Benchmarking the Small Satellite Industry – Identifying Emerging Trends to Increase Access to Space

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Key Questions

• Are there any emerging trends in small satellite designs?
• How have these design trends influenced access to space?
• How do university built spacecraft compare to the remainder of the industry?
• What possibilities exist to improve manifesting opportunities for small satellites?
Overview

• Data collection methodology
• Physical trends
• Capability trends
• Recent launch trends
• Chicken and egg problem
• Opportunities for improvement
  – Near term solutions
  – Long term solutions
Data Collection Methodology

- Data collected for 172 missions
- Satellites flown from 1990 – present
- Launch mass < 300 kg
- Various parameters collected
- Constellations:
  - Physical trends only included 1 spacecraft from each constellation in their first year
Physical Trends

- Historical data of average spacecraft mass
- Historical data of mass distribution

Average mass from 1990-2003: 83 kg
Physical Trends – Universities Only

- Average mass of university built spacecraft

**Average Mass by Year (Universities Only)**

Average mass from 1990-2003: 69 kg
Capability Trends

• “Complexity Index”
  – Incorporates multiple attributes to create a basis for comparison
    • Launch mass, type of solar array mounting, type of attitude control system, number of major payloads
  – Basis of calculation
    • Launch mass and number of payloads – given a percentage of the maximum value in the population
    • Type of solar array and ACS – assigned values, then percentage calculated in same manner.
    • Total complexity index = Sum of four parameter totals

• Calculated for 71 out of 172 missions
Complexity Index Results

- Complexity index over time
- Average complexity index by launch year

![Complexity Index Versus Time](image1)

![Average Complexity Index](image2)

No statistically significant increase apparent
Complexity Index – Universities only

- Complexity index over time
- Average complexity index by launch year

Correlation seems more probable
Possible Explanations

- Emerging parties in the small satellite industry
  - University built spacecraft have an increasing average complexity index
- Weakness of the complexity index itself
- Trend to favor deployed solar arrays and 3-axis stabilized spacecraft

### Solar Array Trends

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<tbody>
<tr>
<td>Body-Mounted</td>
<td>80%</td>
<td>46%</td>
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<tr>
<td>Deployed</td>
<td>20%</td>
<td>54%</td>
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### ACS Trends

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<tr>
<td>No ACS or gravity gradient</td>
<td>43%</td>
<td>17%</td>
</tr>
<tr>
<td>Spin Stabilized</td>
<td>30%</td>
<td>21%</td>
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<tr>
<td>3-Axis Stabilized</td>
<td>27%</td>
<td>62%</td>
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Recent Launch Trends

- All spacecraft included
- Constellations counted as 1 per launch

**No statistically significant trend apparent**
Recent Launch Trends – Universities Only

Launch data for university built spacecraft

No trend evident for university data
Chicken & Egg Problem

• Example of the Pegasus launch vehicle
• Small, low-cost programs are becoming difficult to initiate because of lack of launch capability.
• But, then this makes it appear that there is no market requiring the development of a small satellite launcher.
Near-Term Solutions

• Multiple Payload Adapters (MPAs)
  – ESPA
  – Minotaur MPA
  – ASAP
  – SPORT
  – SHELS

• New launch vehicles
  – Space Exploration Technologies developing the Falcon
  – Scheduled to fly in late 2003 or early 2004
Long-Term Possibilities

- RASCAL
- Xerus
- Balloon launched platform
- Microcosm’s Sprite
- Operationally Responsive Space Lift
Conclusions

• Benchmarking 172 small satellite missions since 1990
• Mass remained fairly constant
• Capability likely increasing
• Recent launch trends flat
• Outline near and long term solutions to increase access to space