A Custom Launch System for Satellites Smaller than 1kg

Dorin Patru, Jeffrey D. Kozak, Robert J. Bowman
Rochester Institute of Technology
Rochester, New York, USA
0. Overview

1. Motivation
2. Current Launch Options
3. Assembly
4. Concept
5. Characteristics
6. Launch Vehicle
7. Development
8. Benefits
9. Summary
1. Motivation

- Student groups at many universities have designed and built small satellites – in the recent past the Cubesats.
- Because of the prohibitive launch costs, few have been flown and operated.
- Students are interested in the complete cycle: design – implementation – launch and operation.
- Therefore, the need for a launch system for small satellites.
2. Issues with Current Launch Options for Small Satellites

- Secondary payload status, i.e.
  - No control of orbital parameters,
  - No control of launch date.
- Launch opportunities every 3-5 years, i.e. non-responsive.
- Launch Costs: >80k per small satellite.
A Custom Launch System for Satellites Smaller than 1kg
Patru, Kozak, Bowman

3. Launch System Assembly
4. Launch System Concept – Video
4. Launch System Concept - Reviewed

A Custom Launch System for Satellites Smaller than 1kg
Patru, Kozak, Bowman

Rochester Institute of Technology
5. Launch System Characteristics

- No fixed ground infrastructure.
- Launch location can be at any latitude.
- Virtually zero atmospheric drag.
- Low max-q $\rightarrow$ relaxed structural design.
- Weather independent powered flight.
- Nozzle geometry optimized for vacuum.
- Responsive and high launch frequency.
6. Launch Vehicle

- Hybrid Propellant: HTPB and NOX
- $I_{sp} = 235$ seconds
- Need a 4-stage vehicle to reach orbital velocity
- Vehicle initial mass ~200kg

Note: Calculation details in the paper
7. Development – Instrumentation Platform

- **Activity:** Instrumentation Platform Design and Testing.
- **Objective:** Design, Implementation and testing of a high altitude balloon tethered instrumentation platform.
- **Duration/Status:** Started in Fall 2003 – on going.
- **Senior Design Students Involved:**
  - Platform Team 2004 – 7
  - Platform Team 2005 – 2
  - Platform Team 2006 – 5
7. Development – Instrumentation Platform

A Custom Launch System for Satellites Smaller than 1kg
Patru, Kozak, Bowman

Rochester Institute of Technology
7. Development – Instrumentation Platform
7. Development – Launch Vehicle

• **Activity**: Launch Vehicle Design and Testing.
• **Objective**: Design, implementation and ground testing of a hybrid propellant rocket.
• **Duration/Status**: Started in Spring 2005 with the design of one stage, ~ 5 kg – on going.
• **Senior Design Students Involved**: Rocket Team 2006 – 8
7. Development
– Launch Vehicle

A Custom Launch System for Satellites Smaller than 1kg
Patru, Kozak, Bowman

Rochester Institute of Technology
7. Development – Launch Vehicle
7. Development – Launch Vehicle
7. Development – Launch Vehicle

Thrust vs. Burn Time (Long Chamber)

- Thrust (lbf)
- Burn Time (sec)

- Thrust and burn time graph showing the relationship between thrust and burn time for a long chamber launch vehicle.
7. Development – Satellite

- **Activity:** Pico-Satellite design, construction and testing.

- **Objective:** Design, implementation and ground testing of the Pico-Satellite, to include a radio beacon.

- **Duration/Status:** Started in Spring 2004 – on going.

- **Senior Design Students Involved:**
  - Satellite Team 2007 – 6
7. Development – Future Activities

• Sub-orbital test flight of one rocket stage.

• Complete Launch System testing.

• Launch System improvements and upgrades / Pico-Satellite developments.
8. Benefits

• Regular launch opportunities
• Domestic launches
• Short integration timeline
• Small satellite has primary payload status
• Hands-on, multidisciplinary education
• Use of new technologies
• Test bed for space qualification.
9. Summary

• A Custom Launch System for Satellites Smaller than 1kg.

• Concept:
  – A high altitude balloon lifts an instrumentation platform, a four stage 200kg rocket, and a 1kg satellite to ~30km.
  – At this altitude the rocket will fire and after a brief powered flight it will place the satellite in Low Earth Orbit.

• Objectives:
  – Unique and stimulating capstone design experience.
  – Space Technology Development

• The project has engaged 22 students so far, co-advised by a faculty member from each department.
Acknowledgements

• Dr. Edward Hensel, Dr. Elisabeth DeBartolo, James Stefano, Kenneth Snyder, Dave Hathaway, Robert Krynik and Dave Snyder.
• Amateur Radio Operators who have assisted us during our instrumentation platform launches.
• RIT’s financial support
• Donations received from a large number of companies, which are listed on the project’s website: http://meteor.rit.edu
• Harris Corporation: $100K over the next four years.