Platform Independent Launch Vehicle Avionics

Small Satellite Conference
Logan, Utah

August 5th, 2014
Company Introduction

• **Founded in 2011**
  – The Co-Founders blend Academia and Commercial Experience

• **~20 Employees**
  – Eclectic Leadership experience in Traditional and New Space
  – “Young Veterans” involved in developing, testing, operating and launching first and second generation NanoSats
  – Projected 25+ by the end of 2014

• **Locations**
  – Headquarters in Irvine, CA
    • 8743 ft² facility to support Vehicle Systems Group
  – San Luis Obispo, CA
    • Offices and lab hosting Launch Services Group
**Tyvak Avionics Technology**

**Overview**
- Tyvak personnel have been developing CubeSat avionics systems since 2001 with a focus on miniaturized systems.
- All components are COTS at either the IC or module level.
- The core systems (C&DH, EPS, ADCS) are custom designed, with supporting functionality (GPS, radios, IMUs) purchased off the shelf and integrated.

**Developing Approach**
- Follow the cell-phone model using modern components, and an OS environment utilizing open-source software.
- Reliability with simplicity
Tyvak Avionics Applied to a NLV

**Nano-Satellite and NLV Avionics Commonality**

- Ground Support Equipment
- Command and Data Handling
- State Estimation and Control System
- Transmitters
- Distributed Electrical Power System
- Use of Modern Parts for Mass and Cost Reduction
- Use of Modern Components in High Reliability Environment.

**Example:**

- Tyvak C&DH
- Tyvak Reaction Wheels
- Tyvak Star Tracker
- Example Gyro
- Example GPS
- Radios (S-Band, UHF,
- Distributed EPS

**Change Actuation Mechanisms**

Sensor Fusion using Kalman Filter. Control system Software to be updated given environment, actuators, and Launch profile.
SBIR E1.02 Overall Program Overview and Goals

• Funded through NASA Launch Services Program Phase II SBIR

• Development of Nano Launch Vehicle (NLV) capable of carrying approximately 20kg of payload mass to a Low Earth Orbit (LEO)
  – The overall NLV architecture shall be capable of reducing mission costs
  – Avionics system shall be small, lightweight, and robust
  – Avionics shall allow NLV control, system monitoring, and automated flight termination control that meets range safety requirements
  – Avionics shall interface with ground control infrastructure for ground operations

• The NMSLV shall be smaller than a Pegasus launch vehicle
Phase II Technical Objectives

Flight Opportunity
- Launch & Mission Operations
- Generation Orbit NASA NEXT Opportunity

NLV SBIR Phase II
- Technology Development
- Technology Demonstration
- System/Subsystem Development
- System Test

IRAD and NLV SBIR Phase I
- Basic/Applied Research
- Feasibility Demo
Key Technology Elements Demonstrated

- **Supports Multiple GNSS Receivers**
- **Low Mass Avionics Module**
  - C&DH, EPS w/ Batteries
  - Wireless Comm Interfaces
  - State Estimator (GPS, IMU)
- **Modular Independent Redundancy**
  - GPS Metric Tracking
  - Automated Flight Safety System
- **Clean Interfaces**
  - Simple command interfaces to actuators
- **Ground Support Equipment Interface**
  - Power over Ethernet
  - DC Power
  - Vehicle Safeing and Diagnostics
- **Supports Multiple S-Band Transmitters**
- **Vehicle Independent**
  - Specific interfaces tailored for the vehicle
- **Intra-Vehicle Wireless**
  - Data link between stages
  - Wireless data umbilical
- **Distributed Sensor Collection**

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Tyvak Nano-Satellite Systems Inc.
Interconnected Module Initial Concept Configuration

**Module Functionality**

- Each module is functionally independent, built using common designs
- This configuration still requires traditional range tracking and flight termination system independent from the control system
Concept Configuration on Vehicle

Module 1
Vehicle Control and Telemetry Transmission Payload Sep Sequencer

Module 2
Sensor Node

Module 3
Sensor Node

Module 4
Sensor Node

Range Tracking Transponder and FTS

Ethernet Switch and NLV Power Control Board

GPS Signal

Vehicle Telemetry

Range Tracking

Flight Termination
Interconnected Modules on Vehicle with GPS Metric Tracking

- Module 1: Vehicle Control and Telemetry Transmission Payload Sep Sequencer
- Module 2: GPS Metric Tracking
- Module 3: GPS Metric Tracking
- Module 4: Sensor Node
- Module 5: Sensor Node

Removed need for tradition range tracking assets using GPS Metric Tracking
Interconnected Modules on Vehicle with Automated Flight Safety System

- **Module 1**: Vehicle Control and Telemetry Transmission Payload Sep Sequencer
- **Module 2**: AFSS Flight Termination System (Vehicle SW Issued)
- **Module 3**: AFSS Sensor Node
- **Module 4**: Sensor Node
- **Module 5**: Sensor Node

Removed Need for ALL Traditional Range Assets with Automated Flight Safety System Implementation

**Vehicle Telemetry**

**GPS Signal**

**Downlink**
GNC - System Overview

- **State Estimator**
  - Raw Sensor Outputs
  - Filtered State

- **ADIS16488 IMU**
  - Acceleration (3 axis)
  - Angular Rate (3 axis)

- **JNS100 GPS**
  - Position and Velocity

- **Guidance**
- **Controller**

- **Vehicle Independent**
- **Vehicle Specific**

- **Actuator Commands**
GNC – Heritage Solutions

- Simulation / Autocoding
  - Heritage simulation built in MATLAB/Simulink
  - Used for CubeSat Proximity Operations Demonstration (CPOD)
  - Flight algorithms are autocoded for ease of modification

- Hardware in the Loop
  - Sensors simulated and connected to flight algorithms on embedded target via flight like hardware interfaces
  - Sensor models can easily be replaced to support the NLV mission (modeled in Simulink)
Summary

- Utilizing heritage CubeSat electronics and software for Launch Vehicle applications was shown to be feasible.
- Leverage commercial standards (Ex. Power over Ethernet).
- Conservative estimates show significant mass savings.
- Modular nature provides path towards reducing range costs.
- Tailoring of the avionics on a per vehicle bases optimizes payload mass fraction.
  - Ex. A sensing node could be the size of a deck of cards.

Intrepid 1U for Scale

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<tr>
<th>Name</th>
<th>Tyvak NLV Avionics</th>
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<tbody>
<tr>
<td>Dimensions [cm]</td>
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<td>S-Band Transmitter</td>
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Questions?