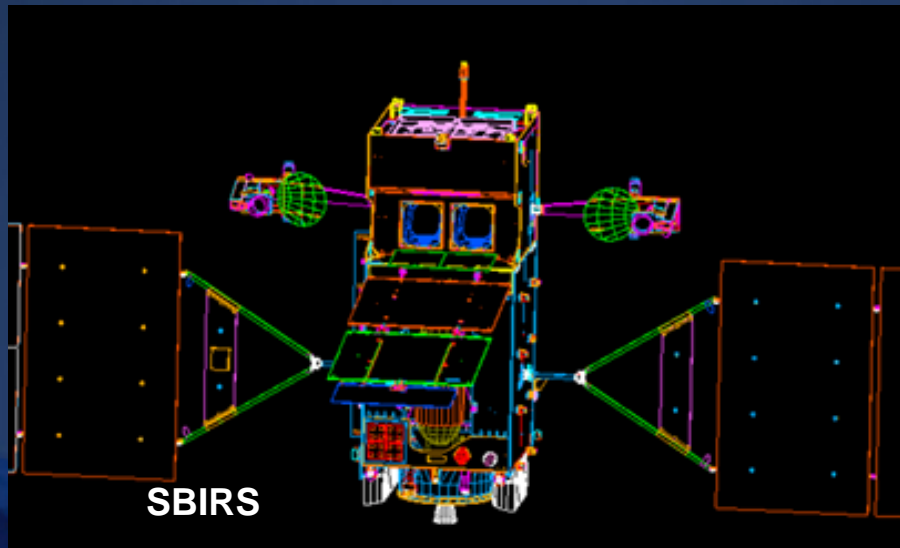


- Company execs and managers are definitely paying attention
- But, still no fundamental changes yet observed

Some Potential Reasons:

- Too early to detect changes since timeline from proposal to launch can be on the order of 5-15 years
- Size and complexity of satellite project is a function of customer need
 - Long term reliability is generally a key design driver

The CubeSat Contrast



Typical Large Sat Project

CubeSat

Build Time	~ 10 years	~ 2 years
Estimated Cost	> \$400 M	~ \$100k
Estimated Use	~ 10 years	~ 1 year
Demonstrated Complexity	Very High	Improving
Demonstrated Capability	Very High	Medium-Low

Indirect Impacts:



- **Customer expectations are changing!**
 - “If they can have it, why cant we?”
 - The low cost, quick development appeal of CubeSats is shifting the customer’s mindset of what solutions will meet their needs

Several Key Advantages in Using Small Sats:

- Deployment of newer technologies in space missions
- “Good enough” rather than optimal solution
- Meet today's needs today, not in 10 years down the road
- Responsive Space - short term missions & quick turn around

The Real Message:

- Direct impact of small satellite development will become more prevalent in the coming years to augment current space mission needs

Challenges Ahead:



- Even though customer expectations are changing, the need for demonstrated customer value is not!
 - The need to mitigate risk is still a primary design driver
 - Currently, university CubeSat projects are viewed to have a certain degree of freedom to fail
 - But as university CubeSat complexity increases, so does project time and cost.
 - An invested interest to ensure mission success and performance

Where the Two Intersect:

- An increased need for systems engineering training, formal testing and requirements verification

High Demand For System Engr Skills:



- Industry spacecraft projects are highly complex, integrated systems
- One important way to mitigate risk is to minimize complexity through smart design
 - Simplify interfaces
 - Identify key design drivers
 - A technically advanced solution is not always best (Space Pen Ex.)
- The ability to understand the interrelation between subsystems and furthermore to effectively make tradeoffs between subsystems is a highly desired skill at aerospace companies

A Customary Industry Approach to Space Systems Design:

- Compartmentalize and Specialize
- “Throw it over the Wall”

One Way of Meeting the Challenge:



- Form academic institution and industry collaborations such as the Stanford Spacecraft Design Program

Benefits:

- A creative mix of students with space systems experience working highly talented students and instructors with research experience toward a common goal:
 - Creating innovative approaches and aerospace solutions in a dynamic systems engineering environment
 - “Thinking outside the box”
- Focus on holistic satellite system design
- Gain invaluable systems experience with imposed design constraints and a reduced set of very real world mission requirements

Possible Area of Improvement:



- The need for requirements verification, or at least a heightened awareness of the need
- In industry, the method that will be used to verify the functionality and capability of the system is an important consideration before or at the time of design
- At minimum, this ensures ability to test and demonstrate the your system can perform what it was designed to do
- Yet another way to mitigate project risk
- Nevertheless, requirements definition (or lack thereof) have been known to lead some projects to their ultimate doom

Possible Benefits as a Result:

- So, use innovative CubeSat approaches to find better methods to convey and communicate space mission needs and requirements

If Time Allows...



QuakeSat Pointers and Lessons Learned



Things that Helped QuakeSat Succeed:



- **The Twiggs Touch (Persuasion and Motivational Speaking)**
- **Close customer interaction throughout the project lifecycle**
 - **Customer brought Pizza every week, for a year!**
- **Project Reviews (SRR, PDR, CDR) in front of experienced industry professionals enabled design inefficiencies to be identified, tracked, and resolved.**
 - **Ensured product quality**
 - **Was a driving force to produce at least a minimum set of documentation**
- **An identified launch date, even in the face of slip in date, provided a needed level of urgency in just getting along and demonstrating progress**
- **Ability to use Lockheed Martin environmental test facilities**



Questions?